United States Patent [19]
Gehman

[11] **3,794,992**
[45] **Feb. 26, 1974**

[54] **RADIO FREQUENCY INTRUSION DETECTION SYSTEM**

[75] Inventor: **John B. Gehman,** La Jolla, Calif.

[73] Assignee: **General Dynamics Corporation,** St. Louis, Mo.

[22] Filed: **Feb. 7, 1972**

[21] Appl. No.: **224,130**

[52] **U.S. Cl.** .... **343/5 PD,** 340/258 B, 340/258 C
[51] **Int. Cl.** **G01s 9/02,** G08b 13/26
[58] **Field of Search**.... 340/258 B, 258 C; 343/5 PD

[56] **References Cited**

UNITED STATES PATENTS

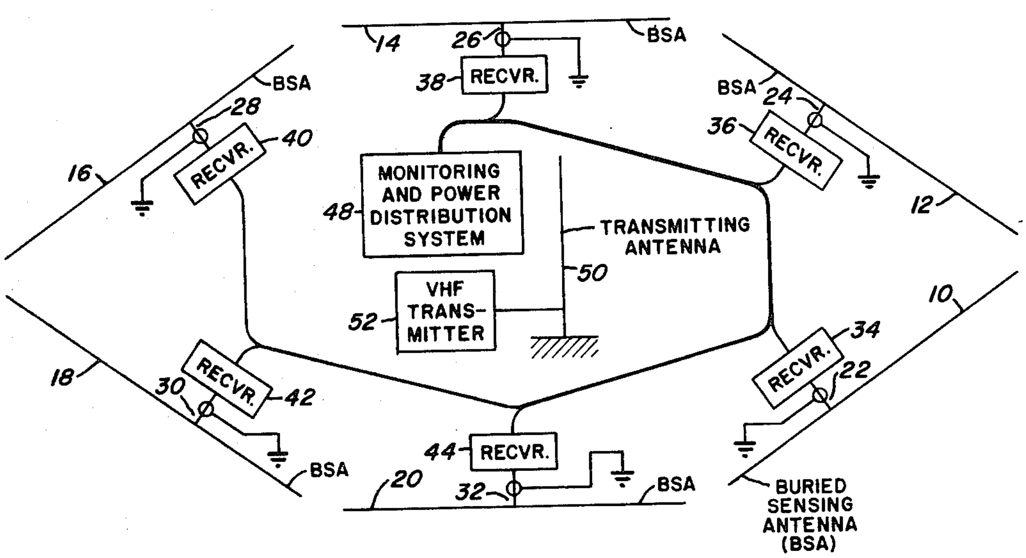
3,727,208	4/1973	Anderson et al.	340/258 C
3,497,995	3/1970	Forsberg	340/258 C X
3,164,802	1/1965	Kleist et al.	340/258 C X
2,455,376	12/1948	Lindsay	340/258 C
3,237,105	2/1966	Kalmus	340/258 C
3,163,861	12/1964	Suter	343/5 PD X
2,656,527	10/1953	Tillman	340/258 C
3,242,486	3/1966	Corbell	343/5 PD

Primary Examiner—Malcolm F. Hubler
Attorney, Agent, or Firm—Martin Lukacher

[57] **ABSTRACT**

In order to detect personnel and other intruding objects in open terrain, one or more long wire antennas are buried in the ground and located orthogonal to a vertically polarized souce of VHF radiation, such as a continuous wave transmitter which feeds an elevated vertical dipole. The intruder couples the radiation to the buried antenna which feeds a receiver. The receiver produces an output responsive to the characteristics of the radiation coupled to the antenna by the intruder to produce an alarm indicative of the presence of the intruder.

24 Claims, 12 Drawing Figures



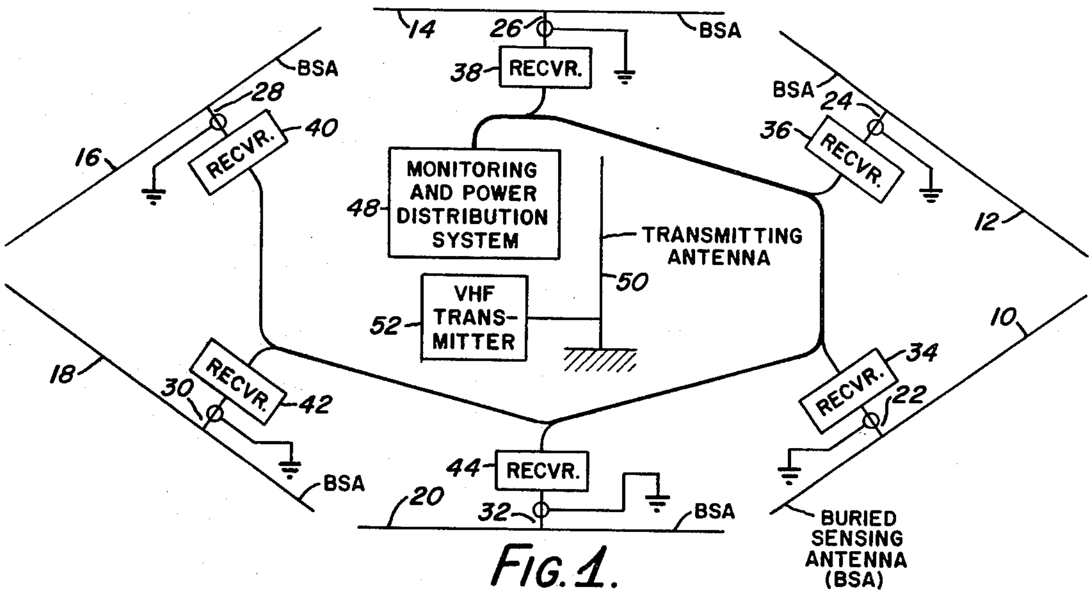


FIG. 1.

