May 13, 1952 C. A. WILEY 2,596,190

DIELECTRIC HORN

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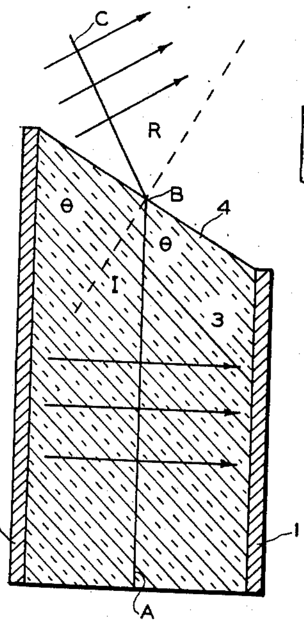
FIG. 1.



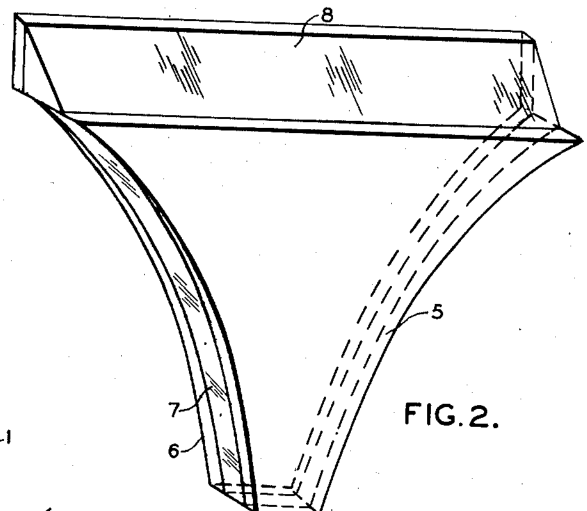


FIG. 2.

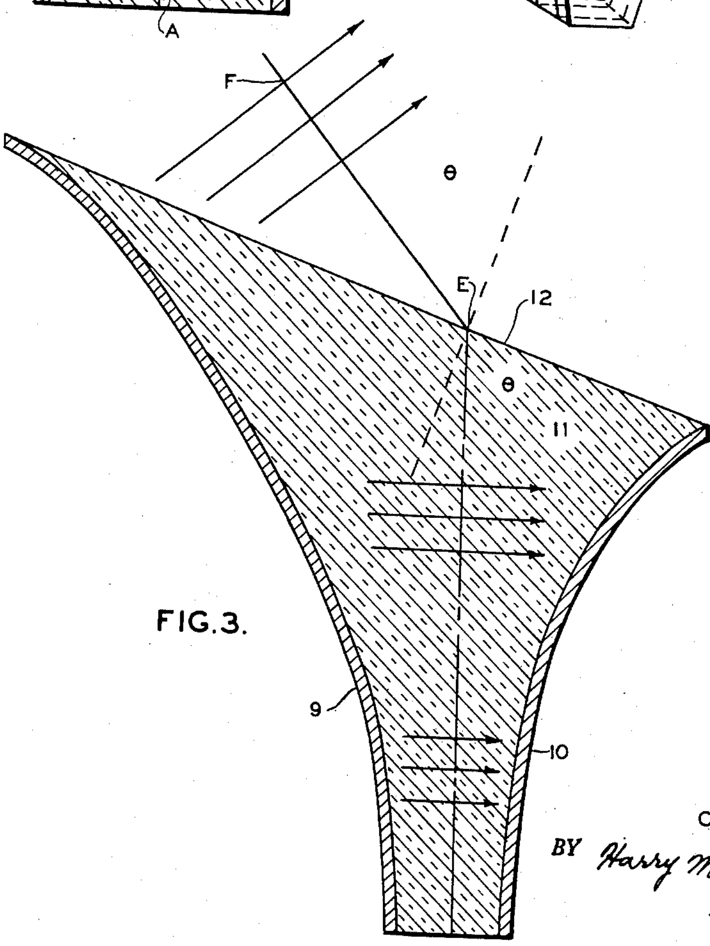


FIG. 3.

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DIELECTRIC HORN

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4 Claims. (Cl. 250—33.63)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

My invention relates to a novel antenna or radiator for the radiation and reception of radio signals which makes use of the selective refraction of polarized waves, as will appear. Some of the advantages of my radiator are that it provides theoretically perfect coupling between the ether and the radiator over an extended band of frequencies, that it may be made highly directional for both transmission and reception and that it is selective not only as to direction of transmission and reception but also as to direction of polarization of the signal.

It is accordingly a purpose of my invention to provide a radiator and receiver of radiation with close coupling to the ether, so that large amounts of energy may be radiated by relatively small antenna currents.

It is another purpose of my invention to provide an antenna in which the electric stress passes from a dielectric to the ether.

It is another purpose of my invention to provide a directional radiator and receiver.

It is another purpose of my invention to provide a radiator and receiver of polarized radiation.

It is another purpose of my invention to provide a radiating horn filled with dielectric material.

It is another purpose of my invention to provide a wave guide radiator of high dielectric constant whereby a close impedance match to free space is secured.

The nature of my invention is set forth in particular in the following specification which makes reference to the accompanying drawing. In the drawing:

Figure 1 represents in vertical section a wave guide radiator embodying my invention.

Figure 2 represents in perspective a dielectric horn having flat walls, and embodying my invention.

Figure 3 represents in section a dielectric horn having flared walls and embodying my invention.

In Figure 1 there is shown a wave guide type of radiator comprising two metallic side walls 1, 2 shown in section and covering two opposite faces of a rectangular prism of dielectric material 3. The front and rear faces of the prism are without metallic covering. The lower end of the wave guide is connected to a transmitter or other source of travelling electric waves (not shown). The upper end of the prism is cut at an angle θ with the axis of the prism. Angle θ is made equal

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to Brewster's angle for the dielectric of the prism, and is defined by the relation

$$\tan \theta = \eta$$

where η is the index of refraction of the dielectric referred to air. The dielectric may be glass, distilled water, plastic, or other dielectric.

