

Jan. 20, 1959

P. HINES

2,870,441

MICROWAVE ANTENNAS

Filed Oct. 23, 1952

2 Sheets-Sheet 1

FIG. 1

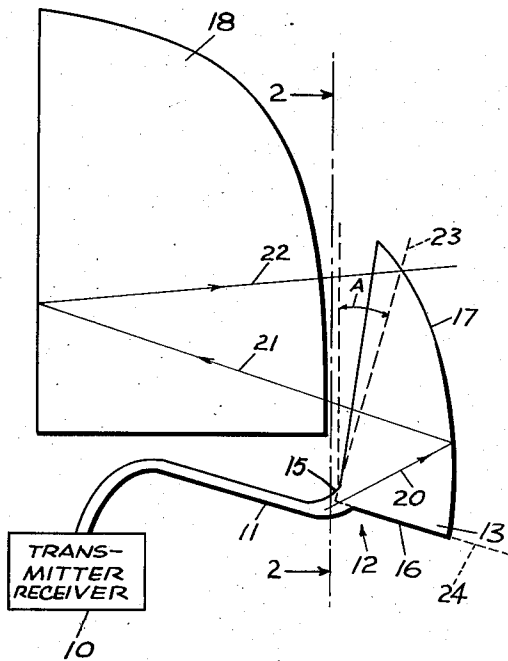


FIG. 2

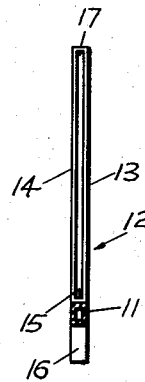
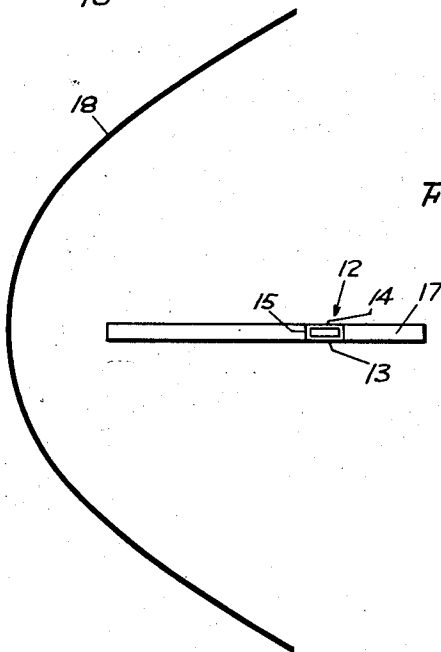


