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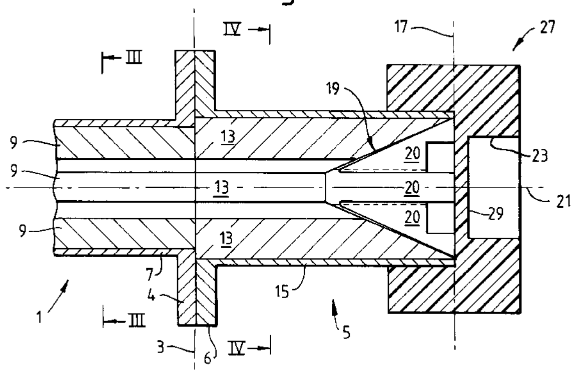
(54) **Microwave antenna.**

(57) A circular horn antenna having a wide beam and an extended bandwidth of 6-18 GHz, for use with signals having orthogonal polarization planes. The horn (5) is required to adapt to a standard square polarizer (1) having differential delay ridges (9) and is itself provided with corresponding metal ridges (13) which are continuous with the polarizer ridges (9). These horn ridges (13) are tapered at the mouth end of the horn to cooperate with the reverse taper of a dielectric cone (19) of cruciform cross section. This dielectric cone (19) has an axial hole (22) throughout the cone (19) and a larger axial cylindrical recess (24) in the base of the cone (19). A dielectric lens (27) is fitted to the mouth of the horn (5) for beam widening and matching purposes. The lens (27) has a large bore in the rear end to receive the circular horn mouth and a small bore (23) in the front end. The two bores are separated by a thin wall of dielectric material (29) contributing significantly to the matching. A circular horn antenna is thus provided having a very wide bandwidth (6-18 GHz), good matching and return loss over the band, while at the same time achieving good power handling capacity and weight reduction.

Fig.1.



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This invention relates to microwave antennas.

More particularly the invention relates to microwave antennas having a wide beamwidth in both azimuth and elevation and being operable over a wide frequency band for orthogonally polarized signal components. Such antennas find application, for example, in airborne ground surveillance radar systems where the antenna is mounted on the nose of the aircraft and directed ahead of the aircraft. One such antenna is described in our co-pending patent application No.9104319.

One object of the present invention is to provide a novel form of microwave antenna which, while maintaining the large bandwidth and return loss performance of the antenna referred to above has improved power handling and/or weight characteristics.

According to the present invention, a microwave horn antenna, for use with signals having orthogonal polarization plane components, comprises a circular horn adapted to interface with a square polarizer having axial metallic ridges providing differential polarization-plane phase-shifting, the horn comprising corresponding metallic ridges adapted to abut the polarizer ridges, the internal face of each horn ridge being continuous with the internal face of the corresponding polarizer ridge, the horn ridges extending to the mouth of the horn and being tapered down to substantially zero radial dimension at the mouth, and dielectric means disposed at the mouth providing beam shaping and matching.

The dielectric means preferably comprises a lens mounted on the mouth of the horn and tapered dielectric matching means disposed within the horn mouth. The lens preferably comprises a cylindrical annulus surrounding the horn mouth and extending forward of it. In particular, the lens may comprise a cylindrical block having an axial cylindrical hole in one end face to accommodate the horn mouth and a smaller diameter axial cylindrical hole in the opposite face, the two holes being separated by a wall of dielectric material.

The matching means preferably comprises tapered ridge portions, each extending from the axis of the horn to the tapered face of a respective horn ridge throughout the axial length of the horn ridge, each ridge portion being aligned with a respective horn ridge.

The ridge portions may be integrated in a conical member of cruciform cross-section, the base of the conical member abutting the wall of said lens.

One embodiment of microwave antenna according to the invention will now be described, by way of example, with reference to the accompanying drawings, of which:

Figure 1 is a sectional elevation on the axis of the antenna;

Figure 2 is an end view of the antenna;

Figures 3 and 4 are sectional views on the lines III and IV of Figure 1;

and Figure 5 is a perspective view (not to scale) of a generally conical dielectric member 19 also shown in Figures 1 and 4.

Figure 1 shows the combined polarizer and antenna horn making up the antenna unit.

