

[54] FIRE ALARMING SYSTEM

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[58] Field of Search..... 340/227, 228, 191, 340/179, 181, 408, 182, 185, 224, 171 PF, 184, 413, 416, 171, 237; 310/8.1; 343/6.5, 6.5 SS

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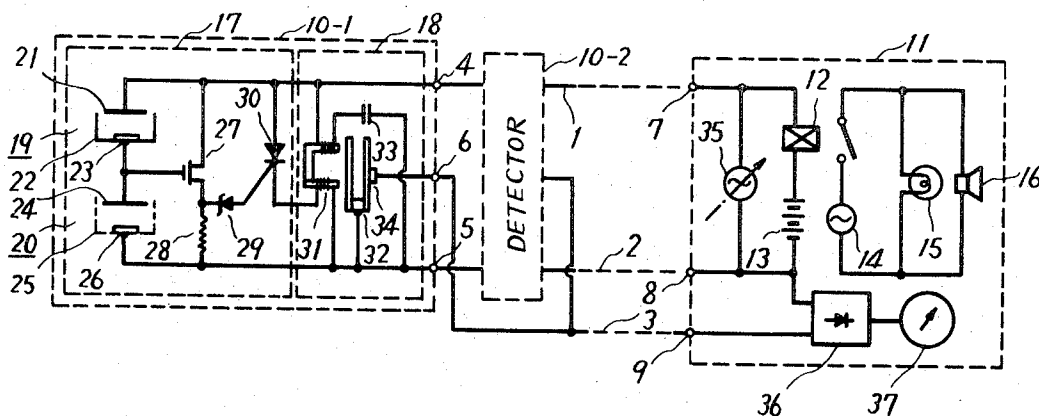
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[57] ABSTRACT

A fire alarm system having a plurality of fire detectors connected in parallel to a transmission line, each detector having a band pass filter resonating at a specific individual frequency. A receiver is connected to the transmission line and generates a plurality of frequencies corresponding to the frequencies of the detectors and has means for detecting specific frequencies returned thereto when one or more of the detectors are activated by fire, thus enabling detection and location of a fire.

4 Claims, 11 Drawing Figures



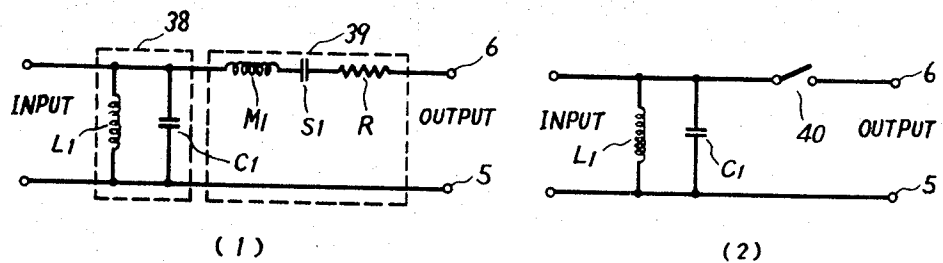
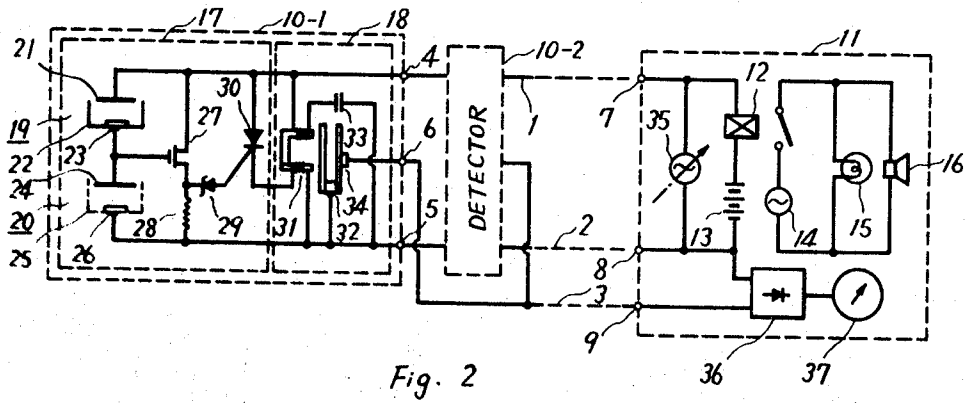
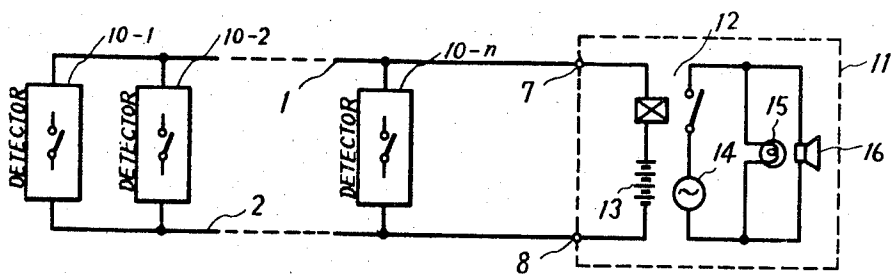
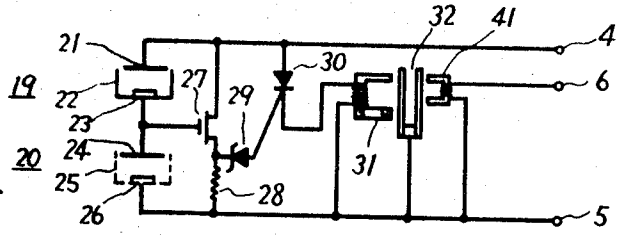


