A. BISBERG **3,559,194**

FIRE ALARM SYSTEM

Filed Sept. 13, 1967 3 Sheets-Sheet 1

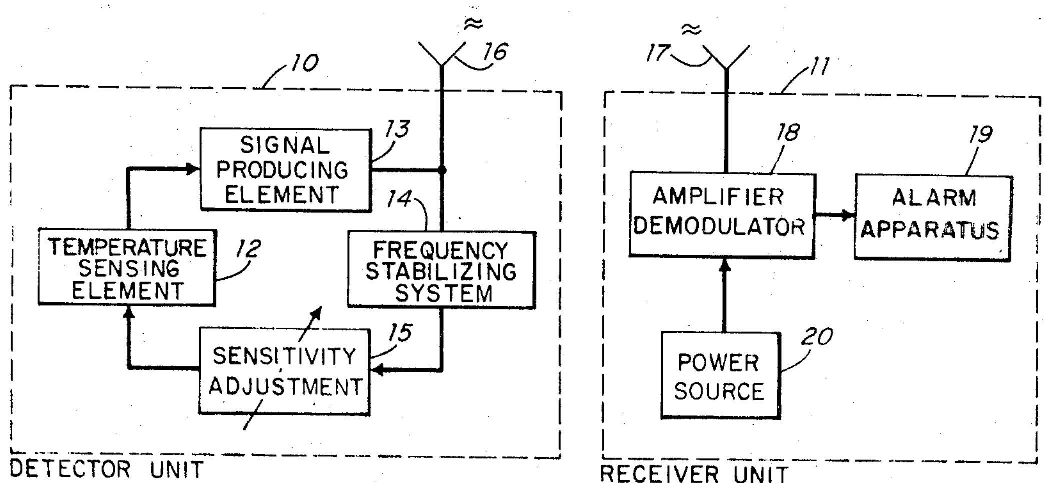

FIG. 1

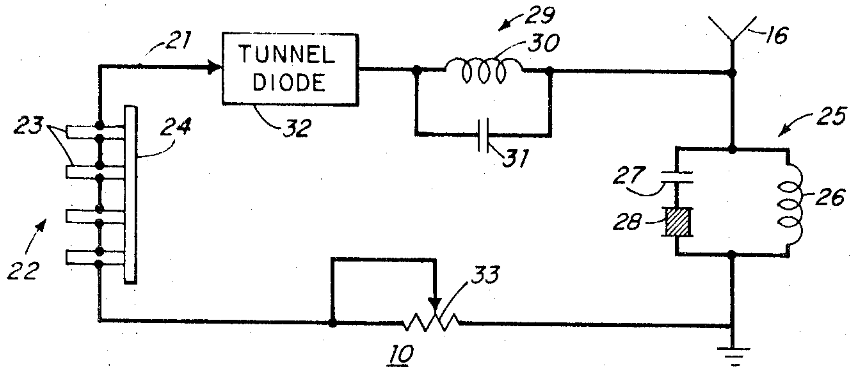

