

[54] **INTRUSION ALARM SYSTEM**
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[58] Field of Search **340/258 A, 258 B,**
 340/15, 16 R; 331/116, 154

[56] **References Cited**

UNITED STATES PATENTS

3,597,754	8/1971	Lerner.....	340/258 B X
2,400,309	5/1946	Kock.....	340/258 B X
3,065,455	11/1962	Roth.....	340/258 B X

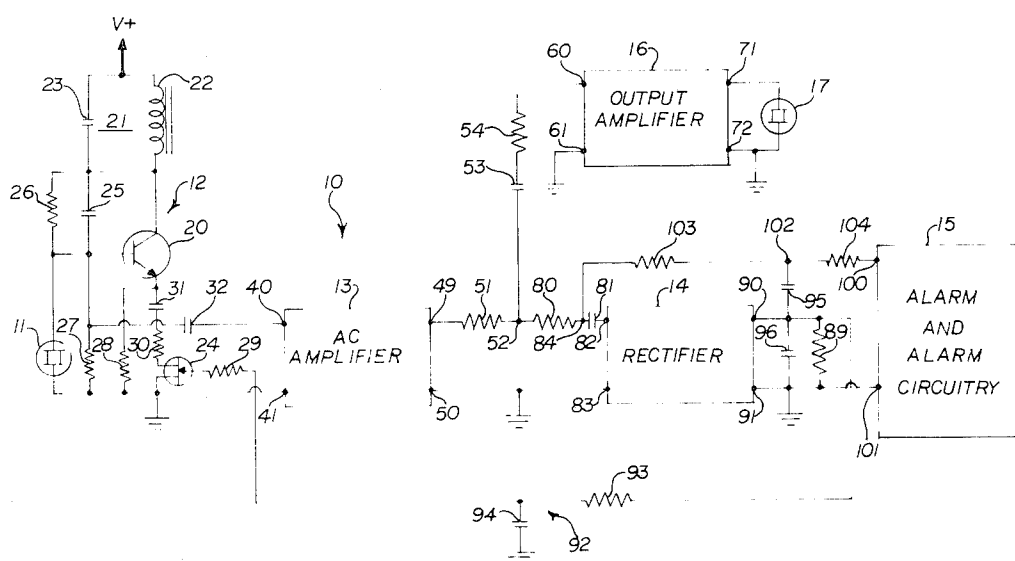
2,950,447	8/1960	McShan.....	331/154 X
2,769,972	11/1956	MacDonald.....	340/258 A

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[57] **ABSTRACT**

An intrusion alarm system includes separate transmitting and receiving transducers. The system detects the presence of an intruder in a protected area by generating carrier waves in the area and sensing the modulation of the carrier waves reflected from the intruder. The system uses the receiving transducer as a frequency control device to generate an oscillatory signal of controlled amplitude at the resonant frequency of the receiving transducer. The transmitting transducer is excited by the oscillatory signal, thereby carrier waves are generated by the transmitting transducer at the resonant frequency of the receiving transducer.

