

- [54] **ULTRASONIC ALARM CIRCUIT**
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- [51] Int. Cl. .... **G08b 13/16**
- [58] Field of Search ..... **340/258 A, 27 C**

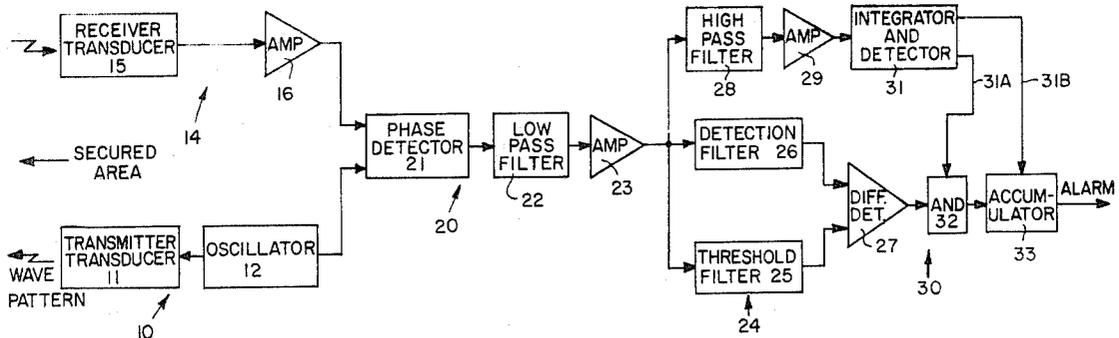
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Primary Examiner—John W. Caldwell  
 Assistant Examiner—Glen R. Swann, III

[57] **ABSTRACT**  
 The circuit is preferably located within an area that is to be secured, is of the type that transmits an ultra-

sonic signal to establish an ultrasonic wave pattern in the area, and includes doppler phase detection circuitry responsive to both the transmitted and received ultrasonic signals for providing a doppler signal of a frequency corresponding to the velocity of motion in the area. In one embodiment the circuit includes a threshold filter and a detection filter each having different frequency responses, both coupling to separate inputs of a differential detector, an output accumulator circuit coupled from the differential detector, and a high pass filter for inhibiting the output accumulator circuit upon receiving signals of above a predetermined frequency, but inhibiting the accumulator for only up to a preselected time interval. In another embodiment of the invention the circuit includes, in addition to a threshold filter, detection filter, differential detector, and output accumulator circuit, a separate cancel channel and associated receiver transducer responsive preferably to higher frequency noise signals at frequencies just below the frequency of the transmitted ultrasonic signal to inhibit the output accumulator upon receipt of such signals but only for a preselected time interval.