FIG. 2

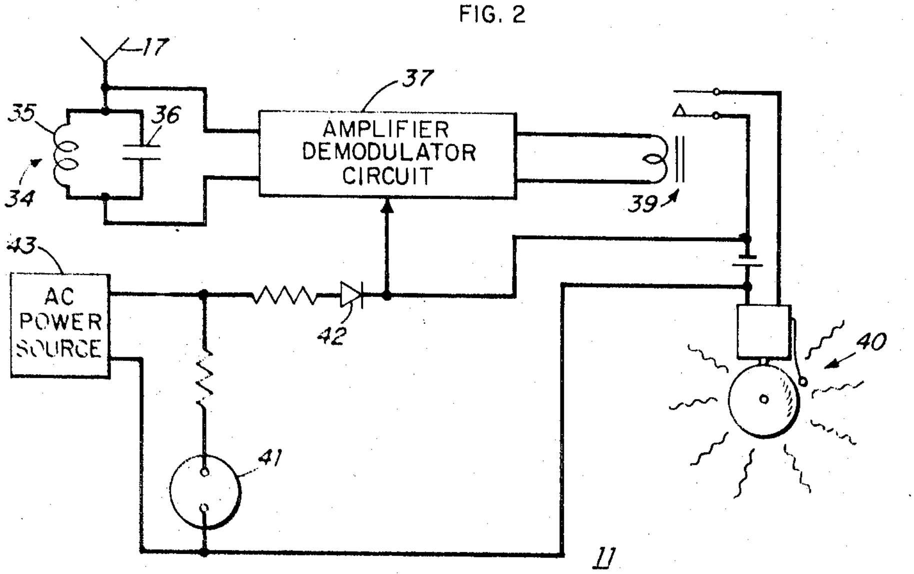

FIG. 3

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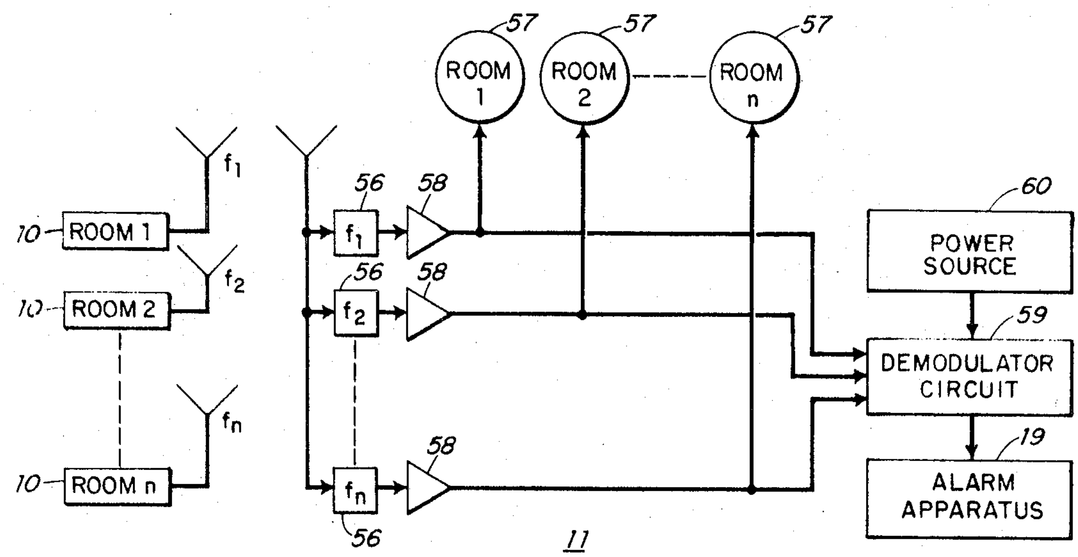

