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MICROWAVE PROTECTIVE SYSTEM

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Fig. 1.

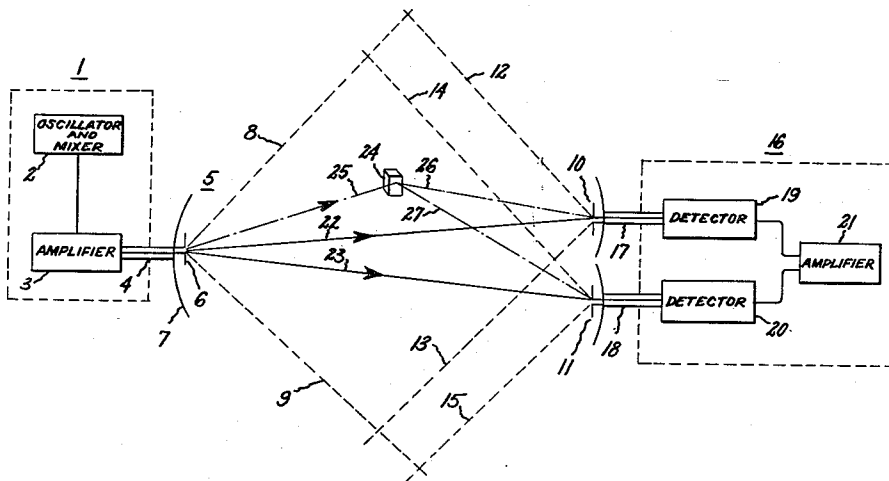


Fig. 2.

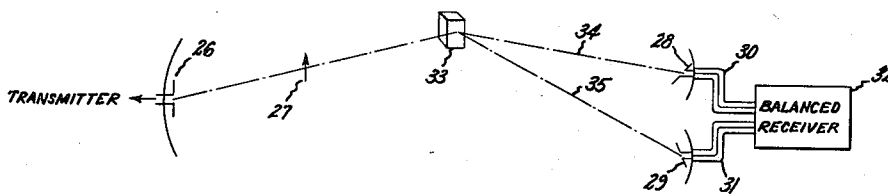


Fig. 3.

ANTENNA	A	B	C
28	↗	↑	↘
29	↖	↑	↗

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MICROWAVE PROTECTIVE SYSTEM

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This invention relates to electronic protective devices and, more particularly, to a microwave system for detecting a foreign object, such as an intruder in a predetermined area.

In a protective system such as is used to detect the presence of an intruder passing into a specified area, it is necessary that the system employed produce a signal upon its detection of an intruder. It is usually desirable, however, that the system be unaffected by external changes such as, for example, rain, snow or smoke.

Another characteristic of the system which is sometimes desirable is that the system does not impede necessary traffic when the system need not be in use. In such a case, an obstruction such as a fence is impracticable because it is not easily removed and later replaced. Protection of an airport is an example in which a fence might be undesirable. Protection of a span of water is another such example.

To prevent an intruder from discovering and using a means whereby the protective device may be outwitted, it is desirable that the intruder be unaware of the existence of the protective system. Another desirable characteristic is that the required apparatus to outwit the device be too complex or too bulky to be readily transported without being noticed.

In accordance with this invention, an object entering a given area is detected although there is no visible means of protection at the point in question. This system is unaffected by normal changes in weather conditions and no physical obstructions are required. Very briefly, this is accomplished with a microwave signal transmitted by an antenna toward a pair of receiving antennas which are connected to a balanced receiver. If an intruder passes into the transmitted wave, his entry into the field either unbalances the amplitudes of signals at the receiver by absorption of part of the wave or the signal reflected from him arrives at the two receiving antennas out of phase and unbalances the receiver, either of which produces a signal.

It is, therefore, an object of this invention to provide a reliable protective system which will detect an object entering a specified area.

Another object of this invention is the provision of a protective system which will be unaffected by normal changes in weather conditions such as snow, rain, etc.

A further object of this invention is the provision of a protective system of which a possible intruder will remain unaware.

