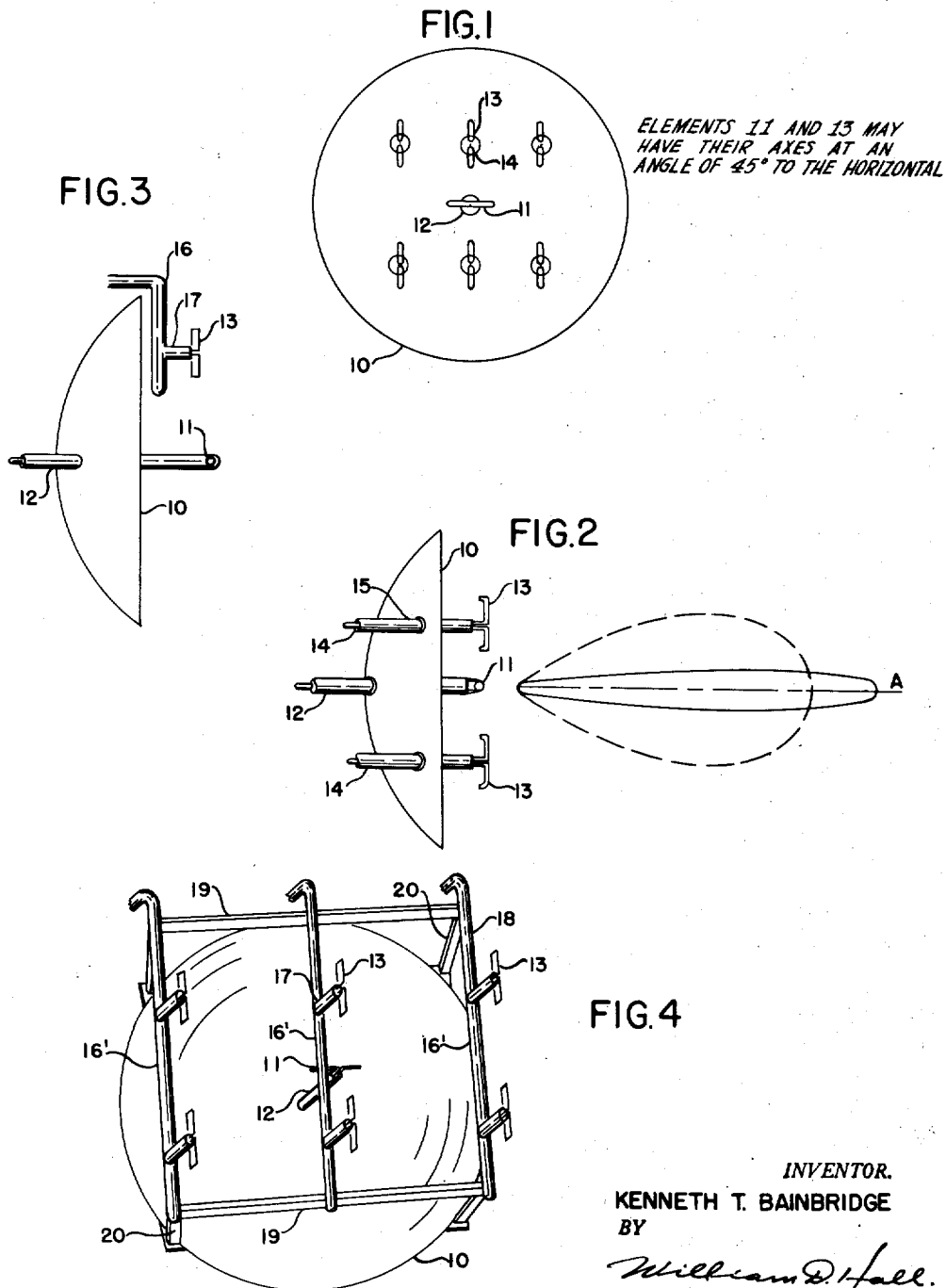


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DUAL FREQUENCY ANTENNA

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## DUAL FREQUENCY ANTENNA

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This invention relates to antennas for communication systems and more particularly to an antenna having a reflector adapted to transmit and receive electromagnetic energy in a directive manner.

