

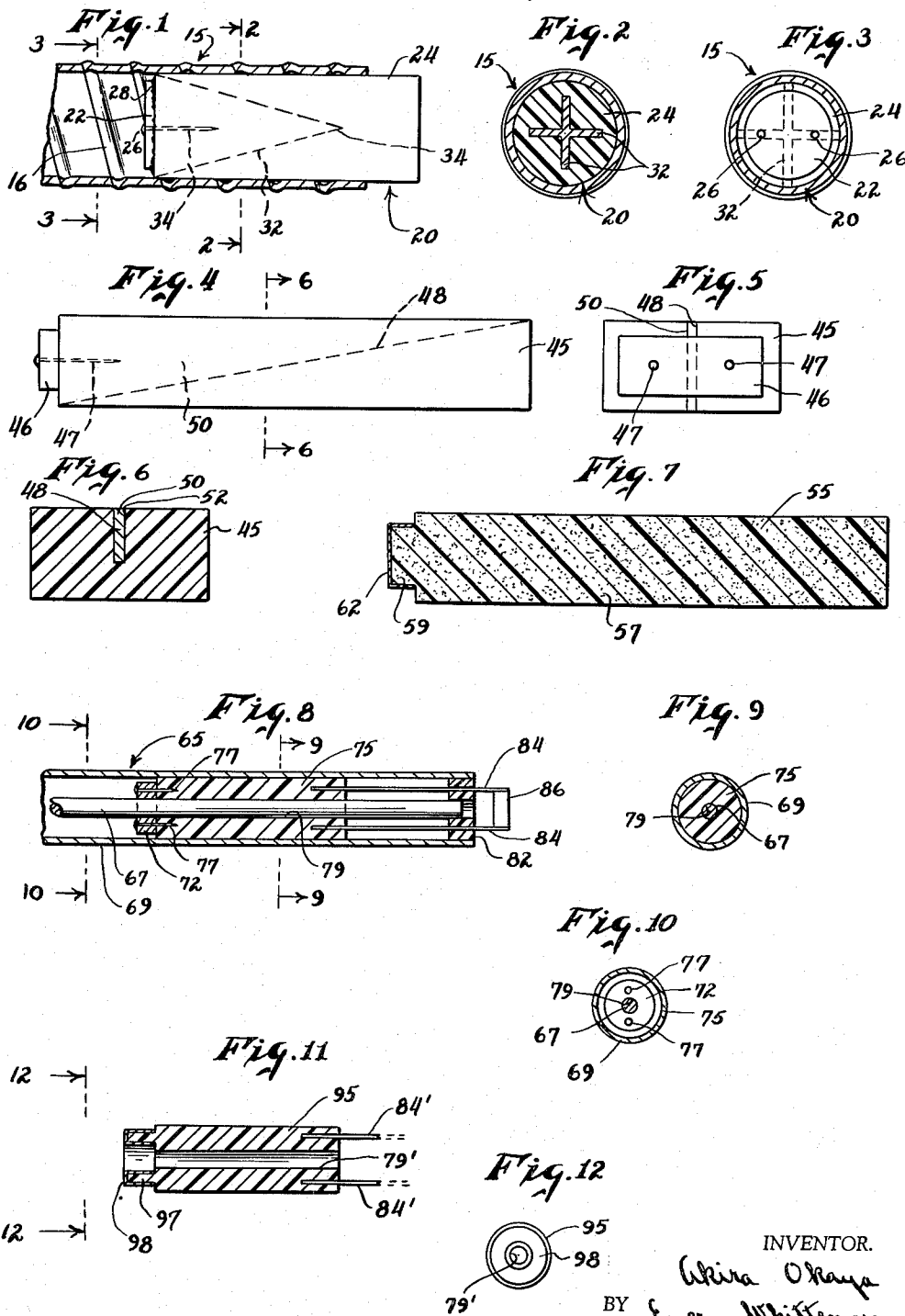
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ADJUSTABLE WAVE GUIDE REFLECTION END

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ADJUSTABLE WAVE GUIDE REFLECTION END
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This invention relates to reflector ends for wave guides, the term "wave guide" being used herein to designate also coaxial wave guide.

It is a common practice to have reflectors at the ends of wave guides, and to move the reflectors lengthwise of the guide for the purpose of tuning the wave guide.

