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[54] **RADIO FREQUENCY BURGLAR ALARM SYSTEM**

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[51] **Int. Cl.** **G08b 13/00**
[58] **Field of Search** ..340/258 A, 258 B; 325/29, 131

[56] **References Cited**

UNITED STATES PATENTS

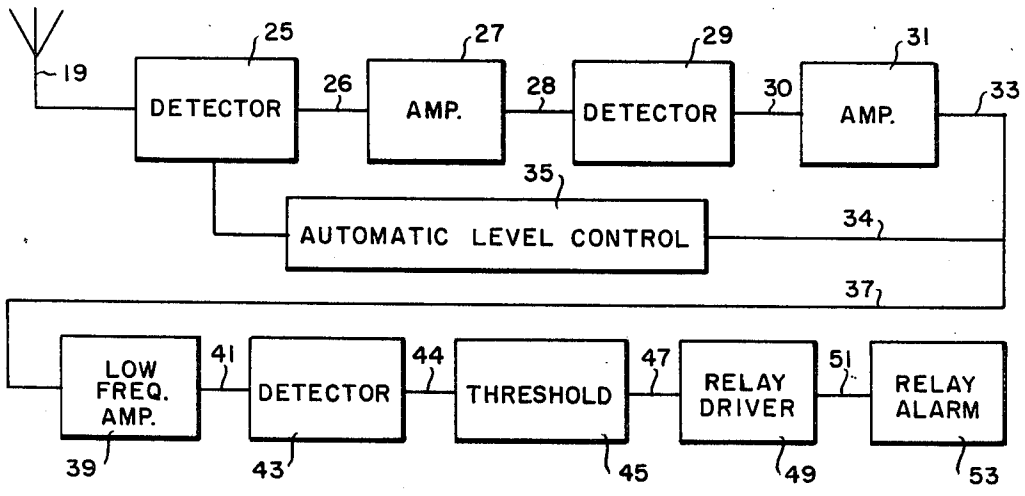
3,193,823	7/1965	Laakmann	340/258 A X
3,260,991	7/1966	Laakmann	340/258 A UX
3,331,065	7/1967	McDonald	340/258 A
2,749,537	6/1956	Loudon et al.	340/258
2,794,974	6/1957	Bagno et al.	340/258
3,242,486	3/1966	Corbell	340/258
3,530,472	9/1970	Fukata et al.	325/131 X

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[57] **ABSTRACT**

The burglar alarm system utilizes a transmitter that transmits an RF signal which is both amplitude modulated and frequency modulated. The signal is received by a receiver which is capable of sensing increases or decreases in the received energy due to movement through or into the energy field which is generated and radiated by the transmitter. This change in energy level causes the receiver to trigger an alarm.

12 Claims, 5 Drawing Figures



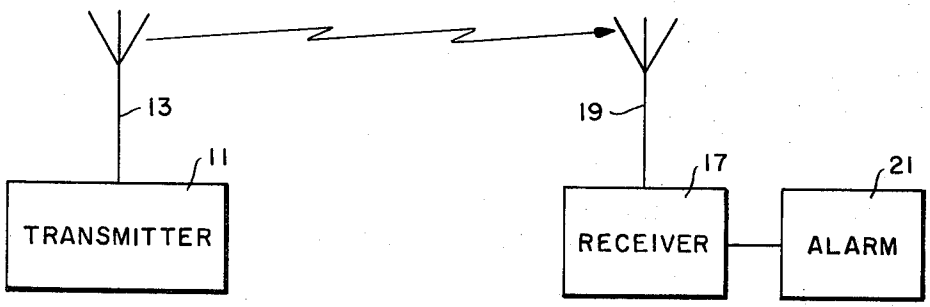


FIG. 1.

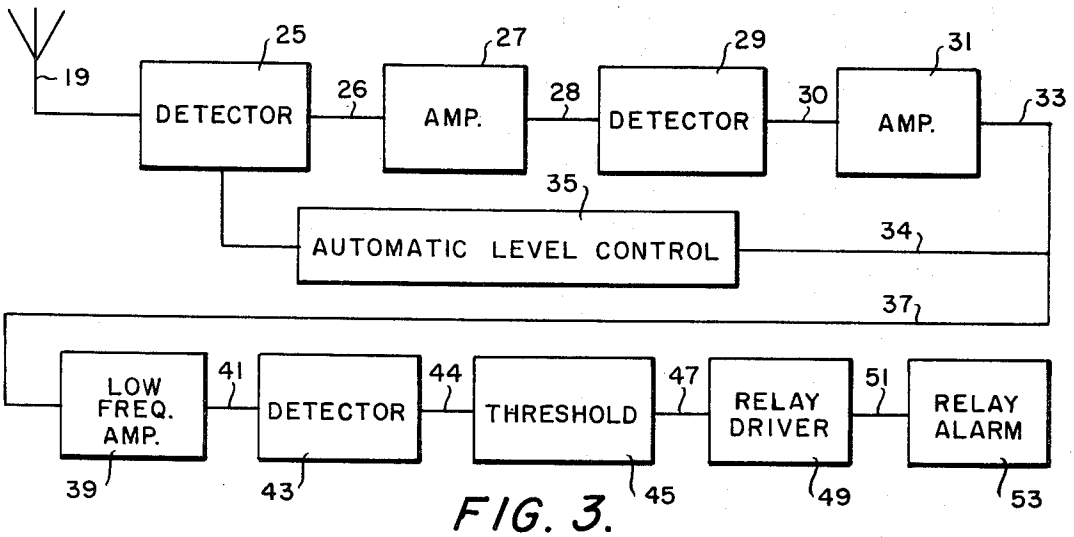
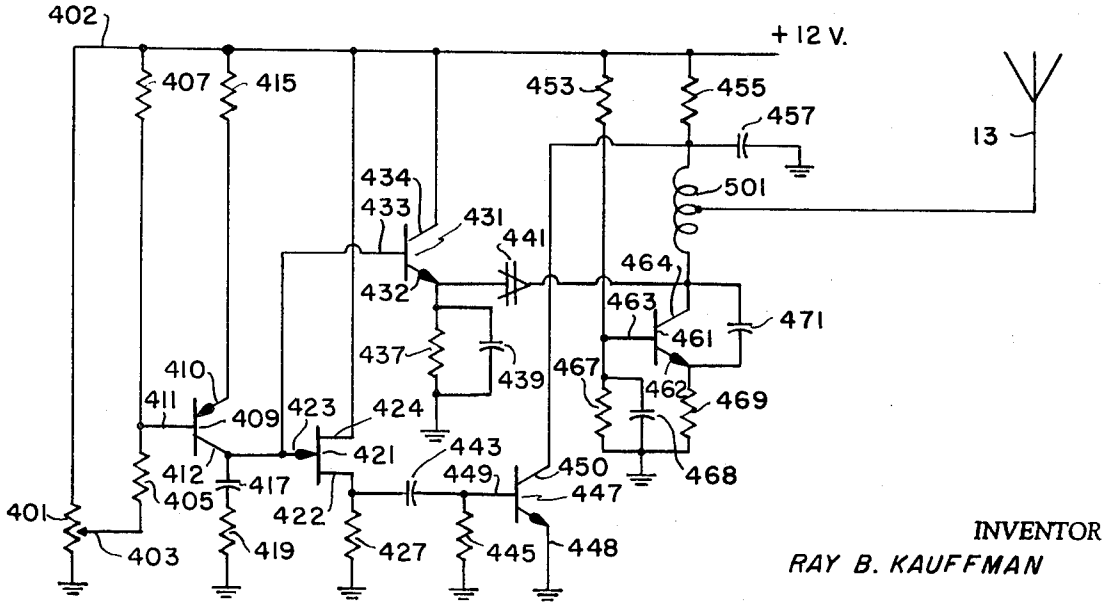