Fig. 3

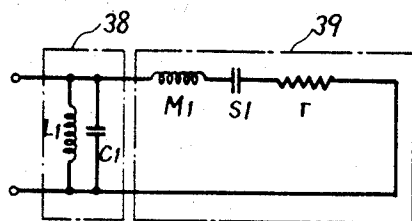


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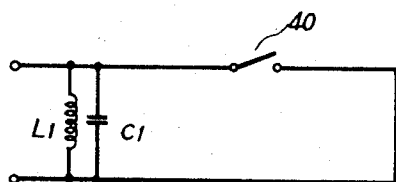
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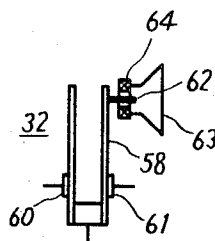


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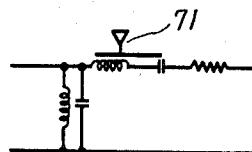


(2)

Fig. 5



(1)



(2)

Fig. 6

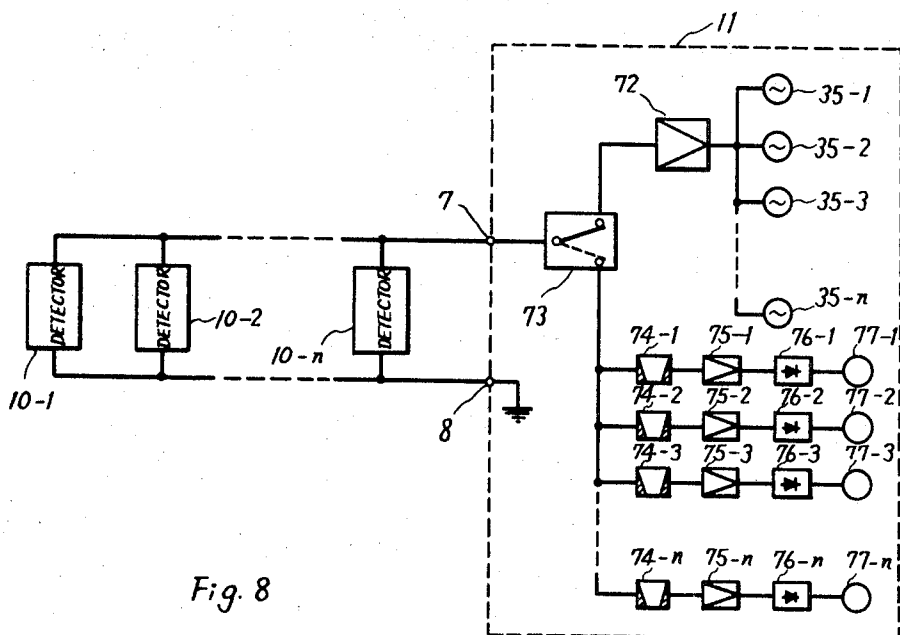


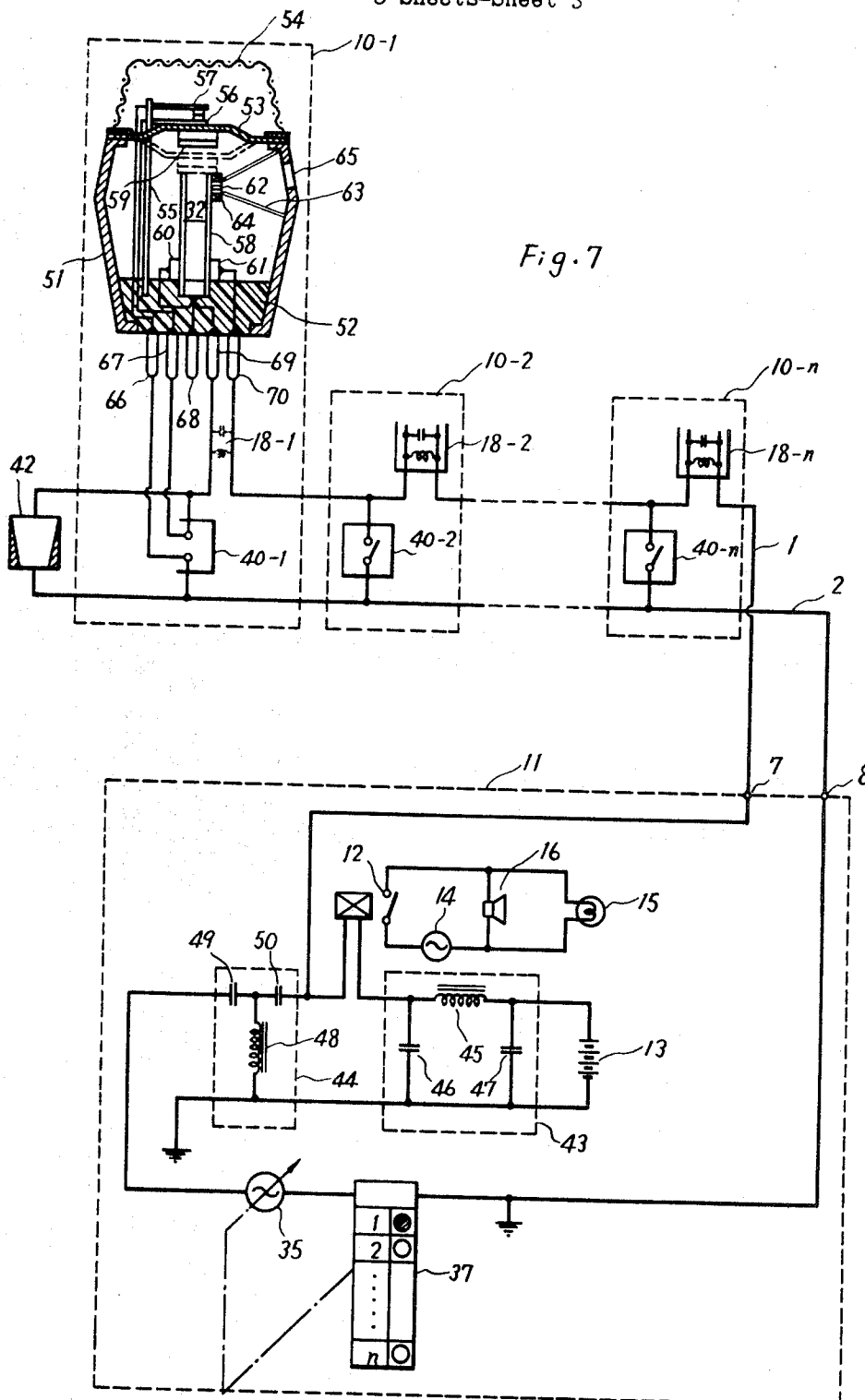
Fig. 8

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FIRE ALARMING SYSTEM

This invention relates to a fire alarm system and more particularly to such a system including novel and improved means in detecting the location of a fire.