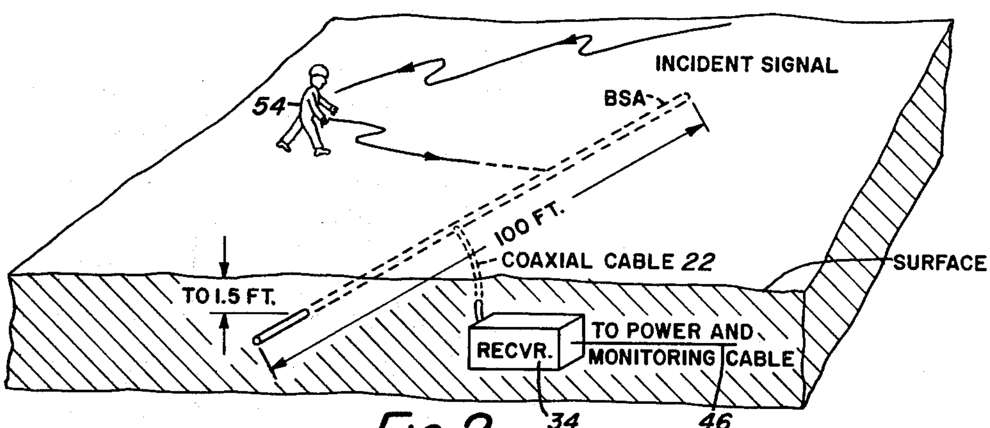


FIG. 2.

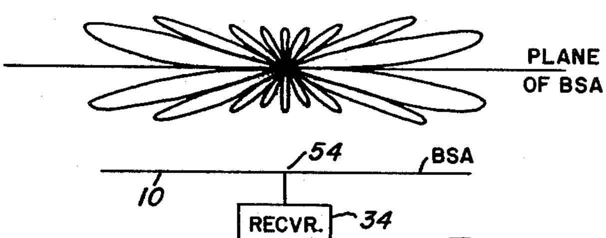


FIG. 3A.

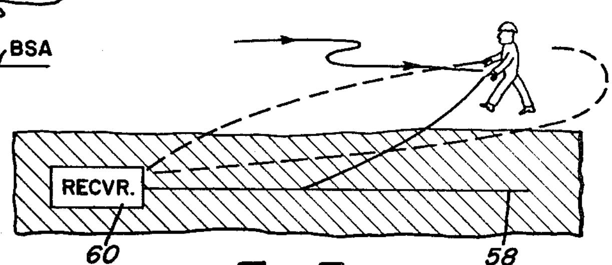


FIG. 3B.

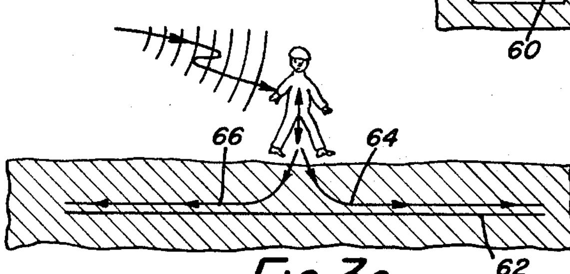


FIG. 3C.

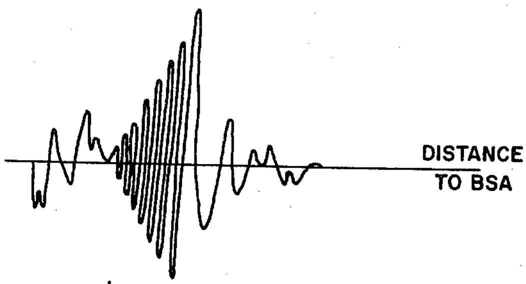


FIG. 4.

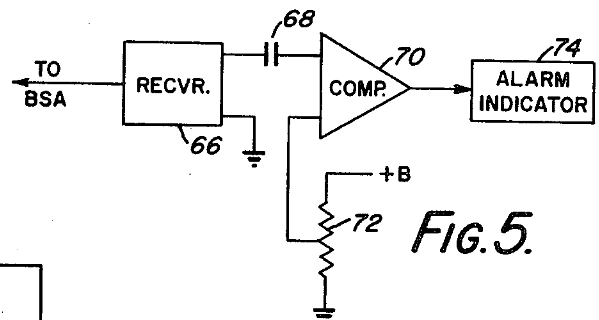


FIG. 5.

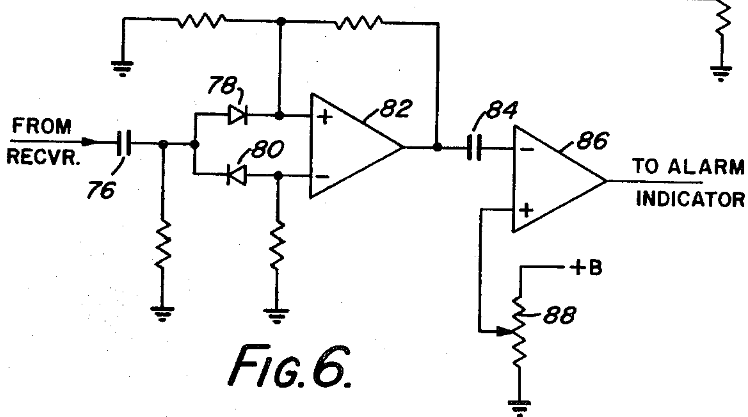


FIG. 6.