FIG. 3.



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FIG. 5.

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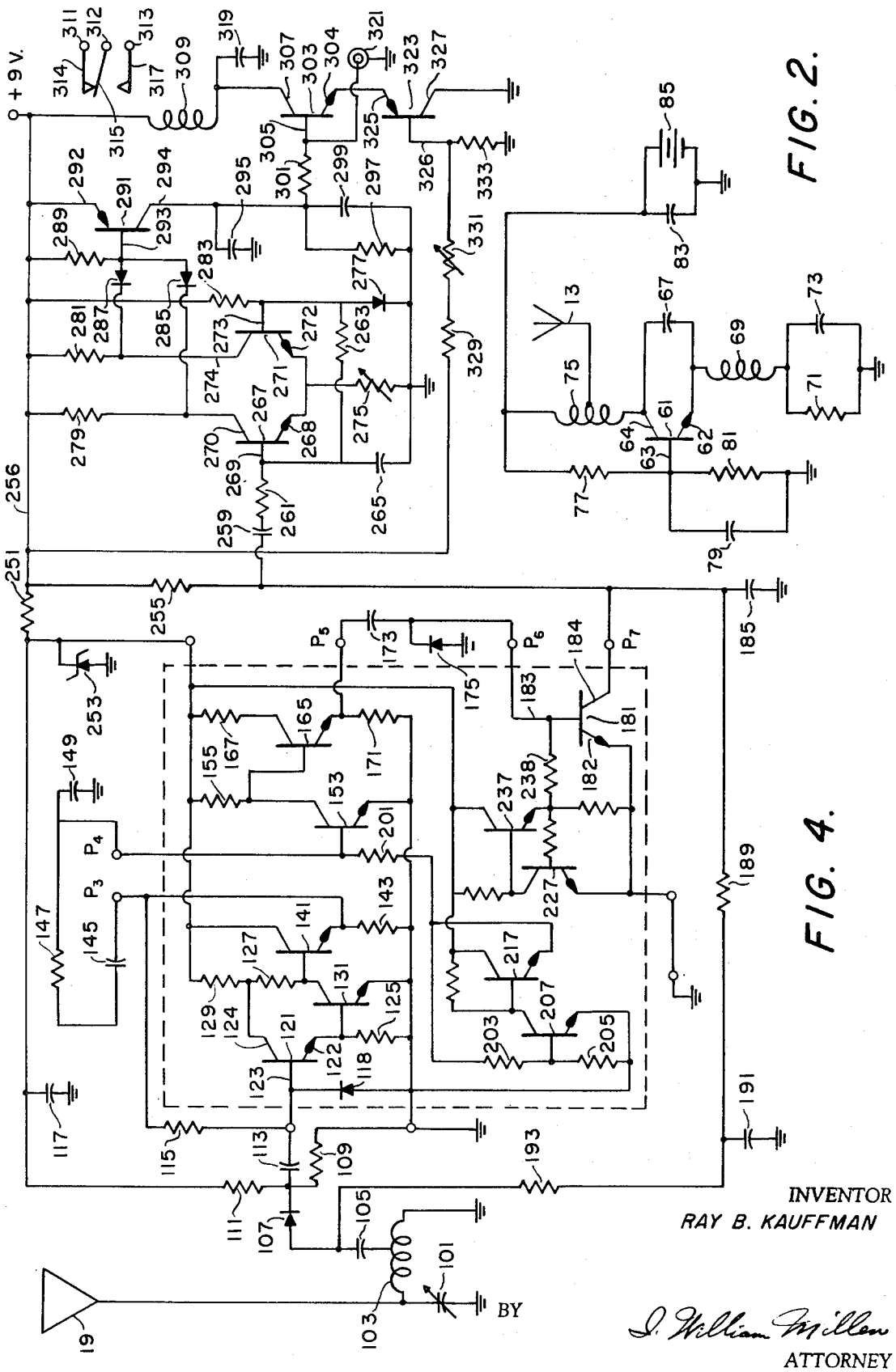

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FIG. 2.

FIG. 4.

RADIO FREQUENCY BURGLAR ALARM SYSTEM

The invention relates to a burglar alarm for protecting a given area and more particularly, to a burglar alarm system which radiates a field of RF energy over the area to be protected and a receiver for monitoring the RF energy in the protected area.

For example, the desireability of protecting a given space by an electronic device has been established. Very briefly, the automatic protection of a given space by an electronic monitoring system of moderate cost can be a help to the law enforcement divisions of the cities and states. Burglar alarms of various types have been used in the prior art. However, the prior art RF burglar alarm system can be triggered by stray radiations from other electronic devices, are relatively complex and are costly to purchase.

An object of the invention is to provide an RF burglar alarm system which is insensitive to electrical disturbances caused by radios, the operation of electronic equipment and by the movement of motor vehicles and airplanes in the proximity of the area which is to be protected.

A further object of the invention is to provide a simple RF burglar alarm system for protecting a given area.

Another object of the invention is to provide a simple electronic burglar alarm system for protecting the perimeter of an area to be protected.

A still further object of the invention is to provide an RF burglar alarm which utilizes a pulse and frequency modulated carrier wave as the protective medium.