FIG. 7

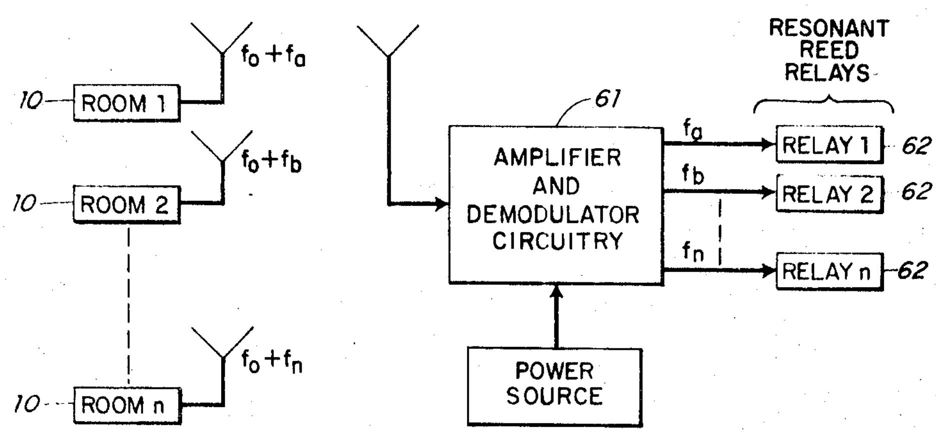

FIG. 8

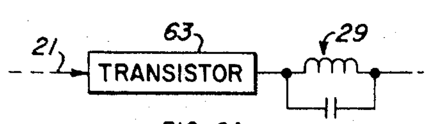

FIG. 2A

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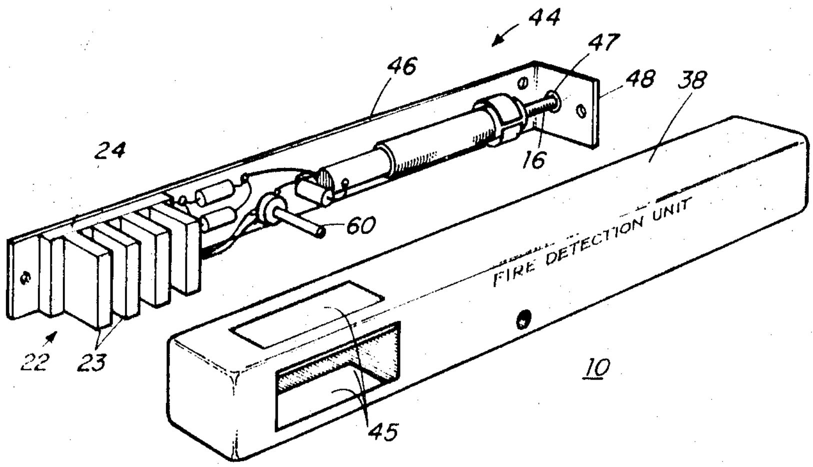

FIG. 4

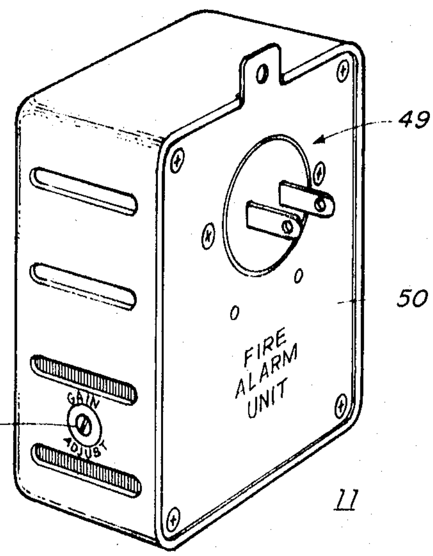

FIG. 5

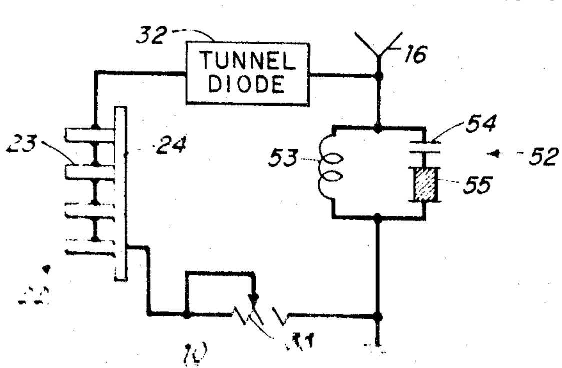

FIG. 6

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3,559,194

FIRE ALARM SYSTEM

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Int. Cl. G08b *17/12*
U.S. Cl. 340—224 5 Claims

ABSTRACT OF THE DISCLOSURE

A fire alarm system which utilizes a plurality of low energy fire detection units, each operating solely from energy received from a fire and each being capable of producing and transmitting a stabilized radio frequency signal in response to an environmental temperature change resulting from a fire. A single remote alarm unit receives and demodulates the transmitted signal received from one or more detection units and produces an audible and/or visual alarm in response thereto. The sensitivity of the detection units is made adjustable and the radio frequency signal from each of such units may be appropriately modulated by an audio frequency signal. The frequency values of such radio frequency signals and/or audio frequency signals may be different for each detection unit and such signals may be suitably utilized at the receiver alarm unit to identify the location of the fire.