In certain radio object locating systems, it is desirable to utilize a "friend or foe" interrogation (IFF) with a target search indication in a directional manner. Heretofore, one antenna has been utilized for directional searching and tracking, such as by scanning a particular sector in space with a pencil type beam which is characteristically narrow in azimuth and elevation, while a separate antenna has been required for the IFF interrogation. In order to facilitate recognition of targets such as aircraft or ships, it is desired that the IFF be directional and cooperate with the target searching and tracking system particularly for early warning of approaching targets. This may be achieved, according to the principal object of the invention, by utilizing a single directional antenna adapted to transmit and receive energy at two different frequencies simultaneously, such as a microwave frequency having a wavelength of the order of centimeters for searching and a longer wave frequency for the IFF.

It is another object of the invention to provide an antenna having a single reflector adapted to transmit and receive two different signals of electromagnetic waves of energy in such a way that neither interferes with the other.

It is still another object of the invention to provide an antenna with feed elements adapted to be excited separately from two different sources and suitably mounted to illuminate a single directional reflector.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, in which like numerals are employed to designate like parts throughout the same and in which:

Fig. 1 is a front elevation view of one embodiment of the antenna according to the invention;

Fig. 2 is a side elevation view of the antenna of Fig. 1 with a diagrammatic illustration of the radiation patterns produced by the antenna;

Fig. 3 is a side elevation similar to Fig. 2 showing another embodiment of the antenna according to the present invention; and

Fig. 4 is a perspective view of the modification of the antenna shown in Fig. 3.

In the drawings, 10 designates a reflector hav-

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ing a generally parabolic reflecting surface or surface otherwise suitably shaped to reflect a beam of radiant energy in a directional path. Reflector 10 is preferably shaped as a paraboloid of revolution but may also be in the form of a parabolic cylinder. By way of example and for simplification of illustration and description, the invention will be described herein as pertaining to a reflector formed as a paraboloid of revolution which when properly illuminated by a suitable radiating element is adapted to reflect energy in a pencil type beam characteristically narrow both in azimuth and elevation.

One means of illuminating reflector 10 is by a radiating element 11 located at the approximate focal point of reflector 10. Radiating element 11 may be of any suitable design adapted for radiating microwave energy having wavelengths of the order of centimeters. Thus radiating element 11 may be in the form of a dipole of conventional design or in the form of a wave guide aperture type or horn type radiator, energy being fed thereto by means of a transmission line 12. Transmission line 12 may be a hollow pipe wave guide or coaxial conductor type transmission line located in any well known manner, but preferably passing through the vertex region of reflector 10 as shown. Radiating element 11 is so arranged that energy radiated therefrom may be horizontally or vertically polarized and for the present description it may be considered that the radiant energy is horizontally polarized.

As thus far described, it will be understood that the antenna embodying reflector 10 and radiating element 11 is of a well known type and is adapted to radiate energy in a pencil type radiation pattern as generally indicated by the solid line configuration of Fig. 2, with the axis of the pattern being substantially coincident with the axis of reflector 10, this axis being designated A.

As will be understood, it is desired that this antenna be utilized for simultaneously transmitting or receiving energy having a different wavelength than that radiated by element 11. This may be achieved according to the invention by feeding the energy to reflector 10 by means of at least one other radiating element. According to one embodiment of this invention this additional radiating element designated 13 may be of any suitable design, such as a folded dipole as shown in the drawings, fed by means of a transmission line 14 extending through a suitable aperture 15 in a reflector 10. Radiator 13 is disposed and arranged so that energy

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emanating therefrom has a polarization which is perpendicular to that radiated by element 11 and is preferably of a longer wavelength than the energy from element 11, such wavelength being preferably of the order of meters or longer.