A still another object of the invention is to provide a burglar alarm system having an automatic level control thereby permitting the transmitter and receiver to be placed at varying distances from each other.

In accordance with the preferred form of the invention, a transmitter is provided with an oscillator which produces a frequency modulated signal which sweeps a preselected frequency band. This frequency modulated signal is also amplitude modulated. The receiver is tuned to receive the frequency band of the transmitter. Objects entering or leaving the radiated field of the transmitter change the amount of energy received at the receiver. The change in the received energy actuates an alarm.

In a second embodiment of the invention the transmitter produces a frequency modulated signal which sweeps through a band from a first frequency to a second. The receiver receives both the direct radiation of the transmitter and the reflected wave from the intruder. The received waves will generate a beat note difference signal. Only the received waves which generated a beat signal in a precise range corresponding to a given perimeter which encloses the transmitter and the receiver will be permitted to get through the receiver bandwidth filter to trigger the alarm.

Other objects and many of the intended advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a block diagram illustrating the broad principles of an RF burglar alarm system;

FIG. 2 is a schematic circuit diagram of a suitable transmitter unit for use in a burglar alarm system constructed in accordance with the present invention;

FIG. 3 is a schematic block diagram of a suitable receiver constructed in accordance with the present invention;

FIG. 4 is a circuit diagram of the receiver illustrated in block diagram form in FIG. 3; and

FIG. 5 is an alternate circuit diagram for a suitable transmitter.

Referring to FIG. 1. There is illustrated a transmitter **11** connected to an antenna **13** for radiating an RF energy field about the transmitter. At a suitable distance from the transmitter **11** is located a receiver **17** having an antenna **19**. The antenna **19** detects the energy radiated from the antenna **13**. The receiver **17** monitors the detected energy from the antenna **19** and if a sudden change in the energy level should occur, either upwards or downwards, then the alarm **21** is triggered. A change in energy occurs when a foreign object moves into the RF field radiated from the antenna **13** and detected by the antenna **19**.

Referring to FIG. 2. There is illustrated a suitable oscillator for generating the RF energy for use in transmitter **11**. The oscillator is provided with an NPN transistor **61** having an emitter electrode **62**, a base electrode **63** and a collector electrode **64**. It is to be understood throughout this disclosure that NPN transistors can have PNP transistors substituted therefor with the simple expedience of changing the bias polarity and that PNP transistors may also have NPN transferred for them by the same expediency. For the transistor in this embodiment, a 9-volt battery **85** is connected through a resistor **77** to the base **63** of the transistor **61**. A second resistor **81** is connected between the base electrode **63** of the transistor **61** and ground. A by-pass capacitor **79** is connected across the resistor **81** and a low impedance by-pass capacitor **83** is connected across the battery **85**.

The oscillator has an inductor coil **75** connected between the positive terminal of the battery **85** and the collector electrode **64** of the transistor **61**. A feedback capacitor **67** is connected between the collector electrode **64** of the transistor **61** and the emitter electrode **62** of the transistor **61**. The combination of the inductor **75** and the capacitor **67** determines the resonant frequency of the pulses generated by the oscillator. This resonant frequency for a suitable laboratory embodiment was approximately 280 megaHertz. An inductor **69** has one of its ends connected to the emitter electrode **62** of the transistor **61** and its other end connected to one end of a resistor **71**. The other end of resistor **71** is connected to ground. The resistor **71** has a capacitor **73** connected in parallel therewith.

The operation of the oscillator illustrated in FIG. **2** is as follows. As soon as the battery **85** is connected into the circuit, a voltage is developed on the base **63** of the transistor **61** and on the collector **64** of the transistor **61** such that it begins to conduct and oscillate. The oscillations of the transistor **61** are in the order of 280 megaHertz at the beginning of the oscillatory circuit cycle. The current flowing through the transistor **61** is fed back in phase by the capacitor **67** from the collector electrode **64** of the transistor **61** to the emitter electrode **62** of the transistor **61**. The DC bias on the emitter electrode **62** is gradually being built up during the oscillatory cycle to a point wherein the emitter is biased more positive than the base electrode **63** of the transistor **61**. When this occurs, the transmitter is cut

off. As the capacitor **73** charges up making the emitter **62** of the transistor **61** more positive, the frequency of the oscillator drifts, sweeps downward from 280 megaHertz to 270 megaHertz. The net effect of the operation is thus: there is an oscillating frequency swept from 280 megaHertz to 270 megaHertz in bursts of 10 kiloHertz each. That is to say the time constant between bursts of oscillatory energy is determined by the resistor **71** and the capacitor **73**. When the resistor **71** discharges the capacitor **73** to a sufficient amount then the emitter electrode **62** will then be biased to a low enough voltage to permit the transistor **61** to become conductive again and to begin the cycle all over. The positive DC bias on the emitter electrode controls the conductivity of the transistor **61**. As the DC bias builds up it reduces the conductivity of the transistor thereby amplitude modulating the frequency modulated wave of the oscillator. The output of the oscillator is a series of pulses, each pulse containing a sweep frequency from 280 megaHertz down to 270 megaHertz, each pulse having a width of approximately 1 microsecond, and the pulses are spaced apart approximately 100 microseconds in the laboratory embodiment built by the inventor.

Referring to FIG. **3**. There is illustrated a block diagram of a receiver which is utilized in the preferred embodiment of the invention. The circuitry of the receiver is illustrated in FIG. **4** and will be discussed hereinafter. The antenna **19** of the receiver has its output connected to an input of the detector **25**. The detector **25** is connected through a suitable channel **26** to the amplifier **27**. The output of the amplifier **27** is connected through a suitable channel **28** to a second detector **29**, and the output of the second detector is fed through to a second amplifier **31**. The output from the amplifier **31** is fed through a channel **33** to the input of a low frequency amplifier **39** and simultaneously through a second channel **34** to an automatic level control **35**. The output of the automatic level control is fed to a level adjusting input of the detector **25**. The output of the low frequency amplifier **39** is fed to a third detector **43** and is then fed to a threshold detector **45**. The output of the threshold detector **45** is fed to a relay driver **49** which drives a relay alarm **53**.