This invention relates generally to systems for detecting the presence of fire and for providing a warning alarm to the occupants of a building or others and, more particularly, to a system for producing an oscillating signal having a stabilized frequency in the radio-frequency range, such signal being generated solely in response to energy obtained from the fire itself, and for transmitting said signal to a remote receiver alarm unit.

In fire alarm systems, particularly those which are adaptable for use in homes or business establishments, it has long been desired to obtain a system which is reliable and relatively inexpensive and which can be easily installed, tested and maintained by an untrained individual, such as a homeowner himself. Presently available fire alarm systems usually require relatively high manufacturing costs and include elaborate wiring arrangements which in turn increase installation and maintenance costs so as to make the overall expense to the average homeowner excessively high, if not generally prohibitive. Moreover, even relatively expensive presently known systems are not always reliable, especially those systems using wires which are subject to damage or destruction by the fire itself thereby causing the system to fail to operate at the very time when it is needed.

Moreover, wireless fire alarm systems which have been proposed up to now utilize self-contained detection-alarm units having power requirements so high that the overall unit does not operate effectively or the detection portion thereof requires auxiliary external power, as from A-C power lines or batteries, in order to provide a sensing signal which has sufficient power to actuate an audible alarm loud enough to be heard in other parts of a building. A-C power failure or limited battery shelf life contribute to the danger of system failure. Such self-contained wireless units as are now known are not capable of providing a remote alarm indication which is more desirable in most practical applications.

The system of this invention, on the other hand, provides an overall capability for detecting fire at many different locations throughout a building or group of buildings and for further providing an alarm indication at an appropriately located remote point such as at or near the bedroom of a home, for example, to warn the occupants of the presence of fire. Moreover, the system can be manufactured so as to sell at a relatively low cost in comparison to presently available systems and, as will subsequently be shown, is capable of being installed with little effort by a homeowner or other untrained individual. Furthermore, the system is extremely reliable and requires little or no maintenance for continued reliable operation.

In order to achieve the superior operation of the system of the invention, the invention utilizes one or more self-energized fire detection units, suitably located throughout a building, and a remotely located receiver unit. The fire detection units produce a frequency stabilized oscillating signal as a result of a rate of rise in environmental temperature. Such units require little energy for operation and, since they comprise elements which operate solely in response to energy produced by the fire itself, they do not require external sources of power. Moreover, such low energy units are extremely sensitive to small changes in environmental temperatures, the level of such sensitivity being capable of adjustment over a relatively wide range to provide an output oscillating signal in response to a rate of temperature rise as low as 15° F. per minute.

In one preferred embodiment of the invention, for example, such a unit includes means for providing a stabilized radio-frequency carrier signal which is suitably modulated by an audio frequency oscillating signal produced in response to the output of a thermoelectric sensing element. Such modulated R-F signal is thereupon transmitted to a remote receiver warning alarm unit appropriately placed in the building. The received modulated signal is then amplified and appropriately demodulated to provide an actuation signal for an alarm such as a bell, gong, buzzer, or other suitable indicator which can alert the occupants of the building to the presence of the fire. Since no external power sources are required for the plurality of fire detection units located at the points where the fire is likely to occur, reliability of the overall system is considerably increased over presently known fire alarm systems.

In order to appreciate the advantages of the system of the invention, the operation thereof can be best described in more detail with reference to the accompanying drawings in which:

FIG. 1 shows a block diagram of the overall system of the invention;

FIG. 2 shows a representative circuit used in the self-contained fire detection unit of FIG. 1;

FIG. 2*a* shows an alternate embodiment of a portion of the circuit shown in FIG. 2;

FIG. 3 shows a representative circuit of a remote receiver alarm unit of the invention;

FIG. 4 shows a pictorial representation of a typical fire detector unit of the invention;

FIG. 5 shows a pictorial representation of a typical remote receiver alarm unit of the invention;

FIG. 6 shows an alternative embodiment of the circuitry which can be used in the fire detection unit of FIG. 1; and

FIG. 7 shows an embodiment of the overall system of the invention for identifying the location of a fire as well as providing an alarm; and

FIG. 8 shows an alternative embodiment of the overall system of the invention.