The polarizer 1 is shown to the left of an interface plane 3 and the circular horn 5 to the right of this interface. The polarizer 1 is a standard waveguide component of square section and the horn 5 is circular,or rather, cylindrical, having an internal diameter slightly greater than the internal side dimension of the square polarizer 1. Both components are provided with flanges (4,6) by means of which they are screwed together.

The antenna transmits (and in some applications may receive) signals having electric field components in both horizontal and vertical planes. Circularly polarized signals in space are derived from (or are converted to) plane polarized signals in the transmitter/receiver associated with the antenna. This requires a 90° differential phase shift between the horizontal and vertical signal components and it is the function of the polarizer 1 to provide this shift. The polarizer consists of a square metallic waveguide 7 having longitudinal metal ridges 9 fixed centrally along each internal face. One pair of opposing ridges 9 are plain while the other pair, ie in the orthogonal plane containing the waveguide axis, are corrugated. Components in the 'corrugated ridge plane' are delayed relative to those in the orthogonal plane and the length of the polarizer is chosen to produce a relative delay of 90°. The left hand end of the polarizer 1 (not shown) is coupled to the transmitter/receiver in known manner.

Such polarizers are well known. The present invention is concerned with the design of the antenna horn when the horn is required to couple to a standard polarizer of the above kind and is also required to be circular to obtain, as far as possible, rotational symmetry of the radiation characteristic, ie the same radiation pattern in all axial planes.

An object of the presently described antenna design is that the bandwidth and return loss performance should be comparable with that of the antenna referred to above, but that the power handling capacity and weight factor should be significantly improved.

A major problem in the design of the present antenna is the limitation imposed by the need to interface with the existing polarizer, of fixed dimensions, which has to be employed. The square polarizer being considered has an internal side dimension of 19.4 millimetres which cannot be increased. The ridges 9 have a radial depth of 5 millimetres.

In the design now described, the internal diameter of the cylindrical metallic horn is set at 22 millimetres. Metallic ridges 13 are provided in the circular horn 5 to correspond with and abut those (9) in the polarizer. The ridges 13 have inner faces and lateral faces continuous with the corresponding faces of the polarizer ridges 9. The horn ridges thus have a radial dimension of 6.38 millimetres.

The continuity of the ridges 13 at the interface 3 improves the match across the interface 3.

The ridges 13 may be formed integrally with the cylindrical horn 5, eg by extrusion and machining, fixed on to it by brazing, or more simply by screws passing through the wall 15 of the circular guide, into tapped holes in the ridges.

The ridges 13 extend from the interface 3 to the plane 17 of the mouth of the horn. They have a length, which is not critical, of 40 millimetres. However, it is kept to a minimum consistent with maintaining the performance, in the interests of weight reduction, At the mouth end they taper down to zero radial dimension over an axial extent of 15 millimetres, giving a taper angle of about 23°.

While this taper gives some degree of matching, significant further matching is provided by a 'conical' member 19 of dielectric material, eg PTFE. This member 19 comprises essentially four tapered ridge portions 20 as illustrated in Figure 5, whose taper faces complement the taper faces of the horn ridges 13, as shown in Figure 1. The power handling capacity of the antenna is to some extent limited by the mass of dielectric material used for matching and beamforming purposes, It has been found that the mass can be reduced in certain ways without detracting significantly from the matching capabilities. Thus an axial hole 22 is provided in the cone member 19, this hole 22 being open ended. A further mass reduction is provided by relieving the base of the cone member to provide a cylindrical recess 24 having an axis aligned with that of the cone. The hole 19 breaks out into this recess 24. The diameter of the hole 22 is 5 millimetres, ie about one-quarter wavelength at an opening frequency of about 15 GHz, ie towards the upper end of the operating band. The diameter of the cylindrical recess 24 is 12 millimetres, about three-quarters of a wavelength at 18 GHz, while its depth is 4 millimetres. The dimensions may be varied about these values and the latter depth value may vary between the hole 22 diameter and a value one-quarter down from this. The cruciform nature of the conical member 19 may also be seen in Figure 4, the cone ridges 20 being in alignment with and partly obscured by the horn ridges 13.

Mounted on the mouth of the horn antenna, is a dielectric lens 27, also of PTFE, shown in section in Figure 1 and in end view in Figure 2. This lens produces a widening of the beam (ie the radiation characteristic) to give a beam angle of about 90° at the 3dB points. The lens is 40 millimetres outside diameter, 16 millimetres inside diameter (ie the front bore 23), 20 millimetres axial length and has an internal shoulder in which the horn cylinder 5 fits snugly to a depth of 10 millimetres.