**32 Claims, 4 Drawing Figures**



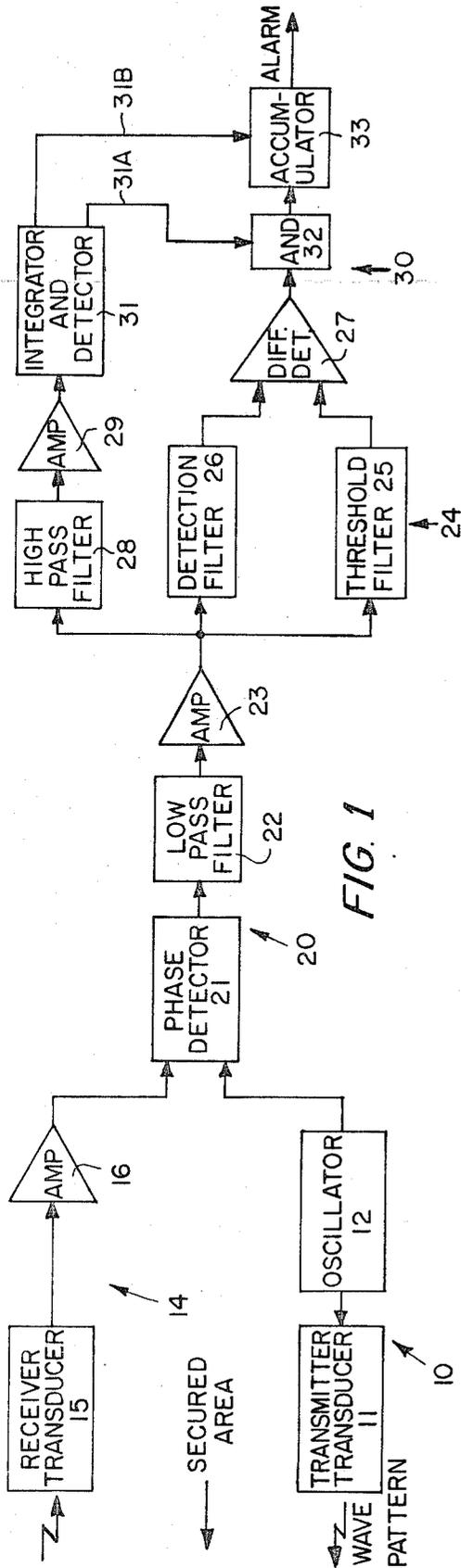


FIG. 1

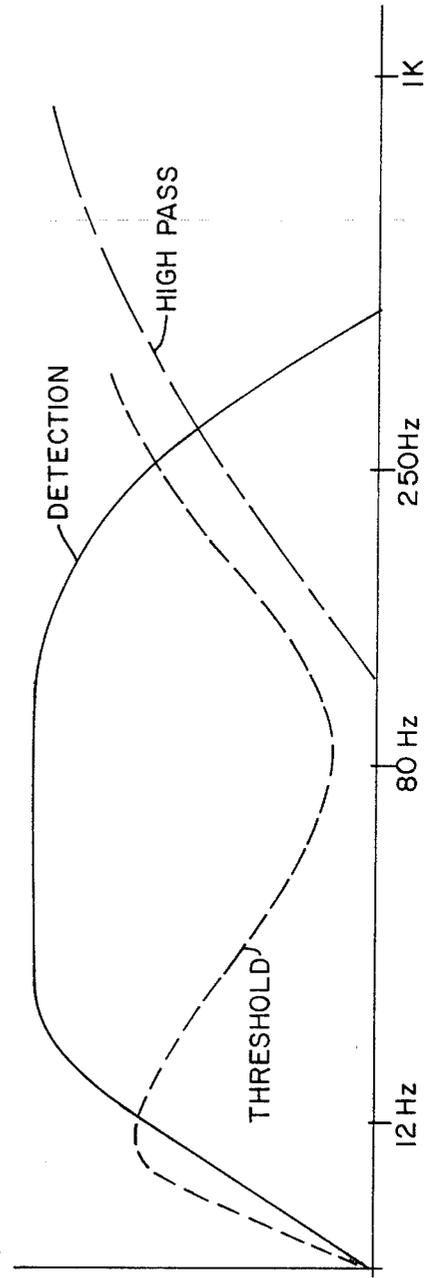


FIG. 4



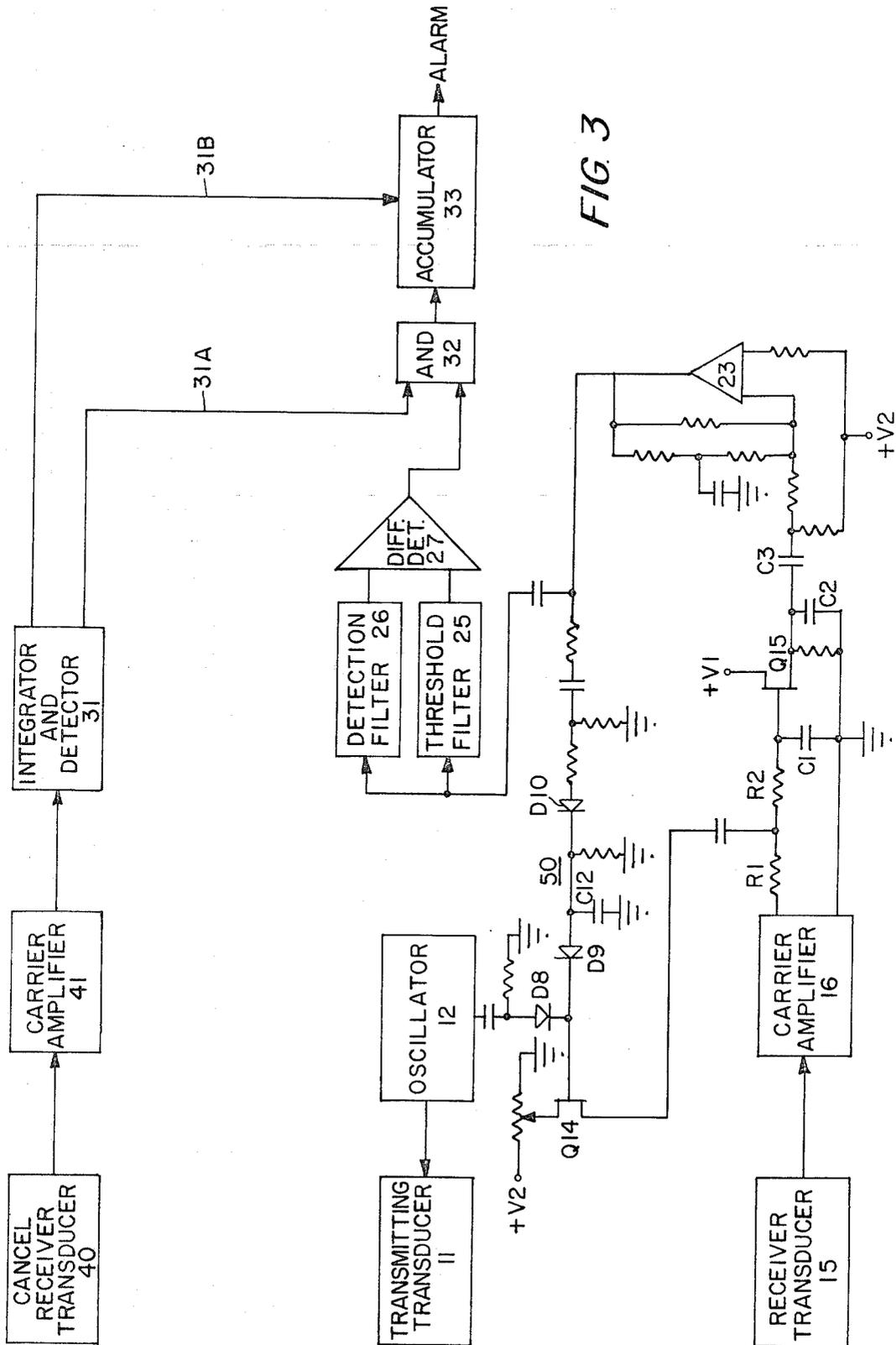


FIG. 3

**ULTRASONIC ALARM CIRCUIT****FIELD OF THE INVENTION**

The present invention relates in general to an alarm circuit preferably disposed within a secured area for detecting the presence of an intruder in the secured area. More particularly, the present invention relates to an alarm circuit of the type that transmits an ultrasonic signal to establish an ultrasonic wave pattern in the secured area. A doppler phase detection technique is used to provide a doppler signal whose frequency at any one time corresponds to the velocity of movement of, for example, an intruder in the secured area.

