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Birchfield et al.

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[45] **Sept. 4, 1973**

[54] **DIVERSITY RF ALARM SYSTEM**

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[52] **U.S. Cl.** **340/224**, 325/56

[51] **Int. Cl.** **H04b 1/00**, H04b 7/02, G08b 21/00

[58] **Field of Search** ..... 325/154, 113, 47, 325/51, 53, 56, 304, 364, 372; 179/15 BY, 15 FD; 340/224, 207, 209, 181

[56] **References Cited**

UNITED STATES PATENTS

3,149,317	9/1964	Brugliera	340/224
3,114,106	12/1963	McManus	325/56
3,230,454	1/1966	Burkleo	340/224 X
3,310,742	3/1967	Adams	325/56
3,444,471	5/1969	French	325/304
3,452,156	6/1969	Engelbrecht	325/56 X

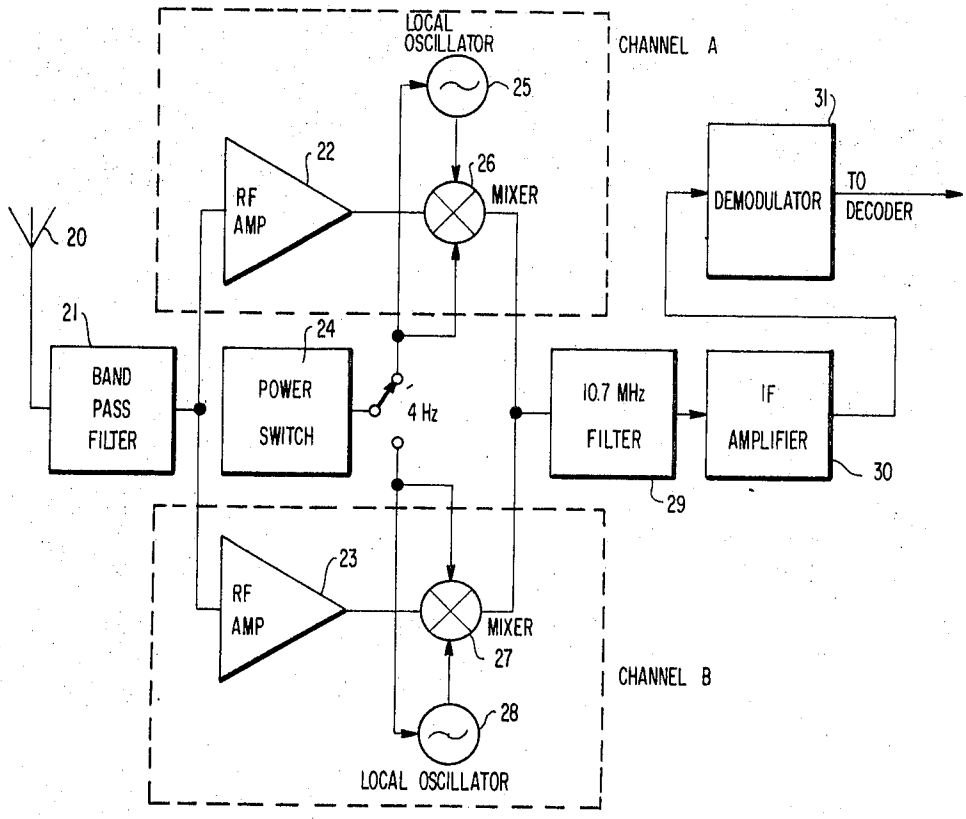
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[57] **ABSTRACT**

An alarm system incorporating radio links between a plurality of remotely located alarm condition sensing units and a central receiving station. Each alarm condition sensing unit is comprised of at least one sensing means which is comprised of an alarm sensing element in combination with a frequency diversity radio transmitter means. The transmitter means of all of the sensing units transmit frequency diversity carrier signals having the same carrier frequencies but the carrier signals associated with different units have modulation signals of differenct frequency impressed thereon. At the receiving station a frequency diversity receiver means which has two channels and a means for switching therebetween demodulates the frequency diversity signals received. The demodulated signals pass to a plurality of pulse rate discriminators equal in number to the number of sensing units in the system. Each pulse rate discriminator is responsive to a different modulation signal to emit a different alarm output which alarm output indicates the sensing unit which has triggered. Each pulse rate discriminator means indicates whether a given modulation frequency is present or not by comparing the time between successive negative going zero crossings of the demodulated signal with the duration of a plurality of fixed length pulses.