A feature of the present design is that the forward bore 23 of the lens 27 does not extend right through the lens. There is a remaiming wall 29, of thickness 2 millimetres which assists considerably in achieving a good match between the horn and free space.

It is explained in the above referenced patent application that the basic dielectric lens 27 inherently reacts differently to horizontally and vertically polarized signal components. Considering a radiation pattern in an azimuth axial plane, the beam pattern is widened for vertically polarized components (ie components transverse to this azimuth beam plane) as compared with its response to horizontally polarized components, because of the inherent nature of the characteristics of the circular horn.

A simple dielectric lens would thus produce a departure from the desired rotational symmetry for both polarization components since, in the azimuth plane the vertical component is transverse to the plane so that the 'vertical polarization' beam is widened, whereas, in the elevation plane the horizontal component is transverse to the plane so that the 'horizontal polarization' beam is widened.

These effects are particularly apparent above about 12 GHz, ie the octave of the lower band limit.

Apart from this problem - of loss of rotational symmetry - the lens 27 requires matching to free space to improve the return loss characteristic, ie to level out and reduce the peaks In the characteristic. The wall 29 of the lens 27 produces a good free space match but the solution adopted in Application No.9104319 may be incorporated additionally to provide further improvement. This solution comprises grooving the radiating surface of the lens with, either, concentric equi-spaced grooves (or a single groove), or with radial grooves, or a combination of the two. Slots generally do of course tend to reduce beamwidth. However, radial slots tend to reduce the beamwidth for polarization transverse to the scanning plane, eg for vertical polarization in the azimuth plane, to a much greater extent than they affect the beamwidth for polarization aligned with the scanning plane. ('Scanning' plane does not imply that there is any physical scanning of the antenna - it merely indicates the plane of the characteristic being considered, eg the azimuth and elevation planes.) In addition, radial slots improve the matching considerably, and particularly above 12 GHz, for polarization transverse to the scanning plane (eg for vertical polarization in the azimuth plane).

On the other hand, circular slots tend to reduce the beamwidth for polarization aligned with the scanning plane and have little effect on transverse polarization beamwidth. The converse matching situation also applies in that good matching is achieved for aligned polarization above 12 GHz.

The arrangement which could be adopted in the present embodiment to take best advantage of these various effects is a combination of eight radial slots spaced at 45°, and one concentric slot. These slots would have a width of 2 millimetres and a depth of 5 millimetres.

It may be seen that, in the antenna described a good match is achieved while avoiding the use of a mass of solid dielectric in the signal path. There is consequently a relatively small dissipation of energy and greater power handling capacity. In addition, the reduction of the mass of the lens produces an overall weight reduction.

While the matching dielectric cone member 19 above provides better power handling capacity, an adequate design may use a cone member as described but having no axial hole 22 and/or no cylindrical recess 24. The design described above is, however, much to be preferred.

Claims

1. A microwave horn antenna for use with signals having orthogonal polarization plane components, the antenna comprising a circular horn (5) adapted to interface with a square polarizer (1) having axial metallic ridges (9) providing differential polarization-plane phase-shifting, characterised in that the horn comprises corresponding metallic ridges (13) adapted to abut the polarizer ridges (9), the inner face of each horn ridge (13) being continuous with the inner face of the corresponding polarizer ridge (9), the horn ridges (13) extending to the mouth (17) of the horn (5) and being tapered down to substantially zero radial dimension at said mouth (17), and dielectric means (27) disposed at said mouth (17) providing beam shaping and matching.

2. An antenna according to Claim 1, characterised in that said dielectric means (27) comprises a lens mounted on the mouth of the horn (5) and tapered dielectric matching means (19) disposed within the horn (5) mouth.

3. An antenna according to Claim 2, characterised in that said lens (27) comprises a cylindrical annulus surrounding the horn mouth (17) and extending forward of it.

4. An antenna according to Claim 3, characterised in that said lens (27) comprises a cylindrical block having an axial cylindrical hole in one end face to accommodate the horn mouth (17) and a smaller diameter axial cylindrical hole (23) in the opposite face, the two holes being separated by a wall (29) of dielectric material.

