Jan. 13, 1959 W. L. PRITCHARD ET AL 2,869,085

SELECTIVE ABSORBERS

Filed Jan. 19, 1954 2 Sheets-Sheet 1

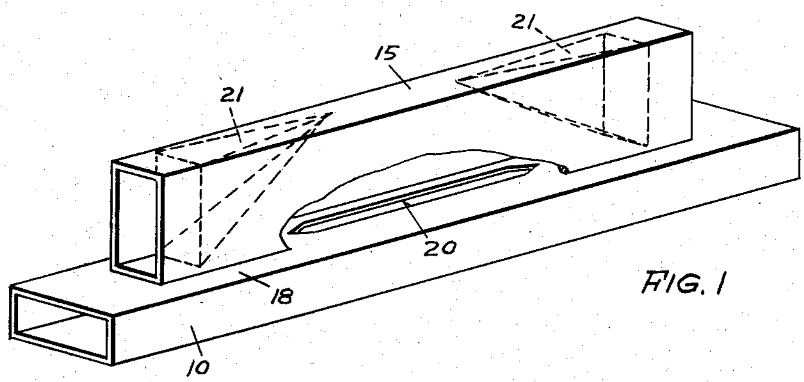

FIG. 1

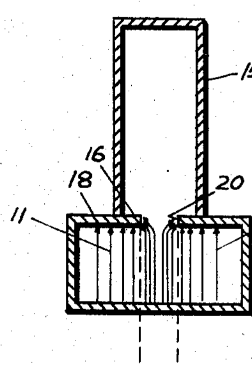

FIG. 2

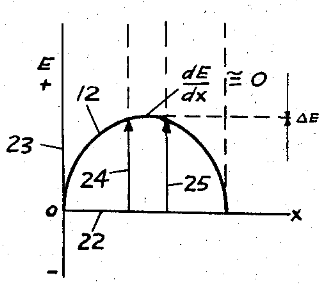

FIG. 3

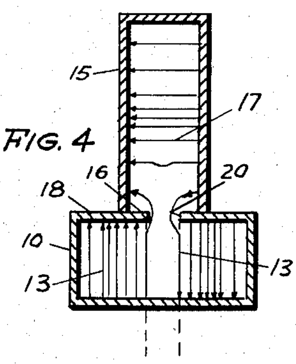

FIG. 4

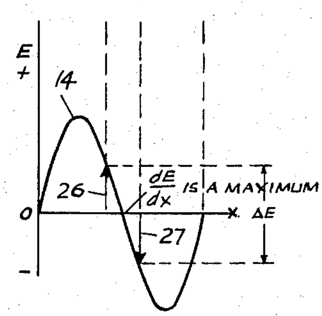

FIG. 5

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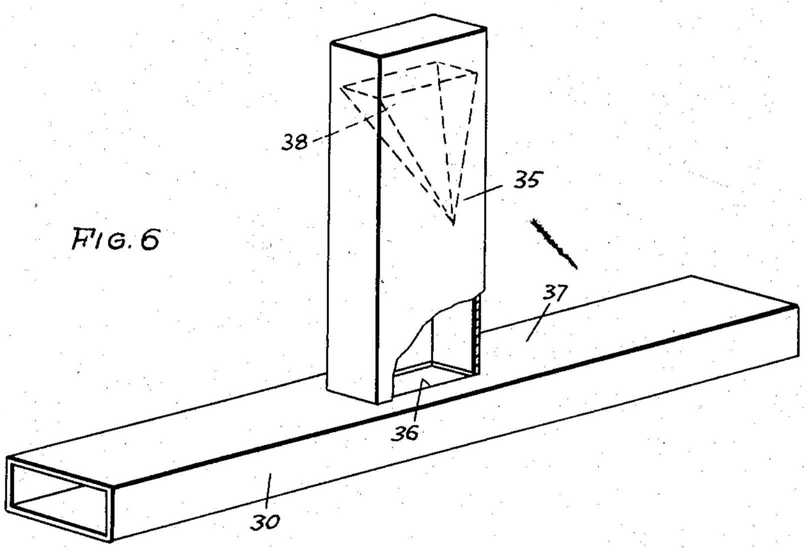
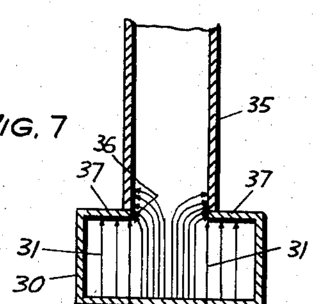


