

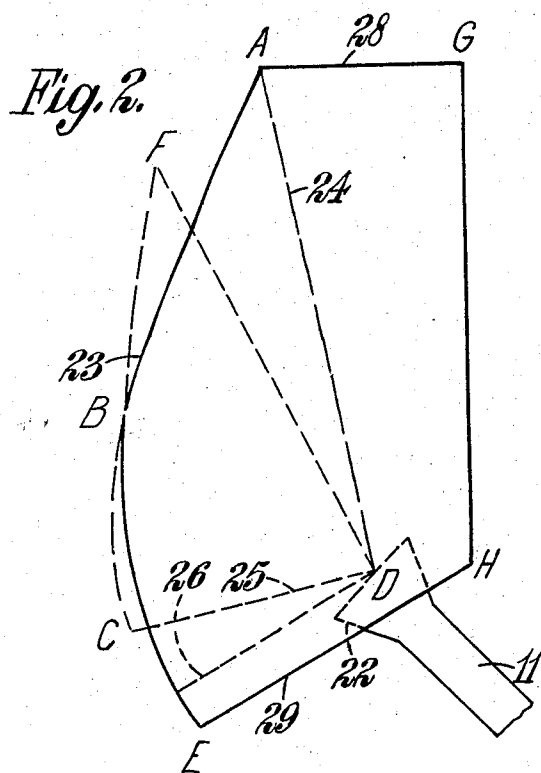
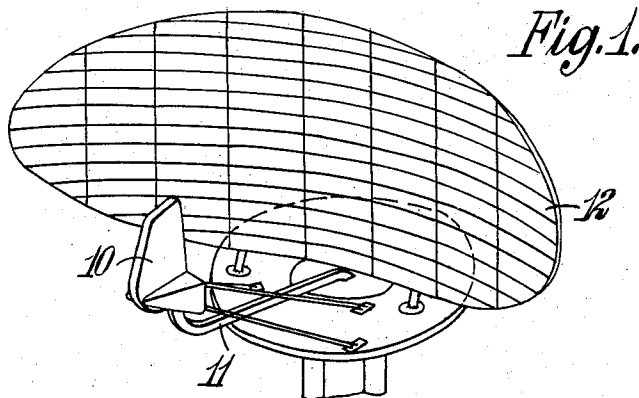
Dec. 20, 1960