5. An antenna according to any of Claims 2, 3 and 4, characterised in that said matching means (19) comprises tapered ridge portions (20), each tapered ridge portion (20) having a taper face which extends contiguously with the tapered face of a respective said horn ridge, and each tapered ridge (20) portion being aligned with a respective said horn ridge (13).

6. An antenna according to Claim 5 or Claim 6, characterised in that said ridge portions (20) are integrated in a conical member (19) of cruciform cross-section, the base of the conical member abutting said wall (29) of said lens (27).

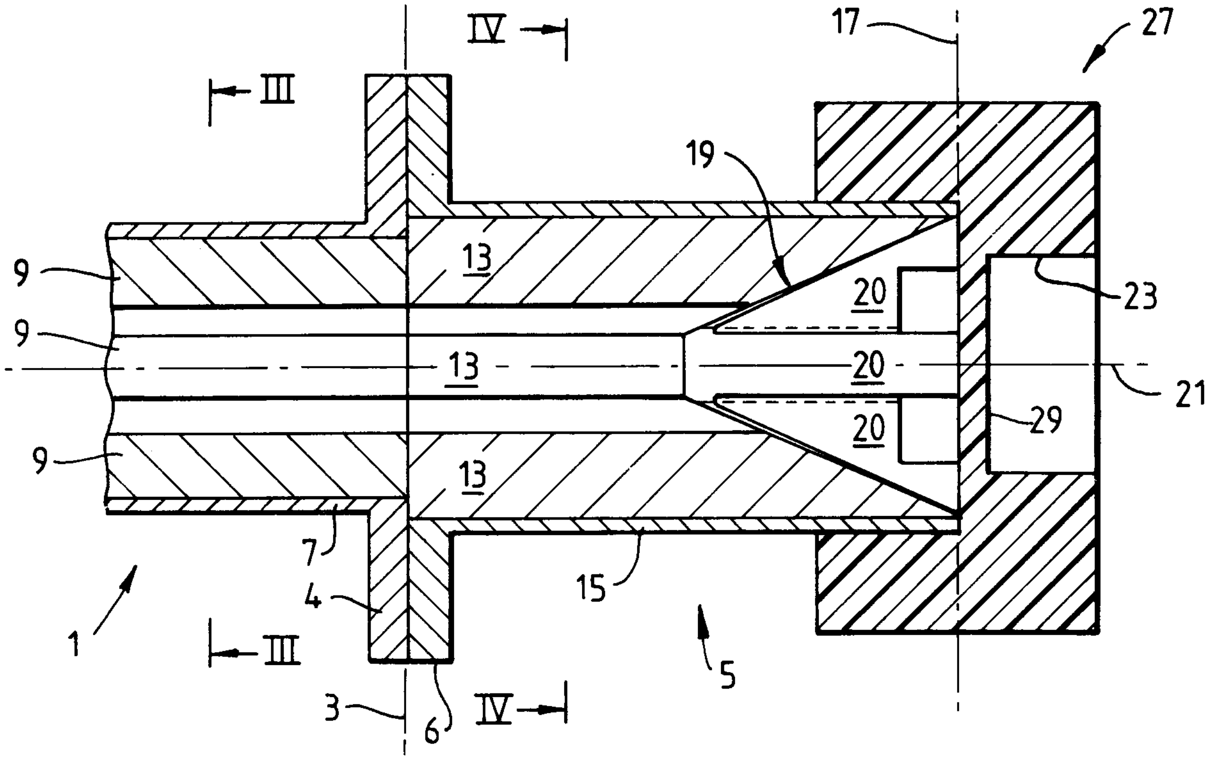
7. An antenna according to Claim 6, wherein said conical member has an axial hole extending therethrough.

8. An antenna according to Claim 7, characterised in that said axial hole (22) has a diameter of approximately one-quarter wavelength at the upper end of the operating frequency band.

9. An antenna according to Claim 6, 7, or 8 characterised in that the base of said conical member (19) has a cylindrical recess (24) whose axis is aligned with that of the conical member (19).

10. An antenna according to Claim 9 as appended to Claim 7 or Claim 8, characterised in that said cylindrical recess (24) has a diameter approximately three times that of said axial hole (22) and an axial depth dimension between the diameter of said axial hole (22) and a value 25% less than the diameter of said axial hole (22).