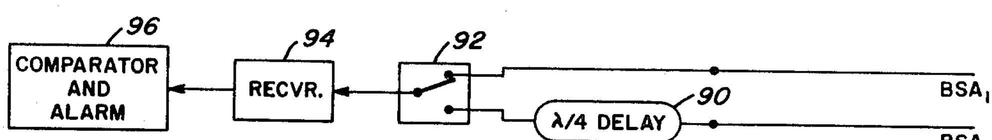


FIG. 7.

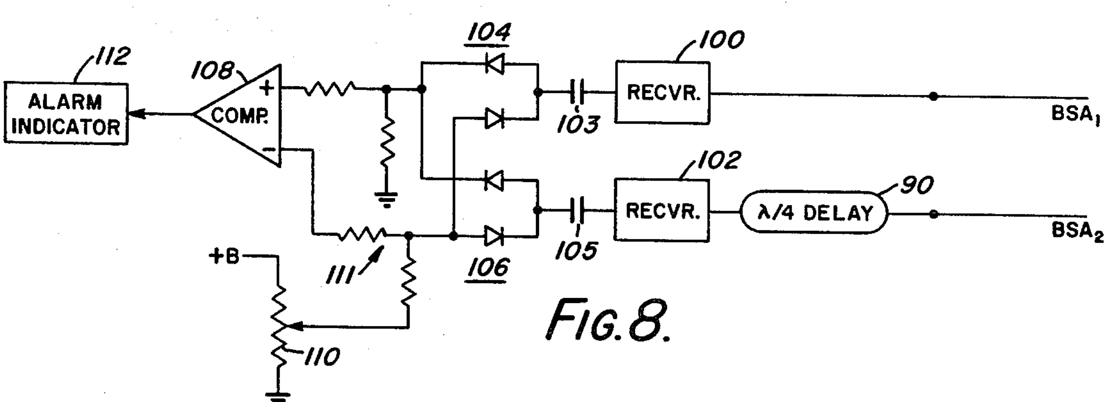


FIG. 8.

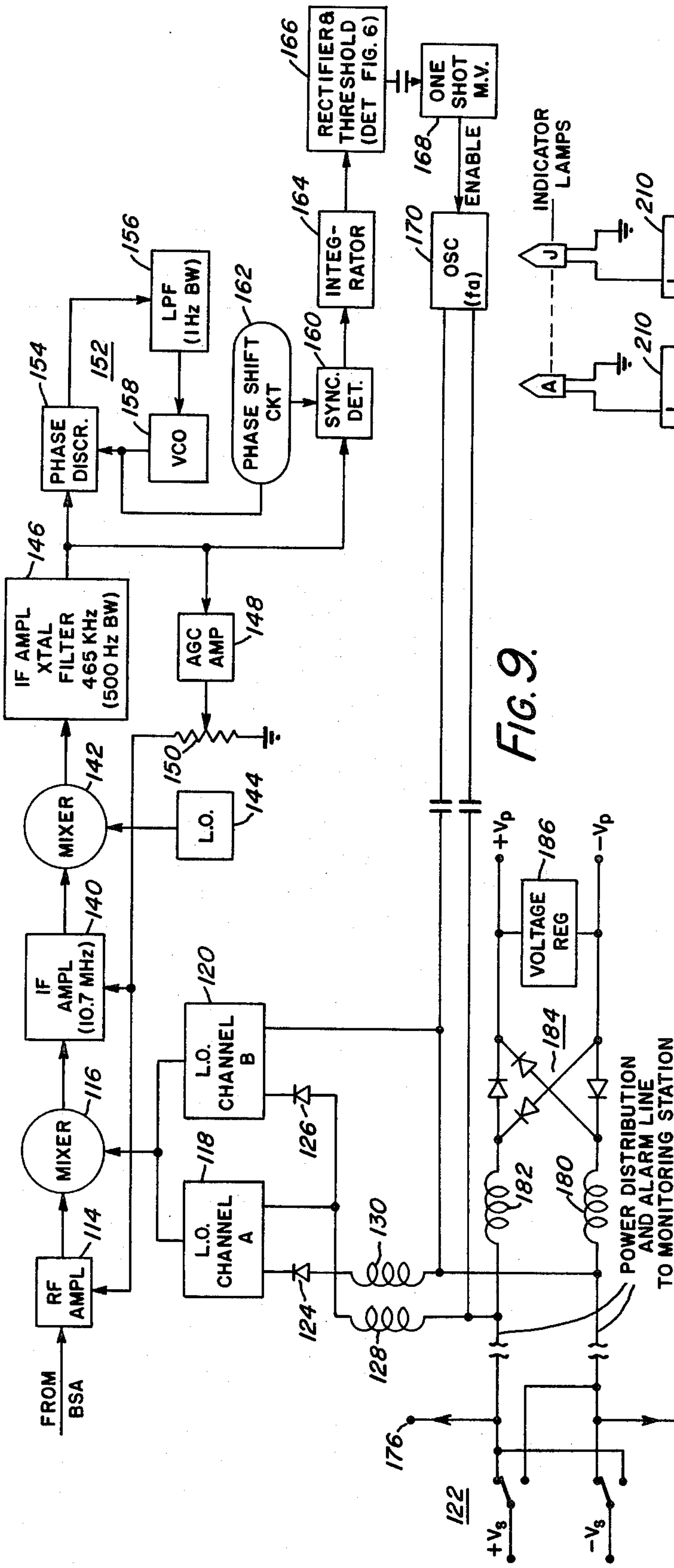

FROM BSA
RF AMPL
114
MIXER
116
IF AMPL (10.7 MHz)
140
MIXER
142
IF AMPL XTAL FILTER 465 KHz (500 Hz BW)
146
PHASE DISCR.
154
LPF (1 Hz BW)
156
152
VCO
158
PHASE SHIFT CKT
162
SYNC. DET.
160
INTEG-RATOR
164
RECTIFIER & THRESHOLD (DET FIG. 6)
166
ONE SHOT M.V.
168
ENABLE
OSC (fa)
170
AGC AMP
148
150
L.O.
144
L.O. CHANNEL A
118
L.O. CHANNEL B
120
124
126
128
130
182
180
184
VOLTAGE REG
186
+Vp
−Vp
POWER DISTRIBUTION AND ALARM LINE TO MONITORING STATION
176
178
122
+Vs
−Vs

FIG. 9.

