April 14, 1953 L. E. SWARTS, JR 2,635,191

ANTENNA

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FIG.2

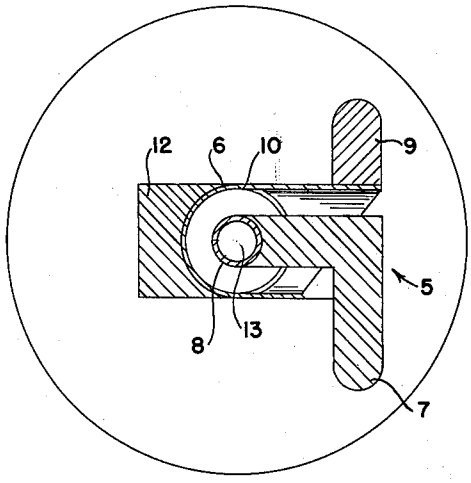


FIG.1

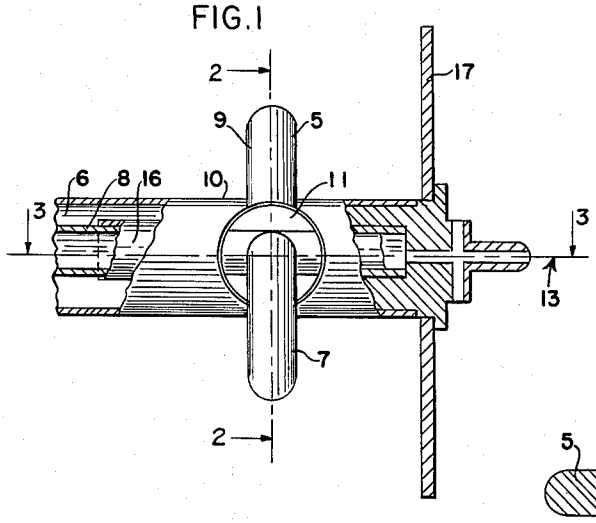


FIG.3

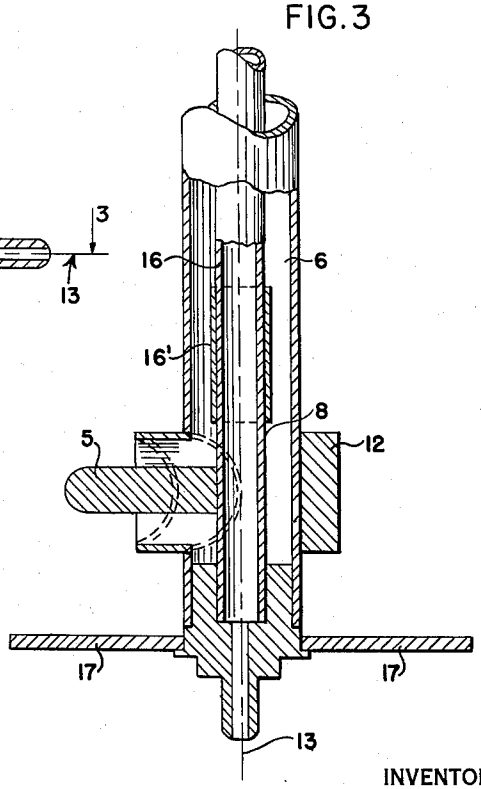
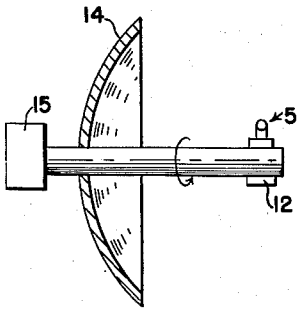


FIG.4



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3 Claims. (Cl. 250—33.65)

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This invention relates to antennae and more particularly to antennae having conical scanning patterns.

It is one object of this invention to provide an antenna which will produce a conical scanning pattern by revolving a dipole which has its electrical center at its physical center.

It is another object of the invention to reduce undesirable lobing effects.

It is another object of this invention to provide a conical scanning pattern such that the polarization is always generally tangential to the cone formed by the axis of radiation.

It is another object of this invention to provide a conical scanning pattern having the described polarization that is capable of rapid conical scanning.

It is a further object of the invention to provide an antenna which will scan conically and the radiation from which will be generally vertically polarized near the extreme horizontal departures of the scanning pattern when the antenna is pointed in a generally horizontal direction.

Still further objects of the invention are to provide means for establishing a conically scanning energy pattern in space which will improve the response, accuracy, and range of an automatic tracking radio object locating system, and which, more particularly, will improve the horizontal discrimination and range, response and accuracy of such a system in tracking targets in a generally horizontal plane.