FIG. 3



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FIG. 4

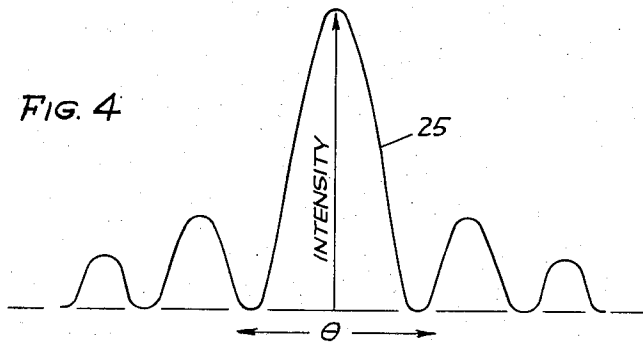


FIG. 5

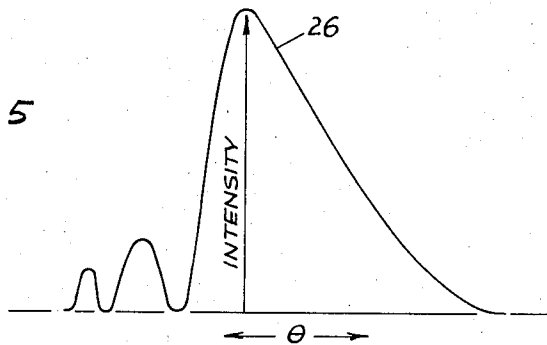
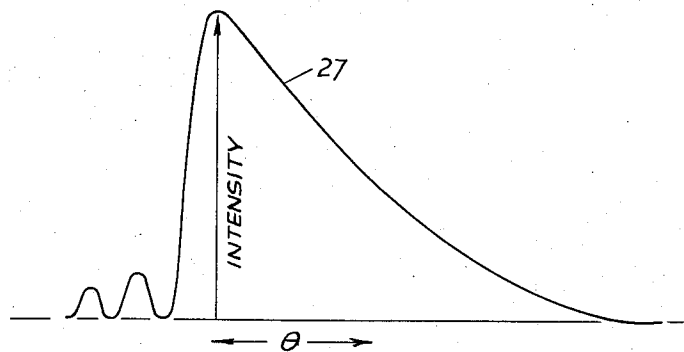


FIG. 6



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MICROWAVE ANTENNAS

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5 Claims. (Cl. 343—781)

This invention relates to microwave antenna systems for producing asymmetrically shaped beams.

In certain radar applications, such as surface based air search radar, it is desirable to have a beam that is narrow in the horizontal plane and wide in the vertical plane. It is also desirable that such an antenna receive signals of equal intensity from targets at the same altitude but at different ranges. In such a system the power density pattern varies approximately at the square of the cosecant of the elevation angle. Hence, this type of system is known as a cosecant squared antenna. Such a radiation pattern can be obtained by the combination of a horn radiator with one or more reflectors. An antenna system using a horn radiator positioned at the focus of a cylindrical parabolic reflector produces a relatively narrow beam in the vertical plane. If the horn of such a system is enlarged and a reflector positioned across the opening of the horn, the propagated energy will have an asymmetrical intensity pattern in the vertical plane. This asymmetry of the pattern is further increased by directing this energy toward a second cylindrical parabolic reflector with its axis perpendicular to the axis of the first reflector and at an angle to the directrix of the parabolic cylindrical surface of the first reflector. These changes in design do not affect the geometry of the horizontal plane of the system, and thus do not affect the intensity pattern in this plane. Such an antenna system is capable of propagating as broad a band of frequencies as the simpler system. Band widths of four percent of the central frequency have been obtained easily with designs embodying this invention.

Other and further advantages of this invention will become apparent as the description thereof progresses, reference being had to the accompanying drawings wherein:

Fig. 1 is a diagrammatic side view of a radar system embodying the invention;

Fig. 2 is a front view of the horn taken along the line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic plan view of the antenna system of Fig. 1;

Fig. 4 is a graph of the intensity of radiation with respect to angular displacement from the center of radiation of a combination of a horn radiator and a parabolic reflector;

Fig. 5 is a graph of the intensity pattern of the horn with an integral parabolic cylindrical reflector; and

Fig. 6 is a graph of the intensity pattern of the antenna system of Figs. 1, 2, and 3.

In Fig. 1, the reference numeral 10 indicates diagrammatically a radar transmitter for generating microwave energy, a receiver for receiving such energy, and an indicator connected by a wave guide 11 to a horn radiator 12. The horn 12 is formed with two parallel walls 13 and 14 (Fig. 2), and two flared walls 15 and 16. The end of the horn 12 is closed by a parabolic cylindrical surface 17 forming a reflector. This reflector may conveniently be formed by the extension of one of the flared walls of the horn shaped to the desired parabolic curve. The para-

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bolic curve of this reflector lies in the magnetic plane of the radiated energy from the horn 12. A second cylindrical reflector 18, having a parabolic cross section in the horizontal or electrical plane of this energy, is positioned in the path of the reflected energy from the reflector 17 and reflects the radiated energy back toward the right, as seen in Figs. 1 and 3. This is indicated by the lines 20, 21, and 22 which represent the direct radiation from the horn, the path after reflection from reflector 17, and the path after reflection from the reflector 18. It will be noted that the side wall 16 is formed so as to make a larger angle with the principal axis of propagation represented by the line 20 than the side wall 15. The parabola of the first reflector 17 is constructed with reference to two coordinates, indicated by the dotted lines 23 and 24. The coordinate 23 is parallel to the directrix of this parabola and is displaced from a position parallel to the axis of the second reflector 18 by an angle A.