There is especial advantage in using dielectric of high dielectric constant, because the size of the wave guide required to transmit a given wave length is considerably reduced. Alternatively for a wave guide of given section increase in dielectric constant increases Brewster's angle and increases the area of the beveled face of the prism, thereby increasing the sharpness of the radiated beam and the impedance match between the wave guide and the ether.

Dielectrics with particularly high dielectric constants at radio frequencies and low absorption are water, anatase, rutile, brookite, $BaTiO_3$, and a compound of $BaTiO_3$ with 3% $SrTiO_3$.

In utilizing the radiator of my invention, plane polarized electromagnetic waves are introduced into the bottom with the electric vector directed as shown by the arrows from one metallic plate to the other. The waves travel up the radiator in the direction of the line AB parallel to the prism walls. At the interface of air and dielectric the waves are refracted according to Snell's law of refraction. It follows as a consequence of the structure shown that the interior angle of incidence I satisfies the relation

$$\cot I = \eta$$

and the exterior angle of refraction R satisfies the relation

$$\tan R = \eta$$

and so

$$R = \theta$$

and

$$I + R = 90°$$

It is a property of waves which strike an interface with their electric vector in the plane of incidence and with the ray making the proper angle of incidence not to be reflected from the interface but to pass entirely through the interface by refraction. In the case of the ray passing from air into the dielectric the proper angle of incidence is Brewster's angle; in the case of the ray passing from the dielectric out into the air the proper angle of incidence is the complement of Brewster's angle. The conditions for no internal reflection are thus met in my wave guide radiator. Accordingly the waves pass out the end of the guide and are radiated in their entirety.

Since there is no internal reflection there are no standing waves within the wave guide, hence there is no loss of energy within the wave guide due to such standing waves. The energy of the waves is all radiated along the line BC as plane polarized radiation. Since there are no standing waves all wave lengths capable of being received by the wave guide are transmitted equally well and all in the same direction with the same polarization. Thus my wave guide makes an excellent broad band radiator. The sharpness of the radiated beam will depend on the transverse dimensions of the wave guide. For greatest sharpness they should be of the order of several wave lengths of the waves to be radiated.

The wave guide of Figure 1 may also be used as a receiver of radiation. In that case radiation entering along the line CB and polarized with the electric vector in the plane of incidence is received completely into the wave guide without any exterior reflection at the face of the guide. Radiation received at any other angle or having any other polarization will however be largely reflected and not received. Thus the wave guide can be made very selective as to polarization and direction, and thus interference from unwanted radiation may be largely eliminated.

In Figure 2 the wave guide proper is shown terminated in a flared horn to increase the dimension of the radiating interface and thus increase the sharpness of the radiated beam as in normal horn practice. The metallic walls **5** and **6** are shown as parallel planes with their lower portions forming a wave guide similar to that shown in Figure 1. The dielectric **7** is also placed between them similarly. In their upper portions walls **5** and **6** are flared as shown and the dielectric likewise flares out making a flat walled horn radiator. The upper face of the dielectric makes an angle with the walls equal to Brewster's angle for the dielectric.

In operation a train of waves with the electric vector transverse to the walls **5** and **6** enters the lower end of the wave guide passes up the guide spreading out into the flared horn portion, strikes the upper face **8** at the complement of Brewster's angle and is refracted from face **8** at Brewster's angle. By flaring the horn thus the radiated beam is sharpened in the direction transverse to the long direction of the face **8**.

In Figure 3 the walls of the horn **9** and **10** are shown flared also away from each other. The interior is filled with dielectric **11**. The lower portion of the radiator is in the form of a prismatic wave guide as shown in Figure 1. The upper face **12** of the dielectric is cut at Brewster's angle with the axis of the prismatic lower portion. By flaring thus the beam radiated along ray EF is sharpened additionally in the direction transverse to the flare.

The horn radiators shown in Figures 2 and 3 are equally effective as receivers of radiation when it is received at Brewster's angle and when polarized with the electric vector in the plane of incidence.

It is to be understood that modifications and substitutions may be made to the devices as shown without departing from the spirit of my invention, which is limited only by the appended claims.

I claim as my invention:

1. A radiator and receiver of radio waves comprising, a wave guide of a dielectric having an index of refraction substantially different from unity, means to propagate plane polarized wave energy within said wave guide along an axis of transmission, said wave energy having its electric vector at right angles to said transmission axis, and a radiating face at one end of said wave guide consisting of a plane section of said dielectric making an angle with said axis of transmission equal to Brewster's angle for said dielectric and having said electric vector in the plane of incidence to said plane section.

2. A radiator and receiver of radio waves comprising, a rectangular wave guide of dielectric material having an index of refraction substantially greater than unit, conducting walls on two opposite faces of said wave guide, and a terminating face of said wave guide making an angle with the two said conducting walls equal to Brewster's angle for said dielectric material.

3. A radiator and receiver of radio waves comprising, two plane parallel conducting flared walls, a filling of dielectric material having an index of refraction substantially greater than unity and enclosed between said walls, and a radiating face cut in said dielectric at the flared end making an angle with said walls equal to Brewster's angle for said dielectric.

4. A radiator and receiver of radio waves comprising, a solid horn of dielectric material, conducting walls along at least a portion of the exterior of said horn, means to propagate plane polarized electromagnetic energy within said horn along an axis of transmission, said energy having an electric vector at right angles to said axis of transmission, and an outer face of said horn cut to make Brewster's angle with said axis of transmission and to contain said electric vector in the plane of incidence.

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