Reflector 10 appears parabolic to microwave radiation and is therefore effective to concentrate the microwave energy from the radiating element 11 into a pencil type radiation pattern. However, in the case of the long wave radiation emanating from the dipole radiating element 13, reflector 10 is believed to act essentially as a plane reflector to form the long waves into a single broad main lobe which is substantially coaxial with the microwave pencil beam pattern as indicated by the broken line configuration of Fig. 2. It will be understood that radiating element 13 is so disposed that the energy emanating therefrom has its plane of polarization perpendicular to that from the radiating element 11 and therefore, as shown, will be so disposed that the long wave radiation will be of vertical polarization. If desired the radiating elements 11 and 13 may be arranged so that their axes or the planes of polarization of energy radiated thereby are at an angle of about 45° to the horizontal. While a single long wave radiating element has been described, it has been found that the pattern produced thereby is usually too broad for efficient use, and that a more symmetrical and desirable pattern may be produced by symmetrically spacing a plurality of elements 13 about the radiator 11. Thus, as shown in Figs. 1 and 2, there are preferably six long wave radiating elements 13, the primary patterns of which combine to form the long wave lobe as indicated in the broken line configuration of Fig. 2.

Fig. 3 shows a modification of the dipole radiating elements for the IFF. In this embodiment, the coaxial line 16 feeding energy to, and supporting, a dipole 13 does not pass through reflector 10 but instead extends in front of and substantially parallel to the aperture plane of reflector 10 with its axis substantially perpendicular to the axis of transmission line 12. Dipole 13 is oriented as previously described with reference to Figs. 1 and 2 and therefore dipole 13 and coaxial line 16 lie in a plane substantially perpendicular to the aperture plane of reflector 10. Dipole 13 may be coupled to coaxial line 16 either directly or through a stub line 17 which may extend perpendicularly forward from coaxial line 16.

In the case where a plurality of dipoles 13 (such as six as indicated in Fig. 1) are used, a number of coaxial lines 16 may be used each supporting and exciting one or more dipoles 13. As shown in Fig. 4, it is found advantageous to utilize a lattice-like structure 18 for supporting and feeding energy to dipoles 13. Structure 18 may be of any desired shape depending on the number and arrangement of dipoles 13. As shown, structure 18 comprises three parallel coaxial lines 16' maintained in spaced and proper relation with each other and with reflector 10 by means of struts or bars 19 which connect line 16' and complete the substantially rectangular structure 18. Structure 18 may be supported by legs or brackets 20 connecting its corners to the edge portion of reflector 10 or in any other suitable manner. Each of lines 16 serves to support and feed energy to one or more dipoles in proper phase relationship, the line 16' and dipoles 13 being disposed in the

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manner described with reference to Fig. 3. With the arrangement of Figs. 3 and 4, the major reflection of energy radiated by dipoles 13 is from the adjacent surfaces of coaxial lines 16 or 16', the currents flowing on the outer surfaces of coaxial lines 16 and 16' being effective to give major directivity to the longer wavelength radiation from dipoles 13 and the surface of reflector 10 having a relatively minor effect on the directivity.

With elements 11 and 13 simultaneously radiating energy at two different frequencies with their planes of polarization perpendicular to each other, it has been found that there is no interference one with the other either on reflection from reflector 10 or from the coaxial lines 16 or 16' or while traveling out into space in patterns having substantially coinciding axes of directivity.

With the two different radiations from elements 11 and 13 simultaneously impinging upon the reflecting surface of reflector 10 with their polarization planes perpendicular to each other, it has been found that there is no interference one with the other. The receiving of both microwave and long wave (IFF) response may be shown on a PPI (plan position indication) indicator such as a cathode ray tube and the target picked up may be shown as a narrow azimuth microwave echo followed at a slightly greater radial distance by a stronger wide arc signal indicating the IFF response.

It will be understood from the description above that the antenna as described is adapted to transmit and receive energy of two different frequencies simultaneously in such a way that neither interferes with the other and that energy of both frequencies is adapted to be directed in a directional path.