A still further object of this invention is the

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provision of a protective system that does not include a physical obstruction which will interfere with normal traffic when the system is not in use.

The novel features which we believe to be characteristic of this invention are set forth with particularity in the appended claims. This invention itself, however, both as to its organization and method of operation, may best be understood by reference to the figures of the accompanying drawing, in which Fig. 1 is a plan view of the entire system in schematic form showing the wave propagation from a transmitting antenna which is utilized in carrying this invention into effect; Fig. 2 is a plan view of a modified form of this invention showing the wave propagation from a polarized transmitting antenna; and Fig. 3 is a table of vectors which facilitates an understanding of the operation of the system shown in Fig. 2.

Referring to Fig. 1, there is shown a high frequency transmitter 1, which is of a conventional type comprising an ultra high frequency oscillator 2, a modulator stage in which the high frequency signal is modulated with a low frequency signal, and preferably one or more stages of amplification 3. The high frequency electromagnetic wave generated and modulated with, for example, a sixty cycle wave in the transmitter 1, is fed through a suitable matching network, which is shown in the drawing as a high frequency coaxial cable 4, to a transmitting antenna system 5 but which may also be a stub matching system or some other high frequency matching device.

Although a directive antenna system 5 comprising a simple dipole 6 and a parabolic reflector 7 is shown in the drawing, the functioning of this invention is not dependent upon the employment of a directive type transmitting antenna. In some applications of this invention, such as the case in which a transmitting antenna is positioned in the center of a large area to be protected, and a plurality of receiving stations are placed around it, a non-directional antenna is advantageous. Therefore, the directional antenna system 5 has been shown only for the purpose of facilitating an understanding of the operation of this invention.

Transmitting antenna system 5 radiates the modulated electromagnetic wave which was generated and amplified in transmitter 1 throughout an angle bounded by lines 8 and 9. In the art, this angle is known as the arc of radiation.

Two receiving antennas 10 and 11, which need

not have directional characteristics, are shown to be the same type of directional antenna as the transmitting antenna system 5. Antenna 10 is sensitive to electromagnetic waves arriving at it from any point within the boundaries 12 and 13, and antenna 11 is sensitive to electromagnetic waves arriving at it from within the boundaries 14 and 15.

Receiving antennas 10 and 11 should preferably be spaced at least a few wavelengths apart to prevent them from interfering with one another. Any high frequency electromagnetic wave received by these antennas 10 and 11 is fed through a suitable matching network to a balanced receiver 16. High frequency coaxial cables 17 and 18 are shown in the drawing as the matching networks.

The balanced receiver 16 consists of a pair of conventional detectors 19 and 20 and an amplifier 21 which produces a signal when the difference between the signals applied to its input terminals is changed. The outputs of detectors 19 and 20 are individually variable which permits their output signals to be made equal even though their input signals differ. Because the outputs of the two detectors 19 and 20 may thus be made equal when the signals received from receiving antennas 10 and 11 are unequal, it is unnecessary for the receiving antennas 10 and 11 to be equidistant from the transmitting antenna system 5. Once the output signals from these detectors have been made equal, if the difference in the input signals to the detectors changes, their outputs will not be equal. This difference in output signal is amplified by the amplifier, and the output of the amplifier may be used to sound an alarm or perform some other task.

The direct rays 22 and 23 leave the transmitting antenna system or antenna 5 and go directly to the receiving antennas 10 and 11. These particular direct rays 22 and 23 are only two of the many direct rays which travel directly between the transmitting antenna 5 and the receiving antennas 10 and 11. In addition to these direct rays, there may be other rays which reach the receiving antennas which do not travel directly between the transmitting antenna and the receiving antennas. These other rays include those reflected from the ground and those reflected from permanent obstructions within the operative bounds of the protective device. These permanently received signals are fed from antennas 10 and 11 through the coaxial cables 17 and 18 to the input terminals of the balanced receiver 16. The balanced receiver, which is so adjusted that the permanently received signals being fed to it from the receiving antennas 10 and 11 are balanced out against one another, has zero output voltage.