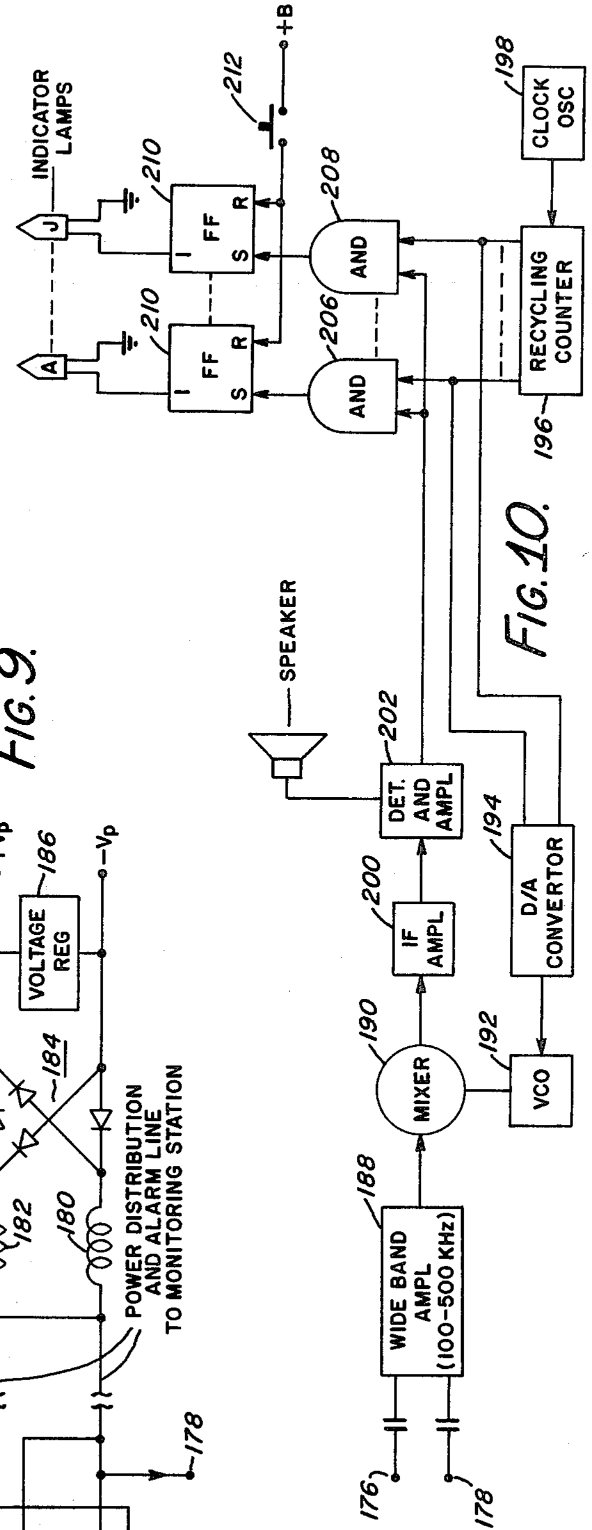

INDICATOR LAMPS
J
A
FF
I
S
R
210
AND
206
208
212
+B
CLOCK OSC
198
RECYCLING COUNTER
196
SPEAKER
DET. AND AMPL
202
IF AMPL
200
D/A CONVERTOR
194
MIXER
190
VCO
192
WIDE BAND AMPL (100-500 KHz)
188
176
178

FIG. 10.

RADIO FREQUENCY INTRUSION DETECTION SYSTEM

The present invention relates to security systems, and particularly to a system for sensing personnel and other intruding objects through the use of radio frequency electromagnetic wave radiation.

The invention is especially suitable for use in security systems for protecting the boundaries of a large area in open terrain by sensing the presence of personnel and other intruding objects crossing these boundaries.

Electromagnetic personnel sensing systems of various types have been suggested. For the most part they operate in accordance with principles of capacitive and inductive coupling between the personnel or other object to be detected and a sensing device (see for example U.S. Pat. Nos. 3,439,358 and 3,462,692). Other systems operate on the basis of the disturbance in a standing wave pattern produced by intruding personnel (see U.S. Pat. No. 2,038,878). Still others operate in a manner similar to radar systems and detect reflections from the intruding personnel (see U.S. Pat. 3,163,861). While it may be feasible to utilize such systems to secure relatively limited areas, they are not particularly adapted for securing a large area, say in open terrain, such as the perimeter of a factory or other large installation. In addition such known systems may be difficult to install, particularly in a manner such that they are not obtrusive to intruding personnel who may be interested in avoiding or disabling the sensing system.

It is therefore, an object of the present invention to provide an improved electronic security system.

It is a still further object of the invention to provide an improved security system which utilizes radio frequency electromagnetic radiation.

It is a still further object of the invention to provide an improved radio frequency security system which is sensitive to moving objects such as personnel.