What is claimed is:

1. An antenna for radiating energy of two different frequencies simultaneously comprising, in combination, a reflector shaped as a paraboloid of revolution, a radiating element located in the approximate focal point of said reflector and adapted to radiate polarized energy within the microwave frequency region for illuminating said reflector, said reflector reflecting said microwave energy in a pencil-type radiation pattern, at least one additional radiating element disposed in front of said reflector and adapted to radiate energy of a lower frequency than said microwave energy and with its plane of polarization perpendicular to the plane of polarization of the microwave energy, a coaxial conductor line for feeding energy to and supporting said one additional radiating element, said conductor line being disposed substantially parallel to both the aperture plane of said reflector and the additional radiating element which it supports, said coaxial conductor line acting as a reflecting surface for a major portion of the lower frequency energy radiated by said additional radiating element, both said radiating elements being adapted to radiate energy of both said frequencies simultaneously without one interfering with the other in directive radiation patterns having their axes of directivity substantially coinciding.

2. An antenna as claimed in claim 1 wherein a plurality of additional radiating elements are provided and symmetrically spaced relative to said microwave radiating element, at least a pair of said radiating elements being aligned, and wherein a plurality of coaxial conductor lines are

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respectively provided for feeding energy to and supporting each pair of said additional radiating elements, and means for supporting said coaxial conductor lines in proper position in front of said reflector.

3. An antenna for transmitting and receiving radiant energy of two different wavelengths simultaneously, comprising a single parabolic reflector, a single dipole radiating element disposed at the approximate focus of said reflector, means for feeding microwave energy to said single dipole, said dipole being adapted to radiate the energy fed thereto towards said reflector, six folded dipole radiating elements disposed in front of said reflector and symmetrically spaced with respect to said single dipole; said folded dipoles being adapted to radiate energy of a wavelength at least 1.5 times the wavelength of said microwave energy, said single dipole and said folded dipoles being so disposed with respect to each other that the planes of polarization of the energies radiated thereby are perpendicular to each other, said reflector being effective to direct said microwave energy without interference with the energy of longer wavelength, the patterns of said radiations simultaneously having a substantially common axis of directivity.

4. An antenna as in claim 3 wherein said six dipoles are disposed in two rows of three dipoles each and said parabolic reflector is a paraboloid of revolution, the axis of said paraboloid passing through the geometric center of the pattern formed by said six folded dipoles.

5. An antenna as in claim 3 wherein said six dipoles are disposed in two rows of three dipoles each and said parabolic reflector is a paraboloid of revolution, the axis of said paraboloid passing through the geometric center of the pattern formed by said six folded dipoles, said antenna further comprising coaxial conductors for supplying energy to said six folded dipoles and for mechanically supporting said dipoles, the outer surfaces of said coaxial conductors acting as a reflector for the energy of the longer wavelength.

6. An antenna comprising a parabolic reflector, a radiating element disposed at the focal point of said reflector for radiating energy polarized in a given plane, at least one additional radiating element in front of said reflector and displaced from said focal point for radiating energy polarized in a plane that is at right angles to the polarization plane of the first named radiating element,

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and at least one transmission line for feeding energy to and supporting said additional radiating element, said line being disposed in front of said reflector in a plane at right angles to the plane of polarization of the first named radiating element.

7. An antenna comprising a parabolic reflector, a radiating element disposed at the focal point of said reflector for radiating energy polarized in a given plane, a plurality of radiating elements disposed in front of said reflector for radiating energy polarized in a plane that is at right angles to the plane of polarization of the energy from said one element, and a plurality of transmission lines for feeding energy to and supporting said plurality of elements, said lines being disposed in a plane at right angles to the plane of polarization of said one element and acting as a reflector for the energy from said plurality of elements.

8. An antenna structure adapted to be placed in front of an antenna reflector, comprising a plurality of parallel transmission lines, a plurality of antenna elements arranged in parallel rows, each row of elements respectively being mounted upon a respective one of said lines, said transmission lines being aligned with said elements and acting as a reflector for energy from said antenna elements, and bracket means interconnecting and supporting said lines.

9. The antenna structure of claim 8, wherein said elements comprise dipoles arranged in three rows, with two dipoles in each row.

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