**BACKGROUND OF THE INVENTION**

Many ultrasonic intrusion detectors are suitable for operation in a secured area under normal conditions. However, some of these detectors indicate a false alarm especially when a broadband noise signal is generated such as that caused by a ringing telephone bell. Another problem with some existing detectors is that they can be too easily jammed usually by using a high frequency jamming signal.

It has been realized in the present invention that ultrasonic intrusion detectors are operated in an environment characterized by (1) motions of the intruder, (2) a variable clutter background level consisting primarily of air motion, and (3) spurious noise signals produced by harmonics of sounds such as telephone bells, banging pipes, etc. The spurious background noise has no definite frequency or amplitude characteristic whereas the turbulence signals caused by moving air are usually low frequency signals. Also, the turbulence signals have a slower rate of change of velocity or amplitude than in the case of a normal intruder signal. Thus, although the turbulence (air motion) signal may exceed or equal the intruder signal, the short term variations about an average value of turbulence signals are smaller than intruder signals, and large value changes occur over a number of seconds.

In the present invention it has also been realized that higher frequency signals above the normal audio frequency range which may be higher frequency harmonics of audio signals, can cause a false alarm condition. One common cause of such a false alarm condition is a periodically ringing telephone. It is necessary to distinguish between such a false alarm condition and a real alarm condition caused by an intruder seeking to jam the detection circuitry by introducing an ultrasonic high frequency signal. The present invention provides means for differentiating between these two conditions.

**OBJECTS OF THE INVENTION**

One important object of the present invention is to provide an improved ultrasonic alarm circuit that is extremely sensitive to the presence of an intruder and yet provides means for preventing false alarm conditions.

Another object of the present invention is to provide an ultrasonic intrusion detection circuit that includes means for providing an alarm condition when the circuit is being jammed by an intruder.

A further object of the present invention is to provide an ultrasonic alarm circuit in accordance with the preceding objects that is relatively compact, inexpensive

to fabricate, that is sturdy, and that can be easily hidden in the secured area.

**SUMMARY OF THE INVENTION**

According to the present invention, the ultrasonic intrusion detection circuit is adapted for use in a secured area and generally comprises a transducer means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area, a second transducer means for receiving the reflected ultrasonic signal, and means responsive to the transmitting and receiving transducer means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area. The circuit further includes a difference circuit and a first frequency responsive means, preferably including a filter circuit, coupled to a first input of the difference circuit for establishing a frequency dependent threshold signal at the first input of the difference circuit. A second frequency responsive means, preferably also a filter circuit, is coupled to the second input of the difference circuit for establishing a frequency dependent detection signal at the second input. An output alarm means is coupled from the output of the difference circuit and is responsive to the detection signal exceeding the threshold signal for providing an alarm condition.

In the preferred embodiment the detection circuit may also comprise a third frequency responsive means, preferably a filter network, which is also coupled from the means for registering to the output alarm means and is adapted to pass high frequency signals above a thousand cycles per second, for example, to inhibit the output alarm means, but only up to a predetermined time interval. After the termination of this time interval if the high frequency signals are still being received this is interpreted as a jamming signal and the inhibiting signal to the output alarm means is removed thereby allowing the generation of an alarm condition. Also, in a preferred embodiment of the present invention the first frequency responsive means for establishing the frequency dependent threshold signal has a frequency response in the normal intruder frequency band that is sufficiently decreased to provide for sensitive detections in that frequency range of, for example, 20 to 300 cycles per second.

In an alternate embodiment of the present invention the ultrasonic intrusion detection circuit generally comprises transducer means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area, first receiving transducer means for receiving the reflected ultrasonic signal, and means responsive to said transmitting and said first signal receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area. In this embodiment the detection circuit also includes output circuit means coupled from said means for registering and responsive to a predetermined band of said doppler frequencies for providing an alarm condition. In this alternate embodiment a second transducer means is provided and is responsive to a group of frequencies preferably just below said first frequency. This second transducer means is coupled to the output circuit means for inhibiting said output circuit means for a preselected time interval, but enables generation of the alarm condition after the predetermined time interval elapses.

## BRIEF DESCRIPTION OF THE DRAWINGS

Numerous other objects, features and advantages of the invention should now become apparent upon a reading of the following detailed description taken in conjunction with the appended drawings in which:

FIG. 1 is a block diagram of a preferred embodiment of the ultrasonic alarm circuit of the present invention;

FIG. 2 shows a detailed circuit diagram of the preferred embodiment of the ultrasonic alarm circuit of FIG. 1;

FIG. 3 shows a partial block, partial circuit diagram of an alternate embodiment of the present invention; and

FIG. 4 shows various waveforms associated with the embodiments of the present invention shown in FIGS. 1-3.

## DETAILED DESCRIPTION

Referring now to the drawings and in particular to the block diagram of FIG. 1, there is shown a preferred embodiment of the ultrasonic alarm circuit of the present invention comprising transmitting means 10 for establishing an ultrasonic wave pattern in the secured area, receiving means 14 for receiving the reflected ultrasonic signal, detection circuitry 20, filter circuitry 24, and output circuitry 30.

The transmitting means 10 includes a transmitter transducer 11 and free-running oscillator 12. The oscillator 12 may be of conventional design, and may include an astable multivibrator operating at a frequency of 26 KHZ, for example. The output of the oscillator 12 is coupled to transducer 11 whose output in turn establishes an ultrasonic wave pattern in the secured area. Transducer 11 may also be of conventional design. The output of oscillator 12 also couples to detection circuitry 20.