22 Claims, 6 Drawing Figures



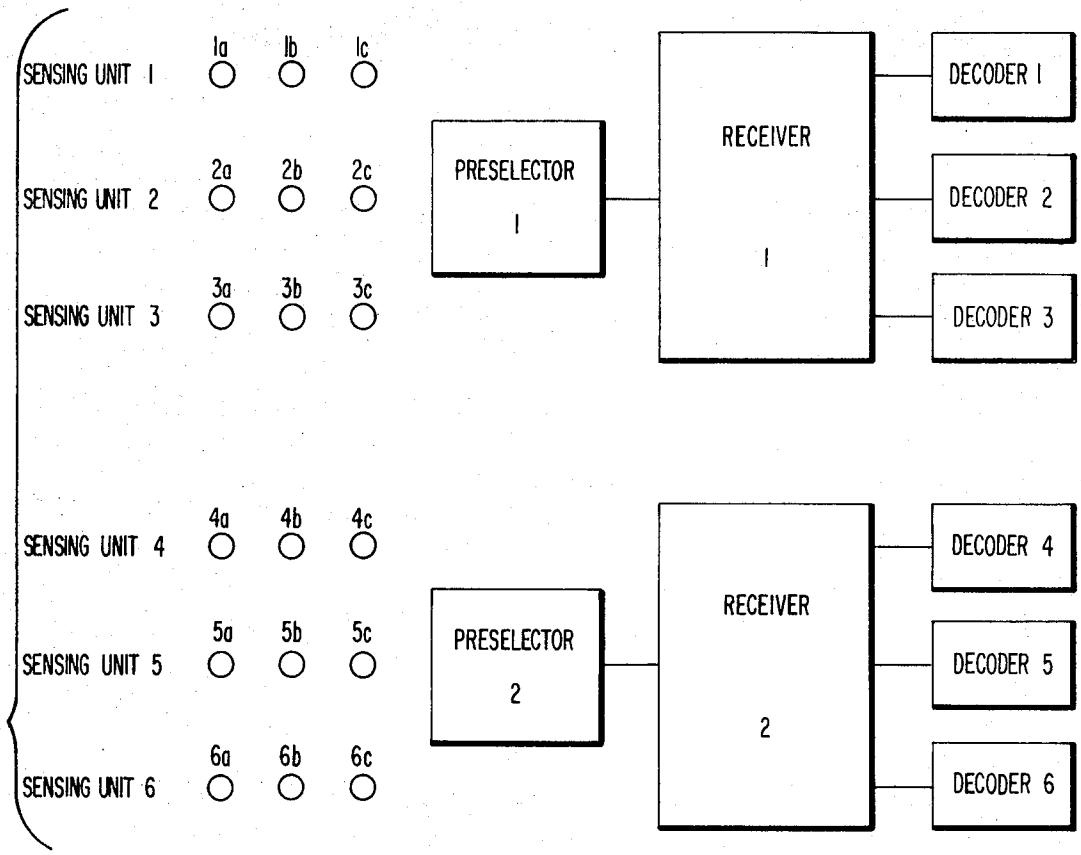


FIG. 1

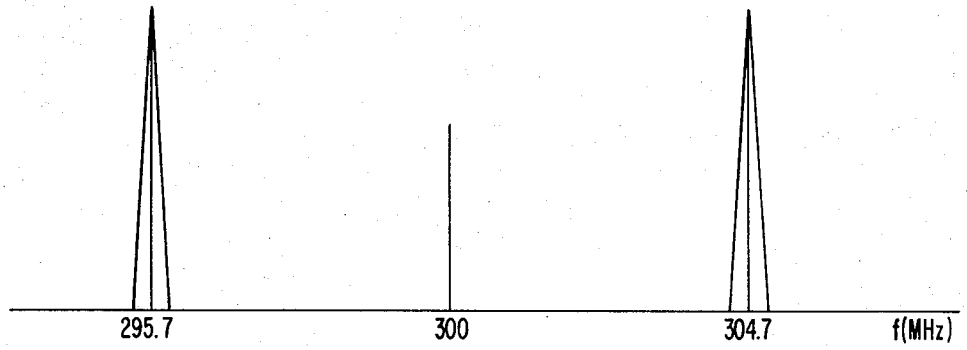
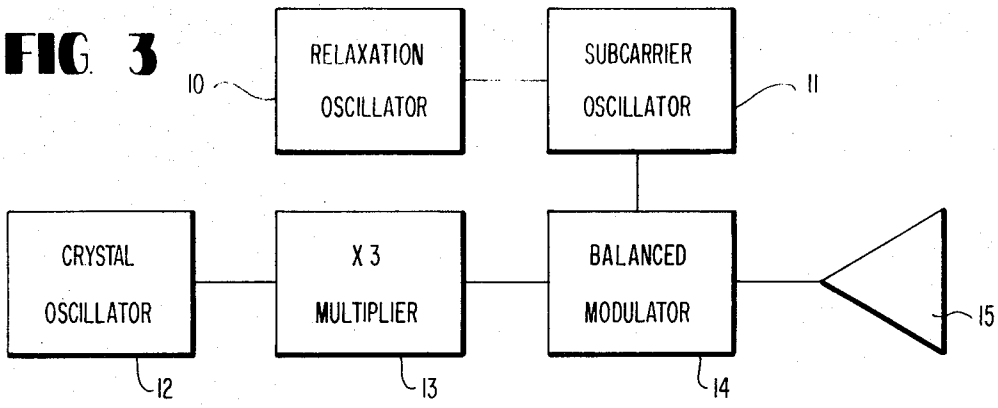


