A rod 9 of ferrite material, for example a magnesium-manganese ferrite is located coaxially of the tube 1 by means of an annular foam spacer 10.

In operation the device of FIG. 1 is secured into a desired waveguide transmission system by the flanges 4 and 6 at its ends; suitable circular to rectangular waveguide transformers are provided if necessary and an earthed source of high frequency modulating signal is connected to the terminal 7.

A modulating signal current flows along the spiral of the tube 1 from the terminal 7 to the end flange 4; the end flange 4 is effectively earthed to the rest of the waveguide system; but the flange 6, although connected to the waveguide system, is insulated from the tube 1 and does not form part of the modulating signal current circuit.

The modulating signal current thus flows helically about the ferrite rod; and the flux in the ferrite rod 9 varies according to the modulating signal current flowing round it.

The result is that the propagation of a wave in the circular tube 1 is controlled in accordance with the modulating signal applied to the terminal 7 and the wave is effectively modulated.

In the construction of the device of FIG. 1 the slot 2 is made small to minimise radiation outwards from inside the tube 1. The thickness of the tube 1 is made small; it should be thick enough to allow waves to propagate along the waveguide system of which it forms part; on the other hand it should be small to reduce eddy current losses in it.

The number of turns of the coil which is effectively formed by the slot 2 in the tube 1 is chosen from considerations of the modulation signal frequency and the frequency of the wave propagated down the tube 1, bearing in mind the magnitude of the modulating current which flows during operation of the device.

In a typical example the circular tube 1 was 0.9 in. in diameter; the overall length of the tube section was 5.5 in. and comprised 14 turns pitched at 3 turns per inch.

The diameter of the magnesium-manganese ferrite rod was 0.25 in. A wave of frequency 9375 mc./s. propagated along the tube 1 was modulated when a current of 1 amp. at 7 mc./s. was fed to the tube 3 at the terminal 7.

The insertion loss was 0.5 db.

The preferred method of manufacture for the tube 1 is that due to E. B. Cowley & G. W. Fynn and is described in copending patent application No. 8,593/57.

Briefly, the method involves a stainless steel mandrel of a length and outside diameter corresponding to the length and inside diameter of the tube which provides the heix.

A helical track and longitudinal lead tracks at each end are cut in the mandrel and filled with an insulating plastic filler, e.g. an epoxy resin such as Araldite, to bring them flush with the surface again. A layer of copper is then deposited on the mandrel in an electroforming bath.

The copper is not deposited over the plastic-filled track and the required tube is thus formed having a helical slot along its length.

After electro-forming a coating of an epoxy resin is applied to the tube, whilst still on the mandrel; the tube is then removed from the mandrel and the end flanges fitted.

The cross-section of the slot due to the presence of the track narrows as the thickness of the copper is increased; although it can be made narrow in any event, it gets still narrower as electro-forming proceeds. Providing, of course, care is taken so that the slot does not bridge over, the slot gap can be made so narrow at the surface of the copper that, in operation of the modulator, there is little leakage of microwave radiation through the slot.
An alternative method proposes the use of printed wiring techniques to provide the tube 1.

A further form of modulator is shown in Fig. 2, where two circular tubes 1A, 1B each carry a helical slot 2A, 2B respectively; the helical slots 2A, 2B are arranged so that they are wound about the axis of the tubes 1A, 1B in opposite-handed directions. The tubes 1A, 1B are connected to a waveguide system at their end flanges 4A, 4B respectively.

The flanges 4A, 4B are electrically connected to their respective tubes 1A, 1B and provide an earthed connection because they are connected to the tubes 1H of the waveguide system.

As in the modulator of Fig. 1 the tubes 1A, 1B are supported by a body 3 of an epoxy resin. The tubes 1A, 1B similarly enclose an annular foam spacer and a rod of ferrite material, both of which extend between the flanges 4A, 4B. A terminal 7 is held in the resin body 3 and is connected at the abutment edge 12 to the tubes 1A, 1B.

In operation an earthed source of high frequency modulating signal M is connected at the terminal 7 and the tubes 1H of the waveguide system feed microwave energy through the tubes 1A, 1B; a circuit is then completed from the earthed source of modulating signal via the connection to the terminal 7 and the contrary-wound helices formed in the tubes 1A, 1B to the earthed flanges 4A, 4B. The result is that the microwave energy in the waveguide system is modulated by the signal from the source M. This construction has the advantage that the flanges are at earth potential and that there is no completely annular break in the waveguide system; only one feed, the terminal 7, is required for the two tubes 1A, 1B and no flanges are required where they abut. This simplifies the electrical arrangement of the modulator. Moreover, in the manufacture of the modulator it is proposed to make the tubes 1A, 1B in one operation, that is, in a single mandrel or electroforming.

Where it is desirable to reduce radiation through the helical slot of a modulator, or to be able to reduce the thickness of the ferrite rod 9 to reduce heating in it a tube of high dielectric constant material can be substituted for the annular foam spacer 36 of Fig. 1. Suitable materials are polytetrafluorethylene (P.T.F.E.); boron nitride would also be suitable and would be of additional advantage owing to its greater thermal conductivity. It is proposed to extend this arrangement to provide for increased cooling by using a fluid dielectric instead of the dielectric tube; dielectric bulkheads would be provided across the waveguide to contain the fluid dielectric. For high duty modulators it may be desirable to provide some cooling if at all possible and it is proposed by the use of a silicone oil, or possibly carbon tetrachloride, as a liquid dielectric to provide a means of cooling the modulator. Suitable circulation and cooling arrangements could also be provided for the fluid. For instance a cooling radiator would be connected to the waveguide by fluid-carrying connections through small holes in the wall of the waveguide.

What I claim is:

1. A modulating device of the kind referred to, comprising a waveguide and a mass of gyromagnetic material located within the waveguide wherein the wall of the waveguide defines a current path for a modulating signal extending in one-handed direction around the axis of propagation of the waveguide and along the length thereof.

2. A modulating device of the kind referred to, comprising a waveguide and a mass of gyromagnetic material located within the waveguide wherein the wall of the waveguide defines two current paths for a modulating signal each extending from a common point in opposite-handed directions around the waveguide and in opposite directions along the length thereof.

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