The receiving means 14 includes a receiving transducer 15 and an amplifier 16. The transducer 15 may be of conventional design, receives reflected ultrasonic signals transmitted from transducer 11 and couples the signals to amplifier 16. The signals on the input to amplifier 16 are in the millivolt range and are amplified by amplifier 16 whose output couples to detection circuitry 20.

The detection circuitry 20 of FIG. 1 generally comprises a phase detector 21, a low pass filter 22, and an amplifier 23. The phase detector 21 receives two inputs, one from oscillator 12 at a 26 KHZ rate, and a second input from amplifier 16.

When there is essentially no movement in the secured area the phase difference between the transmitted and received signals remains constant and the output of the phase detector 21 is a rectified 26 KHZ signal of constant amplitude. When an intruder enters the secured area the output of the phase detector 21 is a modulated 26 KHZ signal, which is modulated at a frequency corresponding to the motion of movement in the secured area. The output of the detector 21 then passes to low pass filter 22 which removes the high frequency carrier. The output of filter 22 couples to amplifier 23 which amplifies the doppler signal and couples the lower frequency signal to the filter circuitry 24.

In this specification and the accompanying claims the term "doppler signal" refers to the phase detected sig-

nal of frequency corresponding to the velocity of motion in the secured area, "intruder signal" refers to the doppler signal occasioned by an intruder movement, and "turbulence signal" refers to the doppler signal occasioned by turbulence or air motion.

The filter circuitry 24 generally comprises threshold filter 25, and a detection filter 26, having differential detector 27 associated with both filters 25 and 26, and high pass filter 28. The threshold filter 25 is preferably a notch filter which may have a frequency response similar to that shown in FIG. 4. At frequencies about 10 hertz the threshold filter 25 has a relatively high gain, whereas at about 80 hertz the gain of filter 25 decreases thus providing a more sensitive detection level for the device. Above approximately 300 hertz the threshold filter 25 again has a relatively increased gain.

The detection filter 26 is a band pass filter and may have a frequency response like the one shown in FIG. 4. In FIG. 4 the gain of the threshold and detection filters are about equal at approximately 12 hertz, and the gain of the detection filter is relatively flat throughout the band of expected intruder frequencies. The gain of the detection filter 26 then falls off at approximately 250 hertz.

The threshold and detection filters 25 and 26 preferably include rectifying means and capacitor-integrator means for converting the frequency signals into a corresponding DC level. The output of filters 25 and 26 connect to a differential detector 27 which may be a conventional differential amplifier. When the output from the detection filter 26 exceeds the output from the threshold filter 25 the differential detector 27 responds and couples an alarm signal to output circuitry 30.

The filter circuitry 24 also includes high pass filter 28 which has a frequency response as shown in FIG. 4. Filter 28 is not responsive to frequencies in the intruder band generally but is responsive to frequencies of 1,000 cycles or more. The output of high pass filter 28 couples to an amplifier 29 which may be a conventional amplifier. The output of amplifier 29 couples to integrator and detector 31 which may be considered as comprising a part of the output circuitry 30.

When no higher frequency signals are detected by filter 28 an enabling signal is provided on output line 31A from integrator and detector 31. At the same time an inhibiting signal is present on line 31B and the accumulator 33 does not receive a charging current by way of line 31B. When an intruder detection is sensed by differential detector 27 the alarm signal is coupled by way of AND gate 32 to accumulator 33. After a charge accumulation time of approximately 2 seconds, for example, accumulator 33 assumes an alarm condition. Accumulator 33 may include an alarm relay which is preferably unlatched to indicate the alarm condition.

When a high frequency signal is received from filter 28 the integrator and detector 31 respond by providing an inhibiting output on line 31A which inhibits AND gate 32 preventing any detection by way of detection filter 26 and threshold filter 25. However, at the commencement of the high frequency signal a charge path is provided via line 31B to accumulator 33 and the accumulator 33 is charged at a slower rate than when it is charged via AND gate 32. After a predetermined time accumulator 33 reverts to its alarm condition.

In a preferred embodiment output circuitry 30 is designed so that the receipt of a high frequency signal for a relatively short time at less than a 50 percent duty cycle does not cause activation of accumulator 33. Such a signal could be caused by a ringing telephone bell. However, when the high frequency signal persists for greater than a predetermined time interval, or at greater than a 50 percent duty cycle the charge current provided by way of line 31B causes accumulator 33 to revert to its alarm condition.

Referring now to FIG. 2 there is shown a detailed circuit diagram of the ultrasonic alarm circuit of FIG. 1. FIG. 2 shows the 26 KHZ oscillator 12 which couples to the transmitting transducer 11. The oscillator 12 also couples to phase detector 21.

The receiving transducer 15 receives the reflected ultrasonic signal and couples the signal to amplifier 16. Amplifier 16 is a two stage amplifier including stages 17 and 18. Stage 17 includes an FET transistor Q1 and a bipolar transistor Q2 along with associated biasing resistors and coupling capacitors. Similarly, the second stage 18 also includes a field effect transistor Q3 and a bipolar transistor Q4 along with associated biasing resistors and coupling capacitor. The output of amplifier 16 may be taken at potentiometer P1 which couples from the emitter of transistor Q4 to ground. The setting of potentiometer P1 determines the gain of amplifier 16 and thus serves as a range control for the circuit of the present invention.