15 Claims, 5 Drawing Figures



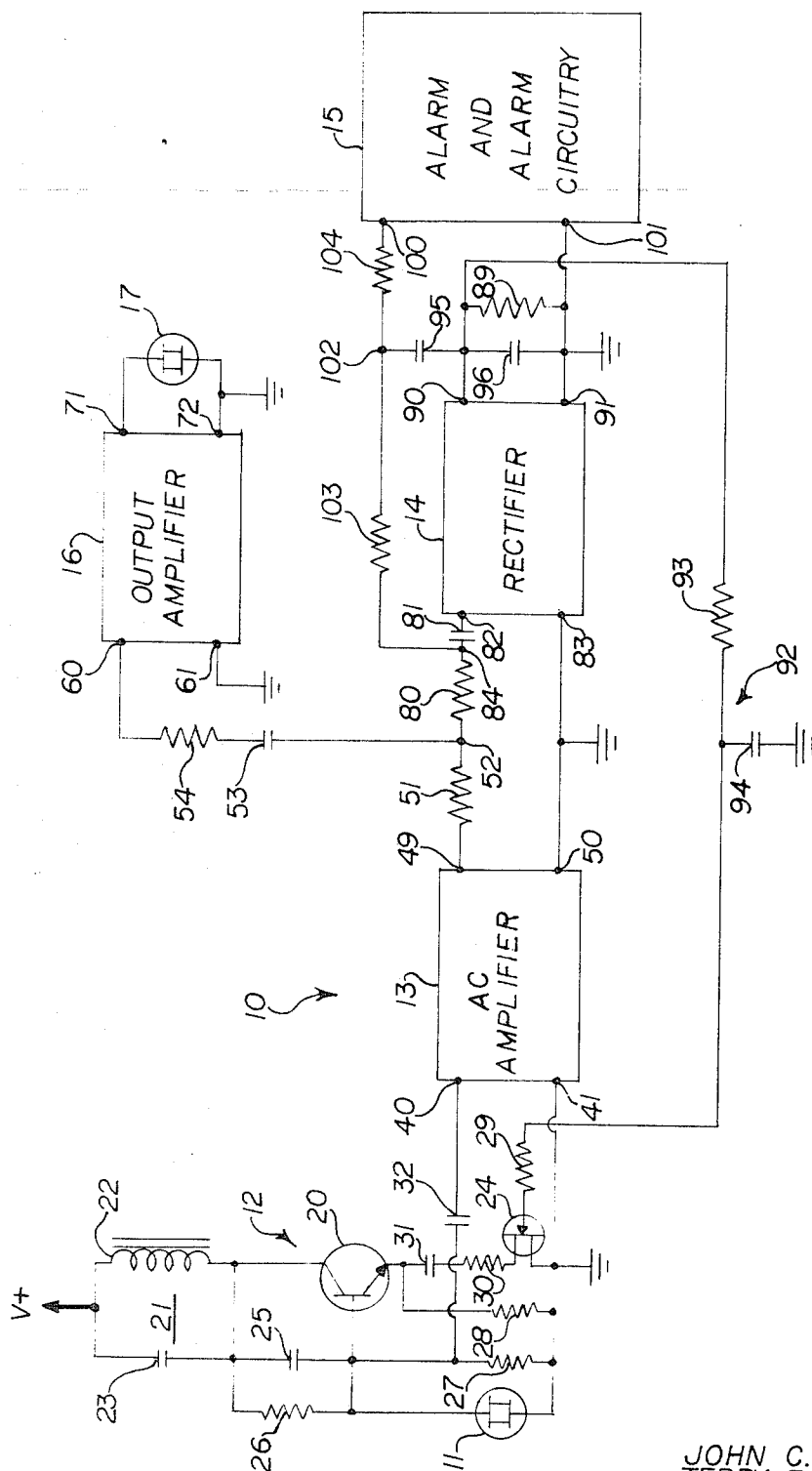


FIG. 1

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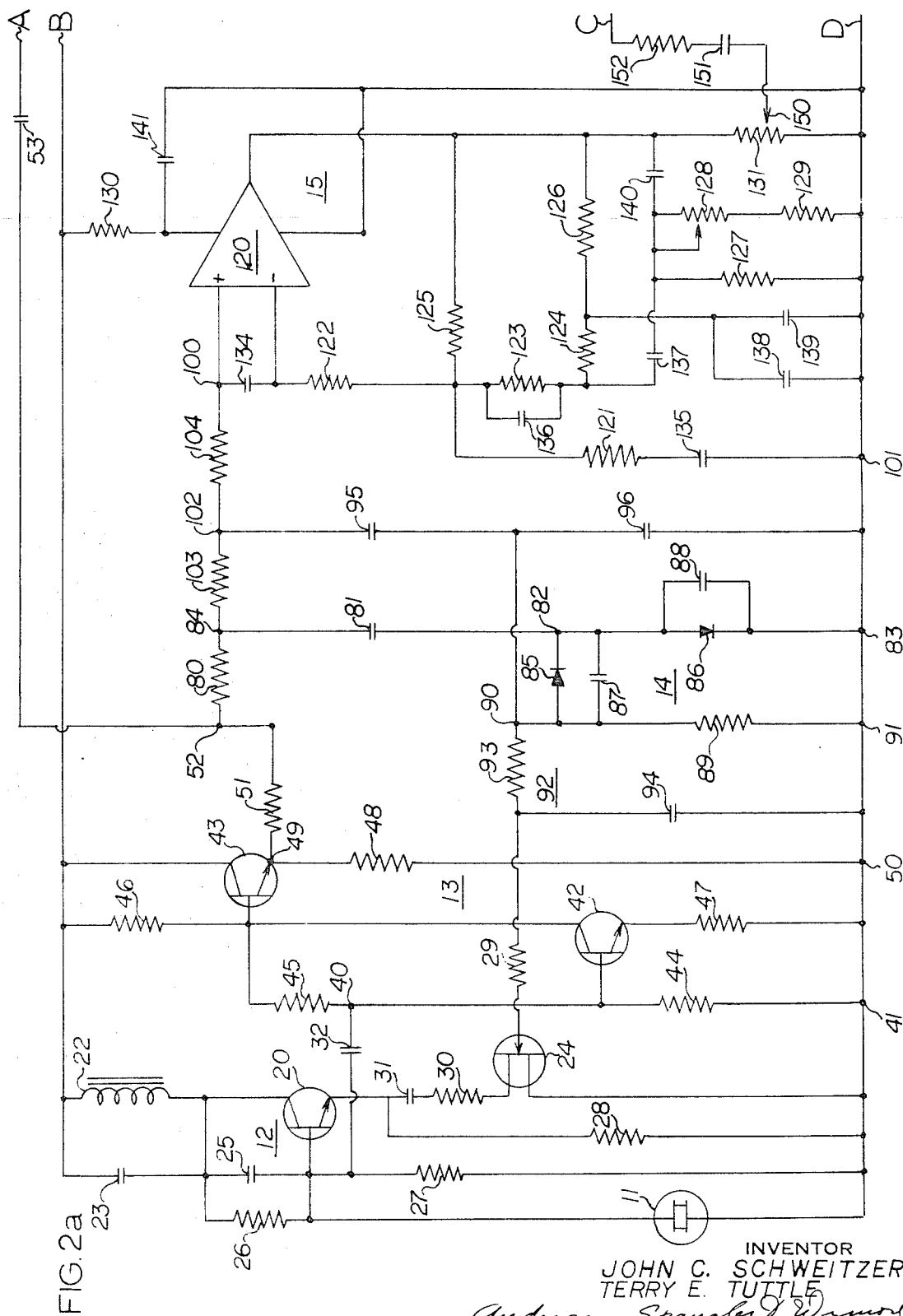
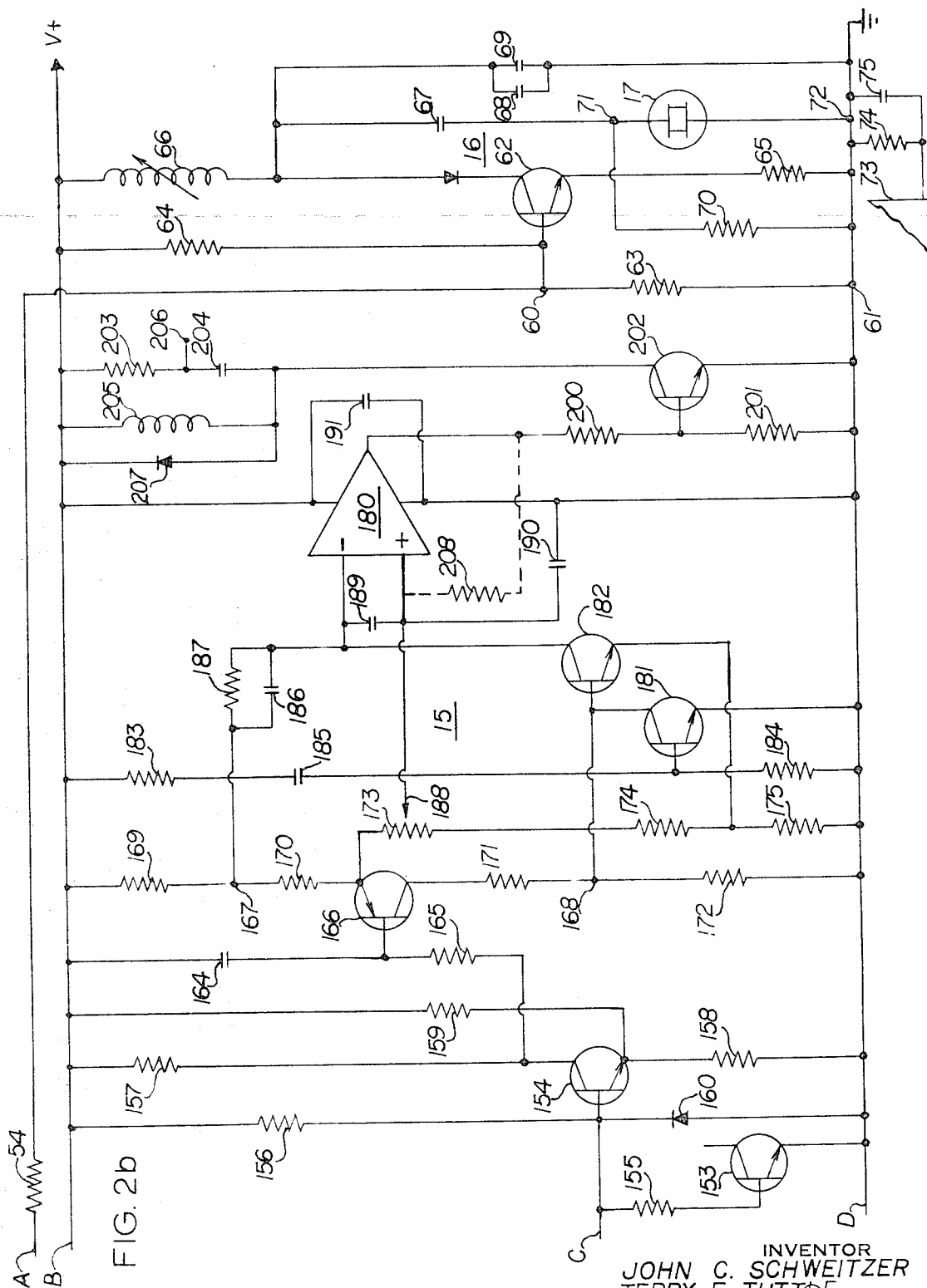