It is a still further object of the invention to provide an improved radio frequency security system which is especially adapted for securing large areas, out of doors and in open terrain.

It is a still further object of the invention to provide an improved radio frequency security system which may readily be installed at low cost.

It is a still further object of the present invention to provide an improved radio frequency security system which is unobtrusive and the operation of which is not readily ascertainable by intruding personnel.

Briefly described, the present invention affords a system for detecting the presence of an object, such as personnel, in a radio frequency, radiation field, through the use of an antenna disposed below the surface of the terrain upon which the radiation field is incident. The antenna may be a long wire, say 50 to 400 feet in length, connected to a receiver which detects the radio frequency signal which is coupled to the antenna by intruding personnel. The intruding personnel act as a receiving antenna or reflector and provide the necessary coupling to the buried sensing antenna. The intruder will then cause a variation in the field strength of the signal monitored by the receiver, such that the receiver produces an output indicative of the presence of the intruder.

The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof will become more readily apparent from a reading of the following description in connection with the accompanying drawings in which:

FIG. 1 is a schematic diagram of a radio frequency object detection system in accordance with the invention, which system is especially adapted for securing the perimeter of a large area;

FIG. 2 is a perspective view, schematically illustrating the operation of the system in sensing intruding personnel;

FIGS. 3*a*, 3*b*, and 3*c* are schematic diagrams illustrative of the operation of radio frequency security systems embodying the invention;

FIG. 4 is a wave form illustrative of the output from a receiver of the system shown in FIGS. 1 and 2 which results when intruding personnel pass over the buried sensing antenna;

FIG. 5 is a block diagram of the receiver portion of a system embodying the invention;

FIG. 6 is a schematic diagram of circuits used in the receiver portion of a system embodying the invention;

FIG. 7 is a block diagram illustrating a radio frequency object detection system in accordance with another embodiment of the invention;

FIG. 8 is a block diagram of a system in accordance with still another embodiment of the invention;

FIG. 9 is a more detailed diagram, partially in block form and partially in schematic form, which illustrates a receiver system in accordance with an embodiment of the invention; and

FIG. 10 is a block diagram of a monitoring system suitable for use with a number of receivers of the type illustrated in FIG. 9, which monitoring system is provided in accordance with features of the present invention.

The system provided by the invention, unlike systems requiring electromagnetic (either inductive or capacitive) coupling to a sensing device or direct reflection of signals to a pick-up antenna, is especially adapted to protecting large areas in open terrain. Thus, when a large area, such as several acres is to be secured, several buried sensing antennas, e.g., six antennas **10, 12, 14, 16, 18** and **20**, may be disposed about the perimeter of the area to be secured.

Each of these antennas may be a length of insulated wire (No. 10 to No. 30, wire being suitable) which are disposed in linear paths about the perimeter of the area and buried below the surface of the ground. Perferably, the sensing antennas are buried to a depth of one to three inches. They may, however, be buried up to **18** inches below the ground. The antennas are connected in the center thereof, via coaxial cables, **22, 24, 26, 28, 30** and **32**, to receivers **34, 36, 38, 40, 42** and **44**. The center connection reduces losses due to attenuation in the wire of the antennas. The receivers may, however, be connected to one end of their respective antenna wires. The receivers are preferably sensitive narrow bandwidth radio receivers of the type to be described hereinafter in connection with FIG. **9**. However, any receiver capable of detecting signals in the frequency range of the radio frequency radiation field established in the vicinity of the antennas may be used. The receivers, **34, 36, 38, 40, 42** and **44** may also be buried underground, and receive power and transmit alarm signals through a power distribution and alarm line or cable, **46.** This cable, **46,** is connected to a monitoring and power distribution system **48** which translates the alarm outputs from the receivers into visual or aural indications, say an array of lights, which designates which antenna **10** through **20**, has sensed the presence of an intruding object or person.

The radio frequency radiation is established by a transmitting antenna **50** which preferably is a vertical dipole which transmits a vertically polarized radiation field. The antenna **50** is driven by a VHF continuous wave transmitter **52.** Frequencies between 40 MHz and 150 MHz are preferable. For personnel detection a frequency of 60 MHz is especially preferred since a man is approximately one quarter wavelength long at about 60 MHz, and thus acts as a good receiving antenna or reflector to translate the radio frequency radiation from the transmitting antenna into the buried sensing antennas.

It will be noted that the buried sensing antennas are disposed orthogonally to the transmitting antenna **50** rejecting the direct vertically polarized signal. However, the vertically polarized signal from the transmitting antenna reflected or coupled to a vertical target such as a person, is especially well picked up by the buried horizontal sensing antenna. The vertical target is believed to cause ground current to flow near the buried sensing antenna wire, which in turn induces the signal into the wire. It may also reflect a signal along the axis of the antenna which has a maximum response. In other words, the intruding personnel provides coupling to the wire of the buried sensing antenna and will increase the magnitude of the signal picked up from the remote transmitter by reflection. Thus the receivers **34** through **44** coupled to their respective buried sensing antennas, produce outputs which vary in accordance with the field strength of the signal picked up by the buried sensing antennas. When an intruder approaches a buried sensing antenna, this field strength increases and is detected in the receivers to indicate the presence of the intruder.

The operation of the system may be better understood from FIG. **2.** The buried sensing antenna, **10,** is shown by way of example. It is indicated as being 100 feet long. With normal ground conditions (the ground not being highly conductive) the buried wire of the antenna **10** can be 400 feet long. The antenna is indicated as being buried up to a depth of 1.5 feet and is connected by way of the buried coaxial cable to the receiver **34** which is also buried. The cable to the power and monitoring station **46** is also shown as being buried.