The doppler phase detector 21 generally comprises transistor Q5 and resistors R1 and R2. Transistor Q5 is cyclically conductive and non-conductive at a 26 KHZ rate as controlled by oscillator 12. Thus, the junction between resistors R1 and R2 is cyclically grounded and floating depending upon whether transistor Q5 is conductive or cut off. When transistor Q5 is conducting the signal from amplifier 16 is essentially grounded, and when transistor Q5 is turned off the signal is allowed to pass to low pass filter 22. When there is no intruder motion in the secured area the phase of the signal from amplifier 16 remains constant with reference to the 26 KHZ signal and thus capacitor C1 of low pass filter 22 remains charged to a relatively constant value. If an intruder enters the secured area the phase of the signal from amplifier 16 changes in accordance with the velocity of movement of the intruder and a corresponding low frequency is detected by capacitor C1. In essence, filter 22 removes the carrier component (26 KHZ) of the phase detector signal and has an output proportional to the phase difference between the transmitted and received ultrasonic signals.

Capacitor C1 also couples to the base of transistor Q6, and the collector of transistor Q6 couples to capacitor C2 which functions as a further low pass filter. Transistor Q6 may be considered as another amplifying stage between the low pass filter 22 and filter capacitor C2. In order to remove the DC phase component from the signal and to further prevent slow phase changes due to oscillator drift and atmospheric changes from affecting the system, the capacitor C3 is coupled from the collector of transistor Q6 to amplifier 23. Amplifier 23 has biasing resistors associated with its input and also has impedance means connected between its input and output for stabilizing the operation of amplifier 23 and for controlling or setting its gain.

The output of amplifier 23 couples by way of capacitor C4 to the threshold filter 25 and the detection filter

26. The detection filter 25 includes a filter section 25A and a rectifier section 25B. Similarly, detection filter 26 includes a filter section 26A and a rectifier section 26B. The filter section 25A shown in FIG. 2 is a conventional Bridge-T filter network and includes resistors R5, R6, and R7, and capacitors C5 and C6. Capacitor C5 is arranged to pass the lower frequencies, and capacitor C6 is arranged to pass higher frequencies. The values of resistors R5-R7 and capacitor C5 and C6 are conventionally chosen to provide a notched frequency response such as the one shown in FIG. 4.

The output of filter section 25A couples to diode D1 of rectifier section 25B. The rectifier section also includes a pair of resistors and a storage capacitor C7. The rectifier section 25B rectifies the alternating signal from filter section 25A and integrates the signal. Capacitor C7 in FIG. 2 is a 100 microfarad capacitor and the rectifier section 25B has a time constant of approximately 2 seconds.

The detection filter section 26A comprises a conventional band pass filter including capacitors C8 and C9 and resistors R8 and R9. The frequency response of the filter section 26A may be the same as the one shown in FIG. 4.

The output of filter section 26A couples by way of diode D2 to rectifier section 26B which also includes a resistor R10, capacitor C10, and potentiometer P2. Potentiometer P2 is used to initially set the detection level at the input to amplifier 27. The diode D2 rectifies the frequency signal from filter section 26A and capacitor C10 integrates this rectified signal. Capacitor C10 is a ten microfarad capacitor and the time constant of the rectifier section 26B is on the order of one-third second. Capacitors C7 and C10 couple, respectively, to separate inputs of difference detector 27.

The filter network 24 discriminates between input signals occasioned by the presence of an intruder and input signals that occur from environmental changes which cause different types of turbulence in the secured area. As indicated in FIG. 4, the gain of the detection filter is higher than the gain of the threshold filter over the range of frequencies (12 to 250 hertz) where the probability of intruder motion is the highest. On the other hand, the threshold filter has a higher gain where the probability of turbulence is higher (12 hertz and lower) and has a decreased gain where the probability of turbulence can be expected to be low and where the intruder motion probability is high. It is the filter section 25A and 26A that thus provide the frequency weighting of the doppler signal.

As previously mentioned, the turbulence signals tend to be in the lower portion of the frequency spectrum below 50 cycles. However, the rate of change of velocity and amplitude of turbulence signals is usually much slower than for normal intruder signals. Turbulence signals may equal or exceed intruder signals in amplitude, yet the short time variations about an average value are smaller for turbulence signals than for intruder signals. Also, for turbulence signals large average value changes usually occur over a number of seconds. This realization of the characteristics of turbulence and intruder signals has led to the adoption of time weighting in the circuitry of the present invention. This time weighting is provided by rectifier sections 25B and 26B.

In order to provide the time weighting the time constant of the threshold rectifier section 25B is longer

than the time constant of the detection rectifier section 26B. In one embodiment the time constant of section 25B is six times longer than that of section 26B. The time constants of both sections 25B and 26B are determined in part by capacitors C7 and C10, respectively. Whereas the time constant of an RC network is the product of the resistance and capacitance, the larger value of capacitor C7 (100 microfarad) provides a longer charging time constant than the time constant provided by capacitor C10 (10 microfarad).

Therefore, for turbulence signals, the output variations of the detection rectifier section 26B occur gradually and the output of the threshold rectifier section 25B has time to alter its threshold level so as not to be sensitive to these types of variations. On the other hand, when there is intruder motion which is more abrupt than turbulence motion, and even though the intruder motion may be at a relatively low frequency of say 50 hertz, the faster time constant of the detection rectifier section 26B permits sensitive intruder detections even at relatively low doppler frequencies.

The differential detector 27 may be of conventional design and may include a differential amplifier. When the voltage across capacitor C10 exceeds the voltage across capacitor C7, thereby indicating that an intruder motion has been detected, the output of the differential detector 27 goes from a negative or ground level to a positive voltage level. The output of differential detector 27 couples to AND circuit 32 which may be considered as comprising diodes D3, D4, and D5 and resistor R11 which couples to the +V2 power supply. When high pass filter 28 is not activated, diode D5 is back-biased. When the output of differential detector 27 is positive diode D3 is also back-biased and a charging current is provided by way of resistor R11 and diode D4 to accumulator 33. Accumulator 33 generally comprises transistors Q7-Q10, alarm relay K1, zener diode ZD1, capacitor C11, and associated biasing resistors. As previously mentioned, in addition to the input by way of line 31A to accumulator 33 there is also a charging input provided from integrator and detector 31 via line 31B to accumulator 33. The operation of this input is discussed in more detail hereinafter with reference to the discussion of high pass filter 28 and integrator and detector 31.