As can be seen in the block diagram configuration shown in FIG. 1, the system comprises at least one, and preferably more thon one, fire detector unit **10** and a receiver unit **11**. Fire detector unit **10** is a self-contained unit which responds to a rate of change in temperature of the environment in which it is placed and thereupon produces an output oscillating signal in the radio frequency range which can be transmitted by an appropriate antenna **16**. Receiver unit **11** receives the transmitted signal at an appropriate antenna **17** and suitably utilizes the incoming signal to trigger an alarm apparatus.

The receiver unit may be placed in an appropriate location, such as at or near the bedroom of a house, and one or more fire detector units can be placed at various other locations, remote from the receiver unit, throughout the house wherever the likelihood of fire may exist. A single receiver unit, thus, can be used to provide an alarm in response to many different detector units.

In general, each detector unit is provided with a temperature sensing element **12** for providing a D-C output voltage in response to a rate of rise of the environmental temperature and a signal producing circuit responsive to such voltage for producing a radio frequency oscillating signal. The frequency of the latter signal is appropriately stabilized by a frequency stabilization device **14** and the signal is applied to an antenna **16** for transmission. The sensitivity of the overall unit may be adjusted by a signal adjusting element **15** which is used to set the point at which oscillation of the signal producing circuit begins in response to the voltage output from element **12**. Receiver unit **11** receives the transmitted oscillating signal by way of antenna **17** which signal is then applied to an appropriate amplifier-demodulator circuit **18** to produce a signal for actuating an appropriate alarm apparatus **19**. The amplifier-demodulator circuit is energized via a suitable power source **20** which may be conventional 60-cycle A-C line power or a battery source. Thus, only the single receiver unit of the overall system requires an external power source and reliability of the system is extremely high.

FIG. 2 shows a representative circuit for fire detector unit **10** in which a thermoelectric generator **22** produces an output voltage in response to an environmental temperature change. The operation of thermoelectric generator **22** depends on the well-known Seebeck effect in which a D-C output voltage results from a difference in temperature between two dissimilar metals having a common junction. In a suitable thermoelectric generator for use in the invention, the dissimilar metals may be a bismuth-telluride combination in which a plurality of hot junctions **23** are in contact with a suitable cold junction **24** to produce a D-C voltage at line **21**. Cold junction **24** may be appropriately attached to a heat sink, such as the wall of the room, while hot junctions **23** extend into the interior of the room where they are appropriately exposed to the temperature therein. D-C output voltage **21** is thereupon applied in the embodiment shown to a tunnel diode element which produces an output oscillating signal, the frequency of which can be controlled by the use of an output tuned circuit **29** comprising a parallel connected inductance **30** and capacitance **31**.

In the particular embodiment shown, circuit **29** may be tuned so as to produce a signal in the audio frequency range which can then be used to modulate a fixed carrier frequency signal in the radio frequency range which carrier signal is generated by the operation of parallel circuit **25** which includes a quartz crystal **28** and a tuned circuit combination of inductance **26** and capacitance **27**. Carrier frequency generator circuit **25** produces a signal in the radio frequency range which, when amplitude modulated by the audio signal from the output of tuned circuit **29**, can be transmitted by antenna **16** to a remote location. The sensitivity of the overall unit may be appropriately varied by adjusting the value of a variable resistor **33**. The use of a bismuth-telluride thermoelectric generator enhances the sensitivity of the unit since it can produce a voltage sufficient to cause oscillatory operation of tunnel diode **32** in response to a rate of rise of environmental temperature as low as 15° F. per minute. Variable resistor **33** allows such sensitivity to be adjusted over a relatively wide range of temperature changes.