It is an object of this invention to provide an improved reflector for use at the end of a wave guide; and more especially, it is an object of the invention to provide a reflector which can be moved easily for tuning but which prevents the escape of any radiant energy from the end of the guide. One difficulty presented by reflectors of the prior art has been that reflectors which fit loosely enough to be easily adjusted, left clearances through which radiant energy escaped. Since such energy and loose fitting are likely to raise the noise level and unstability of other electronic equipment in the vicinity, it is desirable to prevent such loose fitting and escape of energy around the edges of a reflector.

This invention combines, with a highly reflective surface, a piston-like holder for the reflective surface and includes in the piston-like holder lossy material which dissipates any energy which leaks past the reflector. The lossy material is contained in or combined with material of the holder which is transversely compressible so that the holder fits snugly in the wave guide but with low-contact friction which permits convenient axial adjustment of the holder.

The expression "lossy material" is used herein to designate material of high di-electric loss, such as carbon black, metal powder, and spattered metal.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views;

FIGURE 1 is a sectional view through a wave guide with a reflecting end made in accordance with this invention, the reflecting end being shown in elevation;

FIGURE 2 is a sectional view taken on the line 2—2 of FIGURE 1;

FIGURE 3 is an end view of the reflecting end, the wave guide being shown in section along the line 3—3 of FIGURE 1;

FIGURE 4 is a side elevation of a modified form of reflecting end made in accordance with this invention;

FIGURE 5 is an end elevation of the structure shown in FIGURE 4;

FIGURE 6 is a sectional view on the line 6—6 of FIGURE 4;

FIGURE 7 is a sectional view through another modified form of the invention;

FIGURE 8 is a sectional view showing the invention embodied in a coaxial wave guide;

FIGURES 9 and 10 are sectional views taken on the lines 9—9 and 10—10, respectively, of FIGURE 8;

FIGURE 11 is a sectional view showing another modified form of the invention for use with coaxial wave guide;

FIGURE 12 is an end elevation of the structure shown in FIGURE 11.

FIGURE 1 shows a wave guide 15 which is of circular cross section and formed with a spiral seam 16. Such wave guides are made by wrapping a preformed strip around a mandrel and the adjacent edges of successive

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convolutions are ordinarily interlocked and seamed by bending a fold of one convolution over an interlocking edge of the next convolution. The seam is commonly sealed with solder. In the construction shown there is a slight depression in the inside wall of the wave guide along the seam and this depression forms, in effect, a screw thread within the wave guide. With other methods of manufacture, a helically wound wave guide may have a projection on the inside wall along the seam, forming, in effect, a screw thread.

A reflecting end 20 is located at the end of the wave guide 15 and projects somewhat beyond the end of the wave guide. This reflecting end 20 includes a reflector 22 which may be made of brass, copper, silver, gold, or various other metals which are known to be effective for reflecting the electro-magnetic waves within a wave guide. The reflector 22 is attached to the end of a holder 24 by fastening means such as brads 26 or adhesive 28, or both.

The holder 24 has a cross section substantially equal to the inside cross section of the wave guide, and the diameter of the holder is slightly greater than the diameter of the reflector 22.

The holder 24 is a snug fit in the wave guide 15 and is preferably made of material which has some transverse compressibility so that the holder is distorted slightly to a smaller diameter when inserted into the wave guide. This eliminates clearance between the holder and the wave guide through which energy could otherwise escape between the edges of the reflector 22 and the inside wall of the wave guide.

The transverse compressibility of the holder 24 may be the result of actual compression of the material of the holder, when the holder is made of a material which is compressible; but it is not necessary that the material be actually compressible, and it is sufficient that the material be capable of flowing, that is, the holder becoming longer to compensate for the reduction in diameter. With a wave guide having a spiral seam which forms a screw thread, such as the seam 16 in FIGURE 1; the material of the holder 24 will protrude into the depressions of the seam 16 and the holder will move one way or the other upon rotation in the manner of a screw.

The same effect is obtained if a spiral of the wave guide projects inwardly from the tube wall. In such a case, the screw thread formed by the seam compresses the side of the holder 24 to a greater extent at the seam and causes the holder to screw forwardly or rearwardly upon rotation about its longitudinal axis.

If the wave guide has a smooth inside surface with the seam flush, or with no seam at all, then the holder 24 is movable back and forth in the wave guide in a manner similar to a piston in a cylinder. Where there is no thread in the wave guide, small adjustments of the holder 24, axially in the wave guide, must be made more carefully. In any event, the material of the holder 24 is preferably smooth and desirably unctuous so as to obtain a low-contact friction between the holder and the wall of the wave guide. Some plastics are suitable for the purpose if plasticized so as to obtain the necessary radiant compressibility. Some rubber formulations are also suitable if soft and at the same time smooth enough to avoid excessive friction. The preferred material for the holder 24, however, is "Teflon." This is the trade name of the Du Pont Company for polytetrafluoroethylene.