Transistor Q7, resistor R12 and zener diode ZD1 provide a current source for capacitor C11. When the output of differential detector 27 is positive and diode D3 is back-biased the charging current by way of resistors R11 and R12 is fed across the collector and emitter of transistor Q7 to one side of capacitor C11. Transistor Q7 is functioning essentially as a current source and thus, the charge across capacitor C11 rises linearly. After a predetermined charging time period the voltage at the base of transistor Q8 goes sufficiently positive with respect to the voltage at the emitter of transistor Q8 to cause this transistor to turn off. When this occurs, transistors Q9 and Q10 also turn off inhibiting current from relay coil K1 and thereby causing an alarm condition. Previously, when capacitor C11 was not charged all of the transistors Q8, Q9, and Q10 were conducting. A malfunction of any one of the transistors Q8-Q10 causes an alarm condition thereby signalling that one of these transistors has malfunctioned, or alternatively, that there has been an actual alarm. In one embodiment the charge time of capacitor C11 is two seconds when charged via line 31A.

The output of amplifier 23 also couples to high pass filter 28. In the embodiment shown high pass filter 28 may be of conventional design and comprises capacitors C12-C14 and resistors R13 and R14. The filter 28 has its components chosen so that it has a frequency response similar to the one shown in FIG. 4.

The purpose of the high pass filter 28 and associated circuitry is primarily to distinguish between broadband noise signals such as those generated by telephone bells, banding pipes, etc., which contain high frequency harmonics, and a jamming signal that may be used by an intruder to prevent the generation of an alarm condition.

The output of high pass filter 28 couples by way of biasing resistors to amplifier 29. Amplifier 29 also includes impedance means connected between its input and output for stabilizing the operation of the amplifier and for controlling its AC or DC gain.

The output of amplifier 29 couples to integrator and detector 31 which generally comprises transistors Q11, Q12, and Q13. When no high frequency signals are being detected by way of high pass filter 28 integrator and detector 31 is in a condition wherein transistor Q11 is cutoff, transistor Q12 is conductive, and transistor Q13 is cutoff. For this condition there is no charging current provided by way of line 31B and with transistor Q13 off diode D5 is back-biased as previously discussed. However, when a higher frequency signal of, for example, 1,000 hertz is detected by high pass filter 28 the output of amplifier 29 goes negative turning on transistor Q11. This action in turn causes transistor Q12 to stop conducting and transistor Q13 to go into conduction. Diode D5 is then forward biased because the +V3 supply voltage is more negative than the +V2 supply voltage ( $V1=+12$  volts,  $V2=+7.5$  volts and  $V3=+4.7$  volts) and no charging current can be provided by way of diode D4 and resistor R12 to accumulator 33. However, with transistor Q12 off a charging current is provided by way of line 31B and resistor R15 to transistor Q7 of accumulator 33.

Thus, the detection of a high frequency signal inhibits any detections by way of differential detector 27 but allows a slower charge rate by way of resistor R15 and transistor Q7 to capacitor C11. After a slow charge rate of approximately six seconds capacitor C11 is sufficiently charged to cause transistor Q8 to turn off. This turns off transistors Q9 and Q10 and generates an alarm condition.

Referring now to FIG. 3 there is shown another embodiment of the present invention. Much of the circuitry shown in FIG. 3 is similar to the circuitry shown in the block diagram of FIG. 1, and the corresponding circuit diagram of FIG. 2. Thus, the like blocks in FIG. 3 carry the same reference numbers as their counterparts in FIG. 1.

In particular, the threshold filter 25, detection filter 26, and differential detector 27 operate in the same manner as discussed with reference to the same arrangement shown in FIGS. 1 and 2. Also, the AND circuit 32 and accumulator 33 may be identical to the ones shown in FIG. 1 and 2. The structure of the integrator and detector 31 may also be the same as the one shown in FIGS. 1 and 2.

In the embodiment of FIG. 3 a separate cancel channel transducer is used in place of the high pass filter 28 of FIG. 1. This transducer 40 is responsive to high frequency signals close to the frequency of oscillator 12

and may be more particularly responsive to signals in the 24 kilohertz area. The circuit embodiment of FIG. 3 also includes an AGC control loop 50. The loop 50 allows the receiver to operate over a large dynamic range of input signals and the loop has a time constant of about four seconds. This loop is responsive to the output of amplifier 23 and controls the average DC level of the phase detected signal.

The oscillator 12 is a 26 KHZ oscillator, the output of which couples to transmitting transducer 11. The output of the transducer 11 is an ultrasonic signal that establishes an ultrasonic wave pattern in the secured area. The receiver transducer 15 receives the reflected signal from transducer 11 and couples this signal to carrier amplifier 16. Carrier amplifier 16 amplifies the millivolt signal from transducer 15 to higher voltage levels.

The output of oscillator 12 also couples by way of diode D8 to FET transistor Q14. Transistor Q14 functions in a similar manner to transistor Q5 of FIG. 2 and couples to the midpoint between resistors R1 and R2. An AGC (automatic gain control) voltage is provided by way of diode D9 from AGC loop 50 to the gate electrode of FET transistor Q14. The output of oscillator 12 causes transistor Q14 to alternatively conduct and switch between its low resistance state and its high resistance state. The current fed by way of diode D9 controls the high resistance state of transistor Q14 and transistor Q14 and resistor R1 form a variable voltage divider which controls the amplitude of the signal at the junction of resistors R1 and R2. Thus, the network including transistor Q14 serves the double function of phase detection and AGC control.