FIG. 6

FIG. 7



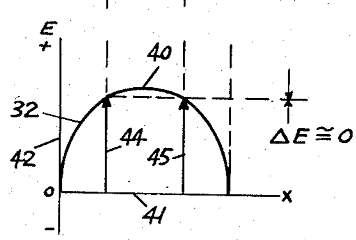
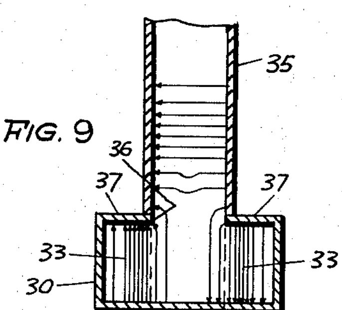


FIG. 8

FIG. 9



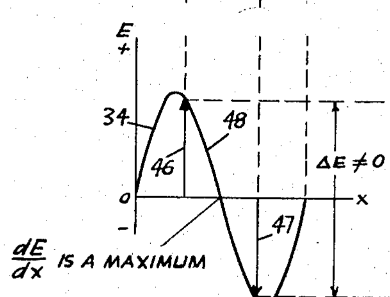


FIG. 10

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2 Claims. (Cl. 333—98)

This invention relates to means for absorbing radio frequency energy at a certain frequency propagating at a higher mode than the desired mode while permitting this energy to be propagated along a transmission line in the lower mode.

When it is required to transmit radio frequency energy through a wave guide or other transmission line over considerable distances, it is frequently desirable to use a size of guide that is larger than required for the wave length of the energy to be propagated in order to take advantage of the lower attenuation of the larger wave guide. However, it is possible, if the larger wave guide is sufficiently large, for energy at the desired frequency to be propagated in the larger wave guide in the next higher mode, such as the TE_{20} mode. Energy in this higher mode can be generated by the presence of a discontinuity in the wave guide, such as a bend in the H plane of the wave guide. Under certain conditions, the line may become resonant to energy propagated at this higher mode and build up sufficient voltage to break down. This is particularly likely to happen if the larger guide is joined to the smaller guide at both ends, in which case the energy generated at the higher mode in the larger guide cannot be propagated in the sections of smaller guide and is reflected from the junction points to build up in the larger guide. Consequently, it is desirable to absorb any energy generated in the larger guide in the higher mode without appreciably attenuating the energy at the lower mode. This is accomplished in the present invention by coupling an auxiliary wave guide so dimensioned as to propagate energy at the desired frequency in the TE_{10} mode and so connected to the main guide as to permit only energy propagating in the main guide in the TE_{20} mode to be coupled into the auxiliary guide. Resistive terminations in the auxiliary wave guide absorb the energy propagating in it. In one embodiment, the auxiliary wave guide is mounted with its axis parallel to that of the main guide and coupled to it through an opening in the wall of the main guide. In another embodiment the axis of the auxiliary guide is perpendicular to that of the main guide.