The amplitude modulated signal from fire detector unit **10** is then transmitted to receiver unit **11**, the circuit diagram of which is shown in FIG. 3. In that figure, receiver **11** utilizes an input tuned circuit **34** comprising a parallel combination of inductance **35** and capacitance **36** which circuit is tuned to the carrier frequency of the incoming signal from fire detection unit **10** as received at antenna **17**. Such a signal can be appropriately amplified and demodulated by a conventional amplifier-demodulator circuit **37**, which, for example, may be in the form of a multi-stage transistor receiver circuit. Such circuit produces an audio output signal for operating a relay **39** which, when its contacts are closed, actuates alarm apparatus **40** as shown. Appropriate power is supplied to amplifier-demodulator **37**, for example, from an A-C power source **43**, such as the conventional A-C line power source found in the home. The A-C power from power source **43** is appropriately converted to D-C voltage by a suitable power supply rectifier **42** and an appropriate panel light **41** can be used to indicate that the unit is in operation.

FIG. 4 shows a pictorial representation of one particular embodiment of a typical fire detector unit **10** of the invention. In such figure the unit is shown as comprising a mounting section **44** having a rear mounting plate **46** on which thermoelectric generator **22** is mounted with its hot junctions **23** exposed to the environmental temperature via openings **45** in an appropriate cover **38** which in a preferred embodiment is fabricated from a suitable plastic material. Cold junction material **24** is mounted on a rear mounting plate **46** which operates as a heat sink which can be bonded to the wall of a room, for example. Appropriate inductance, resistance and capacitance elements are also mounted on rear mounting plate **46** along with tunnel diode **32**. An externally available screwdriver adjustment **60** for varying the position of the movable arm of variable resistor **33**, for example, is provided for adjusting the sensitivity of the operation of unit **10**, that is, for controlling the voltage level at which oscillation occurs. An antenna **16** radiates R-F energy via an aperture **47** in side wall **48** of mounting structure **44**. The overall structure is very light in weight and can be bonded to the wall of a room by screws or by an appropriate adhesive placed on its rear surface. Thus, detector unit **10** can be installed in any desired location by an untrained individual, such as the homeowner or any member of the household.

A pictorial representation of receiver unit **11** is shown in FIG. 5 wherein an appropriate A-C plug **49** is mounted at the rear wall **50** of the overall alarm unit case. A screwdriver adjustment **51** for varying the gain of the amplifier-demodulator circuit and, hence, the loudness of an audio alarm, for example, is placed on a side wall thereof. Thus, the receiver unit can be easily installed by a homeowner merely by plugging it in at the rear of the unit to a conventional A-C outlet.

Although the circuitry shown in FIG. 2 for fire detector unit **10** represents one preferred embodiment thereof, other alternative embodiments such as the one shown in FIG. 6, for example, may be used. In such figure, thermoelectric generator **22** produces an output voltage which can be applied to tunnel diode **32**, the output of which is tuned so as to produce an oscillating signal having a frequency in the radio frequency range by means of a tuned circuit **52** comprising inductance **53**, capacitance **54** and a frequency stabilizing quartz crystal **55**. Such a system thereby provides an unmodulated R-F frequency signal at antenna **16**, the frequency of which is determined by the values of the elements of tuned circuit **52** and is stabilized specifically by means of quartz crystal **55**. In such an embodiment, the receiver system can merely be tuned to the particular radio frequency involved and then appropriately amplified and detected to produce an alarm actuation signal.

As can be seen from the figures, fire detector unit **10** is made up of elements which are relatively small and, therefore, its overall size is such as to provide an extremely lightweight unit occupying little space. Such a unit can be inconspicuously placed in a room where it is not easily seen or it can be made in a decorative fashion so as not to detract from the overall decor of the room. Its size permits easy handling and, as mentioned above, the unit can be made with an appropriate adhesive backing so as to be easily placed in any appropriate location and just as easily removed therefrom. An important advantage of the system is that it can be readily tested at any time by a homeowner. Because of its high sensitivity, the remote alarm unit can be actuated by a relatively small rate of rise in environmental temperature. Hence, a simple non-destructive method of checking the operation of the system can be readily made merely by placing the fingers on the detection unit or by breathing thereon. Such action causes a sufficient temperature rise to produce an appropriate audible alarm at the remote receiver unit. Such a unit provides a unique advantage over presently known systems which require relatively high temperatures in order to test the alarm system.