FIG. 2

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FIG. 3


RELAXATION OSCILLATOR
10
SUBCARRIER OSCILLATOR
11
CRYSTAL OSCILLATOR
12
X 3 MULTIPLIER
13
BALANCED MODULATOR
14
15

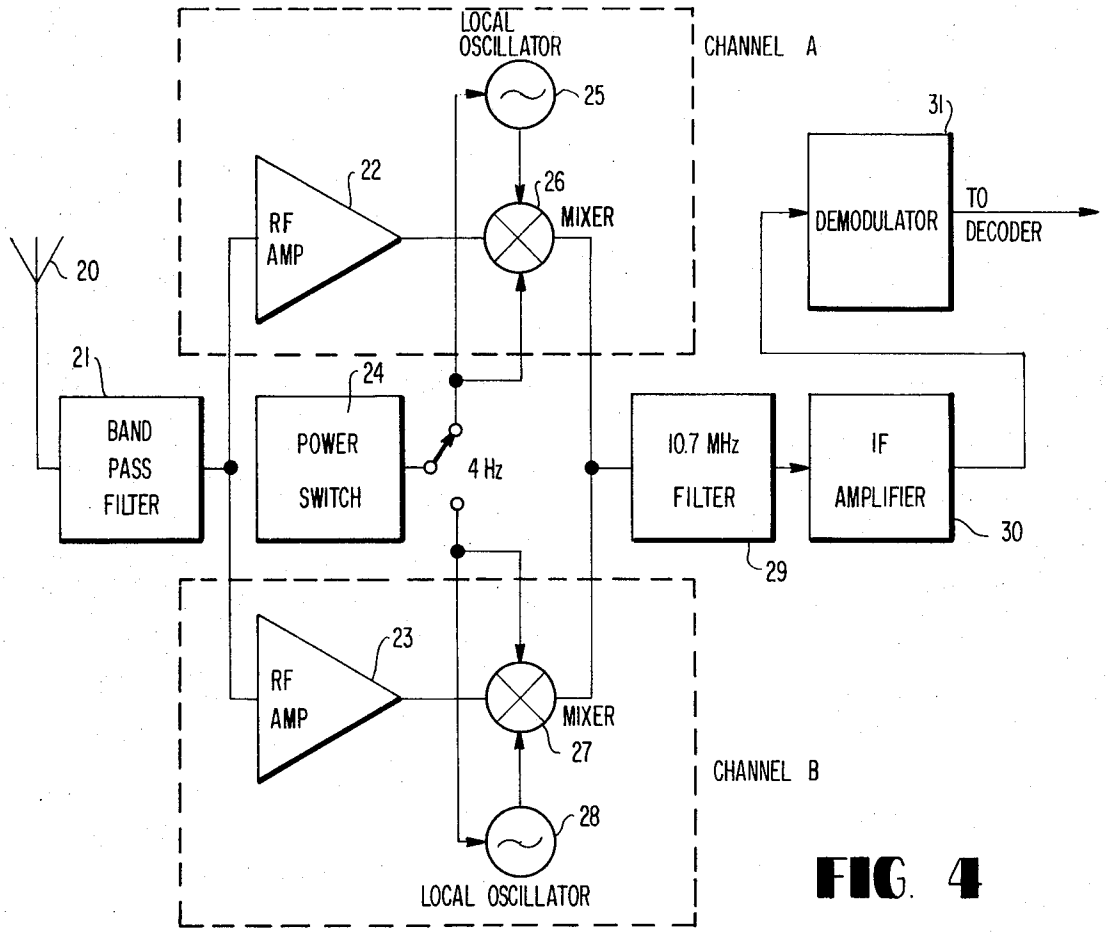

LOCAL OSCILLATOR
25
CHANNEL A
31
22
RF AMP
26
MIXER
DEMODULATOR
TO DECODER
20
21
24
BAND PASS FILTER
POWER SWITCH
4 Hz
10.7 MHz FILTER
IF AMPLIFIER
30
29
23
RF AMP
MIXER
27
CHANNEL B
28
LOCAL OSCILLATOR

FIG. 4

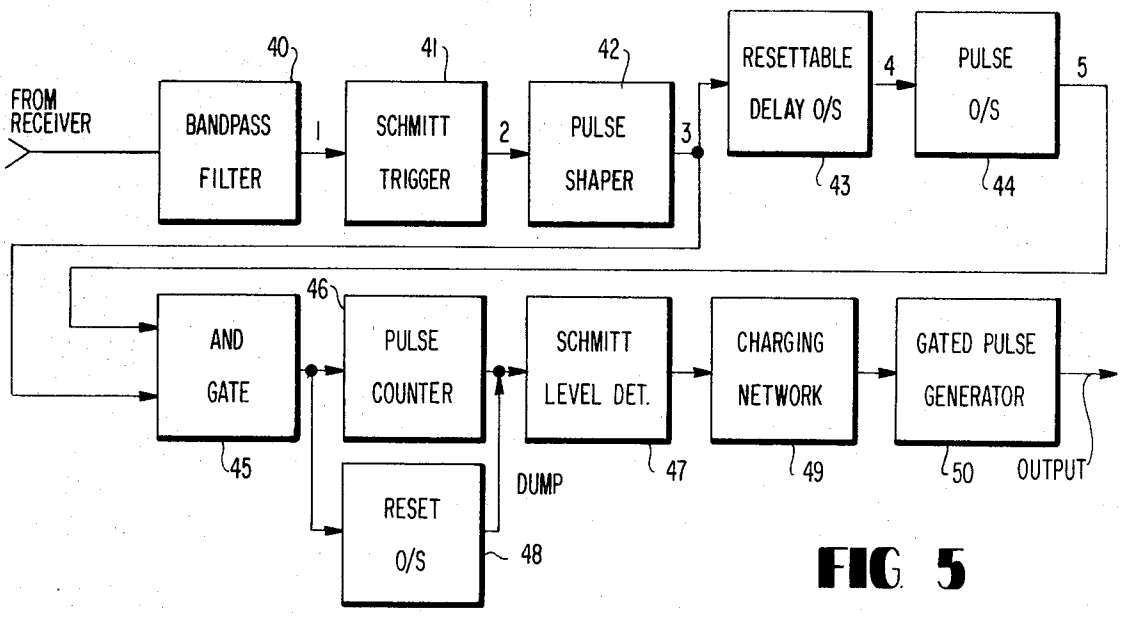

FROM RECEIVER
BANDPASS FILTER
SCHMITT TRIGGER
PULSE SHAPER
RESETTABLE DELAY O/S
PULSE O/S
AND GATE
PULSE COUNTER
SCHMITT LEVEL DET.
CHARGING NETWORK
GATED PULSE GENERATOR
RESET O/S
DUMP
OUTPUT
40
41
42
43
44
45
46
47
48
49
50
1
2
3
4
5