When an intruder 24 enters into the area included within the boundaries 8, 9, 12 and 15, the transmitter field will be modified either by absorption or reflection, a number of the transmitter rays being reflected from his person and many others being absorbed by his person. One such ray 25 may strike the intruder 24, and many rays will be reflected from him in many directions. Two of these reflected rays 26 and 27 travel to the receiving antennas 10 and 11, respectively, where they excite voltage signals which are supplied to the balanced receiver 16.

The voltage signals developed at the receiving antennas by the reflected rays will, in all probability, be out of phase because the distance from the intruder 24 to receiving antenna 10 is shorter

than the distance between the intruder and receiving antenna 11. If the difference between the distances traveled by the reflected rays from the intruder to the two receiving antennas is exactly one wavelength, a condition which cannot be maintained by an intruder, the signals arriving at the antennas are in phase and no unbalance of the receiver results. If the transmitter field is modified by absorption, then on entering the protected zone the intruder causes an unbalance of the receiver.

A modification of this system which increases its sensitivity is the use of transmitted polarized waves in place of the unpolarized waves previously described. It is known that an electromagnetic wave which has been reflected from a flat surface is partially polarized. This is because the components of the wave in some planes of polarization are absorbed more by the reflecting body than are the components of the wave in some other planes of polarization. Hence, the physical shape of the reflecting body determines the degree of absorption of a polarized electromagnetic wave. If the transmitted wave is not completely polarized, which is so in a practical case, this greater absorption of the component of the wave in one plane of polarization than in another causes the plane of polarization of a reflected polarized wave to be rotated.

Referring to Fig. 2, a polarized electromagnetic wave transmitting antenna 26, represented conventionally in the drawing, transmits a polarized wave that is represented by the vector 27. Because Fig. 2 is a plan view of the system, the direction of the vector 27 indicates that the transmitting antenna radiates a horizontally polarized wave, and it is conventionally termed a horizontally polarized antenna.

A pair of receiving antennas 28 and 29 are polarized in the directions indicated by the arrows in column A of the table in Fig. 3. Antennas 28 and 29 are each polarized at an angle of 45 degrees with respect to the plane of polarization of the transmitting antenna 26 and at an angle of 90 degrees with respect to one another. Hence, they are said to be cross-polarized.

Column B of the table indicates the direction and magnitude of the direct polarized electromagnetic waves arriving at the receiving antennas 28 and 29. The components of the direct ray which are in the planes of polarization of the receiving antennas are equal or very closely thereto. The signal voltages which are developed at the individual receiving antennas are consequently also equal and are supplied through the coaxial cables 30 and 31 to the balanced receiver 32. Because the input voltages to the balanced receiver are equal, its output is zero.

Referring again to Fig. 2, an intruder 33 is in a position to reflect and to absorb many rays radiated by antenna 26. One such ray 27, striking the intruder, is reflected by him in many directions. Two of these directions are represented by rays 34 and 35 which travel between the intruder and the receiving antennas 28 and 29, respectively.

Having been reflected from the intruder, the plane of polarization of these waves 34 and 35 is, in general, somewhat different from that of the transmitted rays. The reason for this rotation of the plane of polarization of an electromagnetic wave upon reflection was previously explained. A possible set of the directions and magnitudes of the reflected wave arriving at

receiving antennas 28 and 29 is indicated in column C of the table in Fig. 3.

The component of these reflected waves in the direction of the plane of polarization of antenna 28 is greater than the component of the reflected wave in the direction of the plane of polarization of antenna 29. There will thus be a larger signal voltage developed at antenna 28 than at antenna 29. This change in the difference between the voltages applied through coaxial cables 30 and 31 to the balanced receiver 32 will, by means previously discussed, cause an output signal to appear at the output of the receiver. Of course, absorption of one of the direct rays will also unbalance the receiver.