The operation of the antenna system of the invention can best be understood with reference to the graphs of Figs. 4, 5, and 6. A horn radiator positioned at the focus of a parabolic reflector would produce an intensity pattern with respect to the angular displacement from the center of radiation, as indicated by the curve 25 in Fig. 4. It will be seen that this pattern has a central symmetrical lobe and secondary side lobes symmetrically disposed at either side of it. The curve 26 of Fig. 5 represents the pattern produced by the horn radiator 12 when formed with an integral parabolic reflector 17. It will be noted that the central lobe is no longer symmetrical and that the side lobes have disappeared on one side and have been reduced in amplitude on the other. This pattern approaches the desired cosecant squared pattern. The asymmetrical arrangement of the walls 15 and 16 about the main axis of propagation produces this pattern. The addition of a second parabolic cylindrical reflector 18, positioned to intercept the radiation from the horn and with its axis disposed at an angle A to the directrix 23 of the parabolic reflector 17, produces a pattern represented by the curve 27 of Fig. 6. The wide lobes are further reduced and the desired cosecant squared pattern is more closely approached than with the horn and parabolic reflector alone. This effect is obtained by the positioning of the second reflector with its axis at an angle to the directrix of the parabola of the second reflector. This tilt causes the waves impinging on the upper part of the second reflector to be retarded in phase with respect to the waves impinging on the lower part of this reflector.

The design principle of this antenna could be used with any radar application requiring a cosecant squared radiation pattern, such as air-borne radar for surface search, with appropriate modifications while maintaining the operating principle.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is, accordingly, desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A microwave antenna system comprising a wave guide having at its termination a reflector the surface of which intersects the magnetic plane of the radiation along a parabola, a second reflector the surface of which intersects the magnetic plane of the radiation along a straight line positioned at an angle to the directrix of the parabola of the first reflector.

2. A microwave antenna system comprising a wave guide having at its termination a horn, a reflector the surface of which intersects the magnetic plane of the radiation along a parabola, a second reflector the surface of

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which intersects the magnetic plane of the radiation along a straight line positioned at an angle to the directrix of the parabola of the first reflector.

3. A microwave system comprising a wave guide having at its termination a horn, a reflector formed integral with one side of the horn the surface of said reflector intersecting the magnetic plane of the radiation along a parabola, a second reflector the surface of which intersects the magnetic plane of the radiation along a straight line positioned at an angle to the directrix of the parabola of the first reflector.

4. A microwave antenna system comprising a wave guide having at its termination a horn, a reflector formed integral with one side of the horn the surface of said reflector intersecting the magnetic plane of the radiation along a parabola, a second reflector the surface of which intersects the magnetic plane of the radiation along a straight line positioned at an angle to the directrix of the parabola of the first reflector, said reflector also intersecting the electrical plane of the radiation along a parabola.

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5. A microwave antenna system comprising a wave guide having at its termination a horn, a reflector formed integral with one side wall of the horn the surface of said reflector intersecting the magnetic plane of the radiation along a parabola, said side wall being positioned to make a larger angle with the axis of propagation of the horn than the opposite wall, and a second reflector the surface of which intersects the magnetic plane of the radiation along a straight line positioned at an angle to the directrix of the parabola of the first reflector.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,870,441

January 20, 1959

Paul Hines

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 21, before "Figs." strike out "of"; column 3, line 4, after "microwave" insert -- antenna --.

Signed and sealed this 19th day of May 1959.

SEAL)

test:

ARL H. AXLINE

Testing Officer

ROBERT C. WATSON
Commissioner of Patents