Fig.1.


IV
III
17
27
19
9
13
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23
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7
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4
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III
5
3
6
IV

Fig.2.

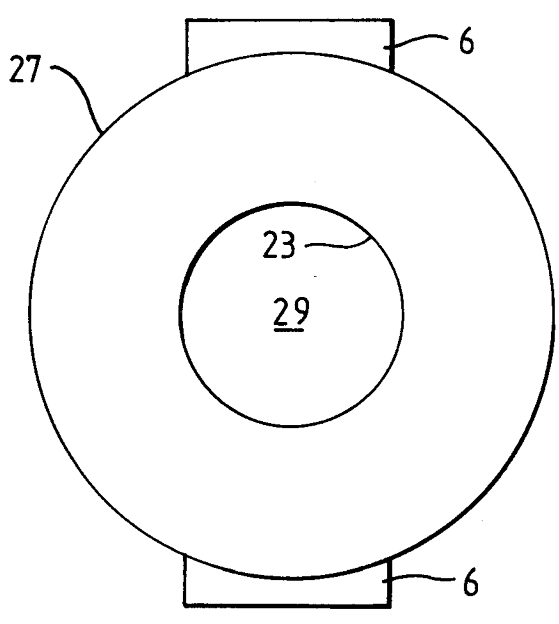

6
27
23
29
6

Fig.3.

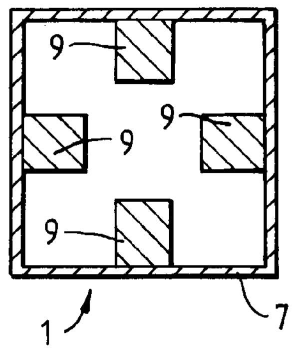


Fig.4.

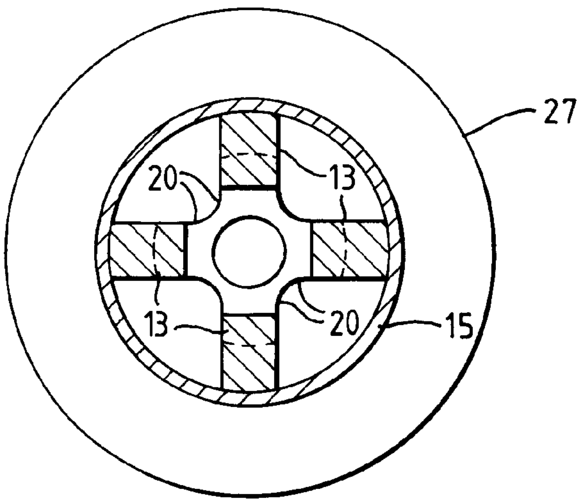
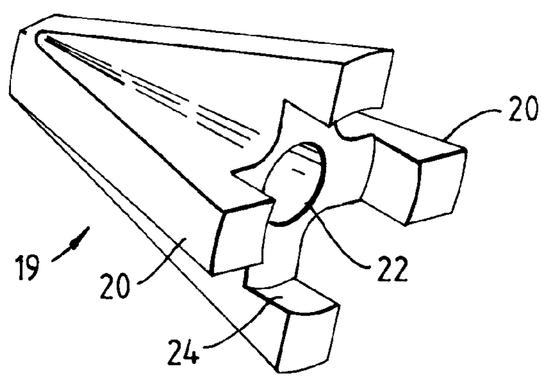


Fig.5.



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EUROPEAN SEARCH REPORT

Application Number
EP 92 30 6789

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-3 205 500 (LEONARD ET AL.) * the whole document * ---	1,2	H01Q13/02 H01Q19/08
Y	EP-A-0 131 328 (N.V.PHILIPS`GLOEILAMPENFABRIEKEN) * claims 1-7; figure 1 * ---	1,2	
A	WO-A-8 706 066 (MARCONI) * claims 1-7; figures 1,2 * ---	1,5-10	
A	WO-A-8 802 933 (HUGHES AIRCRAFT) * claims 1-24; figures 5-19 * ---	1	
A	US-A-3 758 882 (MÖRZ) * abstract; figure 1C * ---	1	
A	BE-A-556 362 (BELL TELEPHONE) * abstract; figures 2-5 * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H01Q
H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09 NOVEMBER 1992	ANGRABEIT F.F.K.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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