The operation of the receiver is as follows. The RF field from the transmitter antenna **13** is picked up by the antenna **19** of the receiver. The detector **25** converts this RF energy into a series of DC pulses which are amplified by the amplifier **27** and the amplified pulse train is then further detected by detector **29**. The output of detector **29** is further amplified by the amplifier **31**. Part of the amplified energy of the amplifier **31** is fed back through an automatic level control **35** to a level control input of the detector **25**. This feedback controls the sensitivity of the detector **25**. Therefore, if the transmitter is very close to the antenna, amplifier **27** will not be overloaded because the feedback from the amplifier **31** through the automatic level control **35** to the detector **25** will reduce the sensitivity of the detector **25** and hence the size of the pulse entering amplifier **27**.

The remaining output of the amplifier **31** is fed to a low frequency amplifier **39**. The output of the low frequency amplifier **39** is a variable DC voltage which varies when someone walks within the field range of the RF energy of the transmitter antenna **13**. The variations in the output of the low frequency amplifier is detected by detector **43**. Specifically, the detector **43** detects either an increase or a decrease in the level of the voltage from the output of the low frequency amplifier **39**. The threshold detector **45** determines how much this voltage must deviate before it is passed on to a relay driver **49** which in turn trips the relay **53**.

Referring to FIG. **4**, wherein the detailed circuitry of the block diagram of FIG. **3** is illustrated. The antenna **19** is connected to the junction of a capacitor **101** and an inductor **103** of the receiver. The capacitor **101** and inductor **103** are tuned to a value to permit the FM bandpass of 270 to 280 megaHertz to be received by the FM receiver. The other end of capacitor **101** is connected to ground and the other end of the inductor **103** is connected to ground. A capacitor **105** is connected between a center tap on the inductor **103** and the anode of the diode **107**.

A resistive divider of resistors **111** and **109** are connected in series between ground and one side of resistor **251**. The resistors **111** and **109** set the bias on the cathode of the diode **107**. A capacitor **113** has one of its ends connected to the cathode of diode **107** and its other end connected to the base electrode **123** of the transistor **121**. A diode **118** has its cathode connected to the base electrode **123** of the transistor **121** and its anode of diode **118** is connected to ground. A filtering capacitor **117** is connected between one end of the resistor **251** and ground to filter out any AC voltages on the B+ supply line. The Zener diode **253** is connected between the same terminal as the capacitor and ground and prevents positive excursions from shorting out or burning out the transistors of the circuit. Additionally, the Zener diode prevents false activation of the alarm due to power supply changes and/or transients. A feedback resistor **115** is connected between the emitter of transistor **141** and the base electrode **123** of the transistor **121**.

The transistor **121** is an emitter follower transistor and has a resistor **125** connected between the emitter electrode **122** of the transistor **121** and ground. The base electrode of the transistor **131** is connected directly to the emitter electrode **122** of the transistor **121** and the collector electrode **124** of the transistor **121** is connected between the junction of the resistors **129** and **127**. The resistors **129** and **127** are connected in series between a terminal of the resistor **251** and the collector of the transistor **131**. The emitter of transistor **131** is directly connected to ground. The collector of transistor **131** is directly connected to the base electrode of the transistor **141**. A resistor is connected between the emitter electrode of the transistor **141** and ground. The output of the amplifiers **121**, **131** and **141** is directly connected to P3.

Between P3 and P4 is connected a high pass filter comprising a capacitor **145** and resistor **147** and a low pass filter which comprises a capacitor **149** is connected between P4 and ground. The center point of the filter is 10 kiloHertz and the *3db* points are at 7 kiloHertz and 13 kiloHertz. The output of the filter at P4 is directly connected to the base electrode of transistor **153**. The DC bias level on the base of transistor **153** is set by the series resistors **201**, **203** and **205**. The emitter of the transistor **153** is directly con-

nected to ground. The collector of the transistor 153 is connected through a resistor 155 to the junction point of the cathode of the Zener diode 253 and the resistor 251. The output of the collector electrode of transistor 153 is directly connected to the base electrode of the transistor 165. A resistor 167 is connected between the junction of the cathode of Zener diode 253 and the resistor 251 and the collector electrode of the transistor 165. The emitter electrode of the transistor 165 is connected through a resistor 171 to ground. The emitter electrode of transistor 165 is connected to P5 as an output of the amplifier stage.

At this point it may be well worthwhile to state that the diode 107 is the detector 25 and the amplifier 27 comprises the transistors 121, 131, 141, 153 and 165.

The voltage at terminal P5 is coupled by a capacitor 173 to the terminal P6. The diode 175 has its cathode connected to the P6 terminal and its anode connected to ground. The diode 175 is the detector 29 of the block diagram of FIG. 3. The amplifier 31 of FIG. 3 is the transistor 181.

The transistor 181 has an emitter electrode 182 which is directly connected to ground. A base electrode 183 which is connected to P6 and a collector electrode 184 which is connected to P7. The resistor 225 has one of its ends connected to the collector electrode 184 of the transistor 181 and its other end connected to the line 256 which is to be connected to the source of B+ potential. The other end of resistor 251 is connected to the line 256. The transistors 227 and 237 perform the function of a voltage regulator and set the amplifying level of the transistor 181. This is accomplished by setting the bias level on the base of electrode 183 of the transistor 181 through adjusting the potential across the resistor 238. The transistors 207 and 217 perform the function of a voltage regulator and set the amplification level of transistor 153. The output of the amplifier 184 is connected to P7 which in turn is connected to one end of the capacitor 185. The other end of the capacitor 185 is connected to ground. The capacitor 185 is a filter capacitor.

The resistor 189 has one of its ends connected to the capacitor 185 and has its other end connected to one terminal of a capacitor 191. The other terminal of capacitor 191 is connected to ground. The capacitor 191 is a second filter capacitor. The capacitor 191, resistor 189 and capacitor 185 perform the function of the automatic level control element 35 of FIG. 3. The capacitor 191 is connected to the anode of the diode 107 by way of a resistor 193.

The output of P7 is coupled to a capacitor 259 and a resistor 261 to the base electrode 269 of the transistor 267. The transistor 267 and the transistor 271 perform the function of the low frequency amplifier 39 of FIG. 3. The transistor 267 has an emitter electrode 268, a base electrode 269 and a collector electrode 270. A capacitor 265 is connected between the base electrode 269 of the transistor 267 and ground. The emitter electrode 268 of the transistor 267 is connected to the emitter electrode 272 of the transistor 271. The emitter electrodes 268 and 272 of the respective transistors 267 and 271 are connected through a variable resistor 275 to ground. The transistors 267 and 271 are a differential amplifier.