FIG. 2a

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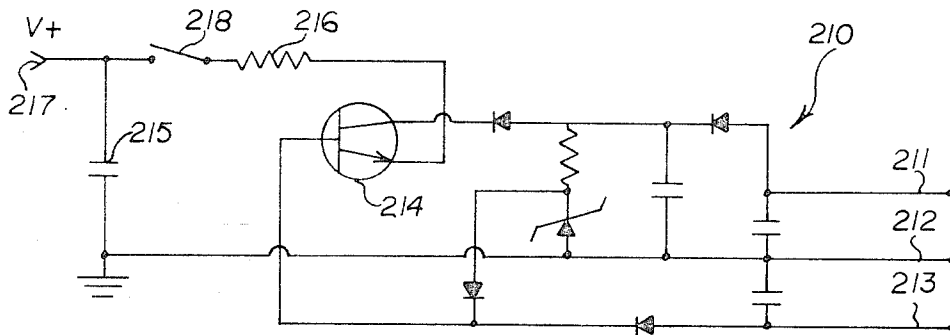


FIG. 3

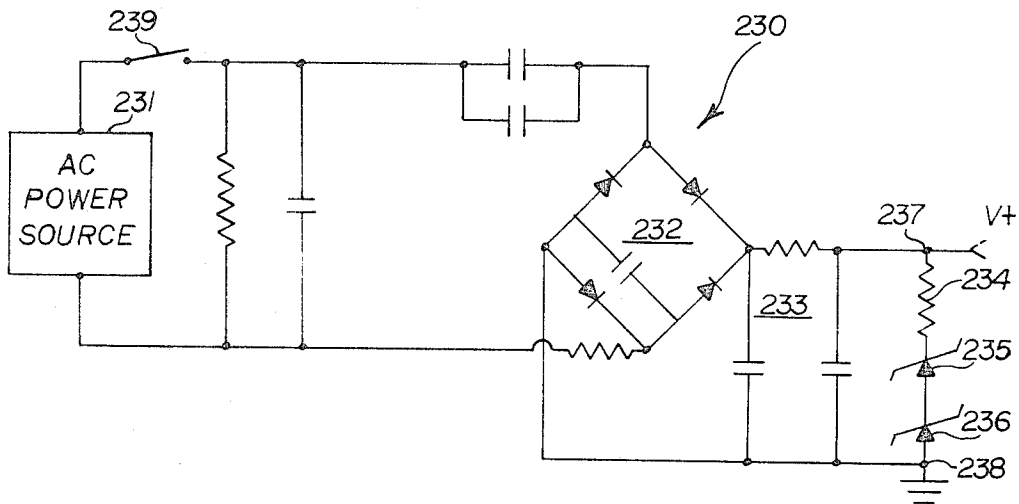


FIG. 4

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INTRUSION ALARM SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to alarm systems and more particularly to an improved intrusion alarm system.

Heretofore, ultrasonic type intrusion alarm systems have been devised. Generally, these alarm systems have included separate transmitting and receiving elements or transducers, and each of these elements have been designed for natural resonance at the same ultrasonic base frequency. In the operation of these alarm systems, the transmitting element was excited to generate ultrasonic waves at the ultrasonic base frequency within a defined area to be protected and the receiving element was positioned to receive reflected ones of these ultrasonic waves which were reflected from objects within the protected area.

The presence of an intruder in the protected area is detected in these systems by sensing changes or disturbances in the reflected wave pattern being received by the system's receiving element. The entry of an intruder into the protected area has basically two effects on the wave pattern of the reflected ultrasonic base frequency waves being received by the receiving element. First, movement of the intruder toward or away from the receiving element frequency modulates the reflected base frequency waves by frequency shifting the waves from their ultrasonic base frequency. This frequency shift, which is termed the Doppler effect, is proportional to the speed at which the intruder is moving away from or toward the receiving element and is generally of an extremely small magnitude in comparison to the base frequency of the ultrasonic waves. Secondly, the entry of an intruder into the protected area causes shifts in the magnitude of the reflected waves being received by the receiving element, thereby amplitude modulating the reflected base frequency waves.

In these ultrasonic intrusion alarm systems which utilize separate transmitting and receiving elements, the ultrasonic base frequency waves generated by the transmitting element function as carrier waves for carrying information representing the presence of an intruder in the protected area, this information being in the form of a frequency and/or amplitude modulation of the carrier waves. As a consequence, the sensitivity of these intrusion alarm systems depends upon the response sensitivity of the system's receiving element to the base frequency ultrasonic waves generated by the transmitting element. It is for this reason, as before-mentioned, that the transmitting and receiving elements are designed to have the same natural resonant frequency.

A common disadvantage with the prior art ultrasonic alarm systems is that generally no provision is made in these systems to insure that the transmitting element generates at all times carrier waves at the same ultrasonic frequency as the optimum point of resonance or sensitivity of the receiving element. This is a significant problem since it has been found that substantial nonuniform variations in the natural resonant frequencies of both the transmitting and receiving elements may result due to ageing of the elements, variations in their operating temperatures and for other reasons. As a consequence, the ability of such an alarm system to detect intruders may be significantly reduced by such shifts in the resonant frequencies of the transmitting and receiving

elements since the natural resonant frequency of the receiving element after these shifts may no longer correspond to the ultrasonic frequency of the carrier waves being generated by the system's transmitting element. Thus, the receiving element will be less sensitive to the reflected carrier waves which carry the information indicating the presence of an intruder and the sensitivity of the entire alarm system will have been decreased.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the present invention to provide an improved ultrasonic intrusion alarm system characterized by being operable to generate carrier waves at a base frequency which substantially corresponds at all times to the optimum point of sensitivity or resonance of the system's receiving element or transducer whereby to obviate the aforementioned disadvantage of the prior art ultrasonic intrusion alarm system.

It is further an object of the present invention to provide an improved intrusion alarm system having separate transmitting and receiving elements or transducers which has a locked loop type of operation wherein the system's transmitting element is at all times operated at substantially the same frequency as the maximum sensitivity point of the system's receiving element.