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DIRECTIONAL RADIO ANTENNAE

2,965,899

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2 Sheets-Sheet 1



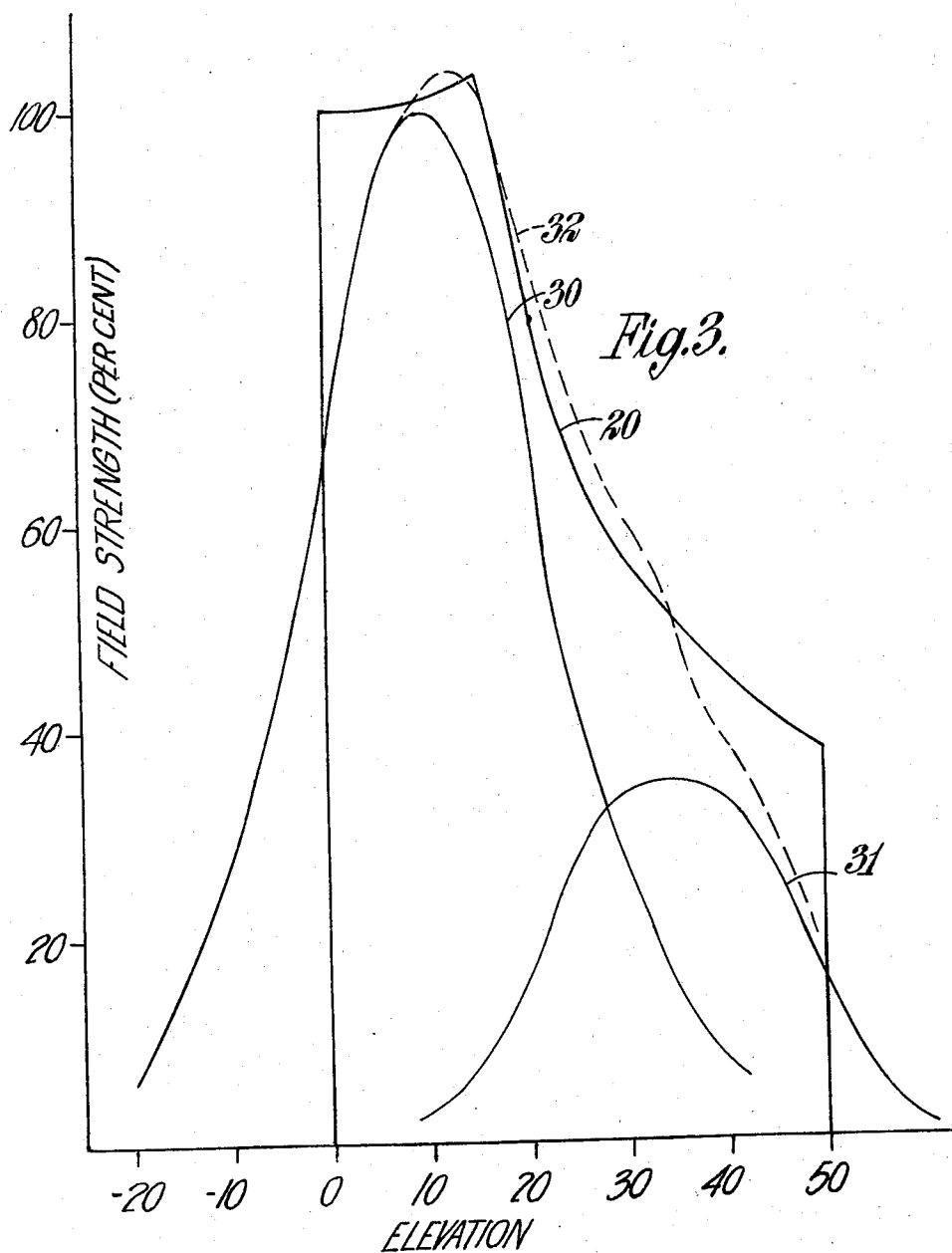
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DIRECTIONAL RADIO ANTENNAE

Otto Moritz Böhm, Gerrards Cross, and Henry Arthur John Barrett, London, England, assignors to The Decca Record Company Limited, London, England, a British company

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This invention relates to directional radio antennae of the kind in which (considering a transmitting antenna) signals to be radiated are fed from a primary feeding device, in the form of a horn, onto a secondary reflector or (considering a receiving antenna) signals to be received are reflected from the secondary reflector into a horn for feeding to a receiver. For convenience in the ensuing description the antenna will be considered only as transmitting antenna, that is to say the signals to be radiated are fed from the horn on to the secondary reflector. It will be understood, however, that the invention is equally applicable to receiving antennae and no limitation of the scope of the invention is intended by reference merely to transmitting antennae.

Particularly for radar apparatus, it is often necessary to obtain a beam which is sharply directional in one plane but which has some other not so sharply directional radiation pattern in another plane. For example it is frequently required to have a beam which, in the horizontal plane, is sharply directional but which, in the vertical plane, has the form known as a cosecant squared pattern. Such a pattern may be produced by having the secondary reflector parabolic in one plane and a particular shape in the other plane such as will give the required pattern. However, the calculation of the required shape of reflector with such double curvature is tedious and complicated whilst the manufacture of the reflector is a lengthy and costly business.

According to this invention, in a directional radio antenna comprising a horn arranged to fit a secondary reflector, the secondary reflector is a parabolic cylinder (that is to say the reflector is parabolic in one section through the focus and straight in section in planes normal thereto) and the horn has at least two substantially parabolic reflecting surfaces with common foci arranged so that signals from the common foci are reflected from said parabolic reflecting surfaces through the horn aperture onto said secondary reflector. In this arrangement the secondary reflector is a parabolic cylinder which is very much easier and cheaper to make than a secondary reflector having double curvature. The required directional effect in the plane normal to the parabolic section of the secondary reflector is obtained by suitable choice of the reflecting surfaces of the horn; the design and manufacture of such a horn is a very much simpler problem than the design of a double curved secondary reflector.