In the prior fire alarm systems, a number of fire or smoke detectors are generally connected in parallel between a pair of conductors which are connected to a single receiver including a power supply and an alarm device. When any of the detectors is excited, a closed circuit including the power supply and alarm device is completed through said detector and an alarm signal is generated from the alarm device. In such a fire alarm system, however, the alarm signal is generated whenever at least one of the detectors is excited but it cannot indicate which detector has been excited. That is, such a system can only detect a fire but cannot detect where the fire has started. Therefore, the prior fire alarm system has required other means, such as patrols for finding the location of the fire. However, such a procedure is difficult especially when large numbers of detectors are distributed over a wide area or in a tall building.

In order to overcome this difficulty in some of the prior systems, the detectors are individually connected to the receiver, but such systems require a bulky bundle of cables and the cost of installation is high. As described in a co-pending U.S. Pat. application, Ser. No. 120,178, filed Mar. 2, 1971, this inventor describes a novel system wherein each of the detectors includes an oscillator which generates its own characteristic frequency when excited and the receiver includes means for detecting the frequency and indicating the corresponding detector. Although the system is very effective in comparison to the prior systems, the detectors are rather bulky and costly.

Therefore, one object of this invention is to provide an improved low cost fire alarm system which can quickly indicate any detector now being excited.

According to this invention, each of the detectors includes a filter which can pass only its own characteristic frequency when excited and the receiver includes means for generating AC signals having at least the characteristic frequencies of the detectors and means for detecting these frequencies and indicating the corresponding detectors. Therefore, the system of this invention can generate an alarm signal and at the same time indicate the detectors being excited. In addition, the detectors of this system can be made rather compact and at a low cost since they have few and relatively simple structural components.

Other features and operation of this invention will be more clearly understood from the following description and the accompanying drawings.

In the drawings:

FIG. 1 is a diagram representing partly in block form a general circuit configuration of a prior fire alarm system;

FIG. 2 is a diagram representing, partly in block form, a circuit configuration of an ionization type smoke detecting system including an embodiment of this invention;

FIG. 3(1) and 3(2) are schematic circuit diagrams explaining operation of the embodiment of FIG. 2;

FIG. 4 is a schematic circuit diagram representing an ionization smoke detector in accordance with another embodiment of this invention;

FIGS. 5(1) and 5(2) are schematic circuit diagrams explaining the operation of the embodiment of FIG. 7;

FIGS. 6(1) and 6(2) are schematic diagrams representing a sounding device to be included in the detector of this invention;

FIG. 7 is a schematic diagram representing a circuit configuration of a bimetal type fire detecting system and the construction of the detector in which this invention is embodied; and

FIG. 8 is a block diagram representing a further embodiment of fire alarm system according to this invention.

Throughout the drawings, like reference numerals are used to denote like structural components.

Referring first to FIG. 1 representing a prior fire alarm system, a number of fire detectors 10-1, 10-2, . . . , 10-n are connected in parallel between a pair of conductors 1 and 2 which are respectively connected to the both input terminals 7 and 8 of a receiver 11. The receiver 11 includes an electromagnetic relay 12, a power supply 13 indicated as a battery and connected in series with the electromagnet of the relay 12 between both input terminals 7 and 8. Another power supply 14 is indicated as an AC source and is connected in series with the normally open contact of the relay 12 and an indicating lamp 15 and a sounding device 16 such as a bell or buzzer which is connected in parallel with the indicating lamp 15. Although there are many types of detectors 10, most of them can be represented by a single-pole, single-throw normally open switch as indicated schematically in the drawing, which is closed when the detector is excited.