FIG. 5

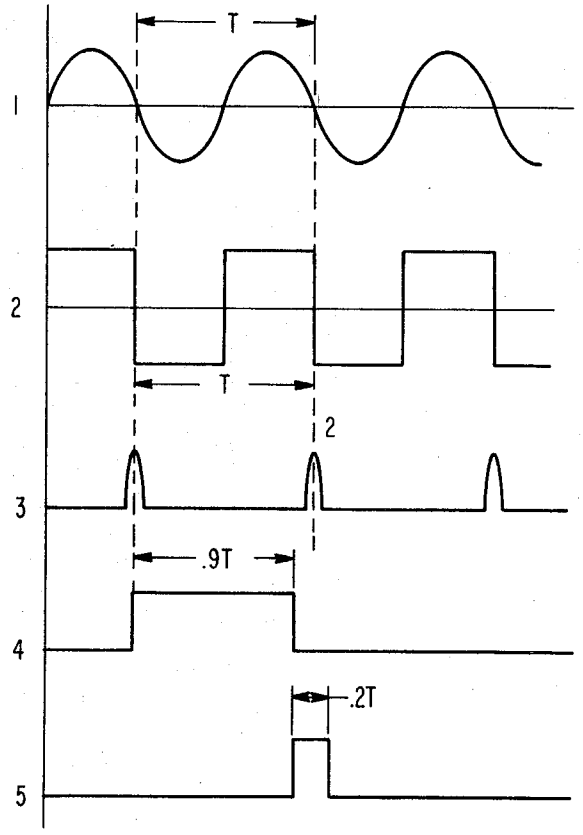

T
1
2
T
2
3
.9T
4
.2T
5

FIG. 6

DIVERSITY RF ALARM SYSTEM

This invention relates to an alarm system utilizing radio links between a plurality of remotely located condition sensing units and a central receiving station and has the ability to indicate at the central receiving station which of the plurality of remotely located sensing units has triggered. The alarm system according to the present invention is easily expanded or contracted to include more or less remote sensing locations and is extremely reliable and is highly immune to false alarms.

Residential and industrial alarm systems can employ several methods for relaying the alarm signal from an alarm sensing unit to an alarm actuator. One method is to install wires over which the alarm signal can be transmitted. Another method is to transmit the alarm signal over power lines already present in the installation. Alarm systems using these methods of relaying the alarm signal are undesirable because they cannot easily be expanded or contracted to encompass more or less remote sensing locations and are therefore not flexible. Additionally, there is a great amount of labor involved if an installation is to be wired.

The above problems can be obviated by the use of an alarm system which incorporates radio alarm links. The prior art alarm systems, however, which have utilized radio links have been unsuitable because they have not been sufficiently reliable and have been subject to false alarms. With a radio alarm link it is of critical importance to eliminate interference from nearby electromagnetic sources such as commercial radio and television stations as well as from motors and other sources of power. Also the alarm system should not be triggered by the harmonics of the alarm signal itself and a radio alarm transmission link must be completely reliable and must not be dependent upon weather conditions or signal fading. An alarm system using radio links should additionally be capable of being used in conjunction with other similar alarm systems in the same vicinity without the alarm systems interfering with each other.

The alarm system of the present invention overcomes the disadvantages of the prior art alarm systems by employing a plurality of frequency diversity radio transmitter means in conjunction with alarm condition sensing elements at remote locations and a single frequency diversity receiver means at a central location. The frequency diversity radio links are extremely reliable and overcome the problems of multipath fading and cancellation which have seriously hampered the performance of prior art radio alarm systems.

Additionally, the alarm system of the present invention overcomes the problem of false alarms triggered by spurious signals by the use of a plurality of pulse rate discriminator means at the central receiving station to respond to the different modulation signals of the transmitters associated with different sensing units. The pulse rate discriminator means indicate whether a given frequency is present by comparing the time between negative going zero crossings of the input wave to the discriminator with the duration of a plurality of fixed length pulses generated by pulse generating means. The pulse rate discriminator means are therefore responsive only to the frequency of the demodulated radio signals and not to the amplitude of the demodulated radio signals or to the amplitude of any spurious signals, and therefore cannot be triggered by interference signals or by harmonics of the alarm signal itself.

It is therefore an object of the invention to provide an alarm system incorporating radio links between a plurality of alarm condition sensing units and a central receiving station which is reliable and which is not subject to false alarms.

It is a further object of the invention to provide an alarm system incorporating radio links between a plurality of alarm condition sensing units and a central receiving station which is not subject to signal fading.

It is a further object of the invention to provide an alarm system utilizing radio links between aplurality of remotely located alarm condition sensing units and a central receiving station which has the ability to indicate at the central receiving station which of the plurality of remotely located sensing units has triggered.

It is a further object of the invention to provide an alarm system utilizing radio links between a plurality of remotely located alarm condition sensing units and a central receiving station wherein a plurality of pulse rate discriminators are used at the central receiving station which are responsive only to the frequency of the demodulated signal and not to amplitude to identify the radio signals transmitted by particular sensing units.

It is a further object of the invention to provide a plurality of alarm systems operating within the same vicinity wherein each alarm system comprises a plurality of alarm condition sensing units operating in conjunction with a central receiving station and wherein said plurality of alarm systems do not interfere with each other.

It is also an object of the invention to provide an improved pulse rate discriminator means which generates an output signal only when a signal of predetermined frequency is present at its input and which is responsive only to the frequency of the input signal and not to the amplitude.

The present invention accomplishes the above objects by providing a plurality of alarm sensing units at remote locations and a receiver means at a central location. Each sensing unit is comprised of at least one sensing means which comprises an alarm condition sensing element connected to a frequency diversity radio transmitter means which is operative to transmit a pair of frequency diversity signals displaced in frequency when triggered by the sensing element to which it is connected. The transmitter means are amplitude modulated and all transmitter means associated with a particular receiving location transmit frequency diversity signals having the same carrier frequencies. The carrier signals of transmitters of different units have modulation signals of different frequency impressed thereon.

The frequency diversity receiver means at the central location is a superhetrodyne type receiver which is tuned to the carrier frequencies of the frequency diversity signals. The frequency diversity signals are demodulated in the receiver means and trigger one of a plurality of pulse rate discriminator means depending on the modulation frequency of the demodulated signal. Each pulse rate discriminator means is a novel device for indicating whether a signal of predetermined frequency is present at its input terminals and works by comparing the time period between negative going zero crossings of the input wave with the duration of a plurality of fixed length pulses generated by pulse generating means.

Each frequency diversity transmitter means of the invention includes a crystal oscillator and a times three multiplier for generating a center carrier frequency, a subcarrier oscillator for generating a subcarrier frequency, and a balanced modulator for mixing the center carrier frequency with the subcarrier frequency for generating two side band signals displaced in the frequency spectrum. A relaxation oscillator modulates the subcarrier oscillator with an ultrasonic modulation signal.