In order to dissipate energy which leaks past the reflector 22, the holder 24 must have a high di-electric loss. In the holder 24, this high di-electric loss is obtained by making the holder with a composite construction having vanes 32 imbedded in the Teflon of which the rest of the holder is constructed. The vanes 32 are located at right angles to one another and angu-

larly spaced 90° apart around the longitudinal axis of the holder 24. They have their outer edges converging to a point 34. It is unnecessary that these vanes 32 extend for the full length of the holder 24 and usually vanes shorter than the holder 24 are sufficient to absorb the radiation energy which leaks around the edge of the reflector 22.

The vanes 32 are preferably of one-piece construction with each other and form, in effect, a spike over which the Teflon is tightly fitted, when making the holder 24. The advantage of having the vanes 32 taper toward the point 34 is that such a construction permits the Teflon portion of the holder 24 to have a continuous circumferential extent along its entire length and to have a thicker uninterrupted section as the Teflon extends away from the reflector 22.

The vanes may be made of lossy material, such as a sintered semi-conductor or mixture of semi-conductor powder with a binder; also they can be made of a homogeneous metal, or glass, or plastic coated with carbon or spattered with metal, the coating being relied upon to make the vanes 32 lossy so that they dissipate radiant energy which passes around the edges of the reflector 22.

The holder 24 must be long enough to provide the adjustment necessary for tuning. At the same time, it must have sufficient length to leave an adequate bearing surface in the wave guide when the holder is pulled out to the maximum extent for tuning; and the holder should be long enough to provide a portion for gripping the holder by some mechanism which moves the holder when it is pushed in and out to the maximum extent necessary for tuning.

The axial movement for tuning is comparatively small. It is sufficient that it be one-quarter of the wave length of the waves within the guide. Ordinarily the diameter of the guide, or the wide width of a guide of rectangular cross section is somewhat less than one-half of the wave length of the electromagnetic waves in the open. There is, therefore, some correlation between the length of the holder 24 and the diameter or width of the holder, but this correlation provides for a certain range of choice and in the preferred construction of the invention the length of the holder 24 is greater than one-half the diameter of the holder, or one-half the wide width when the holder is of rectangular cross section, and less than twenty times the diameter or wide width.

FIGURE 4 shows a modified form of the invention in which a holder 45 is made of transversely compressible material, preferably Teflon, and a reflector 46 is connected to the end of the holder 45 by fastening means 47. This holder 45 has a slot 48 in its top surface, and a fin 50 fits into the slot 48. The slot and fin are tapered to a progressively smaller height toward the rearward end of the holder 45.

The holder 45 is of rectangular cross section for use with wave guides of similar shape. The fin 50 may be made of the same material as the vanes 32. The advantage of the construction shown in FIGURE 4 is that the holder 45 can be made of bar stock with the slot 48 cut in the stock by machinery, which has the advantage of simplicity in manufacture. However, the construction shown in FIGURES 4-6 is not as strong as that shown in FIGURES 1-3, but the strength can be increased by using an adhesive 52 which bonds the sides of the slot 48 to the surface of the fin 50.

FIGURE 7 shows another modified form of the invention. In this construction, a holder 55 is made of material, such as Teflon or other material having the necessary transverse compressibility and smooth surface, and particles of carbon or metallic or semiconductor powder 57 are distributed throughout the mass of the holder 55 so as to produce a non-homogeneous mass which is a lossy material. No vanes or fins are necessary in the

holder 55. A reflector can be connected to the end of the holder 55; but in the modified construction illustrated, the holder 55 has an end portion 59 of slightly reduced diameter and a layer of metal 62 is plated or painted or sputtered on the surface of the end portion 59. Also metal 62 can be made by a press-formed thin metal plate which is tightly fitted to the head of holder 55. These expedients can, of course, be also used on the holders 24 and 45 shown in the other views.

FIGURES 8-10 show another modified form of the invention in which the wave guide is a coaxial wave guide 65. The wave guide 65 has a center conductor 67 extending along the axis of the wave guide, and has a sheath 69 forming the wall of the wave guide. An annular reflector 72 is located in the space between the conductor 67 and the sheath 69. This reflector 72 is connected to the end of a holder 75 by fastening means 77.