Other and further advantages of this invention will be apparent as the description thereof proceeds, reference being had to the accompanying drawings wherein:

Fig. 1 is a schematic diagram of one embodiment of the invention;

Fig. 2 is a transverse section of the embodiment shown in Fig. 1 showing the electrical vectors of the TE_{10} mode;

Fig. 3 is a graph of the variation of voltage with distance across the guide for the TE_{10} mode;

Fig. 4 is a transverse section of the embodiment shown in Fig. 1 showing the electrical vectors of the TE_{20} mode;

Fig. 5 is a graph of the variation of voltage with distance across the guide for the TE_{20} mode;

Fig. 6 is a schematic diagram of a second embodiment of the invention;

Fig. 7 is a transverse section of the embodiment shown in Fig. 6 showing the electrical vectors of the TE_{10} mode;

Fig. 8 is a graph of the variation of voltage with distance across the guide for the TE_{10} mode;

Fig. 9 is a transverse section of the embodiment shown in Fig. 6 showing the electrical vectors of the TE_{20} mode; and

Fig. 10 is a graph of the variation of voltage with distance across the guide for the TE_{20} mode.

In Fig. 1, the reference numeral **10** designates a section of wave guide dimensioned so that energy at the desired frequency can be propagated along it in either the TE_{10} or the TE_{20} mode. The energy propagated in the TE_{10} mode has a single maximum of the electrical vector, as shown by the concentration of the arrows **11** representing the electrical vectors in Fig. 2 and the single maximum of the graph **12** in Fig. 3 representing voltage distribution across the guide. Any energy propagated in the TE_{20} mode has two maxima of the electrical vectors, as shown by the two regions of concentration of the arrows **13** representing the electrical vectors in Fig. 4 and the two maxima of the graph **14** in Fig. 5 representing voltage distribution across the guide.

An auxiliary section of wave guide **15** is mounted with its axis parallel to that of the main guide **10**. The guide **15** is dimensioned so as to propagate energy at the operating frequency in the TE_{10} mode only. A wall **16** of this guide parallel to the electrical vector of energy propagated in this manner, as indicated by the arrows **17** in Fig. 4, is in common with a wall **18** of the guide **10** and is perpendicular to the electrical vector of energy propagated in the guide **10**, as indicated by the arrows **13**. A slot **20** is formed in this common wall **16**. The auxiliary guide **15** is terminated at each end by a block **21** of lossy dielectric material.

In operation, energy at the operating frequency propagated along the wave guide **10** in the TE_{10} mode produces a voltage maximum at the slot **20**, as indicated by the greater concentration of the arrows **11** in this region. The voltage maximum is shown by the graph **12** in which the distance along the horizontal axis **22** represents the distance across the guide, and the distance along the vertical axis **23** represents the amplitude of the voltage at different points across the wave guide **10**. The amplitudes of the two vectors at the edges of the slot **20** are represented by the arrows **24** and **25**. It will be seen that there is little change in voltage in the region of the slot, that is

$$\frac{dE}{dx}\cong 0 \text{ and } \Delta E\cong 0$$

Consequently, little or no energy is propagated in this mode through the slot **20** into the guide **15**.

However, in the case of energy at the operating frequency propagated in guide **10** in the TE_{20} mode, as shown by the arrows **13** shown in Fig. 4, the vectors are in opposite phase on opposite sides of the slot **20**, as shown by the arrows **26** and **27**, and the voltage varies rapidly in this region, as shown by the graph **14** which has its maximum slope

$$\frac{dE}{dx}$$

in this region and its maximum difference, ΔE, in the same region. The result is that considerable energy propagating in the TE_{20} mode in the main guide **10** is coupled through the slot **20** to the auxiliary guide **15** where it is propagated in the TE_{10} mode, as shown by the arrows **17**. This energy is propagated in both directions towards the ends of the guide **15**, where it is absorbed by the blocks **21** of lossy dielectric material. Thus any energy developed in the main guide at the harmonic of the desired frequency is coupled into the auxiliary guide and dissipated without appreciable loss of energy propagating in the useful TE_{10} mode.

A second embodiment is illustrated in Figs. 6 through 9. In this embodiment, reference numeral **30** designates a section of wave guide dimensioned so that energy at the desired frequency can be propagated along the guide in the TE_{10} and TE_{20} modes. The energy propagated in the TE_{10} mode, as shown by the arrows **31** in Fig. 7 representing the electrical vectors, reaches a maximum at the center of the guide **30**, as shown by the graph **32** in Fig. 8.