It is additionally an object of the present invention to provide an improved intrusion alarm system which detects the presence of an intruder within a protected area by sensing the modulation of carrier waves reflected from the intruder and which is operable to stabilize the amplitude of the oscillatory signals generating the carrier waves.

It is a further object of the present invention to provide an improved intrusion alarm system which on sensing movement establishes an alarm condition for a predetermined period of time and recycles at the end thereof unless there is no further detected movement.

A further object of the invention is to provide an improved intrusion alarm including integrative circuit means adapted to remove the effects of short term bursts of energy within the frequency range of the system to avoid false alarms due thereto.

In accomplishing these and other objects, there is provided in accordance with the present invention an improved intrusion alarm system including separate receiving and transmitting transducers or elements. The system detects the motion of an object or intruder in a protected area by generating ultrasonic carrier waves in the protected area and sensing the frequency shift or modulation of the carrier waves reflected from the intruder. The alarm system uses the receiving transducer as a frequency control device to generate an oscillatory signal of controlled amplitude at the resonant frequency of the receiving transducer. This oscillatory signal is amplified and used to excite the transmitting transducer. Thereby, the transmitting transducer generates carrier waves in the protected area at a base frequency which substantially corresponds to the optimum point of sensitivity or resonance of the receiving transducer. The alarm system further includes integrator means adapted to effectively eliminate the effects of short term bursts of energy within the frequency range of the system and further includes timer means which will time out after a predetermined period of

time if further motion or movement is not detected within the area protected.

Additional objects of the present invention reside in the specific construction of the ultrasonic intrusion alarm system hereinafter particularly described in the specification and shown in the several drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of an intrusion alarm system according to the present invention.

FIGS. 2a and 2b are circuit diagrams which in combination illustrate one suitable circuit arrangement for the intrusion alarm system of FIG. 1.

FIG. 3 is one form of DC power supply suitable for use with the intrusion alarm system of FIG. 1.

FIG. 4 is another form of DC power supply suitable for use with the intrusion alarm system of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in more detail, there is shown in FIG. 1 an exemplary intrusion alarm system generally designated by the numeral 10. The system 10 includes a receiving transducer or element 11, a frequency controlled oscillator 12, an AC amplifier 13, a rectifier 14, an alarm and alarm circuitry 15, an output amplifier 16 and a transmitting transducer 17.

The frequency controlled oscillator 12 is shown in detail in both FIGS. 1 and 2a and includes an NPN transistor 20, a tank circuit 21 made up of an inductor 22 and capacitor 23, and a field effect transistor (FET) 24. The inductor 22 and capacitor 23 are connected in parallel in the L-C resonant tank circuit 21 and V+ bias voltage is applied to one terminal of the tank circuit 21 while its other terminal is connected to the collector electrode of the transistor 20.

The resonant frequency of the oscillator 12 is controlled by the resonant frequency of the receiving transducer 11. The transducer 11 is connected between the base electrode of the transistor 20 and ground. Regenerative feedback is provided in the oscillator 12 by capacitor 25 and DC bias of the transistor 20 is set by the resistors 26-28. The capacitor 25 and resistor 26 are each connected between the base and collector electrodes of the transistor 20. The resistor 27 is connected from the base electrode of the transistor 20 to ground and the resistor 28 is connected between ground and the emitter electrode of the transistor 20.

The drain to source resistance of the FET 24 controls the amplitude of the oscillatory signal generated by the oscillator 12. As is hereinafter explained, a DC control voltage is generated and applied to the gate electrode of the FET 24 to control its drain to source resistances so as to stabilize the amplitude of the output voltage of the oscillator 12 at a specific predetermined level. This control voltage is applied to the FET gate electrode through a resistor 29 which is connected thereto. The drain to source resistance path of the FET 24 is connected in series with a resistor 30 and capacitor 31. The source electrode of the FET 24 is connected to ground while its drain electrode is connected to one terminal of the resistor 30. The capacitor 31 is connected between the other terminal of the resistor 30 and the emitter electrode of the transistor 20. In operation of the oscillator 12, the capacitor 31 in conjunction with the resistor 30 and the drain to source resistance of the FET 24 function as an emitter by-passing arrangement

to control the gain of the transistor 20 by varying the gain of the transistor 20 inversely in proportion to the amplitude of the oscillatory output signal of the oscillator 12.

The oscillator 12 operates, as is hereinafter explained, as a tuned collector-tuned base oscillator and generates an oscillatory output signal across the resistor 27. The terminal of the resistor 27 common with the base electrode of the transistor 20 is connected through a DC blocking capacitor 32 to the input terminal 40 of the AC amplifier 13. The other input terminal 41 of the amplifier 13 is connected to ground. The amplifier input terminals 40 and 41 are identified in FIGS. 1 and 2a.

The AC amplifier 13 is shown in detail in FIG. 2a and is a conventional two stage common emitter type transistor amplifier. The amplifier 13 includes NPN transistors 42 and 43 and DC bias resistors 44-48. Each of the transistors 42 and 43 makes up one of the amplifier stages and the DC bias resistors are connected in a conventional manner to appropriately bias the transistors 42 and 43. V+ and ground voltages are used for biasing the operation of the amplifier 13.

The oscillatory signal received from the oscillator 12 is linearly amplified by the amplifier 13 to generate across the resistor 48 an amplified oscillatory output of sufficient magnitude to drive the rectifier circuit 14 into hard conduction and cut off. The amplifier output appears on amplifier output terminals 49 and 50, which terminals are identified in both FIGS. 1 and 2a. The amplifier output terminal 50 is grounded while the terminal 49 is connected through a resistor 51 to junction point 52.

The junction point 52 is connected through a series connected DC blocking capacitor 53 and resistor 54 to the input terminal 60 of the output amplifier 16. The other input terminal 61 of the amplifier 16 is grounded. The output amplifier 16 is shown in detail in FIG. 2b. It is here noted that FIG. 2b is a continuation of the circuit diagram of FIG. 2a and that the circuit points marked A-D in FIG. 2b are the same as the identically designated points in FIG. 2a.

The output amplifier 16 includes an NPN transistor 62. The NPN transistor 62 has its base electrode connected to the input terminal 60 and is biased by V+ and ground voltages applied through DC bias resistors 63-65. The output transistor 16 amplifies the oscillatory signal received from the amplifier 13 and drives a conventional type of series resonant output circuit made up of a variable coil 66, capacitors 67-69 and a resistor 70. The output terminals of the series resonant output circuit are the amplifier output terminals 71 and 72. The transmitting transducer 17 is connected between these output terminals 71 and 72, and the terminal 72 is grounded.