The collector electrode 270 of the transistor 267 is connected through a resistor 279 to the common B+ voltage line 256. Similarly, the collector electrode 274 is connected through the resistor 281 to the common B+ line 256. The base electrode 273 of the transistor 271 is connected to the anode of diode 277. The cathode of diode 277 is connected directly to ground. Diode 277 performs the function of a temperature stabilizing reference for transistor 271. A resistor 263 is connected between the base electrode 273 of the transistor 271 and the base electrode 269 of the transistor 267. A resistor 283 is connected between the B+ common line 256 and the base electrode 273 of the transistor 271.

Diodes 287 and 285 perform the function of the detector 43 of FIG. 3. The cathode of diode 285 is connected to the collector electrode 270 of the transistor 267 and the anode of the diode 285 is connected to the base electrode 293 of the transistor 291. Similarly, the cathode of the diode 287 is directly connected to the collector electrode 274 of the transistor 273 and the anode of the diode 287 is directly connected to the base electrode 293 of the transistor 291. A resistor 289 is connected between the common B+ line 256 and the base electrode 293 of the transistor 291. The emitter electrode 292 of the transistor 291 is directly connected to the common B+ line 256. A filter capacitor 295 is connected between the collector electrode 294 of the transistor 291 and ground. A resistor 297 is connected between the collector electrode 294 of transistor 291 and ground. A capacitor 299 is connected in parallel with the resistor 297.

The transistor 303 performs the function of the relay driver 49 of the block diagram of FIG. 3. The transistor 303 has an emitter electrode 304, a base electrode 305 and a collector electrode 307. The base electrode 305 of the transistor 303 is connected through a resistor 301 to the collector electrode 294 of the transistor 291. The collector electrode 307 of the transistor 303 is connected to one end of a relay 309 which operates the switch contacts 317, 315 and 314. The other end of the relay 309 is connected to the common B+ voltage line 256. An output is provided and is taken from the base electrode 305 of the transistor 303 and connected to the output terminal 321 which in this embodiment is not connected to anything and which may be used to remotely disable or enable the alarm or to send a signal to a fire station, a police station, or other place where a central monitoring board may be located.

The threshold detector 45 of the block diagram of FIG. 3 is the transistor 323, variable resistor 331 and resistor 329. The transistor 323 has an emitter electrode 325, a base electrode 326 and a collector electrode 327. The base electrode 326 of the transistor 323 is connected through the series combination of the variable resistor 331 and a fixed resistor 329 to the source of B+ potential line 256. A resistor 333 is connected between ground and the base electrode 326 of the transistor 323. The collector electrode 327 of the transistor 323 is directly connected to ground. The emitter electrode 325 of the transistor 323 is directly connected to the emitter electrode 304 of the transistor 303.

The RF radiated energy which is picked up by antenna 19 is fed through the tuned circuit of capacitor 101

and inductor **103** at the 280 to 270 megaHertz bandwidth. The detector which comprises a diode **107** detects a series of pulses at about the 10 kiloHertz frequency which is the pulsed frequency of the oscillator in the transmitter. The diode **107** is an AM detector which detects the amplitude of the overall FM signal to which the antenna is tuned. This amplitude varies at a 10 kiloHertz rate. The 10 kiloHertz pulses are coupled by the capacitor **113** to the amplifier transistors **121**, **131** and **141** of the first stage of amplification of the amplifier **27**. The output of the first stage is fed through a high pass filter which comprises the capacitor **145** and resistor **147** which passes all frequencies above 7 kiloHertz the sdb point to **P4**. The capacitor **149** is so chosen that its *3db* point is 13 kiloHertz and therefore shorts to ground or frequencies above 13 kiloHertz and passes through to **P4** all frequencies below 13 kiloHertz. The second stage of amplification of the amplifier **27** is accomplished by the transistors **153** and **165**. Therefore, the output frequency at **P5** ranges from 7 kiloHertz to 13 kiloHertz.

The detector **29** (diode **175**) shorts the negative going pulses to ground and provides a positive potential to **P6** which is the amplifier **31** (transistor **181**). The transistor **181** amplifies the signal presented to its base electrode **183** and provides an output at terminal **P7**. Part of this output is filtered through the combination of capacitor **185**, resistor **189** and capacitor **191** and is used as an automatic level control feedback shown schematically in box **35**. The output of the amplifier **184** is a steady state DC level determined by the power of the transmitted field so that if the transmitted field becomes higher, part of the signal which is fed back in the automatic level control is returned through the resistors **189** and **193** to the anode of diode **107**. The network comprising the capacitor **191**, one resistor **189** and capacitor **185** has a very long time constant so that the operation of the diode as regards transients or changes in the RF field is not effected. What this network does, is establishes the DC level at which the diode **107** operates. The cathode of diode **107** is at an elevated positive potential and will be reversed biased if the voltage across capacitor **191** is low. This happens when the transmitting antenna **13** is very close to the receiving antenna **19** and there is a very strong RF field on the receiving antenna **19**. This establishes the condition that the transmitter RF field will never be so strong as to overload the amplifier section of the receiver. This makes it impossible to jam the receiver. Now, for example, as the transmitter and receiver antenni are moved further and further apart, the incoming received signal of the receiver antenna **19** is of lower absolute strength, thereby causing less feedback to compensate for that, and in that case, the voltage across capacitor **193** will go in a more positive direction tending to almost forward bias the diode **107** which, in fact, makes the diode **107** a very sensitive detector. The overall combined effect of this action is such that the output at the junction of the resistors **111** and **109** is the same level regardless of the spacing of the receiver antenna **19** from the transmitting antenna **13**. The resistor **255** acts as a load resistor for the transistor **181**.

In the case where we have a steady state and there is no intruder, capacitor **259** blocks any input to the base electrode **269** of the transistor **267** or to the base electrode **273** of the transistor **271**. The transistors **271** and **267** are connected so as to be a differential amplifier and as long as the DC level at **P7**, the output of transistor **181** does not change, this amplifier will have no output and hence the rest of the circuit will remain stable and the alarm will not be triggered.

In the steady state condition the voltage drop across resistor **279** and resistor **281** is very small, in the order of a few tenths of a volt, and not enough to cause the diodes **285** and **287** to conduct. Therefore, transistor **291** does not conduct. Transistor **291** is connected to transistor **303** which is the relay driver. When transistor **291** does not conduct the transistor **303** does not conduct and consequently the relay is not energized. Transistor **323** sets a small threshold on transistor **303** so that random noise pulses which tend to turn transistor **303** on, will not because of the reverse bias at the emitter electrode of transistor **303** set by the transistor **323**.

