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R. S. ENGELBRECHT

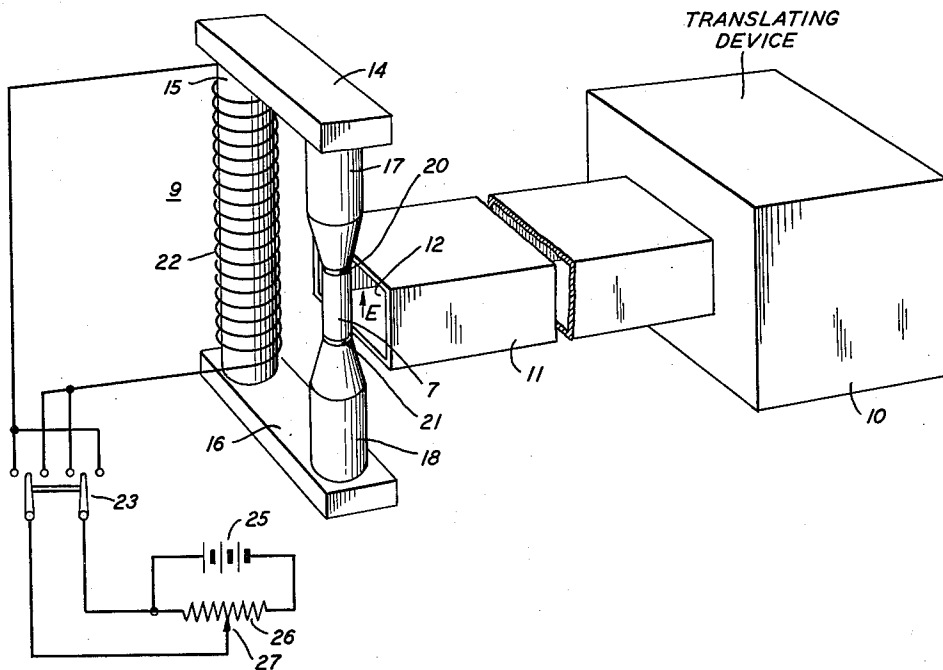
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ANTENNA WITH ELECTRICAL LOBING

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2 Sheets-Sheet 1

FIG. 1



INVENTOR
R. S. ENGELBRECHT
BY
Ralph P. Holcomb
ATTORNEY

Oct. 31, 1961

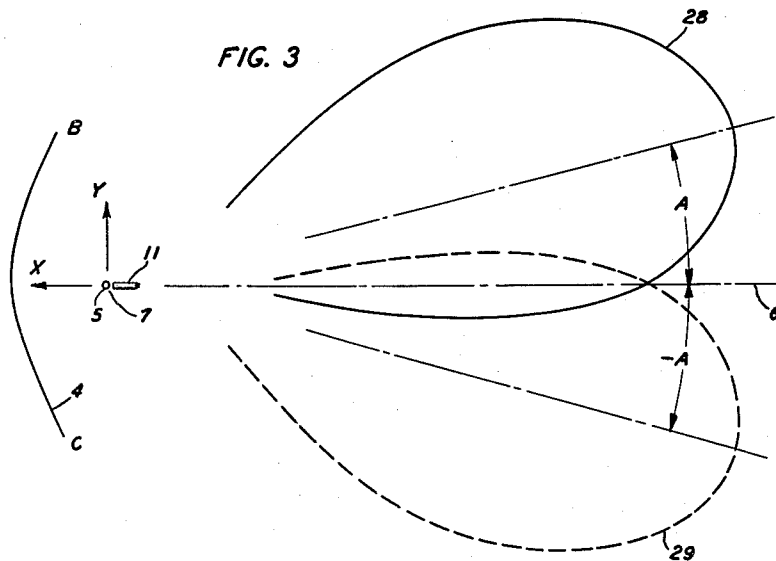
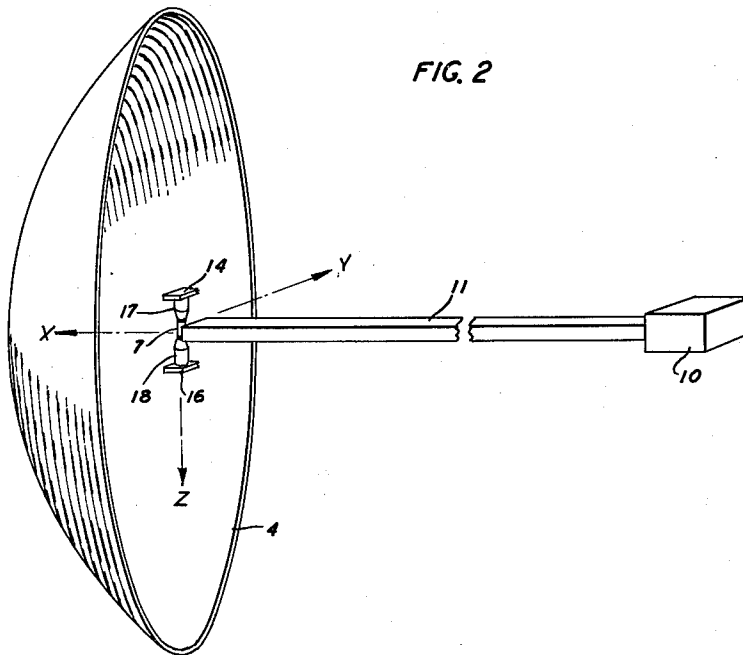
R. S. ENGELBRECHT