Very little signal may normally be received by the buried sensing antenna **10** due to its orthogonal relationship with respect to the transmitting antenna and because the transmitting radiation is vertically polarized, while the buried antenna is disposed horizontally. The intruder **4** acts like a vertical reflector and directly couples the radio frequency signal directly into the antenna **10.** In the event that the antenna **10** picks up some of the incident signal, the signal coupled to the antenna by the intruder will add vectorially to the signal which is normally picked up. The approach of the intruder will then cause a cyclical variation in the output from the receiver **34** as is illustrated by way of example in FIG. **4.** In effect, a doppler signal is generated as the intruder moves toward the sensing wire **10** if he moves in the direction toward the signal source (viz., the antenna **50**). A cycle is generated for every half wavelength of motion at the frequency of the radiation. When the intruder crosses the sensing wire still in the direction toward the *rf* source a much lower frequency doppler signal is generated. This signal characteristic is also illustrated in FIG. **4.** Thus, by viewing the signal from the receiver, say on the chart recorder, the presence of an intruder can be visually ascertained. The receiver may also have a threshold detector, as will be discussed in detail in connection with FIG. **5** through **9** for automatically indicating the presence of the intruder.

The radiation pattern of the antenna **10** is also illustrated in FIG. *3a.* It will be noted that the antenna has a bidirectional pattern centered about the center point **56** of the antenna wire to which the receiver **34** is connected. The antenna pattern has a multiplicity of lobes and favors vertically polarized signals coming at an angle above the ground and along the axis of the wire. Accordingly, vertically polarized signals from the transmitter reflected from the intruder are picked up by the horizontal wire antenna **10.**

In FIG. **3**, one of the lobes (shown in the dash line) of an antenna wire, **58,** which is connected to a receiver **60** at one end thereof, is shown. It will be understood that a plurality of such lobes, the number of which depends on the length of the wire, will exist. The radiation pattern favors somewhat an intruder near either end of the sensing wire antenna **58.** Pickup of radiation signals by a buried horizontal sensing antenna, such as shown at **62** in FIG. *3c*, is also effected by the passage of the intruder above the center of the antenna causing ground currents (illustrated schematically by the lines, **64** and **66**) to flow near the antenna **62** and induce signals therein. It is believed that signals are caused to be picked up due to the presence of an intruding object by one or more of the mechanisms discussed, in connection with FIGS. **2** and **3**, although the invention is not limited to any theory by which pickup of radiation signals may be explained, which explanation is offered herein for purposes of elucidation.

As illustrated in FIG. **5** automatic alarm indication may be afforded by connecting the output of a receiver **66** which receives input signals from the buried sensing antenna by way of a capacitor **68** to a comparator amplifier **70.** In the receiver the signal, such as illustrated in FIG. **4,** which is picked up by the buried sensing antenna and applied to the input of the receiver, is detected to produce a slowly varying analog signal corresponding thereto which is coupled to the comparator **70** via the capacitor **68.** The comparator receives a threshold level from a potentiometer, **72.** When this threshold is exceeded by the amplitude of the signal from the receiver output, the comparator produces a pulse which triggers an alarm indicator **74.** This indicator may, for example, by a latching relay which illuminates a lamp or sounds a buzzer or other audible alarm. The alarm may be reset manually.

Inasmuch as the output from the receiver may vary cyclically, it may be coupled, as shown in FIG. **6,** through a capacitor **76** and oppositely polarized diode rectifiers **78** and **80** to the direct and inverting inputs of an operational amplifier **82.** The rectifier and operational amplifier act as a full wave rectifier and amplifier translating the cyclic input from the receiver into a unipolar output which is coupled through a capacitor **84** to a comparator **86.** The comparator **86** has a threshold voltage applied to another input thereof from a potentiometer **88,** thus the full wave rectified output exceeds the threshold. The comparator **86** provides an output pulse to an alarm indicator, such as discussed above in connection with FIG. **5.**

The motion of the intruder produces a cyclical response when moving toward the buried sensor antenna or on a parallel path. This response is due to the vector addition of direct signal leakage or miscellaneous scattered reflections from fixed objects and the reflected signal from the moving intruder. The positive or negative peaks are in or out-of-phase conditions, zero responses are quadrative additions. To reduce the possibility of a missed detection due to a chance path giving a quadrature addition, zero response, two buried sensor antennas BSA_1 and BSA_2 are used as indicated in FIGS. **7** and **8.** One of the antennas has an added quarter-wavelength section, or a delay line **90** which provides a quadrative shift of the received signal with respect to the other buried sensing antenna. An electronic switch **92** which may be a pair of circuit gates alternately enabled by the output of a free running multivibrator is used to switch the outputs from the antenna alternatively to the input of a receiver **94.** One or the other or both will provide the receiver with a peak signal regardless of any path the intruder takes.

In FIG. **8** instead of an electronic switching circuit **22,** a pair of receivers **100** and **102** are separately connected to the buried sensing antennas BSA_1 and BSA_2, the receiver **102** being connected by way of the delay line **90,** from BSA_2. The outputs of the receivers are capacitive coupled by capacitors **103,** and **105** and are additively combined by way of a diode network **104** and **106.** The rectified signals from receivers **100** and **102** are connected to the input of a comparator **108.** Positive output from **104** and **106** is applied to the non-inverting input of **108** while the negative output from **104** and **106** is applied to the inverting input of comparator **108.** The connection via the resistor pads **111** is additive into comparator **108.** A threshold voltage for the comparator **108** is obtained from a potentiometer **110.** The change in output from the comparator which results when the threshold is exceeded, operates an alarm indicator **112.** Again, in the case of FIG. **8,** the quadrature and in-phase signals resulting from the intruder are additively combined in the circuits **104** and **106** which are connected to the outputs of the receivers **101** and **102,** thus providing an output from an intrusion regardless of the path taken by the intruder.