Resistor R2 couples to capacitor C1 and also to the gate electrode of FET transistor Q15. Capacitor C1 is a low pass filter that removes the carrier component from the signal. Capacitor C2 also couples to transistor Q15 and further functions as a low pass filter. Capacitor C3 removes the DC component of the doppler signal and couples from transistor Q15 to the input of amplifier 23. Amplifier 23 has various resistors associated with the input circuit for properly biasing the amplifier and also includes impedance means connected between its input and output for stabilizing the amplifier and controlling its AC or DC gain.

The output of amplifier 23, in addition to coupling to threshold filter 25 and detection filter 26, also couples to AGC loop 50. Loop 50 comprises a rectifying diode D10 and a low pass filter comprising capacitor C12. The output of amplifier 23 is rectified by diode D10 and the signal is integrated by capacitor C12. The voltage across capacitor C12 is then fed by way of diode D9 during the absence of a signal by way of diode D8 to control the high impedance state of transistor Q14.

The cancel receiver transducer 40 has a somewhat lower frequency response than the main channel receiver transducer 15. This channel detects signals which have a frequency content which is lower than but near the carrier frequency and which is high up in the normal audio band. The cancel channel is thus not sensitive to normal audio signals unless they have harmonics which are close to the carrier frequency where interference with the main detection channel can occur. Detection of noise at a frequency close to the carrier frequency indicates a high probability that the main channel also contains noise because of the broadband

characteristics of noise. The detected noise is used to gate off or cancel the main channel signal during the noise interval in a similar manner to the inhibiting provided by the high pass filter 28 of FIG. 1. For example, if a telephone rings the circuit of the present invention does not activate an alarm as a phone ring occurs at less than a 50 percent duty cycle.

However, to prevent jamming of the circuitry through the transducer 40 the integrator and detector 31 includes an output by way of line 31B to accumulator 33. In one embodiment the accumulator 33 has a charge time of 8 seconds by way of line 31B. Thus, if a jamming signal is being provided for in excess of 8 seconds or at a duty cycle of say greater than 50 percent the accumulator 32 will generate an alarm condition.

The cancel receiver transducer 40 may be of conventional design and carrier amplifier 41 may be similar to amplifier 16.

Having described certain embodiments of the present invention it should be apparent that numerous other embodiments of the invention exist and numerous modifications may be made in the disclosed embodiments, all of which are contemplated as falling within the spirit and scope of the present invention. For example, one particular network has been disclosed for each of the filters, but other filter arrangements can be used as long as they have the desired frequency response.

What is claimed is:

1. An ultrasonic intruder detection circuit for use in a secured area comprising:
  - means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area;
  - means for receiving the reflected ultrasonic signal;
  - means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;
  - a difference circuit;
  - first frequency responsive means coupled from said means for registering to a first input of said difference circuit for establishing a frequency dependent threshold signal at the first input;
  - second frequency responsive means coupled from said means for registering to a second input of said difference circuit for establishing a frequency dependent detection signal at the second input;
  - output alarm means coupled from an output of said difference circuit responsive to said detection signal exceeding said threshold signal for providing an alarm condition,
  - and third frequency responsive means coupled from said means for registering to said output alarm means for passing doppler signals of a frequency higher than the frequency of an intruder doppler signal to thereby inhibit said output alarm means and prevent the generation of an alarm condition for a predetermined time duration.
2. The circuit of claim 1 wherein said output alarm means includes an accumulator circuit having a charging means that is charging during the predetermined time duration and means coupled to the charging means and responsive to the termination of the predetermined time duration for generating an alarm condition.
3. The circuit of claim 1 wherein said means for transmitting an ultrasonic signal includes an oscillator

circuit operating at a carrier frequency and said means for registering a doppler signal includes a phase detector coupled from and responsive to both said oscillator and said means for receiving for providing a modulated carrier signal modulated at a rate corresponding to the velocity of motion in the area.

4. The circuit of claim 3 comprising a low pass filter coupled between said phase detector and said first and second frequency responsive means for removing the carrier frequency from the modulated signal to provide the doppler signal.

5. The circuit of claim 1 wherein each said first and second frequency responsive means includes an RC filter network.

6. The circuit as claim 5 wherein said first frequency responsive means includes a notch filter having a decreased gain at the middle of a predetermined range of frequencies comprising an intruder frequency band in comparison to the gain of the second frequency responsive means.

7. The circuit of claim 6 wherein said intruder frequency band extends between 12 hertz and 250 hertz.

8. The circuit of claim 5 wherein said second frequency responsive means includes a band pass filter having a constant gain higher than the gain of the first frequency responsive means over the range of frequencies commencing at 12 Hertz and ending at 250 Hertz.

9. The circuit of claim 1 wherein said first and second frequency responsive means each include a filter network and each have a low frequency operating point where their gains are equal and a high frequency operating point where their gains are equal, the gain of the second frequency responsive means being greater in the frequency range between said first and second operating points than the gain of the first frequency responsive means.

10. The circuit of claim 1 wherein said first frequency responsive means includes a notch filter, said second frequency responsive means includes a band pass filter, and further comprising a high pass filter coupled from said means for registering to said output alarm means for passing signals above a frequency of 1,000 hertz.

11. The circuit of claim 10 wherein said output alarm means includes an AND circuit coupled from said difference circuit and an accumulator circuit coupled from the AND circuit.