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INVENTOR
R. S. ENGELBRECHT
BY

Ralph T. Holcomb
ATTORNEY

1

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ANTENNA WITH ELECTRICAL LOBING
Rudolf S. Engelbrecht, Washington, D.C., assignor to
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N.Y., a corporation of New York
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This invention relates to directional microwave antenna systems and more particularly to a system in which the direction of the major lobe of the antenna pattern may be changed or switched electrically.

An object of the invention is to control the direction of maximum radiation or the direction of maximum reception of a microwave antenna system. A further object is to control this direction electrically or magnetically. Another object is to switch easily and rapidly between two directions which make equal angles with the normal direction.

The illustrative embodiment disclosed herein of a directional microwave antenna system in accordance with the present invention comprises means for converging an incident plane electromagnetic wave at a focus, a body of gyromagnetic material positioned at the focus, means for subjecting the body to an adjustable biasing magnetic field which is parallel to the electric field of the signal wave and has a magnitude in the region of that required to produce gyromagnetic resonance in the body, a translating device, and means for transmitting the signal wave between the focus and the translating device.

When the system is receiving energy, an incident wave tilted at an angle A with respect to the normal direction of reception will be circularly polarized in a clockwise direction at the focus, while waves arriving at an angle $-A$ will be circularly polarized in a counter-clockwise direction. The invention makes use of the fact that, for a given direction of the biasing magnetic field, the gyromagnetic body will attenuate or absorb the waves circularly polarized in the clockwise direction but will have negligible or little effect on the waves circularly polarized in the counter-clockwise direction. As a result, incoming waves tilted at an angle $-A$ will reach the translating device at a much higher level than will waves tilted at an angle A . The direction of maximum reception, that is, the direction of the major lobe of the antenna pattern, depends upon the magnitude of the biasing magnetic field. In accordance with the invention, the magnitude of the biasing field is controlled electrically to control this direction. Also, means are provided for quickly reversing the direction of the biasing field, thus switching between two directions of maximum reception which make equal angles with the normal. This provides a very rapid beam-switching or lobing action which is useful in radar or other systems. When the system is used to radiate a beam of energy, the direction of maximum radiation may be easily controlled by adjusting the magnitude or reversing the direction of the biasing field, thus providing a scanning action.

The focusing device is shown as a paraboloidal reflector, but it could be some other suitable type of reflector, or a lens. The gyromagnetic material may, for example, be a ferrite. The biasing magnetic field is furnished by an electromagnet which is connected through a reversing switch to an adjustable energizing voltage obtained from a battery shunted by a tapped resistor. The translating device, which may be a radio transmitter, a radio receiver, or other equipment, is connected to the focus by a transmission line in the form of a rectangular wave guide. This wave guide has an open end at the focus and the gyromagnetic body is positioned adjacent to this end but outside of the guide.