Most conveniently the aforementioned surfaces are each a partial parabolic cylinder, the two surfaces being arranged to join or abut to form a single continuous surface. The parabolic surfaces may be of like uniform width in the direction transverse to the plane in which the reflector is of parabolic section and such an arrangement may be considered as comprising, for example, two or more half cheeses intersecting one another. The term "cheese" is used for describing the form of antenna system in which the reflector comprises a parabolic cylinder,

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that is to say it is parabolic in one plane but is straight normal to that plane. In a cheese antenna this reflector furthermore has top and bottom cover plates in the planes in which the reflector is parabolic. A cheese reflector is cylindrical at either side of the axis of the parabola, while a half cheese extends only on one side of the axis of the parabola. It will be understood that only the portions of the half cheeses forming the reflecting surfaces would be provided, i.e. where the cheeses overlap, only the inner surfaces are required. It will be apparent that the proportion of the signals fed to the different reflector surfaces may be varied by varying the angular inclination of the feed at the common foci. Furthermore, the relative phase of the signals fed to the different reflecting surfaces may be varied by lateral shift of the feed. Such adjustments may be readily effected, and thus considerably simplify experimental design of a horn.

The aforementioned parabolic surfaces may be arranged to produce beams of different widths feeding the secondary reflector (considering the widths in the direction normal to the parabolic section of the secondary reflector). It will be appreciated that the beam widths will depend on the effective apertures of the two or more reflecting surfaces. Furthermore the aforementioned reflecting surfaces may be arranged to produce beams through the horn apertures in directions which differ in the plane normal to the parabolic section of the secondary reflector.

As a typical example it is possible to produce a close approximation to the radiation pattern of an antenna having a sharply directional beam in a horizontal plane and a cosecant pattern in a vertical plane by using a parabolic cylindrical secondary reflector and by forming the horn with two partially parabolic reflecting surfaces. The exact dimensions and positioning of these parabolic surfaces will depend on the width of beam required in the vertical plane. It will be appreciated however that many possible forms of pattern may be produced by suitable arrangement of the horn reflecting surfaces.

The following is a description of one embodiment of the invention reference being made to the accompanying drawings in which:

Figure 1 is a perspective view of a directional radio antenna

Figure 2 is a side elevation of the horn employed in the antenna of Figure 1, and

Figure 3 is a graphical diagram for explaining how a desired radiation pattern may be obtained.

Figure 1 illustrates a directional antenna such as may be used in radar apparatus. This antenna comprises a horn 10 fed by a wave guide feed 11, the horn directing the radio energy on to a secondary reflector 12. In the construction of the present invention, this secondary reflector 12 is made in the form of a parabolic cylinder, that is to say, the reflector is parabolic in one section (the horizontal section in the arrangement shown in the drawing) and is straight in section in planes normal thereto (i.e. in vertical planes in the arrangement illustrated). The horn 10 is arranged in the focal plane of the parabolic cylinder. The radiation pattern of this antenna in the horizontal plane will be a narrow beam, the beam-width depending primarily on the width of the reflector 12. In this particular antenna it is desired to provide a radiation pattern in the vertical plane having substantially all the energy radiated between 0 and 50° elevation with, however, the greater part of the energy directed below 25° elevation. The particular form of pattern to which it is desired to approximate is shown by the line 20 in Figure 3 which is a graphical diagram with field strength as ordinate and angle above the horizontal as abscissa and it will be seen that the desired pattern has a sharp cut-off at zero degrees elevation and rises

slightly to 16° elevation then falls according to a cosecant law to 50° elevation after which it is cut-off sharply.

