June 24, 1947. E. O. WILLOUGHBY 2,423,073

ELECTROMAGNETIC WAVE RADIATOR

Filed Sept. 9, 1942

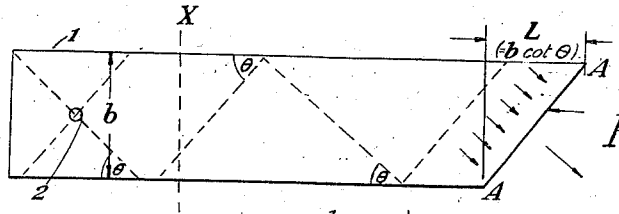


Fig. 1.

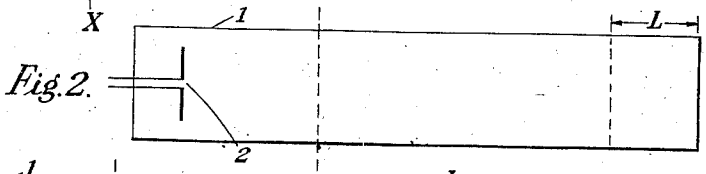


Fig. 2.

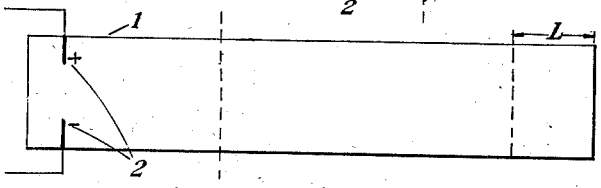


Fig. 3.

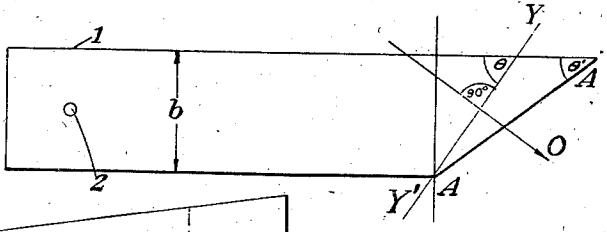


Fig. 4.

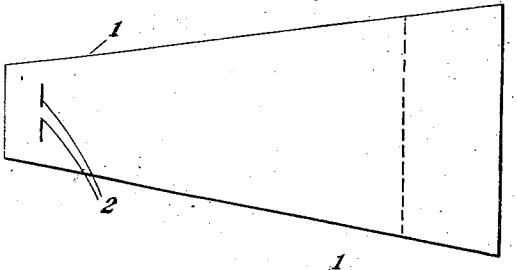


Fig. 5.

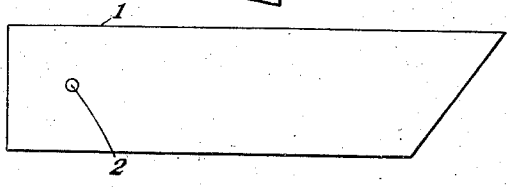


Fig. 6.

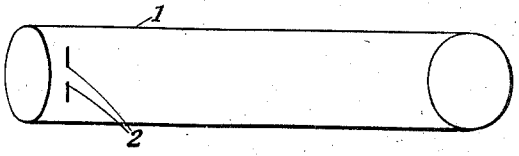


Fig. 7.

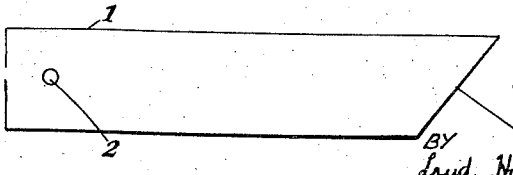


Fig. 8.

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UNITED STATES PATENT OFFICE

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ELECTROMAGNETIC WAVE RADIATOR

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Application September 9, 1942, Serial No. 457,796
In Great Britain June 13, 1941

5 Claims. (Cl. 250—11)

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The present invention relates to antenna arrangements for plane polarised waves and has for its object to provide a simple arrangement for use with wave guides the action of which simulates the action of a parabolic cylindrical reflector.

In its broadest aspect the invention resides in an antenna arrangement for plane polarised waves comprising a tubular wave guide the open end of which is arranged obliquely to the longitudinal axis of the guide at such an angle that the field distribution in space from the end of the guide simulates the field distribution of a parabolic cylindrical reflector in that a substantially plane wave front is produced at the end of the guide.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings which show by way of example three embodiments of the invention.

In the drawings

Fig. 1 shows in side elevation, and Fig. 2 in plan elevation a wave guide of rectangular cross-section embodying the invention;

Fig. 3 shows a slight modification of the arrangement shown in Figs. 1 and 2;

Fig. 4 is an explanatory diagram;

Fig. 5 shows in plan and Fig. 6 in side elevation another embodiment of the invention;

Fig. 7 and Fig. 8 show in plan and side elevation respectively a wave guide of circular cross-section embodying the invention.