The frequency diversity receiver means of the invention is a superhetrodyne type receiver employing dual channels with means for switching therebetween. Each channel includes a radio frequency amplifier, a local oscillator, and a mixer. Switching between the two channels is done at a low frequency rate and the outputs of both channels are connected to an intermediate frequency filter and intermediate frequency amplifier of narrow bandwidth. After passing through the intermediate frequency amplifier the signals are demodulated and passed to the decoder means of the invention which comprises a plurality of pulse rate discriminators. Additionally, a preselector filter is located at the input to the receiver means for rejecting signals outside of a predetermined band.

Each pulse rate discriminator means of the invention comprises a means for generating pulses at each negative going zero axis crossing of the demodulated wave input to the discriminator, said pulse generating having two outputs, one output of which is connected to an AND gate and the other output of which is connected to two one shot multivibrators in series. The output of the second one shot multivibrator is also connected to the input of the AND gate. The coincidence output signals from the AND gate are counted by a pulse counter which is automatically reset by a reset multivibrator if a pulse is missing. A given number of pulses without a missing pulse will fire a Schmitt level detector which charges a charging network when the level deflector is in its on state. After a predetermined time the voltage across the charging network will trigger a gated pulse generator which generates the alarm output pulse. If, however, a coincidence pulse is missing before the charging network has reached the firing voltage of the gated pulse generator the reset multivibrators will operate to turn the Schmitt level detector to the off state which will discharge the charging network. Thus the input signal of predetermined frequency must be present at the input for a predetermined minimum time before an output pulse will be generated.

In the drawings

FIG. 1 is a representation of the overall alarm system according to the invention.

FIG. 2 is a representation of the frequency diversity signals emitted by a single transmitter means of the invention.

FIG. 3 is a block diagram of a single transmitter means of the invention.

FIG. 4 is a block diagram of a frequency diversity receiver means which is located at a central station according to the invention.

FIG. 5 is a block diagram of a pulse rate discriminator means according to the invention.

FIG. 6 is a diagram of the waveforms produced by the pulse rate discriminator means of FIG. 5.

An alarm system according to the present invention is illustrated in FIG. 1. In FIG. 1 receiver means 1 is positioned at a central location in the alarm system installation. Sensing units 1 to 3 are units of remotely positioned alarm condition sensing means, unit 1 being comprised in the diagram of FIG. 1 of sensing means 1*a*, 1*b* and 1*c*, unit 2 being comprised of sensing means 2*a*, 2*b* and 2*c* and unit 3 being comprised of sensing means 3*a*, 3*b* and 3*c*. Each sensing means such as 1*a* is comprised of one alarm condition sensing element such as an ion chamber or mechanical switch connected to one frequency diversity radio transmitter means.

The transmitter means of sensing units 1, 2 and 3 emit frequency diversity radio signals having the same carrier frequencies but the signals emitted by the transmitter means of each different unit have different modulation signals thereon as will be further explained below. The spectrum of a typical pair of frequency diversity signals emitted by a transmitter means of the present invention is shown in FIG. 2. The center carrier frequency of the signals shown in FIG. 2 is 300 mhz with each of the sidebands being displaced from the center carrier frequency by 4.7 mhz. The modulation on each of the sidebands is identical.

All of the transmitter means of sensing units 1, 2 and 3 thus transmit on the same carrier frequencies, for instance at 295.7 mhz and 304.7 mhz if the illustrative frequency spectrum of FIG. 2 is used. Each of the pairs of frequency diversity signals associated with transmitter means in different units however have different modulation frequencies impressed thereon.

Receiver means 1 is tuned to the carrier frequencies of the frequency diversity signals emitted by the transmitter means of units 1, 2 and 3. The frequency diversity signals are demodulated in the receiver means and each of the decoder means 1, 2 and 3 is responsive to a demodulated signal of different frequency to produce an alarm output signal which identifies the sensing unit which has triggered. Thus, for instance, if a sensing element of a sensing means of sensing unit 1 has been triggered by an alarm condition to which the sensing element is responsive it will trigger the transmitter means to which it is connected which will transmit a signal to the receiver means at the central location. The signal will be demodulated by the receiver means and the demodulated signal will operate decoder 1 which will trigger an alarm signal. Corresponsindly, if a transmitter in a sensing means of units 2 or 3 is triggered the signals transmitted will operate decoders 2 or 3 respectively to produce an alarm output signal. It should be noted that while for purposes of convenience only three sensing units, each having three sensing means therein, have been illustrated in an actual installation a great many more than three sensing units and three sensing means per sensing unit may be used. The only requirement is that the number of decoder means at the central receiving location be equal to the number of sensing units.

In the preferred embodiment of the invention all of the sensing elements of each sensing unit are responsive to the same alarm condition while each sensing means of the same unit is located in a different remote position, for instance in different rooms in a building which is being monitored. Thus, in FIG. 1 sensing means 1*a*, 1*b* and 1*c* would all be responsive to the same alarm condition while being located in different remote locations. The sensing elements of unit 1 could, for instance, be thermistors if the condition sensed was to be temperature, and each of the sensing means 1*a*, 1*b*, 1*c* would be located in a different room of a build-

ing being monitored with the receiver means 1 being located at a central point in the building. In such an embodiment the sensing elements of units 2 and 3 would be different from the sensing elements of unit 1 as well as being different from each other and the sensing means 2*a*, 2*b*, 2*c* would be at different remote locations as would be the sensing means 3*a*, 3*b*, and 3*c*. The sensing elements of unit 2 could for instance be mechanical or magnetic switches attached to a door which when opened would indicate the presence of an intruder. The sensing elements of unit 3 could be responsive to yet another condition or in the alternative sensing means 3 could be hand held transmitting units operated by persons such as security guards statione throughout the building being monitored. A signal received at the central receiving station from one of these transmitting units could indicate that help is needed by one of the security guards. In the preferred embodiment then an output signal emitted by decoder means 1, for instance, indicates that the alarm condition to which sensing unit 1 is responsive has triggered one of the sensing means 1*a*, 1*b* or 1*c* at one of the remote locations.