The holder 75 fits within the sheath 69 and is movable axially within the sheath in the same manner as the holder 24 is movable in the wave guide 15 of FIGURE 1. The holder 75 of FIGURES 8-10 has an axial opening 79 which fits snugly around the conductor 67 with some transverse compression of the Teflon, or other material of the holder 75 by the conductor 67. The reflector 72 has an inside opening of a diameter slightly greater than the diameter of the conductor 67, and an outside diameter somewhat less than the inside diameter of the sheath 69.

In the construction illustrated, the conductor 67 is provided with an annular end wall 82 which holds the conductor 67 axially located with respect to the sheath 69.

Since the annular section of the holder 75 can not project past the end wall 82, the holder 75 is made with rods 84 extending through holes in the end wall 82 to a handle 86 by which the holder is moved axially to tune the wave guide.

A screw type adjustment such as shown in FIG. 1 can be applied to a coaxial waveguide case and for fastening the center conductor in place.

The holder 75 is preferably made of Teflon molded with powdered carbon or metal as in the construction shown in FIGURE 7, or a Teflon piece and lossy vanes as shown in FIGURES 4 and 5.

Another modified form of the invention is shown in FIGURES 11 and 12. These figures show a holder 95 similar to the holder shown in FIGURES 8-10, except that the front end of the holder 95 is formed with an end portion 97 on which reflecting metal 98 is made by the same method as used for the plate 62. This end portion 97, with the metal 98, takes the place of the reflector 72 shown in FIGURES 8-10. Parts of the holder 95, shown in FIGURES 11 and 12, which correspond to the holder 75 of FIGURES 8-10, are designated by the same reference characters but with a prime appended.

It will be understood that various constructions which have been illustrated are suitable for use with either rectangular or round wave guides, though some modifications may be necessary where the holder is required to have an annular opening for use with a coaxial wave guide. Different combinations can be made and further modifications of the illustrated constructions can be made without departing from the invention as defined in the claims.

What is claimed is:

1. Apparatus for reflecting electromagnetic radiation including a tubular wave guide, a reflector in the wave guide near one end thereof and having an area that covers most of the cross section of the interior of the wave guide with small clearance between the reflector and the side wall of the wave guide to minimize energy losses around the periphery of the reflector, and a holder for the reflector, the holder extending from the reflector for a distance several times the diameter or wide width of the wave guide, said holder being made of transversely compressible material over its entire length of contact

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with the wave guide and for most of the cross section of the holder, and having an undistorted cross section slightly greater than that of the interior of the wave guide whereby the portion of the holder within the wave guide is slightly compressed and contacts with the inside surface of the wave guide, said holder having lossy material therein for absorbing energy that leaks through any clearance between the reflector and the side wall of the wave guide.

2. The apparatus described in claim 1, and in which the wave guide is circular and made with a wall consisting of a helically wound strip with successive convolutions joined along a helical seam, the wall of the wave guide having a different radius at the seam from that between convolutions of the seam so that the seam forms a thread within the wave guide, the holder in the wave guide having sufficient resilience to accommodate itself to the shape of the inside surface of the wall and thus operate as a screw when rotated in the same guide.

3. The apparatus described in claim 1, and in which the holder has a smooth surface in contact with the wall of the wave guide to reduce the friction of the holder and facilitate axial movement of the holder and the reflector carried by the holder.

4. The apparatus described in claim 3 and in which the holder is made of polytetrafluoroethylene.

5. The apparatus described in claim 1, and in which the lossy material is on a plate embedded in the holder.

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6. The apparatus described in claim 5, and in which the plate has surfaces that progressively change in cross section as they extend away from the reflector end of the holder.

7. The apparatus described in claim 1, and in which the length of the holder is greater than one half the maximum width of the wave guide but less than 20 times said maximum width.

8. The apparatus described in claim 1, and in which the lossy material is dispersed substantially uniformly through the other material of the holder.

References Cited in the file of this patent

UNITED STATES PATENTS

2,438,912	Hansen	Apr. 6, 1948
2,692,977	Koppel	Oct. 26, 1954
2,701,861	Andrews	Feb. 8, 1955
2,828,469	Martinelli	Mar. 25, 1958

FOREIGN PATENTS

663,233	Great Britain	Dec. 19, 1951
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OTHER REFERENCES

Montgomery: Vol. 11, MIT Radiation Laboratory Series, McGraw-Hill Book Co., New York, copyright December 18, 1957 (pages 706-707 relied upon).

Du Pont: "The Teflon Story," Du Pont Plastics Bulletin, vol. 12, 1950.