In the simplest case the invention comprises a wave guide of rectangular section as shown in Figs. 1 and 2. In all the figures a dipole antenna is shown as the source of plane polarised electromagnetic waves, but the polarised waves may be obtained from any other source. The wave guide is given the designation 1 and the antenna 2.

In the drawings, in case of rectangular wave guides, the sides of the guides are the walls of the guide which lie parallel with the direction of polarisation and in the case where the waves are generated by a dipole antenna, the sides of the guide are parallel to the dipole.

Referring to Figs. 1 and 2, advantage is taken of the fact that once a plane polarised wave is established in a wave guide the bulk of the energy

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is propagated in two plane polarised waves whose directions of propagation make angles as shown by dotted lines in Fig. 1 with the sides of the wave guide. These angles are given by the equation

$$b \sin \theta = \frac{\lambda}{2} \qquad (1)$$

The critical wave length $\lambda_0 = 2b$; is the dimension between the sides of the guide.

Hence across a plane making an angle θ with the sides or longitudinal axes of the wave guide, there will be a displacement current sheet, approximately uniform in intensity, which if the said plane terminates the guide at AA so that the energy radiates into space the guide will simulate a parabolic cylinder of an aperture of the same size as the mouth of the guide. That is the diagram of energy distribution in space from the guide will simulate the energy distribution due to a parabolic cylindrical reflector because, like a parabolic cylindrical reflector, a substantially plane wave front is produced at the open end, or mouth, of the guide.

If λ min. represents the shortest wavelength that it is proposed to use, then so long as the length of the projection of the mouth of the guide on one of the sides, or the lip L, Fig. 1, at the aperture exceeds $b \cot \theta'$ where

$$b \sin \theta' = \tfrac{1}{2}\lambda \text{ min.} \qquad (2)$$

for all wavelengths between λ_0 and λ min., there will be a corresponding aperture plane for example, YY', Fig. 4, at which there will be substantially a plane wave front whose general direction of propagation is in the direction of the arrow O perpendicular substantially to YY'.

Expansion of the wave front will be effected by diffraction so that in the case of a plane section YY' asymmetry will develop due to the lip YA, Fig. 4, but this will decrease in magnitude as the wavelength is decreased until at the plane of the aperture AA at the shortest wavelength λ min. the diffraction will be very little different from that of a parabola.

One great advantage of this system is that focussing is not critical and one wave guide antenna can replace an arrangement using a parabolic reflector over a wide range of wavelengths, because with a parabola focussing is critical and the number of wavelengths at which full gain

can be obtained with the same parabola is restricted.

Figs. 5 and 6 show an improved form of guide in which the walls of the guide parallel to the direction of polarisation of the waves, i. e. parallel to the dipole generator 2 are tapered, the width gradually increasing towards the mouth of the guide to increase the radiating aperture in a line parallel to the exciting radiators, thereby improving the directivity of the aperture of the wave guide as a radiator.

Figs. 7 and 8 show a wave guide of circular section with the mouth of the guide obliquely arranged to the longitudinal axis.

Although the wave front of the propagation in a wave guide of circular section is not plane, sharpening of the main lobe of the energy distribution can be obtained by terminating the wave guide with the mouth at a suitable angle to the axis and parallel to the direction of polarisation, i. e. to the line of the exciter aerials in the case shown.

In all cases the main radiation lobe at the mouth of the guide will be approximately at right angles to the plane of the effective aperture YY', Fig. 4, and the radiation pattern will not be seriously affected by small deviations in the aperture from the line formed by cutting off the wave guide at an angle by the aperture plane so long as they do not shorten the "lip L" as given in Fig. 1.

It will be understood by those skilled in the art that the principles apply equally well to transmission and reception, but that diffraction will have less effect in the formation of minor lobes on the radiation pattern in the latter case.

What is claimed is:

1. An antenna arrangement for plane polarised waves comprising a wave guide open at one end the open end forming substantially a plane which is arranged parallel to the direction of polarisation and at an angle θ to the longitudinal axis of the guide, such that $b \sin \theta = \lambda/2$, where b is the dimension between the sides of the guide perpendicular to the direction of polarisation and λ is the working wave length, whereby a substantially plane wave front is produced at said open end.

2. An antenna arrangement as claimed in claim 1, wherein the dimension of the guide parallel to the direction of polarisation gradually increases towards the end of the guide along a length thereof.

3. An antenna arrangement as claimed in claim 1 wherein the guide is of circular cross section.

4. An antenna arrangement as claimed in claim 1 wherein the guide is of rectangular cross section.

5. An antenna arrangement for plane polarised waves comprising a wave guide open at one end the open end or mouth forming substantially a plane which is arranged parallel to the direction of polarisation and at an angle to the longitudinal axis of the guide, wherein the projection of the open end plane on the sides of the guide exceeds $b \cot \theta'$ where θ' is given by

$$b \sin \theta' = \frac{\lambda \text{ min.}}{2}$$

in which b is the dimension between the sides of the guide perpendicular to the direction of polarisation and λ min. is the minimum operating wavelength.

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REFERENCES CITED

The following references are of record in the file of this patent:

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