In another embodiment of the invention instead of the sensing elements of each unit being responsive to the same condition but being in different remote locations the sensing elements of each unit could be responsive to different conditions but would be in the same remote location. Thus, in this embodiment the sensing elements associated with sensing means 1*a*, 1*b*, and 1*c* would each be different from the other but the sensing means of unit 1 would all be in the same remote location, for instance, in the same room in a building being monitored. In this embodiment then, different decoder outputs at the receiving station would be indicative of trouble at a particular remote location instead of trouble with a particular condition being monitored at at least one of the remote locations.

If desired, according to the present invention, another alarm system could be situated in close proximity to the first alarm system without interfering therewith. This second alaram system is illustrated in FIG. 1 as comprising condition sensing units 4, 5 and 6 located at remote positions and receiver means 2 located at a central location. The condition sensing units and receiver means of the second system would be identical to the first except that the transmitter means of units 4, 5 and 6 and receiver means 2 would operate on carrier frequencies displaced from the carrier frequencies used by the transmitter means of units 1, 2 and 3 and receiver means 1. The modulation frequencies on the signals generated by the transmitter means of units 4, 5 and 6 would each be different from the other, although they could be the same as the modulation frequencies on the transmitter means of units 1, 2 and 3, and would trigger alarm outputs at decoders 4, 5 and 6. Because of the different carrier frequencies used in the different alarm systems and the extreme selectivity of the receiver means as will be elaborated on later, interference between the two alarm systems is avoided. Hence, in a typical application one alarm system may be used to monitor one building in a complex of buildings whereas the other alarm system could be used to monitor another building in that complex.

While each unit of sensing means has been described as having only three sensing means for purposes of convenience it is to be understood that in a typical installation each sensing unit may have a great many sensing means. For instance, in the preferred embodiment where each of the sensing means of each unit are responsive to the same condition one, sensing means from each unit might be positioned in a different room in a large building. Likewise while each system has been shown as being comprised of only three sensing units more than three units may be employed in a practical system. And while only two alarm systems operating in proximity to each other have been illustrated in FIG. 1 it is apparent that many more than two systems may be used in the same vicinity where a large complex of buildings is monitored.

According to the FCC rules and regulations the band available for operation is 285 to 328.6 mhz, and all RF channels of different systems operating in the same vicinity lie within this range. An important feature of the present invention is the use of frequency diversity transmittter means and receiver means to provide extreme reliability and to eliminate multipath cancellation and fading. A transmitter means used by the invention to generate a frequency diversity spectrum such as is shown In FIG. 2 is illustrated in block diagram in FIG. 3.

The transmitter means of each unit generate frequency diversity signals having a different modulation thereon. This modulation is provided by relaxation oscillator 10 as shown in FIG. 3. This oscillator generates a modulation signal in the ultrasonic range which is used to amplitude modulate subcarrier oscillator 11 which is an oscillator preferably of Colpitts design which is used to generate the subcarrier signal. If the transmitter means of FIG. 3 is used to generate the illustrative spectrum of FIG. 2 the subcarrier signal would be a signal of 4.7 mhz.

The RF oscillator was chosen to be a crystal oscillator to attain the desired stability. A X3 multiplier is used to multiply the signal attained with the crystal oscillator to obtain an RF frequency within the FCC approved range. If the transmitter means were used to generate the illustrative spectrum of FIG. 2 the RF oscillator and X3 multiplier would generate a signal of 300 mhz. The outputs of the multiplier and the subcarrier oscillator are mixed in a balanced modulator which generates a spectrum as shown in FIG. 2. Antenna 15 may preferably be a monopole antenna which may be positioned on a printed circuit board on which the transmitter is built.

Amplitude modulation was found to be superior to frequency modulation for the radio alarm links because it eliminated the triggering of false alarms due to interference from local FM radio stations. Subcarrier oscillator 11 is amplitude modulated by the output of relaxation oscillator 10 by any standard technique of amplitude modulation such as is well known in the art. Additionally, each block shown in FIG. 3 is a standard electrical network as is well known in the art.

As shown in FIG. 1, receiver means 1 is preceded by a preselector filter to reject signals in the FM and TV broadcast band. This filter should provide significant attenuation to signals below 250 mhz and above 350 mhz and preferably may be a filter of ten pole Butterworth design. The preselector filter is an important component for rejecting unwanted signals before they are processed by the receiver.

FIG. 4 is a block diagram of frequency diversity receiver means 1. Following front end bandpass filter 21 the receiver means has one channel comprised of RF

amplifier 22, local oscillator 25 and mixer 26, and a second channel comprised of RF amplifier 23, local oscillator 28, and mixer 27. The local oscillators are crystal controlled to achieve the desired stability. RF amplifier 22 is tuned to pass one of the side bands of FIG. 2, for instance the lower side band, whereas RF amplifier 23 would be tuned to pass the upper side band. Alternatively each RF amplifier could be tuned to pass both side bands. Local oscillator 25 is adjusted to generate a signal of a frequency which when mixed with the frequency of the lower side band of the frequency diversity signal will result in a signal having the intermediate frequency of the receiver means. In the preferred embodiment of the invention the intermediate frequency used is 10.7 mhz. Likewise local oscillator 28 is adjusted to generate a signal which when mixed with a frequency of the upper side band will result in a frequency of the intermediate frequency. A power switch switches between the two channels at a rate of about 4 cycles per second. After being filtered in narrow-band filter 29 the intermediate frequency signal is amplified in IF amplifier 30 and demodulated in demodulator 31. Demodulator 31 may be any standard demodulation device for demodulating an amplitude modulated signal.