The output oscillator 16 functions to amplify the oscillatory signal from the amplifier 13 so that a signal of sufficient magnitude is generated across the output terminals 71 and 72 to properly excite and drive the transmitting transducer 17. It is noted, as shown in FIG. 2b, that the case 73 of the exemplary intrusion alarm system 10 is also grounded by being connected to ground through a parallel connected resistor 74 and capacitor 75. The resistor 74 and capacitor 75 function to decouple the system's case 73 from its electrical circuitry, thereby to prevent interference in the system's operation which could be caused by stray electrical signals

induced in the case 73. It is also noted that the terminology that a portion of the circuitry is "grounded" as used herein is intended to refer to the connection of the circuitry to either a common voltage bus or directly to earth.

The junction point 52 upon which appears the output signal of the amplifier 13 is also connected through a series connected resistor 80 and a capacitor 81 to the input terminal 82 of the rectifier 14. One terminal of the resistor 80 is connected to the junction point 52 while its other terminal is connected to a junction point 84. The capacitor 81 is connected between the junction point 84 and the rectifier input terminal 82. The input terminal 83 of the rectifier 14 is grounded.

The rectifier 14 is shown in detail in FIG. 2a and includes a pair of diodes 85 and 86. Connected in parallel with the diodes 85 and 86 are the capacitors 87 and 88, respectively. The negative terminal of the diode 85 is connected in common with the positive terminal of the diode 86 to the input terminal 82. The positive terminal of the diode 85 is connected through a resistor 89 to the negative terminal of the diode 86 and the negative terminal of the diode 86 is connected to the rectifier input terminal 83.

The diodes 85 and 86 in the rectifier 14 function to rectify the amplified AC signal received from the linear amplifier 13. As is hereinafter explained, this AC signal which is rectified is the input signal received by the receiving transducer 11 which has been amplified by the oscillator 12 and the amplifier 13. This amplified AC signal is made up of a carrier wave having an ultrasonic base frequency substantially equal to the resonant frequency of the input transducer 11. Further, if an intruder is in the area protected by the intrusion alarm system 10, this carrier wave component of the amplified input signal will be frequency modulated by the movement of the intruder toward or away from the input transducer 11. The frequency modulation component of the amplified input signal will be a relatively low frequency signal which is representative of the motion of the intruder in the protected area.

The rectified output signal of the rectifier 14 is generated on rectifier output terminals 90 and 91 across the resistor 89. The output terminal 90 is connected through a filter 92 and the resistor 29 to the gate electrode of the FET 24. The filter 92 is made up of a resistor 93 and a capacitor 94. The resistor 93 is connected between the rectifier output terminal 90 and one terminal of the resistor 29. The capacitor 94 has one terminal connected in common with the interconnected terminals of the resistors 93 and 29, and its other terminal is connected to ground.

The filter 92 averages the magnitude of the rectified output of the rectifier 14 by generating a DC voltage across the capacitor 94 proportional thereto. This DC voltage represents the average value of the oscillatory output of the oscillator 12 and is applied to the gate electrode of the FET 24 through the resistor 29 to control its gate to source resistance as a function of the magnitude of the oscillator's output, the gate to source resistance of the FET 24 being increased by increases in the voltage charge on the capacitor 94 so as to cause proportional decreases in the magnitude of the output of the oscillator 12 and vice versa. Thereby, the magnitude of the output of the oscillator 12 is stabilized or maintained at a predetermined desired level.

The rectified output of the rectifier 14 is also applied through capacitors 95 and 96 to the input terminals 100 and 101, respectively, of the alarm and alarm circuitry 15. The capacitors 95 and 96 filter the rectified output of the rectifier 14 to remove the high frequency carrier wave portion thereof. Thereby, the low frequency component of the rectified output is detected. As beforementioned, such a low frequency component will be present in the rectified output whenever the ultrasonic carrier waves have been frequency modulated by the movement of an intruder within the area protected by the system 10.

The high frequency filter capacitors 95 and 96 are connected, respectively, between a junction point 102 and rectifier output terminal 90, and between rectifier output terminals 90 and 91. Resistors 103 and 104 are connected from the junction point 102 to the junction point 84 and the alarm circuitry input terminal 100, respectively. The alarm circuitry input terminal 101 is connected to the terminal of the capacitor 96 in common with the rectifier output terminal 91.

The alarm and alarm circuitry 15 may be any conventional type of arrangement which is operable to generate an alarm signal whenever a low frequency signal is received of sufficient magnitude to indicate the presence of an intruder. An exemplary type of alarm circuitry is shown in FIGS. 2a and 2b.

The alarm circuitry shown in FIGS. 2a and 2b includes an operational amplifier 120. The amplifier 120 is appropriately connected in a conventional manner for operation by a network of resistors 121-131 and capacitors 134-141. V+ and ground bias voltages are applied through this network of resistors and capacitors to bias the amplifier 120.

The amplifier 120 functions in a conventional manner and amplifies the low frequency signal detected by the filter capacitors 95 and 96. This amplified output of the operational amplifier 120 is developed across the resistor 131 which is connected between ground and the output terminal of the amplifier 120. The resistor 131 has an adjustable voltage pickoff 150 which may be adjusted to control the sensitivity of the alarm circuitry 15.

The voltage pickoff 150 is connected through a DC blocking capacitor 151 and a resistor 152 to a transistor amplifier made up of NPN transistors 153 and 154. This transistor amplifier is part of the alarm circuitry 15 and includes an input resistor 155 connected between the base electrodes of the transistors 153 and 154. DC bias resistors 156-159 are also connected between the V+ and ground bias voltages and the appropriate electrodes of the transistors 153 and 154 to bias the operation of the transistors. A diode 160 is connected from the base electrode of the transistor 154 to ground to half-wave rectify the AC signal being received thereat.

The low frequency voltage signal on the voltage pickoff 150 is applied through the resistor 155 to the base electrode of the transistor 153 and simultaneously directly to the base electrode of the transistor 154. The amplifier made up of these transistors 153 and 154 functions to amplify and half wave rectify this voltage signal. A half wave rectified output signal is generated on the collector electrode of the transistor 154.

Unless a signal is being applied to the base electrode of transistor 154, this transistor is cut off. The bias network associated with transistor 154 is made up of resistors 158 and 159 which establishes the emitter bias of

transistor 154. Resistors 155 and 156 plus the base-emitter breakdown or conductor voltage of transistor 153 determines the base bias of transistor 154. The base bias and the emitter bias are set such that the transistor is just below cut off and would not be normally conducting until a signal is applied thereto.

The collector electrode of transistor 154 is connected through a resistor 165 to the base of a PNP transistor 166, the primary purpose of which is to eliminate the effects of periodic type noises such as keys, coins and telephone bells. Since these noises are signal bursts, it has been found that they can be substantially eliminated by an integrator which has a charge-discharge time which is balanced such that these signal bursts will not trip the circuit. It has been found that the time constant to eliminate the effects of bursts of approximately 35Khz energy produced by keys, coins and telephone bells which might otherwise pass through the receiver and trip the integrator, is preferably such that there is approximately a one to two ratio between the charge and discharge time. Capacitor 164 connected to the base electrode of transistor 166 is the integrating capacitor and along with resistors 165 and 157 make up the integrator circuit. The charge time of capacitor 164 is controlled by the condition of transistor 154. When transistor 154 is conducting, it charges capacitor 164 through resistor 165. When transistor 154 is cut off the discharge path is through resistors 165 and 157. The values of resistors 165 and 157 are approximately equal, thus the charge time is approximately one half the discharge time.