Any energy at the operating frequency propagated in the TE_{20} or higher modes, as shown by the arrows **33** in Fig. 9, reaches two maxima of opposite polarity, as shown by the graph **34** of Fig. 10.

An auxiliary section of wave guide **35** is mounted with its axis perpendicular to that of the main guide **30**. The guide **35** is dimensioned to propagate the energy at the desired frequency in the TE_{10} mode. The guide **35** is joined to the guide **30** at an opening **36** in a wall **37** of the guide **30** that is perpendicular to the electrical vector **33**. The guide **35** is also terminated by a block of lossy dielectric material **38**.

In operation, energy at the operating frequency propagated along the wave guide **30** in the TE_{10} mode produces a voltage maximum at the opening **36**, as indicated by the greater concentration of the arrows **31** in this region. The voltage maximum is shown by the region **40** on the graph **32** in which the distance x along the horizontal axis **41** represents the distance across the guide, and the distance along the vertical axis **42** represents the amplitude of the voltage at different points across the wave guide **30**. The amplitude of the two vectors at the edges of the opening **36** are represented by the arrows **44** and **45**. It will be seen that there is little change in voltage in the region of the opening that is,

$$\frac{dE}{dx}\cong 0 \text{ and } \Delta E\cong 0$$

Consequently, little or no energy propagating in this mode in guide **30** is coupled through the opening **36** into the guide **35**.

However, as before, the energy at the operating frequency propagating in guide **30** in the TE_{20} mode, as shown by the arrows **33** in Fig. 9, has its electrical vectors in opposite phase on opposite sides of the opening **36**, as shown by the arrows **46** and **47**, and the voltage varies rapidly in this region **48**, as shown by the graph **34** in Fig. 10 which has its maximum slope

$$\frac{dE}{dx}$$

in this region and its maximum difference in voltage ΔE across the opening **36**. The result is that considerable energy at the operating frequency propagating in the main guide **30** in the TE_{20} mode is coupled through the slot **20** to the auxiliary guide **35** where it is propagated in the TE_{10} mode, as shown by the arrows **50** toward the end of the guide **35** where it is absorbed by a block **38**. Thus, as before, any energy propagating in the main guide in the TE_{20} mode is coupled into the auxiliary guide **35** and dissipated without appreciable loss of energy at the operating frequency propagating in the main guide **30** in the useful TE_{10} mode. The embodiments shown disclose the use of rectangular wave guide in carrying out the invention. However, other forms of transmission line, such as coaxial cable and circular wave guide, can also be used.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is, accordingly, desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. In a selective absorber for radio frequency energy, the combination of a section of wave guide of uniform cross section dimensioned to propagate energy at a desired frequency in a first mode and a second mode, a second section of a wave guide dimensioned to propagate radio frequency energy at the desired frequency in the first mode but not in the second mode, and means to couple energy propagated in the first section of wave guide in the second mode but not that propagated in the first mode from the first section of wave guide into the second section of wave guide comprising a wall common to both wave guides and perpendicular to the electrical vector of energy propagating in the first wave guide and parallel to the electrical vector of energy propagated in said second wave guide, and a slot formed in this common wall.

2. In a selective absorber for radio frequency energy, the combination of a section of wave guide of uniform cross section dimensioned to propagate energy at a desired frequency in a first mode, a second section of wave guide dimensioned to propagate radio frequency energy at the desired frequency in the first mode, but not in the second mode, said second section of wave guide being terminated with lossy material, and means to couple energy propagated in the first section of wave guide in the second mode but not that propagated in the first mode from the first section of wave guide into the second section of wave guide comprising a wall common to both wave guides and perpendicular to the electrical vector of energy propagating in the first wave guide and parallel to the electrical vector of energy propagating in said second wave guide, and a slot formed in said common wall.

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