Reverting a moment to a previous section. Transistor **207** and transistor **217** are merely used to establish the amplification conditions for the second two transistors **153** and **165** of the amplifier **27**. Transistors **207** and **217** control the bias condition for the amplifier comprising the transistors **153** and **165**. The collector of transistor **217** is connected to the power supply of the burglar alarm. The base of transistor **207** is connected to the emitter of transistor **217** by resistor **203**. As the emitter voltage on transistor **217** tries to increase, transistor **207** will sense this and decrease the bias voltage on the base of transistor **217**. It, transistor **207**, will start to conduct, therefore holding the emitter of transistor **217** at a voltage determined by the voltage divider resistors **203** and **205** and base of transistor **207**. This voltage is somewhat less than 1 volt. The regulator comprising transistors **207**, **217** is connected to the base electrode of transistor **153** establishing its bias condition at the optimum operating point. The transistors **227** and **237** operate in the same manner to control the bias to transistor **181**, thereby maintaining its operating point at the optimum value. A suitable circuit which may be a single crystal may be bought on the open market and contains the amplifier transistors **121**, **131**, **141**, **153**, **165** and the voltage regulator **207**, **217**, **227** and **237** and amplifier **181** may be numbered: CA **3035**. However, it is to be understood that other amplifiers and other voltage control regulators may be used in this system without affecting the basic invention.

Time constants of the RC circuit resistor **255** and capacitor **259**, and resistor **261** and capacitor **265** are in the order of five seconds so that long transients do not affect it and so that short transients pass through the RC circuit to the base electrodes **269** and **273**. However, a change in the ambient level over a period of time, even especially a slow or slight change will not have any effect on the detector circuit diodes **285** and **287**; but any change which is more rapid than the five second time constant triggers transistor **267** on therefore, triggers transistor amplifier **291** and transistor **303** and setting the alarm through the relay. A steady state situation has now been defined.

Now, assume a man walks into the RF field having a reflective material thereby increasing the energy received by the receiver antenna **19**. As a person enters

into the field and reflects more energy from the transmitter antenna 13 to the receiver antenna 19, the receiving antenna 19 will suddenly pick up more energy; therefore, the output energy of capacitor 101 and inductor 103 will increase, the input energy to the diode detector 107 will increase and the output energy of detector 107 will also increase. Consequently, the output of the amplifier 27 which comprises the two amplifier sections having transistors 121, 131, 141 and transistors 153 and 165 will be a string of pulses having a larger amplitude. This change happens very rapidly and as this happens at a speed at which the person enters the field. As the output amplitude of the pulses at P5 increases the output of the second detector diode 175 which is called detector 29 increases. It can be seen that the output on the detector 29 being diode 175 increases to a higher DC positive level. This increase in voltage makes the transistor 181 more conductive (turn on harder). When transistor 181 turns on harder, the voltage at its collector will drop rapidly. Therefore, the rapid drop in voltage will be passed by capacitor 259 through resistor 261 turning off the transistor 267. When the transistor 267 turns off, its emitter current is decreased, therefore allowing more emitter current to flow into the emitter 272 of differential transistor 271. This turns transistor 271 on causing an increased voltage drop on resistor 281 thereby forward biasing the diode 287 turning on the transistor 291 which in turn, turns on the transistor 303 and keys the relay turning on an alarm signal. The output of detector 29 and the amplifier 31 is rapid enough so that the automatic level control feedback circuit 35 does not change substantially in order to change the conductive level of diode 107 during this portion of the operation. The diode 277 connected to the base 273 of the transistor 271 controls the operating point of the transistor 271. The diode 277 also has a temperature compensation effect so that changes of temperature do not affect the operation of this amplifier.

In the second condition, assuming that the person entering the field absorbs some of the RF energy rather than reflecting it. In this case, they will cause a decrease in signal strength at the antenna 19 of the receiver. The decreased signal strength will be fed to diode 107 and hence smaller voltage will be at the output of the detector 25 which comprises the diode 107. Consequently, the voltage amplitude at P5 of the integrated circuit will be less. This will cause the detector input to transistor 181 to be less positive in value; hence transistor 181 will draw less current and the collector of transistor 181 will go in a more positive direction. This positive change will be passed through the capacitor 259 and resistor 261 and will turn on the transistor 267 increasing the voltage drop across resistor 279 and forward biasing the diode 285, turning on transistor 291 and consequently turning on transistor 303 thereby tripping the relay and setting off the alarm. It is noted that this decrease that has been spoken of heretofore is rapid enough to pass through the circuits which have a 5 second time constant.

Referring to FIG. 5. There is disclosed an alternate oscillator which performs the function of an alternate transmitter for use in the disclosed invention. The resistor 401 having a variable center tap 403 has one of its ends connected to ground and its other end connected to the B+ voltage line 402. A resistor 405 has one of its ends connected to the moveable center tap 403 of the resistor 401 and its other end connected to the base electrode 411 of the transistor 409. A second resistor 407 is connected between the base electrode 411 of the transistor 409 and the B+ line 402. The emitter electrode 410 of the transistor 409 is connected to one end of a resistor 415 and the other end of resistor 415 is connected to the B+ line 402. The collector 412 of transistor 409 is connected through the series connection of capacitor 417 and resistor 419 to ground. A unijunction transistor 421 has its emitter electrode 423 connected to the collector electrode 412 of the transistor 409. The first base electrode 424 of the unijunction transistor 421 is directly connected to the B+ line 402. The second base electrode 422 is connected through a resistor 427 to ground. The second base electrode 422 of the unijunction transistor 421 is connected through a capacitor 443 to the base electrode 449 of the transistor 447.

A resistor 445 is connected between the base electrode 449 of the transistor 447 and ground. The emitter electrode 448 of the transistor 447 is directly connected to ground. The collector electrode 450 of the transistor 447 is connected through a resistor 445 to the common B+ line 402. The base electrode 433 of the transistor 431 is directly connected to the collector electrode 412 of the transistor 409. The collector electrode 434 of the transistor 431 is directly connected to the common B+ line 402. The emitter electrode 432 of the transistor 431 is connected through a resistor 437 to ground. A capacitor 439 is connected in parallel with the resistor 437. A variable capacitor diode 441 has its anode connected to the emitter electrode 432 of the transistor 431 and the cathode of the variable capacitor diode 441 is connected to the collector electrode 464 of the transistor 461. A resistor 453 is connected between the B+ line 402 and the base electrode 463 of the transistor 461. A resistor 467 is connected between the base electrode 463 of the transistor 461 and ground. A capacitor 462 is connected in parallel with the resistor 467. A resistor 469 is connected between ground and the emitter electrode 462 of the transistor 461. A feedback capacitor 471 is connected between the emitter electrode 462 of the transistor 461 and the collector electrode 464 of the transistor 461. A coil 501 is connected between the collector electrode 464 of the transistor 461 and one terminal of the resistor 455. A capacitor 457 is connected between the junction of the resistor 455 and coil 501 and ground. The radiating antenna 13 of the transmitter is connected to a tap on the coil 501.