2

The nature of the invention and its various objects, features, and advantages will appear more fully in the following detailed description of a typical embodiment illustrated in the accompanying drawing, of which

FIG. 1 is a perspective view of a directive microwave antenna system in accordance with the invention, except that the focusing means are not shown;

FIG. 2 is a perspective view, to a smaller scale, of the system including a parabolic reflector for focusing but omitting part of the biasing means; and

FIG. 3 is a diagram of typical field patterns obtainable with the system of FIGS. 1 and 2.

The embodiment of a directive microwave antenna system in accordance with the present invention disclosed herein, by way of example only, comprises a paraboloidal reflector 4 having a focus at the point 5 on the main optical axis 6 (shown in FIG. 3), a body of gyromagnetic material 7 positioned at the focus 5, an electromagnet 9 for subjecting the body 7 to a biasing magnetic field, a translating device 10, and a transmission line 11 connecting the translating device 10 and the focus 5.

The translating device 10, shown only as a box, may comprise a radio receiver, a radio transmitter, or both, or other suitable equipment. The device 10 is operatively connected to one end of the transmission line 11. The line 11 is shown as a wave guide of the hollow-pipe type, with a rectangular cross section. The guide 11 has a wider internal cross-sectional dimension equal at least to a half wavelength at the operating frequency and a narrower dimension equal to approximately half of the wider dimension. As is well known, an electromagnetic wave of the dominant mode propagated in a rectangular wave guide such as 11 will have its electric field perpendicular to the wider sides, as indicated by the arrow E in FIG. 1. The other end of the guide 11 is open to electromagnetic waves, thus constituting a radiating or collecting aperture 12. The aperture 12 faces the concave side of the reflector 4 and the longitudinal axis of the guide 11 coincides with the main optical axis 6.

The gyromagnetic body 7 is cylindrical in form, with a length approximately equal to the narrower dimension of the guide 11 and a comparatively small diameter, is oriented parallel to E, is positioned adjacent to the center of the aperture 12 but outside of the guide 11, and includes the focus 5. The body 7 may be composed of any of the several ferromagnetic materials combined in a spinel structure. As an example, it may comprise an iron oxide with a small quantity of one or more bivalent metals such as nickel, magnesium, zinc, manganese or other similar material, in which the other metals combine with the iron oxide in a spinel structure. This material is known as a ferromagnetic spinel, or a ferrite.

The electromagnet 9 furnishes a biasing magnetic field, parallel to E, for the body 7. It comprises a C-shaped magnetic core, constituted by the members 14, 15 and 16, which terminates in a pair of tapered pole pieces 17 and 18. The pole pieces 17 and 18 support the body 7 but are insulated therefrom by a pair of dielectric disks 20 and 21. The electromagnet 9 is energized by a winding 22, on the member 15, which is connected through a reversing switch 23 to a battery 25 shunted by a resistor 26 with an adjustable tapping point 27.

The operation of the system will now be described, assuming that a plane, vertically polarized, electromagnetic wave is incident upon the concave side of the reflector 4 and that the translating device 10 is a radio receiver. Reference will be made to FIG. 3, which shows diagrammatically the reflector 4, the body 7 including the focus 5, the wave guide 11, and the main optical

axis 6. The axes X and Y define the horizontal plane, which is also the magnetic plane of the signal wave at the focus 5. The electric field of the signal wave is perpendicular to the XY plane, and thus parallel to the arrow E, shown in FIG. 1, and the Z axis, shown in FIG. 2. It is further assumed that the reflector 4 is symmetrical about the X axis. For an incoming wave parallel to the X axis, the field contributions from all points on the antenna, from B to C, arrive in phase at the focus 5. Therefore, the magnetic field vector at this point remains parallel to the Y axis at all times, since the components in the X-direction add to zero. However, if the incoming wave is tilted with respect to the X axis by an angle A, the field contributions from B will arrive at the focus 5 ahead of those from C. The resulting magnetic field vector will now have a strong component rotating clockwise in the XY plane. Similarly, if the wave is tilted at an angle -A, the magnetic field vector will have a strong component which rotates counter-clockwise in the XY plane.