When any of the detectors of the system is excited, a closed circuit including the power supply 13 and the relay 12 is completed to energize the relay 12 and close its contact and thus the existence of a fire is indicated by the lamp 15, and an alarm is sounded by the sounding device 16. As readily understood, in the such system, the receiver can indicate the existence of a fire but cannot indicate the site of the fire since the relay 12 is energized similarly by any of the detectors being excited.

Referring now to FIG. 2 representing an embodiment of this invention, a number of detectors 10-1, 10-2, . . . , are connected in parallel between a pair of conductors 1 and 2 which are respectively connected to input terminals 7 and 8 of a receiver 11. The receiver 11 also has a third terminal 9 connected to a third conductor 3 which is in turn connected to each of the third output terminals of the respective detectors.

As shown in detail in the first detector 10-1 only, each of the detectors consists of a fire detecting section 17 and a frequency filtering section 18. The fire detecting section 17 of this embodiment consists of an ionization type smoke detector including, as well-known in the art, a closed ionization chamber 19 having a pair of electrodes 21 and 22 and a radioactive source 23 for ionizing the ambient air and an open ionization chamber 20 having a similar pair of electrodes 24 and 25 and a radioactive source 26. The electrodes are connected in series between terminals 4 and 5 of the detector which in turn are connected to the conductors 1 and 2, respectively. The smoke detector also includes a field effect transistor 27 having a gate electrode connected to the junction between the both ionization chambers 19 and 20 and a drain-source conduction path connected through a load resistor 28 between the both terminals 4 and 5, and a silicon controlled rectifier 30 having a conduction path connected also between the ter-

minals 4 and 5 and a control electrode connected through a zener diode 29 to the source electrode of the field effect transistor 27. A specific operation voltage is always applied between the both terminals 4 and 5 by a power supply 13 included in the receiver 11.

As well-known in the art, when smoke enters the open ionization chamber 20, it acts to raise the impedance of the chamber and consequently the voltage at the gate electrode of the field effect transistor 27. This action increases the drain-to-source current and in turn increases the source voltage thereof. When the source voltage exceeds the zener voltage of the zener diode 29, it drives the silicon controlled rectifier 30 into conduction to form a short-circuit between the conductors 1 and 2.

The frequency filtering section 18 consists of an electromechanical filter consisting of a tuning fork 32, an electromagnet 31 serving as a magnetostrictive conversion element magnetically coupled to one leg of the tuning fork and a piezoelectric conversion element 34 attached to the other leg of the tuning fork. The electromagnet 31 has a biasing winding wound on one leg thereof and connected between the cathode of the silicon controlled rectifier 30 and the second terminal 5 and a driving winding wound on the other leg and connected between the both terminals 4 and 5 through a blocking capacitor 33. The piezoelectric element 34 is connected to the third output terminal 6 which is connected to the third conductor 3.

As is known in the art, in the resonance condition, the electromechanical filter of this embodiment can be represented by an equivalent four-terminal circuit as shown in FIG. 3(1). The circuit consists of an electrical convertor section 38 consisting of a parallel circuit of an inductance L1 and a capacitance C1, and a mechanical convertor section 39 consisting of a series circuit of an inductance M1, a capacitance S1 and a resistance R which correspond respectively to mass, stiffness and mechanical resistance of the mechanical portion of the filter. The electromagnetic filters of the detectors 10-1, 10-2, . . . , 10-n of this system have their own characteristic resonance frequencies $f_1, f_2, \dots, f_n$, respectively, which are predetermined by selecting the values of the above structural components. When an AC signal having frequency f_1 is fed to the filter 18 of the detector 10-1 through the driving winding of the electromagnet 31, for example, it passes through the filter and appears at the terminal 6 since the series resonance circuit 39 does not materially attenuate a signal having the same frequency as its resonance frequency f_1 . When the input signal has a frequency other than f_1 , however, the filter does not resonate and the signal is greatly attenuated by the filter and will not appear at the terminal 6. This condition can be represented by a circuit, shown in FIG. 3(2), having an open switch 40 in place of the series resonance circuit 39.

Referring again to FIG. 2, the receiver 11 includes a variable frequency generator 35 connected between the terminals 7 and 8, a rectifier 36 connected between the terminals 8 and 9 and an indicator 37, such as a voltmeter, for indicating the level of output of the rectifier 36. In addition, a relay 12, a DC source 13, and an AC source 14, an indication lamp 15, and a sounding device 16 are arranged similarly to those in the receiver 11 of FIG. 1.