Further objects and advantages of the invention will appear more fully herein.

Fig. 1 shows a sectional view of a preferred embodiment of the invention;

Fig. 2 is a cross section along the lines 2—2 of Fig. 1;

Fig. 3 is a cross section along line 3—3 of Fig. 1; and

Fig. 4 shows the dipole and transmission line of the invention with a paraboloid reflector.

It is contemplated that the apparatus shown be used with a paraboloid reflector adapted to radiate a narrow beam of electro-magnetic energy from a source located near its focal point. The general utility of conical scanning patterns is described in the application of Louis N. Ridenour, Serial No. 516,299, filed December 30, 1943, and issued on June 14, 1949, as Patent No. 2,473,175 entitled "Radio Direction Finding System." The geometrical concept of such a type of scan may be understood in full detail by referring to the patent of Wilhelm Runge, No. 2,083,242, entitled "Method of Direction Finding."

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By directing the axis of rotation of a conically scanning antenna toward the vicinity of an isolated target, said target being a source of electromagnetic radiation reflected or transmitted therefrom, electromagnetic waves will be received which, although radiated originally with a substantially constant amplitude, have approximately sinusoidal amplitude modulation if the target is not positioned along the axis of rotation of the beam.

In one employment of conical scanning patterns in conjunction with apparatus such as that described in the aforesaid application of Louis N. Ridenour, rapidly successive pulses of electromagnetic radiation are transmitted by an originating source and received by a moving target, such as an airplane, which may return a pulse of radio-frequency energy of the same frequency as that transmitted by the originating source. This returned signal may be utilized to maintain the paraboloid antenna in automatic alignment with the target. Thus, a greater signal is returned to the paraboloid antenna than would be possible if it were to receive mere echoes from the target.

A type of circuit which might be suitable for causing the target to respond to each pulse from the directive antenna is disclosed, for example, in the application of R. M. Page, Serial No. 468,648, filed December 11, 1942.

One way of producing the desired conical scanning pattern has been by rotating a dipole having its physical center on the focal axis as an axis of rotation. The two halves of the dipole are not symmetrical electrically so that radiation from one half of the dipole is greater than radiation from the other half, thus displacing the electrical center of the dipole from the center of rotation. Another manner of considering this electrical displacement is to explain it as being caused by currents along the conductor and supports of the dipole longitudinal with the focal axis, which produces a radiation with polarization parallel to the focal axis. In other words, there is an effective hypothetical second dipole oriented along the focal axis of the paraboloid. Due to the phasing between this secondary radiation and the radiation from the dipole itself and the differing orientation of the polarization thereof, a lobe effect is produced tending to throw the axis of maximum radiation away from the focal axis of the paraboloid. Whatever viewpoint is adopted, one result of the use of the rotating dipole above described is that the axis of maximum radiation cannot be made to depart from the focal axis of the paraboloid by an amount

greater than a small angle. In fact, theoretical considerations indicate that the maximum angle which the axis of maximum radiation makes with the focal axis cannot be made to exceed by this means an angle whose tangent is a half wavelength divided by the diameter of aperture of the paraboloid. Considering two lobes produced by the above means, the one being displaced at its extreme position from the other, the limitation described carries a further inherent limitation for a beam of given angular width in the amount of energy radiated along the focal axis of the paraboloid which, at least theoretically, passes through a point at which the two energy lobes cross. In practice, it has been found difficult, if not impossible, to decrease the voltage at this point for one lobe to a value less than about 85% of the maximum voltage value (one way) contained along the axis of one lobe and thereby it is apparent that the modulation of the returned signals is severely limited. The resultant radiation is generally polarized radially from the focal axis. Also, an effect has been found which causes the focal axis of the paraboloid to precess about a line to the target, instead of aligning itself therewith, when tracking targets using circularly polarizing antennae. This undesirable effect has been ascribed to the electrical unbalance of the dipole, whether that is the true cause or not.

It may be desired to receive the response signal particularly when the beam of energy is near its extreme horizontal positions. This will provide modulation suitable to cause automatic tracking in a generally horizontal plane. In such employment the target may carry an antenna generally responsive to and radiating vertically polarized signals. An antenna may be built conforming to these requirements to produce the conical scan pattern as shown in the drawings illustrating a preferred embodiment of the invention. Dipole 5 is excited from a coaxial transmission line 6. Element 7 of the dipole 5 is excited from the inner conductor 8 directly, while the element 9 is attached to the outer conductor 10 and excited by energy escaping from the aperture 11 through which element 7 reaches the inner conductor. Generally speaking, methods of construction whereby a dipole may be excited by electromagnetic energy fed by a coaxial or wave guide transmission line are well known.