Referring to the operation of FIG. 5. The resistor 401 is a rate control which varies the voltage applied to the base 409 of the transistor to the base electrode 411 of the transistor 409, thereby varying the collector current of the transistor 409, the higher the collector current in 409, the faster capacitor 417 charges. As capacitor 417 reaches approximately 60 173 percent of the supply voltage, the unijunction transistor 421 discharges capacitor 417 and hence the output of the emitter of the unijunction transistor 421 is a sawtoothed wave. This sawtooth wave form is applied to the base of transistor 431 and the emitter follower's transistor 431, emitter 432 has the same sawtooth wave

on it as is applied to the base **433** except with a higher current value. This sawtooth wave is applied to variable capacitance diode **441** which in turn is connected to the tank circuit of the oscillator **461**. As the sawtooth voltage changes so does the capacitance of the variable capacitor diode **441**, thereby changing the resonant frequency of the transmitter and frequency modulating it from 280 megaHertz to 270 megaHertz. Capacitor **439** provides an RF return path for the variable capacitance diode **441**. When the sawtooth reaches its limit and the unijunction transistor **421** fires, a brief positive voltage pulse is applied across resistor **427**. This pulse is conducted through the capacitor **443** turning on the transistor **447** which shorts the oscillator out of conduction. This shorting of the oscillator out of conduction forms a blanking pulse on the base pulse rate of the oscillator which, in this case, varies from 1 kiloHertz to 100 kiloHertz. Stating this concept another way. When transistor **447** turns on, it momentarily shorts to ground the oscillator. Another way to say it is it increases the voltage drop across the resistor **455** to the point where the transmitter ceases to oscillate. The complete process is repetitive at a rate set by the rate control **401** which controls the rate at which the transistor is blanked.

The FM rate is set by the rate control which controls the rate of change of voltage across capacitor **417** and the total deviation of this voltage. The frequency limits are chosen by the voltage actually appearing at the emitter electrode **432** of transistor **431** which is a function of the type of unijunction transistor and by the choice of the variable capacitor diode **441** and its capacitance change for a given applied voltage. The frequency sweep between the higher value of frequency, 280 megaHertz, and the lower value of frequency, 270 megaHertz, is caused solely by the variable voltage diode **441** which is across the tank circuit of inductor **501** and capacitor **457** and this changes the resonant frequency of the tank circuit and hence the output frequency of the oscillator.

In the case where the transmitter of FIG. **5** is on an operative location then the FM signal is received by two paths to the receiver antenna **19**. One will be a direct path and one will be a reflective path being reflected from objects or people around or near the site of the transmitter. Since the directly received path is the shortest path, any signal arriving by the reflective path will arrive at a later time. Since we are using an FM signal, which varies in frequency, with times from 280 megaHertz to 270 megaHertz, there will be a difference note generated by the direct and reflected waves when they are mixed together. The difference in this note will be determined by the rate control of the FM transmitter which is preset and by the distance of the reflecting objects. If these objects happen to lie at the distance at which a difference note of the desired frequency is produced, it will be passed by the 10 kiloHertz tuned amplifier transistors **121**, **131**, **141**, **139** and **165**. From this point on, it is rectified by the second detector **29** comprising diode **175**. The remainder of the operation of the receiver is exactly the same as in the first description thereof.

However, if an intruder enters the RF field, nothing will happen until he gets at the proper distance from the transmitter and receiver combination, so that the difference note he produces will be within the range of the tuned amplifier. This tuned amplifier, as previously mentioned, is at 10 kiloHertz tuned frequency. When the intruder gets within this small zone then he will disturb the 10 kiloHertz difference note by disturbing the RF field, the amplitude will drop off, therefore the input to the amplifier **27** will decrease from this point. The operation is again the same as the intrusion alarm described before. The other case will be if the intruder enters within this zone so as to produce a 10 kiloHertz difference note of increased amplitude and the signal into the amplifier increases and again the operation is the same as the intrusion alarm heretofore discussed. To further clarify the operation of the receiver, the direct FM signal which arrives directly from the transmitter has its frequency component different than that which arrives from the reflective wave due to the increase in path. The two signals as received across diode **107** are mixed together so there is an output signal which is a difference signal, either below 7 kiloHertz, the bottom threshold of the tuned section, or above 13 kiloHertz. However, if the difference signal is below 7 kiloHertz or above 13 kiloHertz, then the alarm cannot be set off. If the object which is causing the reflections is at such a distance that it causes a difference signal between 7 kiloHertz and 13 kiloHertz, then the amplifier can then perform as described for FIGS. **3** and **4**. The thing which causes the receiver to have a 7 to 13 kiloHertz difference frequency is a certain prescribed distance that the intruder is between the units. This distance can be determined by experiment in a field application or determined by setting the rate control. As a practical matter, this distance will describe an ellipse, and it will be the periphery of an ellipse. In other words, as the rate control of the transmitter is varied, then the distance from the receiver to the transmitter and the point at which the intruder enters to give, say, an 8 kiloHertz signal, can be accurately determined. By varying the rate control of the transmitter, the periphery, or the distance, from the transmitter to the intruder is changed for the prescribed signal difference needed to set the transmitter off. As previously mentioned, the alarm only responds to signals in the 10 kiloHertz region or to mixed different signals produced in the 10 kiloHertz region. In order to produce a difference signal in the 10 kiloHertz region, the intruder must be at such a distance from the transmitter and receiver in combination so that the path from the transmitter antenna to the reflecting body and back to receiver antenna is limited by an amount determined by the sweep rate of the transmitter. If the sweep rate of the transmitter is increased then the intruder must get closer to the receiver and transmitter. If it is decreased then he would have to be further away to produce the same difference signal. Again, the pattern or zone semicircular zone of protection around the receiver and transmitter will be an ellipse with the foci at the transmitter antenna and the receiver and transmitters. The thickness of this band of protection may be varied by changing the tuned 10 kiloHertz filters bandwidth from the 7 to 13 kiloHertz. If it is, if the bandwidth is very wide, then we would have a wide zone of protection about the periphery. If the bandwidth is narrow, then the peripheral zone of protection is narrower. The advantage of this operation of the alarm is that in effect,

people may move inside the circle of protection. In other words, people may move around and about the alarm unit without setting it off. People may also move outside the zone of protection without setting it off, but nobody can cross the zone without triggering the alarm.