The voltage that capacitor 164 has to charge to is determined by the bias string made up of resistors 169, 170, 173, 174 and 175 which is in common with integrator transistor 166 and timer amplifier 180. A voltage is established thereby at the emitter of transistor 166 that must be overcome by the charge on the integrating capacitor 164 before transistor 166 will conduct. The same divider or bias string made up of resistors 169, 170, 173, 174 and 175 is used to establish the DC operating voltage for the timer which is basically the operational amplifier 180 in association with the timing capacitor 186 and resistor 187. The specific DC voltage is selected by adjustment of the slider 188 of potentiometer 173. The DC voltage selected establishes the length of time the timer 180 will run. In basic operation, when a voltage signal is applied to the base electrode of transistor 166 for a sufficient length of time to charge capacitor 164 up to the point where transistor 166 goes into conduction, a voltage will be developed across resistor 172 sufficient to drive transistor 182 into conduction and charges capacitor 186 of the timer circuit to the point where operational amplifier 180 goes into positive saturation, that is the output goes positive and is in saturation at this point. Transistor 181 is a turn on clamp so that when voltage is first applied to the unit, the time constant associated with resistor 183 and capacitor 185 causes transistor 181 to clamp off transistor 182 so that the timer 180 cannot become active for predetermined time interval to allow the area under surveillance to be cleared before the unit becomes armed. Capacitor 186 will be charged negative, and output of operational amplifier will go positive into positive saturation. When the output of the operational amplifier 180 is in saturation, the input still represents a very high impedance and the capacitor 186 is driven very rapidly negative and will stay in that state until the

operational amplifier returns to its linear mode. The operational amplifier 180 now acts like a timer. By charging capacitor 186 until the operational amplifier 180 is driven completely out of its linear mode into positive saturation, transistor 202 is triggered into conduction and an alarm voltage is developed. Operational amplifier 180 will then stay in this state up to the point where capacitor 186 discharges down to where the operational amplifier 180 switches back to negative saturation. If any motion takes place within the interval for which the timer is set, the timer will be recycled again and transistor 166 will go into conduction driving transistor 182 into conduction which will recharge capacitor 186. Once motion ceases, the timer will time out and the alarm no longer will be actuated.

The output voltage from the operational amplifier 180 developed on the voltage divider made up of the resistors 200 and 201 is applied to the base electrode of an NPN transistor 202. The transistor 202 has its base electrode connected to the junction between the resistors 200 and 201. The emitter electrode of the transistor 202 is grounded and a series connected resistor 203 and capacitor 204 are connected between V+ voltage and the collector electrode of the transistor 202.

The transistor 202 functions as a transistor switch and is triggered into conduction whenever a voltage of sufficient magnitude is applied to its base electrode. The predetermined magnitude of output voltage of the operational amplifier 180 necessary to bias the transistor switch 202 into conduction is determined by the relative values of the resistors 200 and 201 with respect to each other and is set to correspond to the minimum output voltage generated by the presence of an intruder in the area protected by the system 10.

Once the transistor 202 is triggered into conduction, a current flows between the collector and emitter electrodes of the transistor 202 and an alarm actuating voltage is developed across the series connected resistor 203 and capacitor 204. This alarm actuating voltage may be employed to energize a relay 205 of a conventional alarm mechanism, as shown in FIG. 2b, or the voltage may be picked off at output terminal 206 and applied to drive another conventional alarm mechanism. The alarm relay 205 is preferably connected in parallel with the series connected resistor 203 and capacitor 204 and a diode 207 is connected in series with the relay 205 to protect the relay.

It is noted that a feedback resistor 208 may be connected between the output terminal of the operational amplifier 180 and its positive input terminal, as shown in dashed lines in FIG. 2b. Insertion of the resistor 208 into the alarm circuitry 15 causes the operational amplifier output to be applied directly as an amplifier input. As a result, once the amplifier output increases to a sufficient level to bias the transistor 202 into conduction, the transistor 202 remains biased into conduction since the output voltage of the amplifier 180 will not decrease from this voltage level but rather will be maintained thereat by the voltage feedback.

Consequently, with the resistor 208 connected in the alarm circuitry, the relay 205 once energized will remain energized, thereby indicating that the alarm circuitry 15 has been previously triggered. An appropriately connected on-off switch must then be included in the alarm circuitry to permit selective de-energization of the alarm circuitry 15 and alarm relay 205. It is

noted that with the resistor 208 removed from the alarm circuitry the magnitude of the output amplifier 180 varies as a function of its variable input so that the alarm relay 205 is then only energized during those instants when the output voltage of the operational amplifier 180 is of a sufficient magnitude to trigger the transistor switch 202 into conduction.

Before discussing the operation of the above-described intrusion alarm system 10, it is noted that one suitable V+ bias voltage is 12 volts and that this bias voltage may be supplied by any suitable DC power supply. One conventional DC power supply is shown in FIG. 3 and is identified by the numeral 210. Another suitable DC power supply is shown in FIG. 4 and is identified by the numeral 230.

The DC power supply 210 has input terminals 211, 212 and 213. A power source is connected to the terminals 211 and 212 and a DC bias voltage is supplied to the terminal 213. The power source connected to the terminals 211-212 drives an NPN transistor 214 and the operation of the transistor 214 is biased by the DC voltage applied to the terminal 213. The output current of the transistor 214 charges a capacitor 215 through a resistor 216 to develop a regulated DC bias voltage V+ on output terminal 217. An on-off switch 218 is connected between the capacitor 215 and the resistor 216 for controlling the operation of the power supply 210.

The other conventional DC power supply 230, which is shown in FIG. 4, includes an AC power source 231 which is connected to excite a diode bridge 232. The AC source 231 may be, for example, a 115 volt 60 Hertz voltage source. The AC voltage generated by the source 231 is full wave rectified by the diode bridge 232, filtered by a filter 233 and applied across an output resistor 234. The output resistor 234 is connected in series with a pair of zener diodes 235 and 236 between output terminals 237-238 of the power source. The output terminal 238 is connected to ground. The zener diodes 235 and 236 bleed to ground any excess DC voltage generated on the output terminal 237. Thereby, a regulated DC bias voltage V+ is generated on the power supply output terminal 237. An on-off switch 239 is connected between the AC power source 231 and the diode bridge 232 to control the operation of the power supply 230.