A counterbalance 12 is provided to assure dynamic balance when the dipole is rotated about axis 13. The dipole 5 and transmission line 6 may be revolved about the desired axis by means of a motor and suitable gearing preferably behind the paraboloid 14, enclosed in suitable housing 15. Transmission of energy through the transmission line is not affected because of the inclusion therein of a rotating joint (not shown).

Broad band impedance matching is desirable, and may be achieved by using a portion 16 of the inner conductor 8 of increased diameter a short distance in advance of the point of attachment of the dipole 5. Reflector 17 is inserted to insure that the major portion of the energy is directed toward the reflecting paraboloidal surface.

If dipole 5 is situated near the focus of the paraboloid reflecting surface, the energy radiated will be in a generally narrow beam having an axis which may be termed the axis of radiation. As dipole 5 revolves, the axis of radiation generates a cone, and it is apparent that the polarization of the radiated beam is generally in a direction tangential to the conical surface so generated at each position of the said axis of radiation. If the paraboloid is directed in a generally horizontal position, although it may have varying angles with respect to an orienting line in the horizontal plane, then when the axis of radiation is near its extreme horizontal displacement, the radiation is generally vertically polarized. The result will be to give improved discrimination in automatically following the target in azimuth, when the target emits vertically polarized radiation. Generally speaking, it has been found preferable to employ vertically polarized antennae on such targets. Since many targets are at such a distance from the detection apparatus that, if detectable at all, they lie in a general horizontal plane of view from the apparatus, vertical angular discrimination loses its value; and furthermore, at large distances vertical angular discrimination is not sufficient to provide altitude information better than that which may be supplied by other means. On the other hand, horizontal angular discrimination is of great importance and generally may not be improved by other known methods.

A further improvement results because the dipole of this invention may be displaced at any desired distance from the focal axis of the paraboloid. Considering two lobes, in positions of extreme departure from each other and more particularly two lobes produced at the extreme horizontal departure of the scanning pattern when the antenna is pointed in a generally horizontal direction, the intensity pattern of these lobes should cross on the focal axis of the paraboloid in the horizontal plane. At this point, the voltage value (one way) contained in one lobe may easily be reduced to a value as small as 70% of the voltage along the axis of one lobe. Thus, the use of this invention provides a much greater modulation of signals returned from targets not aligned with the focal axis of the paraboloid. The invention therefore permits an improvement in response and accuracy of the automatic tracking means.

Empirical results indicate that in the particular employment herein considered, this invention improves over five times the range to which a target having a vertically polarized response signal may be followed and tracked automatically in azimuth as compared with the tracking which would be possible if the polarization of radiation of the originating source were generally normal to the axis of radiation.

This invention also provides improved response generally from antennae adapted to radiate circularly polarized radiation.

Another advantage obtained is that the electrical center of the dipole may substantially correspond with its physical center; consequently, balanced currents flow in the two halves of the dipole and lobing is reduced. The theories herein advanced and the reasons for the improvements afforded by the present construction are believed substantially to present the facts, but it is not desired to limit the invention by such theoretical considerations.

It is apparent that many variations of the invention are possible, depending on the desired employment of the equipment. In particular, the dipole may be oriented at any desired angle and revolved about the focal axis so that radiation will be polarized at any desired angle with the axis of radiation. The antenna may, of course, be used for suitable purposes other than

transmission to a target and reception of a response therefrom. Therefore, it is not desired to restrict the scope of the invention to the particular embodiment herein disclosed.

What is claimed is:

1. In an antenna having a paraboloid reflector, a transmission line extending through said paraboloid reflector centrally along the focal axis thereof, a portion of said transmission line extending substantially at right angles to said focal axis, and a dipole disposed at right angles to said portion of transmission line and electrically coupled thereto, said dipole being adapted to be revolved about said focal axis.

2. An antenna comprising a centrally apertured paraboloid, a first coaxial transmission line positioned through said aperture and along the axis of radiation of said paraboloid, a second coaxial transmission line electrically continuous therewith and disposed at right angles thereto, a pair of electrically balanced radiator elements electrically continuous with said second coaxial transmission line and disposed at right angles thereto, and means to revolve said first and second transmission lines and said radiator elements about said axis of radiation.

3. In a conical scanning system including a centrally apertured parabolic reflector, a transmission line positioned along the axis of said reflector and terminated at the focal point thereof, and means for rotating said transmission line, the combination with said first transmission line of a second transmission line and a dipole antenna, said second transmission line being electrically continuous with said first transmission line and normal thereto, said dipole antenna being electrically continuous with said second transmission line and normal thereto, whereby rotation of said first transmission line results in a conical scan radiation pattern that is characterized by polarization cross-over at diametrically opposed points.

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