Obviously, many modifications and variations of the present invention are possible in the light of the above teaching. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. An intrusion detection system for detecting the intrusion of a moving object, comprising:

means for generating a frequency modulated signal of a first frequency band which continuously sweeps from a first to a second frequency having its amplitude modulated by a second frequency, means for radiating said frequency modulated and amplitude modulated signal connected to said generating means, and

means for receiving said frequency modulated and amplitude modulated signal containing means for detecting amplitude changes in said received frequency modulated and amplitude modulated signal, said signal amplitude changes at the receiving means indicating the intrusion of a foreign object, said means for generating a frequency modulated signal having its amplitude modulated by a second frequency comprising an oscillator including an electronic valve whose bias is gradually being built up to cause said electronic valve to cut off whereby the building up of said bias causing said electronic valve to become less conductive thereby amplitude modulating the frequency modulated signal.

2. An intrusion detection system as defined in claim 1, but further characterized by said receiver means having means for automatically controlling the level of received frequency modulated signal so that the relative position of said radiating means and said receiving means does not affect the operation of said receiver.

3. An intrusion detection system as defined in claim 2, but further characterized by having means responsive to said means for detecting amplitude changes for triggering an alarm indicating means.

4. An intrusion detection system having a receiver for detecting directly radiated frequency modulated and amplitude modulated radio frequency wave from a transmitting antenna and a radio frequency wave which is reflected from an intruder, the intruder affecting the amplitude of the received signal, comprising:

a transmitter means for generating said frequency modulated and amplitude modulated wave comprising an oscillator including an electronic valve whose bias is gradually being built up to cause said electronic valve to cut off whereby the building up of said bias causes said electronic valve to become less conductive thereby amplitude modulating the frequency modulated signal,

means for receiving said frequency modulated and amplitude modulated radio frequency wave energy,

means for detecting said radio frequency modulated wave connected to said receiving means,

means for amplifying said detected frequency modulated signal connected to said detecting means, said amplifier means having an output,

means for detecting both positive and negative changes in amplitude of said frequency modulated detected signal on said output of said amplifier means, and

detector means responsive to said both positive and negative detected amplitude changes of said frequency modulated detected signal for triggering an alarm means whereby both positive and negative changes in said detected signal cause said alarm to be triggered.

5. An intrusion detection system as defined in claim 4, but further characterized by having an automatic level control means for controlling the level of the detected signal connected to said means for detecting said radio frequency wave energy.

6. An intrusion detecting system as defined in claim 1, but further characterized by said receiving means having an antenna, a tuned circuit means tuned to said frequency modulated signal having an input and an output, said means for detecting amplitude changes having an input and an output, said antenna connected to said tuned circuit input, said output of said tuned circuit connected to said input of said means for detecting amplitude changes, and an amplifier means having a tuned bandpass filter, said amplifier means having an input and an output, said amplifier input being connected to said output of said means for detecting amplitude changes and said amplifier output having a signal which is indicative of the amplitude of the received frequency modulated signal.

7. An intrusion detecting system as defined in claim 6, but further characterized by said receiving means having a second detector having an input and an output, a second amplifier having an input and an output, said second detector input connected to said output of said amplifier having a bandpass filter, said output of said second detector being connected to said input of said second amplifier,

an automatic level control means having an input and an output, said automatic level control means input connected to said output of said second amplifier and said output of said automatic level control connected to said means for detecting amplitude changes in said frequency modulated signal,

means for detecting positive and negative changes of signal level having an input and an output, said input of said means for detecting positive and negative changes being connected to said output of said second amplifier, and

an alarm indicating means having an input connected to said output of said means for detecting positive and negative changes in said signal level whereby changes in said signal level trigger an alarm indicating the presence of an intruder.

8. An intrusion detection system having a zone of protection about a periphery, comprising:

means for generating a radio frequency signal which continuously sweeps from a first frequency to a second frequency,

means for radiating said radio frequency signal connected to said radio frequency generating means,

means for receiving said radio frequency signal from said radiating means and reflections of said radio frequency signals from an object entering the electro-magnetic field caused by said radiated radio frequency signal,

means for mixing said received radio frequency signal received from said radiating means with said radio frequency signal reflected from said intruded object generating a beat signal connected to said receiving means,

means for passing said generated beat signal of a predetermined frequency bandwidth connected to said mixing means,

said means for passing said generated beat signal determining the periphery of the zone of protection,

means for detecting amplitude changes of said band passed beat frequency connected to said band passing means, and

means for generating an alarm responsive to said amplitude changes detected by said change detected means connected to said change detecting means whereby amplitude changes in said band passed signal is indicative of an intruding object entering said protected perimeter of said radio frequency radiation field,

whereby an intruder in said zone of protection about said periphery causes said alarm to be sounded.

9. An intrusion detection system having a zone of protection about a periphery defined in claim **8**, but further characterized by said means for generating continuously varying radio frequency signal, is provided with means for varying the rate of the frequency sweep whereby said periphery of said zone of protection is changed when said frequency sweep rate is changed.

10. An intrusion detecting system as defined in claim **2**, but further characterized by said receiving means having an antenna, a tuned circuit means tuned to said frequency modulated signal having an input and an output, said means for detecting amplitude changes having an input and an output, said antenna connected to said tuned circuit input, said output of said tuned circuit connected to said input of said means for detecting amplitude changes, and an amplifier means having a tuned bandpass filter, said amplifier means having an input and an output, said amplifier input being connected to said output of said means for detecting amplitude changes and said amplifier output having a signal which is indicative of the amplitude of the received frequency modulated signal.

11. An intrusion detection system as defined in claim **1**, but further characterized by said means for generating a frequency modulated signal comprising:

an electronic valve having means connected thereto to cause said valve to oscillate,

means causing the frequency of said oscillating valve to change connected to said oscillating electronic valve, and

means for changing the rate of frequency change of said oscillating electronic valve connected to said frequency changing means.

12. An intrusion detection system as defined in claim **11**, but further defined by said means for causing said oscillating frequency to change comprising a variable capacitance diode and said means for changing rate frequency changes comprising a sawtooth wave generator.

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