In operation of the intrusion alarm system 10, the tuned base-tuned collector oscillator amplifier 12 generates an ultrasonic oscillatory output signal of controlled frequency and controlled amplitude. The frequency of the oscillatory output is controlled by the resonance frequency of the receiving transducer 11 and it is noted that the tank circuit 21 is designed to resonate at approximately this same ultrasonic frequency. As beforementioned, the amplitude of the oscillatory output of the oscillator 12 is controlled by averaging the output of the rectifier 14 by means of the filter 92 and feeding the DC voltage generated, which is proportional to the magnitude of the oscillatory output, to the gate electrode of the FET 24. The drain-source resistance of the FET 24 varies directly with this DC control voltage so that the FET 24 acts as a gain control amplifier to stabilize the magnitude of the oscillatory output of the oscillator 12 at a predetermined level.

The oscillatory output of the oscillator 12 is amplified by the amplifier 13 and the output amplifier 16 to

excite the transmitting transducer 17. Thereby, the transmitting transducer 17 is excited at the resonant frequency of the receiving transducer 11. It is noted that by controlling the amplitude of the output of the oscillator 12 that the amplitude of the ultrasonic waves generated by the transducer 17 is also stabilized at a predetermined level.

The transmitting transducer 17 is designed to have approximately the same resonant frequency as the receiving transducer 11. The transducer 17 functions to generate in a defined area to be protected ultrasonic carrier waves at a base frequency equal to the natural resonant frequency of the receiving transducer 11.

The receiving transducer 11 is positioned to receive reflected ones of the ultrasonic carrier waves which are reflected from objects within the protected area. If an intruder is within or enters the protected area, these carrier waves are frequency modulated due to the Doppler effect by movement of the intruder toward or away from the transducer 11.

The transducer 11 senses these frequency modulated carrier waves and they are amplified by the oscillator 12 to produce the controlled frequency, controlled amplitude oscillatory output of the oscillator 12. The frequency modulated carrier waves are as before described amplified by the amplifier 13 and then rectified by the rectifier 14. The frequency shifted or modulation component of the rectified oscillatory output of the rectifier 14 is detected by the capacitors 95 and 96 to produce a low frequency signal the amplitude of which is proportional to the rate of motion of the intruder in the protected area. It is noted that if no intruder is moving in the protected area that no low frequency signal will be present to be detected by the capacitors 95-96 since the ultrasonic carrier waves will have not been frequency modulated.

This low frequency signal representing the presence of an intruder in the detected area is transmitted to the alarm and alarm circuitry 15. The circuitry 15 is then energized in the manner hereinbefore described to indicate the presence of an intruder.

It is noted that the filtering provided by the series connected capacitor 53 and resistor 54 connected between the amplifier 13 and the output amplifier 16 functions to filter and remove the low frequency modulation from the oscillatory signal transmitted to the output amplifier 16. Thereby, the amplifier 16 only amplifies the ultrasonic oscillatory waves generated by the oscillator 12 which correspond to the resonant frequency of the receiving transducer 11.

Thus, there is provided an improved ultrasonic intrusion alarm system operable to generate carrier waves at a base frequency which substantially corresponds at all times to the optimum point of sensitivity or resonance of the system's receiving element or transducer. The system has a locked loop type of operation wherein the frequency of the oscillator which generates the oscillatory signal to excite the transmitting transducer is controlled by the resonant frequency of the receiving transducer. An arrangement is also provided for substantially stabilizing the amplitude of the carrier waves generated by the transmitting transducer.

Although the invention has herein been described in what is conceived to be the preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention.

What is claimed is:

1. An ultrasonic intrusion alarm system of the type which senses the presence of an intruder in a protected area by detecting the modulation of reflected carrier waves, comprising:

a receiving transducer having an ultrasonic resonant frequency;
 a transmitting transducer capable of generating ultrasonic carrier waves at the ultrasonic resonant frequency of said receiving transducer, said transmitting and receiving transducers being positionable relative to each other so that ultrasonic carrier waves generated by said transmitting transducer are reflected from objects within a predetermined area to be protected to said receiving transducer;
 oscillatory signal generating means connected to said receiving transducer for amplifying the reflected carrier waves sensed by said receiving transducer, said signal generating means being frequency controlled by said receiving transducer and operable to generate an amplified oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer;
 output amplifier means connected between said oscillatory signal generating means and said transmitting transducer for amplifying the ultrasonic base frequency component of said oscillatory signal and exciting said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer; and
 detecting means connected to said oscillatory signal generating means for detecting a modulation component of said oscillatory signal so as to detect the presence of an intruder within said protected area.

2. The invention defined in claim 1, including alarm means connected to said detecting means for indicating the presence of an intruder within said protected area.

3. The invention defined in claim 2 wherein the alarm means includes integration means adapted to integrate signal voltages from said detector means until the integrated signals are of a magnitude sufficient to actuate said alarm means, said integrator means having a discharge time constant which is modified according to receipt or nonreceipt of a signal from said detector such that the discharge time of the integrator during nonreceipt of a signal from said detector is substantially longer than the charge time and is approximately equal thereto during receipt of a signal from said detector.

4. The invention defined in claim 3 wherein the ratio of discharge time to charge time during nonreceipt of a signal from said detector is about two to one.

5. The invention according to claim 3 wherein said integrator means includes a changing capacitor having a charge and discharge path and switch means adapted to effectively switch additional resistance into the discharge path during nonreceipt of a signal from said detector.

6. The invention defined in claim 1, wherein said detecting means is operable to detect a frequency modulation component of said oscillatory signal thereby to detect the presence of an intruder in the protected area and including means for stabilizing the output level of said oscillatory signal generated by said oscillatory signal generating means, said output stabilizing means being operable to determine the output level of said os-

cillatory signal and vary the gain of said oscillatory signal generating means inversely in proportion thereto whereby to maintain the output level of said oscillatory signal at a predetermined level.

7. In an ultrasonic intrusion alarm system having separate receiving and transmitting transducers wherein said transmitting transducer is excited at an ultrasonic frequency to generate ultrasonic carrier waves in an area to be protected and the presence of an intruder in the protected area is sensed by detecting the modulation of reflected ones of these carrier waves received by said receiving transducer, the improvement of signal generating means for connection between said receiving and transmitting transducers, said signal generating means being frequency controlled by said receiving transducer and operable to generate an oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer and excite said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer.