When the detector 10-1 is excited by smoke coming in the open ionization chamber 20, the silicon con-

trolled rectifier 30 is driven into conduction as described in the above to short-circuit the both terminals 7 and 8 of the receiver 11. Therefore, the relay 12 is energized and an alarm signal is generated as described in conjunction with FIG. 1. At the same time, the tuning fork resonator 32 is activated by the biasing winding of the electromagnet 31.

In this condition, if the variable frequency generator 35 is operated and its frequency is varied over a wide range, and is applied to the filter through the driving winding of the electromagnet 31 only the frequency f_1 will pass the filter and be picked up by the piezoelectric element 34 and appear at the output terminal 6. This signal is transmitted through the conductor 3 to the receiver 11 and rectified by the rectifier 36 and its level is indicated by the indicator 37. Therefore, the excitation of detector 10-1 can be determined at the receiver 11 by reading the frequency of the variable frequency generator 35 corresponding to the maximum swing of the indicator 37. Similarly when any of the other detectors is excited, the excited detector can be determined by the frequency which gives a maximum swing of the indicator 37.

FIG. 4 shows another embodiment of an ionization smoke detector including a modification of the electromechanical filter shown in FIG. 2. In this embodiment, the mechanical filter consists of a driving magnet 31, a tuning fork 32 and a pick-up magnet 41. The driving magnet 31 has a leg which includes a permanent magnet for constantly biasing the tuning fork 32 in an activated state. The AC signal applied from the variable frequency generator 35 to the terminal 4 passes through the silicon controlled rectifier 30 and the driving winding of the driving magnet 31 in superposition with the DC current applied from the power supply 13 and is picked up by the pick-up winding of the pick-up magnet 41 when the detector is excited.

Since in the above mentioned embodiments the electromechanical filter is used as a four-terminal network, the system requires at least three conductors. However, it has been well known in the art that such electromechanical filters having four terminals can be changed into a two-terminal network by terminating both output terminals with a suitable resistor. In this case, the equivalent circuit of the filter can be represented by the circuit of FIG. 5(1) in its resonant state or by the circuit of FIG. 5(2) in its nonresonant state. As in the case of FIG. 3, a signal having a resonant frequency of a given detector can pass through the series resonant circuit 39 but other signals having other frequencies can pass through neither the series resonance circuit 39 nor the parallel resonance circuit 38 and is blocked by the filter. By applying this principle to the system, the number of necessary conductors can be reduced on two.

Each of the detectors may be provided with a sounding device to produce an audible alarm upon the excitation of a detector. This can be simply accomplished by attaching a dynamic speaker to one leg of the tuning fork as shown in FIG. 6(1). In the drawing, a tuning fork resonator 32 has an input piezoelectric element 60 and an output piezoelectric element 61. A permanent magnet 62 is attached to one leg 58 of the tuning fork and is surrounded by a voice coil 64 of a speaker 63. This arrangement is symbolized by the structure denoted by the numeral 71 in the equivalent circuit diagram of FIG. 6(2). When the tuning fork is driven into resonant condition, the permanent magnet 62 vibrates

with the leg 58 at its resonance frequency and induces an audio current in the voice coil 64. Again due to interaction between the audio current and the permanent magnet 62, the voice coil 64 vibrates at the audio frequency and sounds the speaker 63.

Referring next to FIG. 7 representing another embodiment of the system of this invention, a plurality of detectors 10-1, 10-2, . . . 10-*n* of which 10-1 is shown in detail in a sectional view while the others are shown schematically in block form. All of the detectors are connected in parallel between a pair of conductors 1 and 2 which are respectively connected to a pair of input terminals 7 and 8 of a receiver 11. The other ends of the conductors 1 and 2 are terminated with a high-pass filter 42 which blocks the DC component of a signal but serves as a specific impedance for the AC component thereof.