The receiver unit **11** can be easily adapted to provide for an alarm which is essentially self-locking in that once it is actuated it remains actuated until turned off. Thus, even if the temperature environment should be temporarily reduced for some reason, the alarm remains in an actuated condition to continue to warn the occupants.

Although in order to provide an extremely sensitive system, the preferred embodiment of fire detector unit **10** is shown as utilizing a tunnel diode element responsive to a relatively low excitation voltage such element may be replaced, for example, by a transistor oscillator circuit, such as shown in FIG. 2*a* wherein transistor **63** is connected to line **21** and thence to tuned circuit **29**. In either event, appropriate frequency stabilization can be obtained by utilizing a quartz crystal, or other suitable stabilizing means. Different tuned circuit and crystal combinations can provide for different carrier frequencies in separate fire detector units. In this way the overall system can be made frequency selective so that, if the remote receiver is arranged to employ a plurality of separate input tuned circuits, it can be used not only to indicate the presence of a fire, but also to produce an appropriate signal to identify the location of the fire in accordance with the frequency of the incoming signal. In addition, in those embodiments of fire detector unit **10** which utilize an audio frequency modulation signal, the tunnel diode circuit, for example, can be tuned to produce signals having different audio frequencies for different fire detector units. Thus, by utilizing different radio frequencies as well as different audio modulation frequencies, a wide variety of selection and identification means can be obtained.

One such embodiment is shown in FIG. 7 wherein a plurality of fire detection units **10** are placed in a plurality of different rooms designated as "Room **1**," "Room **2**" . . . "Room *n*" as shown. Each of said detection units is tuned to produce an output R-F signal tuned to a different frequency designated by $f_1, f_2 \ldots f_n$. A receiver unit **11** has an antenna for receiving said signals and for feeding one or more of them to a plurality of tuned circuits **56**, each of said circuits tuned to a different frequency corresponding to the frequencies $f_1, f_2 \ldots f_n$. If a signal is present at the output of any one of tuned circuits **56** such signal is thereupon fed to an amplifier **58** and thence to a demodulator circuit **59**, supplied with power from power source **60**, to actuate alarm apparatus **19**. The output signals from each of amplifiers **58** are separately connected to suitable indicators **57**, such as appropriate panel lamps, one or more of which is thereupon actuated by the presence of a signal at the output of one or more of said amplifiers to identify the location of the fire.

Alternatively, the system shown in FIG. 8 may be used wherein a plurality of fire detection units **10** are placed in a plurality of different rooms in the same manner as suggested above with reference to FIG. 7. In the case of the system shown in FIG. 8, each unit is tuned so as to produce the same R-F reference signal f_0 which is modulated by an appropriate audio signal $f_a, f_b \ldots f_n$ as shown. A receiver unit **11** has an antenna for receiving said signals and for feeding them to appropriate amplifier-demodulator circuitry **61** capable of producing one or more audio frequency signals corresponding to the audio frequency signals from fire detection units **10**. When an audio frequency signal is present, it actuates an appropriate resonant reed delay **62** which thereby produces an audible signal for indicating the presence of fire. The frequency of the audible tone can provide an indication of the location of the fire or, alternatively, the relay actuation signal may be appropriately used to actuate any other suitable display means for identifying the location of the fire.

Thus, the overall system of the invention can be made extremely flexible depending on the application for which it is used. A selection of the actual configuration depends primarily on the degree of complexity which one is willing to utilize in the receiver unit and the fire detector circuit can be made to operate as an amplitude modulation, frequency modulation or pulse modulation system with suitable changes well known to those in the art.

