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DIELECTRIC-LOADED WAVE-GUIDES

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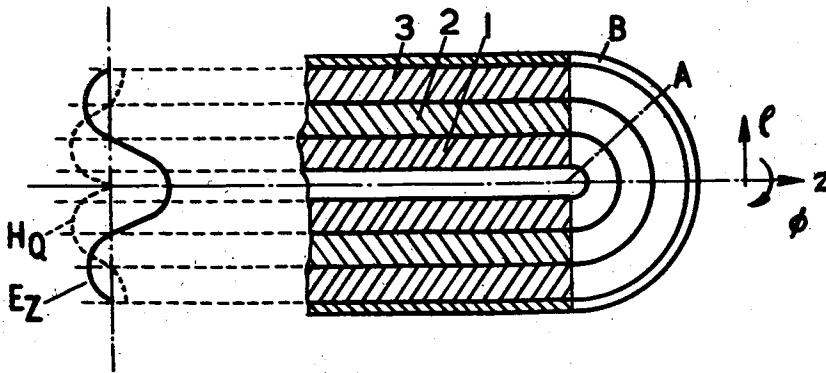


Fig. 1.

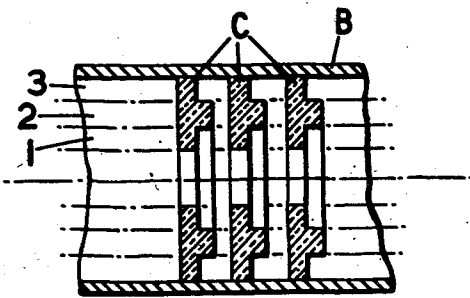


Fig. 2.

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DIELECTRIC-LOADED WAVE-GUIDES

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7 Claims. (Cl. 333—31)

This invention relates to dielectric-loaded wave-guide for example the wave-guides described in Application Serial No. 115,862.

It also relates to linear accelerators of electrons comprising loaded wave-guides.

In accordance with the present invention, the power dissipated in a wave-guide as the result of conduction loss in the metal wall thereof is reduced by making the dielectric to have, over the cross-section of the guide, different degrees of dielectric constant.

The wave-guide may be circular or it may have two parallel flat sides. The dielectric may comprise spaced transverse washer-like rings having inner and outer peripheries similar in shape to the wave-guide cross-section, each ring being thinner at its inner and outer peripheral regions than at the intermediate region.

One criterion of the goodness of a wave-guide for a linear electron accelerator is its "shunt impedance" or "efficiency," η . The relationship

$$\eta \propto \frac{E^2}{w}$$

holds, where E is the longitudinal accelerating field on the axis and w is the power dissipated in the guide per unit length. Thus it is advantageous to reduce the power dissipation which occurs with a given accelerating field. Power dissipation occurs as conduction loss in the metal walls of a wave-guide and as a "dielectric loss" in any dielectric material in the wave-guide. The invention provides a method of reducing the conduction loss.

In the accompanying drawing, Fig. 1 shows the proposed wave-guide in section.

There is an axial hole A for the electrons to pass through. There are then three co-axial tubular regions 1, 2, 3 containing dielectric loading material and finally a metal conductor, B.

The wave propagated is a circularly symmetrical E mode with radial variation as shown on the left of the diagram. The boundary between regions 1 and 2 is in the vicinity of the first radial node of E_z .

The boundary between 2 and 3 is in the vicinity of the first non-zero radial node of H_ϕ . The outer boundary of 3 coincides with the second radial node of E_z to give the correct conditions adjacent to the conductor.

The dielectric in region 2 is arranged to be electrically denser than that in either region 1 or region 3. The dielectric in regions 1 and 3 may advantageously be made anisotropic in the well known manner with $\epsilon_p > \epsilon_z$. The dielectric in region 2 may be either isotropic or anisotropic with its axes of anisotropy in any direction. The dielectrics in regions 1 and 3 may be either the same or different.

An ordinary dielectric loaded guide is bounded outside by a metal wall at a radius equal to that of the first node of E_z , and contains only one kind of dielectric corresponding to region 1 in the improved form. In either the ordinary or the improved kind of guide the conduction loss per unit length is proportional to ρH_ϕ^2 ; where ρ is the outside radius, and H_ϕ is the magnetic field at

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the outside. Calculations show that ρH_ϕ^2 may be made substantially less in the improved kind of guide. For example, using the same simulated anisotropic material in regions 1 and 3 of the improved guide and in an ordinary guide (with characteristics $\epsilon/\epsilon_0=100$, $K=0.3$, where

$$K = \frac{d}{D}$$

as shown in Fig. 2) and an isotropic solid dielectric (with $\epsilon/\epsilon_0=16$) in region 2 of the improved guide, the improved guide had a value of ρH_ϕ^2 about 25 times less than the ordinary guide. Although, in this example, the improved guide was about twice the diameter of the ordinary guide the reduction in H_ϕ , more than compensated for the increase in diameter; this reduction in H_ϕ can presumably be ascribed to a favourable interference between the reflections from the dielectric interfaces.

One simple practical way of making the improved guide is with dielectric discs C as shown in Fig. 2 of the drawing, and by including spacing washers made of a material, such as polythene, having a low dielectric constant in the region 2 between the discs, the location of the discs is readily assured. The discs C may be of composite construction to provide the desired anisotropy.

Such a guide is capable of propagating at least one mode other than the correct mode. An incorrect mode has a different phase velocity from the desired mode and therefore has little effect upon the electrons, but nevertheless power is wasted.

We claim:

1. A dielectric-loaded waveguide for propagating an electromagnetic wave in the E or TM mode of at least the second order in which the effective dielectric constants in the radial direction of adjacent coaxial tubular regions bounded approximately by successive nodal surfaces within the electromagnetic field are of two different values alternating in the radial direction, the innermost and outermost regions being of the lower value, said constants being uniform between nodes.

2. A waveguide as claimed in claim 1 wherein the actual dielectric constant of one region differs from that of an adjacent region.

3. A waveguide as claimed in claim 1 wherein the volume of said solid dielectric material in one region differs from that in an adjacent region.

4. A waveguide as claimed in claim 1 wherein the change in effective dielectric constant is abrupt at the nodal surfaces.

5. A waveguide as claimed in claim 1 wherein the dielectric material in one or more regions is anisotropic.

6. A dielectric-loaded waveguide for propagating an electromagnetic wave in the E or TM mode of at least the second order comprising a tubular metal conductor containing a plurality of coaxially arranged centrally apertured discs of dielectric material each of two different alternating thicknesses within adjacent coaxial tubular regions bounded approximately by nodal surfaces within the electromagnetic field of the waveguide, the thickness between nodal surfaces being uniform, the smaller thickness being in the region nearer the axis.

7. A dielectric loaded waveguide comprising a tubular metal conductor enclosing three coaxial dielectric sleeves the surfaces of said sleeves being substantially coincident with nodal surfaces within the electromagnetic field of the waveguide and the dielectric constant of adjacent sleeves being different, said constants being uniform between nodes and the innermost and outermost sleeves being of the lower value.

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