In addition to the unbalance of the receiver which occurs because of the change of the plane of polarization of a wave when it is reflected, there is the condition of phase difference between the waves arriving at the receiving antennas 28 and 29 which occurred in the non-polarized system. It is the combination of these two effects which makes this system more general than the simple unpolarized system.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for protecting an area by means of a microwave electromagnetic system comprising an oscillator for generating a microwave signal, an amplifier for amplifying said signal, a directive antenna for radiating said signal through an arc in a predetermined direction, a pair of directive receiving antennas, said receiving antennas being so positioned that they are most sensitive in the direction of said directive antenna, and a balanced receiver connected to said receiving antennas for indicating a change in the relationship between the strengths of the signals received from said receiving antennas.

2. Apparatus for protecting an area by means of a microwave system comprising means for producing a microwave signal, a directive transmitting antenna for radiating said signal, a pair of directive receiving antennas for receiving said radiated signal, said directive antenna radiating said signal toward said directive receiving antennas, said directive receiving antennas comprising arrays positioned to have their maximum sensitivity in the direction of said directive transmitting antenna, said directive receiving antennas being separated from one another by a distance greater than one wavelength, and a balanced receiver connected to said receiving antennas for indicating a change in the relationship between the strengths of the signals received from said receiving antennas.

3. Apparatus for protecting an area by means of a microwave system comprising means for producing a microwave signal, a transmitter for radiating said signal, a pair of directive receiving antennas for receiving said radiated signal, said receiving antennas comprising arrays positioned to have their maximum sensitivity in the direction of said transmitting antenna, said directive receiving antennas being separated from each other by a distance greater than one wavelength, a balanced receiver connected to said receiving antennas, said balanced receiver including means for indicating a change in the relationship between the strengths of the signals received from said receiving antennas.

4. Apparatus for protecting an area by means of a microwave electromagnetic system comprising means for producing a microwave electromagnetic signal, a polarized transmitting

antenna for radiating said signal in only one plane of polarization, a pair of cross-polarized receiving antennas, and a balanced receiver properly connected to said receiving antennas for indicating a change in the relationship between the strengths of the signals received by said antennas.

5. Apparatus for protecting an area by means of a microwave electromagnetic system comprising a means for producing a microwave electromagnetic signal, a polarized directive transmitting antenna for radiating said signal in only one plane of polarization in a predetermined direction, a pair of cross polarized receiving antennas for receiving said signal, a balanced receiver connected through a matching device to said polarized receiving antennas for indicating a change in the relationship between the strengths of the signals received from said antennas.

6. Apparatus for protecting an area by means of a microwave electromagnetic system comprising an oscillator for producing a microwave electromagnetic signal, a polarized directive transmitting antenna for radiating said signal through an arc in a predetermined direction, a pair of polarized receiving antennas for receiving said signal, the plane of polarization of one of said receiving antennas being at right angles to the plane of polarization of the other said receiving antenna, said polarized directive transmitting antenna radiating said signal toward said receiving antennas, and a balanced receiver connected through a matching network to said polarized receiving antennas for indicating a change in the relationship between the magnitudes of the signals received from said antennas.

7. Apparatus for protecting an area by means of microwave system comprising means for producing a microwave signal, a polarized directive transmitting antenna for radiating said signal in a single plane of polarization and through an arc in a predetermined direction, a pair of polarized directive receiving antennas for receiving said signal, said receiving antennas being cross-polarized, said polarized directive transmitting antenna radiating said signal toward said polarized directive receiving antennas, the maximum sensitivity of which are in the direction of the transmitting antenna, and a balanced receiver connected to said receiving antennas for indicating a change in the relationship between the strengths of the signals received from said receiving antennas.

8. Apparatus for protecting an area by means of a microwave system comprising means for producing a microwave signal, a polarized directive transmitting antenna for radiating said signal in a single plane of polarization and through an arc in a predetermined direction, a pair of cross-polarized receiving antennas, the plane of polarization of each of said receiving antennas making an angle of 45 degrees with the plane of polarization of the transmitting antenna, said polarized directive transmitting antenna radiating said polarized signal toward said receiving antennas, the maximum sensitivity of which are in the direction of the transmitting antenna, a balanced receiver connected to said receiving antennas, said receiver including means for indicating a change in the relationship between the strengths of the signals received from said receiving antennas.

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