The output of demodulator 31 is connected to decoders 1, 2 and 3 as shown in FIG. 1. The purpose of the decoders are to selectively trigger an alarm signal responsive to the modulation on the transmitted frequency diversity signals. Thus, in FIG. 1 decoder 1 will provide an alarm output signal when a transmitter means of unit 1 has triggered. Likewise decoders 2 and 3 will emit alarm signals when activated respectively by transmitter means of units 2 and 3. The decoders are an important part of the alarm system because the accuracy with which they detect the ultrasonic frequency of the demodulated signals ensures against the alarm system being triggered by false alarms. The decoders take the form of pulse rate discriminator means which respond only to the rate of zero crossings of the demodulated output signal. Hence any dependence upon the amplitude of the demodulated signal or on the amplitude of any interference signal is eliminated. Whereas bandpass filters were found to respond to noise and to harmonics of the alarm signal if they were of sufficient amplitude as well as to large amplitude broadband noise such as generated by SCR controlled, variable speed electric power tools, no such false alarms were triggered when the pulse rate discriminator means were used.

A block diagram of a pulse rate discriminator according to the invention is shown in FIG. 5 and waveforms associated therewith are shown in FIG. 6. The bandpass filter 40 at the input serves to reduce the noise which may be present on the input signal. The output of bandpass filter 40 is shown in FIG. 6 at 1 and is a sine wave signal of period T. Schmitt trigger 41 acts as a squaring means on signal 1 to produce the waveform shown at 2 in FIG. 6 which waveform has a negative going edge every time waveform 1 has a negative going axis crossing point. Pulse shaper 42 generates a pulse each time that waveform 2 has a negative going edge. Thus waveform 3 shown in FIG. 6 consists of a series of pulses with period T. One output from pulse shaper 42 is fed to AND gate 45 and the other output is fed to resettable delay one shot multivibrator 43 which generates a delay pulse as shown at 4 in FIG. 6. The resettable delay one-shot 43 operates only if the input pulse rate is less than some preset maximum value.

The duration of delay pulse 43 is a substantial fraction of the duration T. In the preferred embodiment of the invention this fraction is approximately nine-tenths. The lagging edge of waveform 4 triggers pulse one shot multivibrator 44 which generates a pulse of duration equal to a small fraction of the period T. In the preferred embodiment of the invention this fraction is approximately two-tenths.

The other input to the AND gate is the output from pulse one-shot multivibrator 44. If the frequency to which the decoder is responsive is present at the input wave then the pulse generated by pulse shaper 42 immediately following the pulse which has triggered delay one-shot multivibrator 43 will coincide with the pulse output of pulse one-shot 44. Thus as shown in FIG. 6 when the proper frequency is present at the input, pulse 2 of pulse wave 3 coincides with pulse output 5 of pulse one-shot multivibrator 44. The coincidence or noncoincidence of pulse 2 with waveform 5 is determined by AND gate 45.

Pulse counter 46 generates a ramp output the final amplitude of which is determined by the number of pulses counted. When the amplitude of the output of pulse counter 46 reaches a predetermined level Schmitt level detector 47 is triggered into its on state. Schmitt level detector 47 is a standard two state Schmitt device. Reset one-shot multivibrator 49 acts as a missing pulse detector. Thus it is predetermined that a given number of successive outputs from AND gate 45 without a missing pulse is to be indicative that the proper frequency is present. This given number of outputs from AND gate 45 is the number which will bring the output of pulse counter 46 to the level at which Schmitt level detector 47 is triggered to its on state. If, however, a pulse is missing from the successive train of pulses then reset one-shot multivibrator 49 is triggered which dumps the count of pulse counter 46 to zero and it must start counting all over again to indicate the presence of the proper frequency.

According to one feature of the pulse rate discriminator a signal having the proper frequency must be present for at least 100 milliseconds before an output alarm signal will be generated. Hence, when the output of pulse counter 46 reaches a predetermined amplitude Schmitt level detector 47 is turned on. The Schmitt detector will remain in its on state so long as pulse counter 46 keeps on receiving coincidence pulses from AND gate 45 without a missing pulse. As long as Schmitt detector 49 is in its on state charging network 49 charges. At the end of 100 milliseconds network 49 which may be a simple RC network is charged to the point where gated pulse generator 50 to which the RC network is connected, triggers its alarm output signal. If, however, a successive pulse is missing during the 100 milliseconds reset one-shot multivibrator 49 will be operative to return Schmitt level detector 47 to its off state. When this happens charging network 49 discharges and a new 100 millisecond criterion must be met. Thus the alarm output signal will not be generated unless an input wave of proper brequency is present at the input terminals for at least 100 milliseconds.

While I have described and illustrated a preferred embodiment of my invention, I wish it to be understood that I do not intend to be restricted solely thereto, but that I do intend to cover all modifications thereof

which would be apparent to one skilled in the art and which come within the spirit and scope of my invention.

We claim:

1. An alarm system for indicating at a central receiving location which of a plurality of remotely located alarm condition sensing units has triggered comprising,

a plurality of remotely located alarm condition sensing units, each sensing unit being comprised of at least one sensing means which is comprised of an alarm condition sensing element connected to a frequency diversity radio transmitter means, each transmitter means being operative to emit a pair of frequency diversity radio signals when it is triggered by the sensing element to which it is connected, the transmitter means of each unit including means for generating carrier signals of first and second predetermined frequencies and means for modulating said carrier signals with a modulation signal of a single fixed frequency, the modulation signals produced by the transmitter means of each unit being of a different fixed frequency, whereby the transmitter means of each unit when triggered emit frequency diversity carrier signals having the same carrier frequencies as the carrier signals emitted by the transmitter means of each other unit, which carrier signals are modulated with a different fixed modulation frequency than the carrier signals emitted by the transmitter means of each other unit

and a frequency diversity receiver means at said central receiving location including means for selectively passing said first and second predetermined frequencies and further including a demodulation means for demodulating said frequency diversity signals to produce demodulated signals of said different fixed modulation frequencies, and decoder means responsive to said fixed frequency signals for producing a different alarm output signal for each of said different frequencies whereby the alarm condition sensing unit which has triggered is identified, said decoder means comprising a plurality of pulse rate discriminator means, equal in number to the number of sensing units, each pulse rate discriminator means being responsive to a different one of said fixed frequency signals for producing a different alarm output signal.

2. The system of claim 1 wherein each of said pulse rate discriminator means includes means responsive to the rate of zero axis crossings of said demodulated fixed frequency signals.