Since the signal expected to be produced when an intruder is present has a very slow variation (viz., of the order of 1 Hz or less), the bandwidth of the receiver is desirably narrow. Such narrow bandwidth aids in increasing sensitivity and reducing the adverse effects of noise and interference. The receiver shown in FIG. **9** provides the necessary narrow bandwidth and noise discriminating characteristics as well as other features. The signal from the buried sensing antenna is first amplified in a radio frequency amplifier **114,** and then is applied to a frequency translator including a first mixer **116.** This first mixer may be connected to two local oscillators **118** and **120.** These two local oscillators may be alternatively selected so as to provide two channels, say for radiation at two different frequencies, e.g., 100 MHz and 105 MHz. The channels may be selected by alternating the polarity of the supply voltage from the monitoring station by means of a double poled switch **122.** Since the lines of the power distribution cable, which are of opposite polarity are connected separately

to the local oscillators **118** and **120** through different diodes **124** and **126** by way of chokes **128** and **130,** a different one of the oscillators will be operating at any one time depending upon the position of the switch **122** and the polarization of the diodes. Thus, either channel may be remotely selected from the monitoring station.

After amplification in an intermediate frequency amplifier **140,** a second stage of frequency translation is provided in a second mixer **142** which receives injection signals from a second local oscillator **144.** In order to afford a degree of narrow bandwidth the intermediate frequency amplifier **146** which selects the mixer product at the mixer **142** may have a narrow bandwidth of approximately 500 Hz. The intermediate frequency signals from the amplifier **146** may be detected in an automatic gain control amplifier **148** and applied by way of a gain control potentiometer **150** to the RF and IF amplifiers **114** and **140.** The output of the IF amplifier **146** is applied to a phase lock loop **152** including a phase discriminator **154** and a low-pass filter **156** having a 1Hz bandwidth which controls a voltage controlled variable frequency oscillator **158.** The loop **152** thus remains locked to the frequency of the radiation received by the sensing antenna. The received signal is applied to a synchronous detector **160** together with a signal from the voltage control oscillator **158,** shifted 90° by a phase shift circuit **162.** The phase lock loop, phase shift, synchronous detector and integrator combination affords an additional degree of filtering which narrows the bandwidth to 1Hz reducing the possibility of external interference, and/or audio modulation on the sensing carrier. The double conversion in the receiver intermediate frequency stages also aids in increasing the sensitivity of the system. The output of the synchronous detector which is integrated in the integrator circuit **164** is applied to a rectifier and threshold detector circuit **166** such as shown in FIG. **6,** which changes its level and triggers a one-shot multivibrator **168.** The multivibrator **168** enables an oscillator to produce a burst of oscillation for the period of the pulse in the one-shot multivibrator, say two seconds in duration, the frequency of the oscillations from the oscillator **170** is indicated as f_a. Suitably, this frequency may be any frequency in a band say, from 100 to 500 KHz. The tone burst from the oscillator, **170,** is coupled via capacitors **172** and **174** to the power distribution and alarm line, whence it is delivered to terminals **176** and **178** at the monitoring station.

The power distributed along the line is coupled by way of chokes **180** and **182** to a bridge rectifier **184.** The output of the bridge rectifier is voltage regulated in a voltage regulator **186** which may be a zener diode and produces operating voltages indicated at $+V_P$ and $-V_P$ which are applied to the circuit components of the receiver for operating these components and the entire receiver from voltages generated at the monitoring station and distributed along the line.

A system for displaying the alarm output from several receivers is illustrated in FIG. **10.** The signals are applied to terminals **176** and **178** and capacitively coupled to a wideband amplifier **188.** The wideband amplifier can thus handle and amplify various identification frequencies produced by oscillators, such as the oscillator **170** in the receiver shown in FIG. **9.** The output of the amplifier is applied to a mixer **190** which receives injection signals from a variable frequency voltage controlled oscillator **192.** The frequency at which this oscillator operates is controlled by a digital to analog converter **194** which receives a digital signal from a recycling counter **196.** The counter is driven by a clock oscillator **198** which causes the counter to count, say to 10, recycling every second, for example. Since the number reached by the counter varies as each new clock pulse arrives at the oscillator **198,** the voltage developed by the converter **194** changes correspondingly as does the injection from the voltage controlled oscillator **192.** Accordingly, the frequency at which input signals will provide mixer products which will pass through the bandwidth of an intermediate frequency amplifier **200** will vary with each count. Thus, during each cycle of the counter operation, each of the possible identification frequencies produced by oscillators, such as the oscillator **170** in the several receivers which may be included in the system, will be sampled. The output of the amplifier **200** is detected and amplified in a detector and amplifier circuit **202** which may drive a speaker to produce an audible alarm if any of the receivers detect an intruder. A visual alarm will be provided at an indicator lamp A through J, each of which corresponds to a different tone burst frequency. Thus, AND gates **206** to **208,** each corresponding to a different one of the lamps A through J, will be successively enabled by the counter **196.** These gates will be enabled in time relationship with the different expected identification bursts. If an AND gate **206** to **208** is enabled, a flip-flop **210** associated therewith will be set and current will flow through one of the lamps A through J. The flip-flops may be reset manually through a pushbutton switch **212.** Since there will be a corresponding time relationship for the enabling of the gates **206** to **208** and the arrival of detected outputs corresponding to different frequency tone bursts, each of the indicator lamps will correspond to a different identification burst and therefore to a different receiver and its associate sensing antenna. A panoramic display is therefore provided which facilitates the monitoring of several sensing antennas in the system.