The body of gyromagnetic material 7 is located at the focus 5 and subjected to a biasing magnetic field in the direction of the Z axis. For one direction of this biasing field, the body 7 will absorb the magnetic field component of the incoming wave which rotates clockwise in the XY plane. Under these circumstances, a wave from the A direction will be strongly absorbed by the body 7 but a wave from the -A direction will suffer little absorption. If the direction of the biasing field is reversed, the counter-clockwise component of the incoming wave will be strongly absorbed. In this case, a wave from the A direction will be received relatively unaltered, whereas the received signal will be very weak for a wave from the -A direction.

It is thus seen that switching the direction of magnetization of the body 7 back and forth along the Z axis will switch the receiving antenna pattern back and forth in the XY plane. FIG. 3 shows a typical pair of patterns 28 and 29 which may be obtained in this way. The direction of magnetization may be reversed by throwing the switch 23, shown in FIG. 1, from one side to the other. Lobe switching of this type is very useful, for example, in radar systems, since the only moving part is the switch 23.

The angle A (or -A) depends upon the magnitude of the biasing field, which is controlled by sliding the tapping point 27 along the resistor 26. In order to produce a scanning effect, the magnitude of the biasing field must, as already mentioned, be in the region of that required to produce gyromagnetic resonance in the body 7, but it may be on either side of the resonant value.

If the translating device 10 is a radio transmitter and the system is employed to radiate a beam from the reflector 4, a scanning or beam-switching action similar to that just described may be obtained. It will be assumed that the wave guide 11 propagates an electromagnetic wave of the dominant mode from the transmitter 10 to the aperture 12. The electric field of this wave will be perpendicular to the wider sides of the guide 11, as indicated by the arrow E in FIG. 1. If the biasing magnetic field applied to the body 7 is zero, a normal beam will be radiated in the direction of the major

optical axis 6 of the reflector 4. As this field is increased in magnitude, the beam is shifted in the XY plane from the normal direction by the angle A or -A (FIG. 3), depending upon whether a positive or a negative voltage is applied to the winding 22. Here, also, in order to obtain a scanning action, the magnitude of the biasing field must be in the neighborhood of that which yields gyromagnetic resonance absorption. The beam may be quickly and easily switched from the angle A to -A by throwing the reversing switch 23. Since the volume of the body 7 is comparatively small, the maximum power radiated must be kept correspondingly low to prevent overheating or injuring the body 7.

It is to be understood that the above-described arrangement is illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A directional microwave antenna system comprising means for converging an incident plane electromagnetic signal wave at a focus, a body of gyromagnetic material positioned at said focus, means for subjecting said body to a biasing magnetic field which is parallel to the electric field of said wave and has a magnitude in the region of that required to produce gyromagnetic resonance in said body, and means for changing said magnetic field.
2. A system in accordance with claim 1 in which said first-mentioned means comprise a reflector.
3. A system in accordance with claim 2 in which said reflector is parabolic in form.
4. A system in accordance with claim 2 in which said reflector is paraboloidal in form.
5. A system in accordance with claim 1 which includes means for adjusting the magnitude of said magnetic field.
6. A system in accordance with claim 1 which includes means for reversing said magnetic field.
7. A system in accordance with claim 6 which includes means for adjusting the magnitude of said magnetic field.
8. A system in accordance with claim 1 in which said biasing means comprise an electromagnet.
9. A system in accordance with claim 8 in which said electromagnet has a C-shaped core with pole pieces, and said body is supported by said pole pieces.
10. A system in accordance with claim 8 which includes a source of direct voltage for said electromagnet and means for reversing the polarity of said voltage.
11. A system in accordance with claim 10 which includes means for adjusting the magnitude of said voltage.
12. A system in accordance with claim 1 in which said body comprises a ferrite.
13. A system in accordance with claim 12 in which said body is elongated in one dimension and said dimension is parallel to said electric field.

References Cited in the file of this patent

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