3. The alarm system of claim 1 wherein each of said sensing units is comprised of a plurality of said sensing means.

4. The alarm system of claim 3 wherein the sensing elements of each sensing unit are responsive to a different condition from the sensing elements of each other sensing unit and wherein each sensing element of a single sensing unit is positioned at a different remote location from the other sensing elements in that unit.

5. The alarm system of claim 3 wherein the sensing elements of each sensing unit are positioned at a different remote location from the sensing elements of each other unit and wherein each sensing element of a single unit is responsive to a different condition than the other sensing elements in that unit.

6. The alarm system of claim 1 wherein the at least one sensing element of each sensing unit is responsive to a different condition.

7. The alarm system of claim 1 wherein the at least one sensing element of each sensing unit is positioned at a different remote location.

8. The alarm system of claim 1 wherein said receiver means further includes means for producing said different alarm output signals when only one of any pair of frequency diversity signals is received at said receiver means.

9. The alarm system of claim 1 wherein the signals of each pair of frequency diversity signals are spaced from each other in the frequency spectrum by a small amount compared to the carrier frequency of either of said signals.

10. The alarm system of claim 9 wherein said means for generating carrier signals of first and second predetermined frequencies includes a subcarrier oscillator means for generating a subcarrier signal having a frequency of half said small amount, a crystal controlled oscillator means for generating a center carrier frequency signal having a frequency midway between said first and second predetermined frequencies and a balanced modulator means connected to said subcarrier oscillator means and to said crystal oscillator means for combining said subcarrier signal and said center carrier frequency signal.

11. The alarm system of claim 10 wherein said means for modulating said carrier signals comprises a means for amplitude modulating said signal generated by said subcarrier oscillator means.

12. The alarm system of claim 11 wherein said single fixed frequency is a frequency in the ultrasonic range.

13. The alarm system of claim 12 wherein said means for amplitude modulating is a relaxation oscillator and said subcarrier oscillator means is a Colpitts type oscillator.

14. The alarm system of claim 12 wherein said frequency diversity receiver means at said central location is a two channel superhetrodyne type receiver means, each of said channels including means tuned to receive one of said frequency diversity signals of a pair of said frequency diversity signals and local oscillator and mixer means for converting said signals to an intermediate frequency signal, means for switching between said local oscillator and mixer means of said two channels, and a single intermediate frequency amplifier means for amplifying said intermediate frequency signal.

15. The system of claim 14 wherein each of said pulse rate discriminator means includes means responsive to the rate of zero crossings of said demodulated fixed frequency signals.

16. The alarm system of claim 9 wherein said frequency diversity receiver means at said central location is a two channel superhetrodyne type receiver means, each of said channels including means tuned to receive one of said frequency diversity signals of a pair of said frequency diversity signals and local oscillator and mixer means for converting said signals to an intermediate frequency signal, means for switching between said local oscillator and mixer means of said two channels, and a single intermediate frequency amplifier means for amplifying said intermediate frequency signal.

17. The system of claim 16 wherein each of said tuned means comprises a radio frequency amplifier means.

18. The system of claim 17 further including a preselector filter means connected to the input of said receiver means.

19. The alarm system of claim 1 wherein each pulse rate discriminator means includes means for generating a pulse of duration equal to a fixed fraction of the period corresponding to a given one of said modulation frequencies.

20. The alarm system of claim 19 wherein said means for generating carrier signals of first and second predetermined frequencies includes a subcarrier oscillator means for generating a subcarrier signal having a frequency of half said small amount, a crystal controlled oscillator means for generating a center carrier frequency signal having a frequency midway between said first and second predetermined frequencies, and a balanced modulator means connected to said subcarrier oscillator means to said crystal oscillator means for combining said subcarrier signal and said center carrier frequency signal, and wherein said means for modulating said carrier signals comprises means for amplitude modulating said signal generated by said subcarrier oscillator means and wherein said frequency diversity receiver means at said central location is a dual channel superhetrodyne type receiver means, each of said channels including means tuned to receive one of said frequency diversity signals of a pair of frequency diversity signals, and means for switching between said channels.

21. The system of claim 1 wherein said means for modulating said carrier signals comprises a means for generating a fixed frequency signal in the ultrasonic range.

22. An alarm system comprising a plurality of central receiving locations in the same vicinity, a group of alarm condition sensing units being associated with each central receiving location, each sensing unit being comprised of at least one sensing means which is comprised of an alarm condition sensing element connected to a frequency diversity transmitter means for generating a pair of frequency diversity signals, each of said transmitter means including first generating means for generating a center carrier frequency signal for said pair of frequency diversity signals, the center carrier frequency signal generated by said first generating means of the transmitter means of each group being of the same frequency but of different frequency that the signal generated by said first generating means of the transmitter means of each group, each of said transmitter means further including second generating means for generating a fixed frequency modulation signal, the modulation signal generated by said second generating means of the transmitter means of each unit being of a different fixed frequency than the modulation signal generated by said second generating means of the transmitter means of each other unit in the same group, each transmitter means further including means for combining said carrier signals with said modulation signal whereby each transmitter means when triggered emits a pair of frequency diversity signals having the same center carrier frequency as the signals emitted by each other transmitter means in the same group but a different center carrier frequency than the signals emitted by transmitter means in each other group and having a fixed frequency modulation signal of different frequency than the modulation signal of the signals emitted by transmitter means in other units of the same group,

and a plurality of frequency diversity receiver means at said plurality of central receiving locations, neach receiver means including means for selectively passing signals of the center carrier frequency generated by said first generating means of the transmitter means of the group with which said receiver means is associated, and further including a demodulation means for demodulating said frequency diversity signals to produce different fixed frequency demodulated signals, each receiver means further including a plurality of pulse rate discriminator means connected to its output of a number equal to the number of sensing units of the group with which said receiver is associated, each pulse rate discriminator means being responsive to a signal of different frequency to activate a different alarm output, whereby the particular alarm output activated is indicative of both the group and unit of the transmitter means which has triggered.

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