From the foregoing description it will be apparent that there has been provided an improved object detection system which utilizes radio frequency radiation for the detection of personnel and other intruding objects. While the system has been described in connection with a transmitter and antenna for providing the radiation which is picked up by the sensing antenna, it will be appreciated that the system may also utilize existing sources of signals as may be broadcast by broadcast stations in the vicinity, especially FM broadcast stations. Other variations and modifications within the scope of the invention will undoubtedly suggest themselves to those skilled in the art. Accordingly, the foregoing description should be taken merely as illustrative and not in any limiting sense.

What is claimed is:

1. A radio frequency intrusion detection system for detecting the presence of an intruding object in a radio frequency radiation field adapted to be produced by a radio frequency transmitting source, which comprises a receiving antenna disposed remotely from the transmitting source of said radiation field at such a distance that the capacitative and inductive coupling from the source is insignificant at the radiation field frequency, said antenna being disposed below the surface of the terrain upon which said radiation field is incident and to which said field is coupled when said object is in proximity to said antenna, and receiver means connected to said antenna and responsive to radio frequency signals generated in said antenna by said radiation field when coupled to said antenna by said object for providing an output indicative of the presence of said object.

2. The invention as set forth in claim **1** wherein said terrain is the ground, and said antenna is buried below the surface of said ground a distance less than the penetration depth for the frequency of said radiation field.

3. The invention as set forth in claim **2** wherein said radiation field is of a frequency in the VHF band and said distance is less than 1 foot.

4. The invention as set forth in claim **1** wherein said antenna is a long wire.

5. The invention as set forth in claim **4** wherein said receiver is connected to one end of said wire.

6. The invention as set forth in claim **4** wherein said receiver is connected to the center of said wire.

7. The invention as set forth in claim **4** wherein said wire is at least 50 feet in length.

8. The invention as set forth in claim **5** wherein said wire is from 50 to 400 feet in length from the point where it is connected to said receiver to an end thereof.

9. The invention as set forth in claim **4** wherein said wire is disposed orthogonally to the direction of propagation of said radio frequency radiation field.

10. The invention as set forth in claim **1** wherein said system is adapted to secure an area and wherein a plurality of said antennas are disposed in end to end relationship about the perimeter of said area.

11. The invention as set forth in claim **10** including a plurality of receivers separately connected to different ones of said antennas.

12. The invention as set forth in claim **11** including common monitoring means connected to all of said receivers for detecting the outputs of said receivers indicating the presence of an object in the proximity of each of said antennas.

13. The invention as set forth in claim **1** wherein said antenna is a long straight wire, and including a transmitting antenna for radiating waves polarized vertically with respect to said wire to establish said radiation field.

14. The invention as set forth in claim **13** wherein said transmitting antenna is a whip antenna disposed vertically upon said surface and located remotely from said wire antenna.

15. The invention as set forth in claim **1** including a second antenna disposed in side-by-side relationship with said first named antenna means for providing said second antenna with a length approximately one-quarter wavelength different in length from said first antenna, and means for connecting said first and second antenna to said receiver.

16. The invention as set forth in claim **15** wherein said connecting means comprises switch means for connecting said first and second antennas in rapid succession to said receiver.

17. The invention as set forth in claim **15** wherein said receiver comprises first and second receivers connected respectively to said first and second antennas, each of said receivers providing a separate output and means responsive to the sum of said separate outputs for providing said indication of the presence of said object.

18. The invention as set forth in claim **1** wherein said receiver includes a phase lock loop having a narrow band pass.

19. The invention as set forth in claim **18** wherein said phase lock loop comprises a phase discriminator to which a signal corresponding to the radiation detected by said antenna is applied and a variable frequency oscillator and a narrow band pass filter for applying the output of said discriminator to said oscillator for controlling the frequency thereof, a synchronous detector, responsive to said signal, and means for shifting the phase of the oscillations from said oscillator and applying said shifted oscillation to said synchronous detector, and means responsive to the output of said synchronous detector for providing said output indicative of the presence of said output.

20. The invention as set forth in claim **18** wherein said receiver further includes a frequency translator for heterodyning the signal detected by said antenna to an intermediate frequency signal and means for applying said intermediate frequency signal to said phase lock loop.

21. The invention as set forth in claim **20** wherein said frequency translator includes a mixer, first and second local oscillators connected to said mixer, a direct current power supply line for providing operating voltage to said receiver and means for selectively reversing the polarity of direct current applied to said line for selectively enabling said first and second local oscillators.

22. The invention as set forth in claim **18** wherein said receiver further includes means responsive to said receiver output for translating said output into an identification burst of predetermined frequency and duration which corresponds to the reception of said output.

23. The invention as set forth in claim **22** wherein said system comprises monitoring means responsive to said tone bursts which have different frequencies over a band of frequencies, said monitoring means including a wide band amplifier for amplifying said band of frequencies, a mixer coupled to the output of said amplifier, a variable frequency oscillator also coupled to said mixer, detector means coupled to said mixer for providing signals corresponding to said tone bursts which are converted by said mixer to a given frequency, a recycling counter providing a plurality of outputs corresponding to different counts, means for applying clock pulses to said counter causing it to count, a digital to analog converter connected to said counter for converting the counts stored in said counter into an analog signal and applying said analog signals to said oscillator for varying the frequency thereof correspondingly with said counter, and means operated by said counter for separately displaying said detector means output signals which occur simultaneously with different ones of said counts.

24. The invention as set forth in claim **6** wherein said wire is from 50 to 400 feet in length from the point where it is connected to said receiver to an end thereof.

* * * * *