The detectors 10-1, 10-2 . . . 10-*n*, respectively, consist of electromechanical filter sections 18-1, 18-2, . . . 18-*n* and normally open switch sections 40-1, 40-2 . . . 40-*n*. The switch sections are connected in parallel between the pair of conductors 1 and 2 but the filter sections are connected in series with the first conductor 1. As hereinafter described, the switch sections consist of similar normally open contact switches operated by a bimetal element and the filter sections consist of tuning fork resonators having their own characteristic resonant frequencies $f_1, f_2, \dots, f_n$, respectively.

As shown in detail in the dashed block of the detector 10-1, each of the detectors comprises a cylindrical housing 51 made of a suitable material such as metal or synthetic resin, an insulating base 52 fixed to the bottom of the housing 51 for supporting an insulating support rod 55 and a tuning fork 32, a thermally deformable heat sensing element 53 such as bimetal plate fixed to the top of the housing 51 and a mesh cover 54. The support rod 55 extends upwardly through the heat sensing element 53 so as not to interfere with its movement and supports at its upper end a pair of normally open contacts 56 and 57. The heat sensing element 53 has an original shape which is concave downwardly as shown by dotted lines in the drawing and has a contact block 59 fixed to the lower face thereof, and is so arranged that the contact block 59 contacts with the top of the tuning fork 32 to suppress its vibration in the original state but it is deformed thermally into a shape which is upwardly convex as shown in the drawing and the upper face of the element 53 pushes up the lower contact 56 into contact with the upper contact 57. The tuning fork 32 is provided with a sounding device, which is similar to that described in conjunction with FIG. 6 consisting of a permanent magnet 62 fixed to one leg 58 thereof, a voice coil 64 surrounding the magnet 62 and a speaker horn 63 attached to the voice coil 64. A hole 65 is formed in the wall of the housing 51 to emit sound generated by the speaker. The insulating base 52 is also provided with connector pins 66, 67, 68, 69 and 70. When the detector is installed in the system, as shown in the drawing, the contacts 56 and 57 are connected respectively through the connector pins 66 and 67 to the conductors 1 and 2 and the tuning fork resonator 32 is connected in series with the first conductor 1 through the piezoelectric elements 60 and 61 and the connector pins 69 and 70.

The equivalent circuit of the tuning fork resonator 32 of this embodiment is shown in FIG. 5(1) in the resonant state and in FIG. 5(2) in a nonresonant state.

Since it is assumed in FIG. 7 that only the detector 10-1 is excited, the switch sections of the other detectors are indicated as being open and the series resonant circuits 39 (FIG. 5) are omitted from the filter sections of the other detectors.

The receiver 11 also includes an electromagnetic relay 12, a power supply 13, another power supply 14, an indicating lamp 15 and a sounding device 16 which serve the same functions as those of FIG. 1. In addition, the receiver 11 includes a low-pass filter 43 consisting of a choke coil 45 and capacitors 46 and 47 and is connected between the relay 12 and the power supply 13. A high-pass filter 14 consisting of a choke coil 48 and capacitors 49 and 50 is connected between the terminals 7 and 8. Between the high pass filter 44 and the terminal 8 there are also connected a variable frequency generator 35 and an indicator 37. The indicator 37 has a plurality of indicating lamps which correspond respectively to the detectors 10-1, 10-2, . . . 10-*n* in the system and can be illuminated by an AC current having a level higher than a specific value. The indicator 37 is interlocked with the variable frequency generator 35 so that the indicating lamps respectively correspond to the detectors 10-1 to 10-*n* are successively switched into the line in correspondence with the successive change of frequency from f_1 to f_n of the generator 35. The other end of the power supply 13 and the terminal 8 are grounded as shown in the drawing. Thus the DC component of the input signal flows through the relay 12 and the AC component flows through the indicator 37.