Although the various embodiments of the system described in the figures are shown as utilizing antenna means which may be in the form of a suitable ferrite loop antenna, for example, the system can be made to operate without an antenna at all if the required range of transmission is relatively short. Moreover, in some applications the oscillating signal may preferably be transmitted to the receiver via absorption of a portion thereof by the power lines of the house.

The receiver unit can be either operated via line power or from a battery source or from both. In the latter case the battery may be appropriately connected to the power line source so as to remain on a "trickle" charge so that if the line power fails, the battery which is thereby suitably charged, can be automatically switched into the circuit for operating the receiver. Concurrently, an auxiliary alarm may be actuated, if desired, to indicate that power failure has occurred. Thus, the chance of a system failure due to faulty receiver operation can be reduced considerably and overall system reliability is further increased.

To further improve the versatility of the system, the receiver unit can also be made to operate from a voltage produced by presently known smoke detection devices, such as those utilizing photocell systems which operate in response to a change in light impinging thereon, such as may be brought about by the presence of smoke accompanying a fire. A suitable photoelectric, or other, smoke detector device may be placed adjacent the receiver unit and its output signal can be applied thereto so that the overall system is capable of producing an alarm actuation signal in response to the presence of smoke as well as to the presence of fire.

What is claimed is:

1. A fire alarm system comprising: at least one fire detection means including

temperature sensing means operating solely from energy received from a fire for producing a voltage in response to a rate of change of environmental temperature;

tunnel diode circuit means for producing a radio frequency oscillating signal in response to said voltage whenever said voltage has a value corresponding to a rate of change of environmental temperature of approximately 15° F. per minute or greater;

a quartz crystal means for stabilizing the frequency of said oscillating signal;

means for transmitting said oscillating signal; and

remote means including

means for receiving said transmitted oscillating signal;

means for amplifying said received signal to produce an amplified alarm signal; and

alarm circuit means for producing an alarm in response to said amplified signal.

2. A fire alarm system in accordance with claim **1** wherein said tunnel diode circuit means includes

variable adjusting means for controlling the voltage level at which said oscillating signal is produced.

3. A fire alarm system comprising

a plurality of fire detection units, each of said units comprising

temperature sensing means operating solely from energy received from a fire for producing a voltage in response to an environmental temperature change due to said fire;

solid state circuit means for producing an oscillating signal in response to said voltage whenever said voltage has a value corresponding to a rate of change of environmental temperature of approximately 15° F. per minute or greater, the frequency of said oscillating signal being different in each of said fire detection units;

quartz crystal means for stabilizing the frequency of said oscillating signal; and

means for transmitting said oscillating signal;

remote receiving means for receiving said transmitted oscillating signals; said receiving means including

a plurality of filter circuits for producing a plurality of separate signals, each of said filter circuits being responsive to one of said oscillating signals;

means for amplifying each of said separate signals to produce one or more separate output signals;

a plurality of separate indicator means each responsive to one of said separate output signals for producing an indication of the location of said fire; and

means for producing an alarm in response to any one of said separate output signals.

4. A fire alarm system in accordance with claim **3** wherein

said solid state circuit means produces an audio frequency oscillating signal, the frequency thereof being different in each of said fire detection units and further includes;

means for producing a radio frequency oscillating signal;

means for modulating said radio frequency oscillating signal with said audio frequency oscillating signal; and

said transmitting means transmits said modulated signal; and

wherein said remote receiving means includes

means for receiving said modulated signal;

means for amplifying and demodulating said modulated signal; and

said alarm producing means produces an alarm in response to said demodulated signal.

5. A fire alarm system in accordance with claim **4** wherein

said temperature sensing means comprises a bismuth-telluride element having hot and cold junctions, said hot junction extending into a temperature changing environment and said cold junction thermally connected to a heat sink; and said solid state circuit means comprises a tunnel diode circuit.

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U.S. Cl. X.R.

325—105; 340—227, 228, 333