8. An ultrasonic intrusion alarm system of the type which senses the presence of an intruder in a protected area by detecting the modulation of reflected carrier waves, comprising:

a receiving transducer having an ultrasonic resonant frequency;

a transmitting transducer capable of generating ultrasonic carrier waves at the ultrasonic resonant frequency of said receiving transducer, said transmitting and receiving transducers being positionable relative to each other so that ultrasonic carrier waves generated by said transmitting transducer are reflected from objects within a predetermined area to be protected to said receiving transducer;

oscillatory signal generating means connected to said receiving transducer for amplifying the reflected carrier waves sensed by said receiving transducer and generating an amplified oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer, said oscillatory signal generating means including a transistor and an L-C resonant tank circuit, said transistor being connected as a tuned base-tuned collector amplifier with said tank circuit coupled to the collector electrode of said transistor and said receiving transducer coupled to its base electrode;

output amplifier means connected between said oscillatory signal generating means and said transmitting transducer for amplifying the ultrasonic base frequency component of said oscillatory signal and exciting said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer;

rectifier means also connected to said oscillatory signal generating means for rectifying said oscillatory signal;

means connected to said rectifier means for detecting a frequency modulation component of said rectified oscillatory signal thereby to detect the presence of an intruder in the protected area;

filter means also connected to said rectifier means for generating a DC control voltage proportional to the average value of said rectified oscillatory signal; and

gain control means connected between said filter means and said oscillatory signal generating means for controlling the gain of said oscillatory signal generating means inversely in proportion to the magnitude of said DC control voltage generated by said filter means whereby to maintain the output level of said oscillatory signal at a predetermined level.

9. The invention defined in claim 8, wherein said gain control means is a field effect transistor, said field effect transistor having its gate electrode connected to said filter means to receive said DC control voltage and its drain to source resistance path coupled to the emitter electrode of said transistor in said oscillatory signal generating means; and including alarm means connected to said frequency modulation detecting means for indicating the presence of an intruder within said protected area.

10. An ultrasonic intrusion alarm system of the type which senses the presence of an intruder in a protected area by detecting the modulation of reflected carrier waves, comprising:

a receiving transducer having an ultrasonic resonant frequency;

a transmitting transducer capable of generating ultrasonic carrier waves at the ultrasonic resonant frequency of said receiving transducer, said transmitting and receiving transducers being positionable relative to each other so that ultrasonic carrier waves generated by said transmitting transducer are reflected from objects within a predetermined area to be protected to said receiving transducer; oscillatory signal generating means connected to said receiving transducer for amplifying the reflected carrier waves sensed by said receiving transducer and generating an amplified oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer, said oscillatory signal generating means including a transistor and an L-C resonant tank circuit, said transistor being connected as a tuned base-tuned collector amplifier with said tank circuit coupled to the collector electrode of said transistor and said receiving transducer coupled to its base electrode;

output amplifier means connected between said oscillatory signal generating means and said transmitting transducer for amplifying the ultrasonic base frequency component of said oscillatory signal and exciting said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer; and detecting means connected to said oscillatory signal generating means for detecting a modulation component of said oscillatory signal so as to detect the presence of an intruder within said protected area.

11. An ultrasonic intrusion alarm system of the type which senses the presence of an intruder in a protected area by detecting the modulation of reflected carrier waves, comprising:

a receiving transducer having an ultrasonic resonant frequency;

a transmitting transducer capable of generating ultrasonic carrier waves at the ultrasonic resonant frequency of said receiving transducer, said transmitting and receiving transducers being positionable relative to each other so that ultrasonic carrier waves generated by said transmitting transducer are reflected from objects within a predetermined area to be protected to said receiving transducer; oscillatory signal generating means connected to said receiving transducer for amplifying the reflected carrier waves sensed by said receiving transducer and generating an amplified oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer;

output amplifier means connected between said oscillatory signal generating means and said transmitting transducer for amplifying the ultrasonic base frequency component of said oscillatory signal and exciting said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer; and

detecting means connected to said oscillatory signal generating means for detecting a modulation component of said oscillatory signal so as to detect the presence of an intruder within said protected area, said detecting means being operable to detect a frequency modulation component of said oscillatory signal thereby to detect the presence of an intruder in the protected area and including means for stabilizing the output level of said oscillatory signal generated by said oscillatory signal generating means, said output stabilizing means being operable to determine the output level of said oscillatory signal and vary the gain of said oscillatory signal generating means inversely in proportion thereto whereby to maintain the output level of said oscillatory signal at a predetermined level, said output stabilizing means including rectifier means connected to said oscillatory signal generating means for rectifying said oscillatory signal, filter means connected to said rectifier means for generating a DC control voltage proportional to the average value of said rectified oscillatory signal, and gain control means connected between said filter means and said oscillatory signal generating means for controlling the gain of said oscillatory signal generating means as a function of the magnitude of said DC control voltage generated by said filter means.

12. The invention recited in claim 11, wherein said oscillatory signal generating means includes a transistor and an L-C resonant tank circuit, said transistor being connected as a tuned base-tuned collector amplifier with said tank circuit coupled to the collector electrode of said transistor and said receiving transducer coupled to its base electrode; and said gain control means is a field effect transistor, said field effect transistor having its gate electrode connected to said filter means to receive said DC control voltage and its drain to source resistance path coupled to the emitter electrode of said transistor.

13. The invention recited in claim 12, including alarm means connected to said detecting means for in-

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dicating the presence of an intruder within said protected area.

14. An ultrasonic intrusion alarm system of the type which senses the presence of an intruder in a protected area by detecting the modulation of reflected carrier waves, comprising: 5

a receiving transducer having an ultrasonic resonant frequency;

a transmitting transducer capable of generating ultrasonic carrier waves at the ultrasonic resonant frequency of said receiving transducer, said transmitting and receiving transducers being positionable relative to each other so that ultrasonic carrier waves generated by said transmitting transducer are reflected from objects within a predetermined area to be protected to said receiving transducer; 10 15

oscillatory signal generating means connected to said receiving transducer for amplifying the reflected carrier waves sensed by said receiving transducer and generating an amplified oscillatory signal having an ultrasonic base frequency substantially equal to the ultrasonic resonant frequency of said receiving transducer; 20

output amplifier means connected between said oscillatory signal generating means and said transmitting transducer for amplifying the ultrasonic base frequency component of said oscillatory signal and exciting said transmitting transducer therewith whereby said transmitting transducer generates ultrasonic carrier waves having a base frequency substantially equal to the ultrasonic resonant frequency of said transducer; 25 30

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quency of said transducer;

detecting means connected to said oscillatory signal generating means for detecting a modulation component of said oscillatory signal so as to detect the presence of an intruder within said protected area; and,

alarm means connected to said detecting means for indicating the presence of an intruder within said protected area, said alarm means including timer means adapted to recycle periodically upon receipt of an alarm signal from said detecting means and maintain the alarm means activated upon receipt of an alarm signal within the recycle period of the timer and to deactivate the alarm means in the absence of a further alarm signal within the recycle period.

15. The invention defined in claim 14 wherein the timer means includes operational amplifier means having an input R-C charging network which on being charged by receipt of an alarm signal drives the operational amplifier out of linear mode developing an output adapted to actuate said alarm means during the R-C network discharge period with a further alarm signal being received within the discharge period again charging the R-C network and maintaining said alarm means actuated and in the absence of a further alarm signal being received within the discharge period, allowing the operational amplifier to return to linear mode after a predetermined time period and deactivating said alarm means. 30

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