12. The circuit of claim 11 comprising a detection circuit coupled from said high pass filter and having a first line coupled to the AND circuit for enabling the AND circuit in the absence of a passing of signals above 1,000 hertz, and a slow charge line coupled to the accumulator for charging the accumulator at a slower rate than when it is charged via the AND circuit in the presence of signals above 1,000 hertz.

13. The circuit of claim 12 wherein said AND circuit is inhibited during the time that said high pass filter is passing signals above 1,000 hertz.

14. An ultrasonic intruder detection circuit for use in a secured area comprising:

- means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area;
- means for receiving the reflected ultrasonic signal;
- means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;

first frequency responsive means coupled from said means for registering for passing doppler signals in the expected intruder frequency range;

second frequency responsive means coupled from said means for registering for passing doppler signals above the expected intruder frequency range;

and output timing means having a first input coupled from said first frequency responsive means and a second input coupled from said second frequency responsive means;

said output timing means responsive to said first frequency responsive means for generating an alarm condition after a first predetermined time period.

said output timing means responsive to said second frequency responsive means for generating an alarm condition after a second predetermined time period which is longer than said first predetermined time period.

15. The circuit of claim 14 wherein said output timing means includes a charge accumulator circuit having a capacitor means and means for charging said capacitor means at two different charge time constants.

16. The circuit of claim 15 comprising an AND circuit responsive to both said first and second frequency responsive means for permitting a charging of said capacitor means over the first predetermined time period in the absence of signals from said second frequency responsive means detected above a frequency of 250 Hertz.

17. The circuit of claim 16 wherein said AND circuit is inhibited in the presence of signals detected above a predetermined range of frequencies comprising an intruder frequency range and set accumulator is charged over the second predetermined time period.

18. An ultrasonic intruder detection circuit for use in a secured area comprising:

- means for transmitting an ultrasonic signal of a first frequency to establish an ultrasonic wave pattern in the area;
- means for receiving the reflected ultrasonic signal;
- means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;

output alarm means coupled from said means for registering and responsive to a predetermined frequency band of said doppler signal for providing an alarm condition;

transducer means responsive to signals of said first frequency and coupled to said output alarm means for inhibiting said alarm condition for a preselected time interval.

19. The circuit of claim 18 wherein said means for registering includes a phase detector responsive to both said means for transmitting and said means for receiving for providing said doppler signal and amplifying means.

20. The circuit of claim 19 comprising an automatic gain control loop coupled from said amplifying means to said phase detector for controlling the DC value of the doppler signal.

21. The circuit of claim 20 wherein said means for transmitting includes an oscillator and said phase detector includes a field effect transistor which is cyclically turned off by the oscillator, the on-time resistance

of the transistor being controlled by the automatic gain control loop.

22. An ultrasonic intrusion detection system for use in a secured area comprising:  
means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area;  
means for receiving the reflected ultrasonic signal;  
means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;

first frequency responsive means coupled from said means for registering for establishing a frequency dependent threshold signal;

second frequency responsive means coupled from said means for registering for establishing a frequency dependent detection signal;

detection means for receiving said threshold and detection signal;

output alarm means coupled from an output of said detection means responsive to said detection signal exceeding said threshold signal for providing an alarm condition;

and first and second averaging means coupled respectively from said first and second frequency responsive means to said detection means.

23. The system of claim 22 wherein each said averaging means includes a time integrating circuit.

24. The system of claim 22 wherein each said averaging means includes means defining a charging time constant.

25. The system of claim 24 wherein the charging time constant of said averaging means of said second frequency responsive means is less than the time constant of the averaging means of the first frequency responsive means.

26. The system of claim 25 wherein each said averaging means includes a rectifying means and capacitor means.

27. An ultrasonic intrusion detection system for use in a secured area comprising:

means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area;

means for receiving the reflected ultrasonic signal;  
means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;

first frequency responsive means coupled from said means for registering for establishing a frequency dependent threshold signal;

second frequency responsive means coupled from said means for registering for establishing a frequency dependent detection signal;

detection means for receiving said threshold and de-

tection signals;

and output alarm means coupled from an output of said detection means responsive to said detection signal exceeding said threshold signal for providing an alarm condition;

said first and second frequency responsive means each including filter means having a low frequency operating point wherein their gains are equal, the gain of the first frequency responsive means being greater at frequencies below said low frequency operating point.

28. The system of claim 27 wherein said filter means each include a filter network and each have a high frequency operating point wherein their gains are equal, the gain of the second filter network being greater in the frequency range between said low and high operating points than the gain of the first filter network.

29. An ultrasonic intrusion detection system for use in a secured area comprising:

means for transmitting an ultrasonic signal to establish an ultrasonic wave pattern in the area;

means for receiving the reflected ultrasonic signal;  
means responsive to said transmitting and said receiving means for registering a doppler signal of a frequency corresponding to the velocity of motion in the area;

first frequency responsive means coupled from said means for registering for establishing a frequency dependent threshold signal;

second frequency responsive means coupled from said means for registering for establishing a frequency dependent detection signal;

detection means for receiving said threshold and detection signals;

output alarm means coupled from an output of said detection means responsive to said detection signal exceeding said threshold signal for providing an alarm condition;

and third frequency responsive means responsive to signals of a frequency higher than the frequency corresponding to an intruder,

said third frequency responsive means coupled to said output alarm means to inhibit said output alarm means and prevent an alarm condition.

30. The system of claim 29 wherein said third frequency responsive means includes a transducer means.

31. The system of claim 30 wherein said transducer means is responsive to signals of a frequency on the order of the frequency of the transmitted ultrasonic signal.

32. The system of claim 29 wherein said third frequency responsive means includes a filter network.

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