In operation, if a detector is not excited, all of the switch sections 40-1 through 40-*n* are open and all of the filter sections 18-1 through 18-*n* are in the condition as shown in FIG. 5(2). Therefore, even though the frequency of the generator 35 is varied from f_1 to f_n , there is neither a DC current nor an AC current flowing through the conductors 1 and 2 because a closed circuit is not formed for the both DC and AC signal component. However, when one of the detectors, for example the first detector 10-1 as shown in FIG. 7, is excited, that is, when the heat sensing element 53 is heated to cause the bimetal to deflect upwardly as shown by full lines in the drawing, the lower contact 56 is pushed up into contact with the upper contact 57 to short-circuit the conductors 1 and 2 and at the same time, the contact block 59 leaves the top of the tuning fork 32 to permit it to vibrate. In this condition, the DC component can flow through the relay 12 to generate an alarm signal and the AC component of frequency f_1 which has been blocked only by the filter section of the detector 10-1 flows in the indicator 37 to flash the corresponding lamp. Therefore, if the variable frequency generator 35 is continuously varied over the full range of frequency, the activated detector is automatically indicated on the indicator 37 at the same time an alarm signal is given when any of the detectors is activated by fire.

FIG. 8 represents a variation of the receiver 11. In this receiver, the variable frequency generator 35 of the foregoing receiver is replaced by a plurality of fixed frequency generators 35-1, 35-2, 35-3, . . . 35-*n* which generate frequencies $f_1, f_2, f_3, \dots, f_n$, respectively, and the indicating means consists of a plurality of groups respectively corresponding to the frequencies f_1 and f_n and consisting of band-pass filters 74-1 to 74-*n* having characteristic pass-frequencies f_1 to f_n respectively, am-

plifiers 75-1 to 75-n, rectifiers 76-1 to 76-n and indicating lamps 77-1 to 77-n.

In operation, AC signals having frequencies f_1 to f_n , respectively, are generated by the generators 35-1 to 35-n, amplified by an amplifier 72 and applied through a chopper 73 to a parallel connection of detectors 10-1 to 10-n and terminals 7 and 8. If one of the detectors is excited and passes its characteristic frequency, this frequency is fed back to the receiver 11, filtered by a corresponding band-pass filter, amplified and rectified and flashes one of the indicating lamps which indicates the excited detector. It is obvious that the fire alarm device which handles the DC component is the same as that of the foregoing embodiments, though it is not indicated in the receiver 11 of FIG. 8.

As described in the above, according to this invention, the site of the fire can be easily determined at the receiver and this makes it possible to centrally control a number of fire alarm systems. Moreover, the detectors according to this invention are rather simple in construction and can be manufactured at low cost.

It should be noted that the abovementioned embodiments of this invention are presented only for the purpose of illustration, and various modifications and changes can be made without departing from the spirit and scope of the invention. For example, though the filter used in each detector is indicated as an electromechanical filter and especially a tuning fork resonator, any other type of band-pass filter having suitable narrow frequency characteristics can be adopted. Moreover, though the detectors are illustrated as ionization types and bimetal types, any other type of detector having a normally open switching circuit which is closed when the detector is excited can be used as the occasion demands.

What is claimed is:

1. A fire alarm system comprising a plurality of fire sensing units connected in parallel between a pair of conductors, a receiving unit including a voltage source and an alarm device connected to said conductors, each of said fire sensing units including a normally open switch which is closed to short circuit said conductors and energize said alarm device when a fire is sensed, each fire sensing unit further including a band pass filter connected between said conductors and having a characteristic resonant frequency preselected peculiarly to said sensing unit, said receiving unit further including means for generating a range of AC signals having frequencies corresponding to said characteristic resonant frequencies of said filters in the respective sensing units, each of said filters being operated upon actuation of its associated sensing unit to produce its characteristic frequency, a conductor directly connecting the outputs of said filters in said sensing units to said receiving unit and means in said receiving unit and connected with the last said conductor for discriminating the frequencies of the received AC signals and indicating the specific detector activated by the presence of fire whereby each detector upon activation produces both a general alarm and an indicating signal to identify at the receiving unit the specific detector actuated.

2. A fire alarm system according to claim 1 wherein each of said filters is an electromechanical band pass filter and each of said detectors includes a sounding device driven by said electromechanical filter.

3. A fire alarm system according to claim 1 wherein said indicating means includes a plurality of electric lamps.

4. A fire alarm system according to claim 1 wherein each of said fire sensing units sense both ambient temperature and smoke.

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