To produce an approximation to this required pattern the horn 10 may be shaped as shown in Figure 2. The wave guide feed 11 to the horn has a slightly divergent mouth 22 and directs the radio frequency energy from the wave guide onto a curved reflecting surface 23 at the rear of the horn. This reflecting surface comprises portions of two parabolic cylinders which are parabolic in the side elevation plane shown in the drawing. The first of these parabolic cylinders extends from point A to point B and is continued for clarity as a dotted line from B to C. Dashed lines 24, 25 are drawn from A and from C to a point D showing the focal point of the parabola ABC. The second parabola extends from B to E and is continued by a dash line from B to F. The arc BE extends across the axis of the parabola which is represented by the dashed line 26. This line passes through D as the two parabolas have a common focus although they have different focal lengths in the example illustrated. The curved reflecting surface of the horn thus extends along the arc ABE and the horn is completed by flat upper and lower boundary planes 28, 29, so as to leave a vertical aperture extending between the points G and H on Figure 2. The surface AB is such as to produce a directional beam which is at an angle of elevation of approximately 10° and which has a half-power beam width of 20° after reflection from the secondary reflector 12. The reflecting surface BE is arranged to produce a minor beam of amplitude approximately 35% of the major beam having a half-power beam width of 27° after reflection from the secondary reflector 12, this beam being directed upwardly at an angle of elevation of approximately 35°. The directional patterns in the vertical plane of these two beams, provided by the two parabolic sections of the horn, are illustrated in Figure 3, the major beam being shown by the line 30 and the minor beam by the line 31. These two beams when combined produce a pattern represented by the dash line 32 and it is seen that this is a fairly close approximation to the desired pattern 20.

It will be appreciated that the resultant pattern will depend on the exact dimensioning and positioning of the parabolic surfaces of the horn and that many possible forms of patterns may be produced by suitable arrangement of the horn reflecting surfaces.

The beam widths of the major and minor beams are determined primarily by the effective sub-apertures of the two parabolic surfaces of the horn. The angular directions of the two beams depends on the directions of the axes of the two parabolas. The angular inclination of the feed 22 to the horn will determine what proportion of the total energy is intercepted by each of the two parabolic surfaces and hence will determine the relative amplitudes of the two patterns. Lateral shift of the feed will alter the relative phases of the two patterns. Thus it is a simple matter to make adjustments experimentally to obtain a desired pattern.

It will furthermore be noted that both the secondary reflector 12 and the arcuate reflecting surfaces 23 of the horn are all parabolic cylinders thus avoiding any requirement for shaping reflectors in two planes.

We claim:

1. A directional radio antenna comprising a horn arranged to feed a secondary reflector, wherein the secondary reflector is a parabolic cylinder and the horn has at least two different substantially parabolic reflecting surfaces with common foci arranged so that signals from

the common foci are reflected from said parabolic reflecting surfaces through the horn aperture onto said secondary reflector.

2. A directional radio antenna as claimed in claim 1 wherein said reflecting surfaces are each a partial parabolic cylinder with the axes of the two parabolas mutually inclined at an acute angle, the two surfaces being arranged to form a single continuous surface.

3. A directional radio antenna as claimed in claim 2 wherein said reflecting surfaces are of like uniform width in the direction transverse to the plane in which the reflector is of parabolic section.

4. A directional radio antenna comprising a secondary reflector and a horn arranged to feed said secondary reflector, wherein said secondary reflector is a parabolic cylinder parabolic in one section through the focus and straight in planes normal thereto and wherein said horn has at least two surfaces in the form of parabolic cylinders with common foci but with their axes mutually inclined at an acute angle, which surfaces of the horn are parabolic in planes parallel to the planes in which the secondary reflector is straight and are straight in planes in parallel to the plane of parabolic curvature of the secondary reflector.

5. A directional radio antenna comprising a secondary reflector and a horn arranged to feed said secondary reflector wherein said horn comprises at least two reflecting surfaces which, in one plane, are of parabolic form with common foci but with the axes of the parabolas mutually inclined to one another.

6. A directional radio antenna comprising a secondary reflector and a horn arranged to feed said secondary reflector wherein said horn has a reflecting wall arranged to direct incident radiation onto the secondary reflector which reflecting wall comprises at least two different parabolic cylindrical surfaces each of parabolic form in one plane and straight in directions normal to said one plane, said parabolic cylindrical surfaces being arranged to produce primary beams of different widths for illuminating said secondary reflector.

7. A directional radio antenna as claimed in claim 6 wherein said parabolic cylindrical surfaces are surfaces having the axes of the parabolas in different directions, which surfaces are joined to form a single continuous surface, the join between adjacent surfaces being along a line in a direction normal to said one plane.

8. A directional radio antenna as claimed in claim 6 wherein said parabolic cylindrical surfaces are joined to form a single continuous surface, the join between adjacent surfaces being along a line in a direction normal to said one plane.

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