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PHASE SHIFTING DEVICE

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FIG. 1

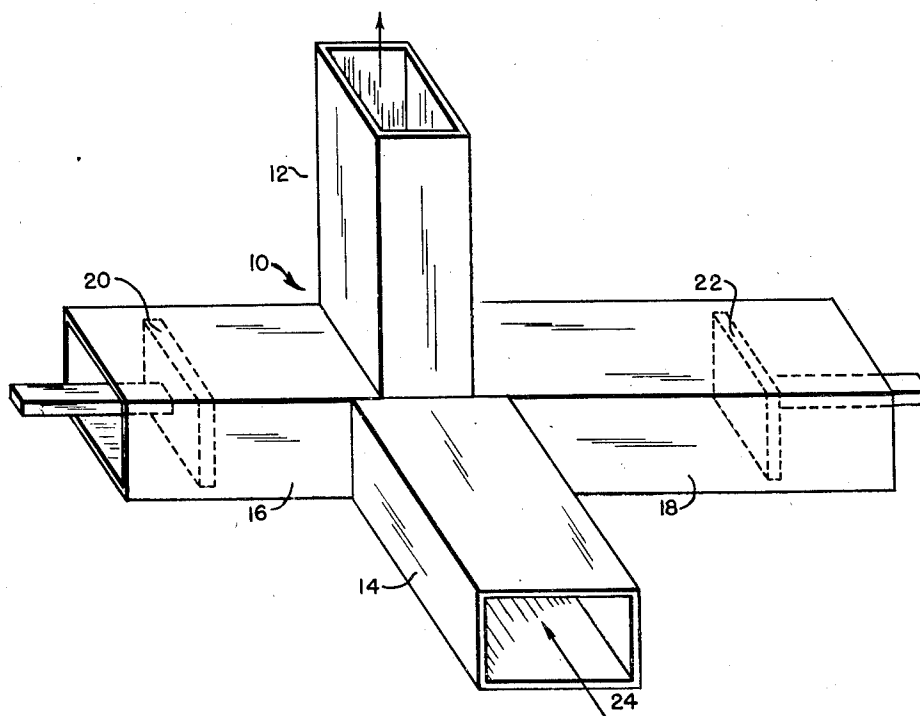
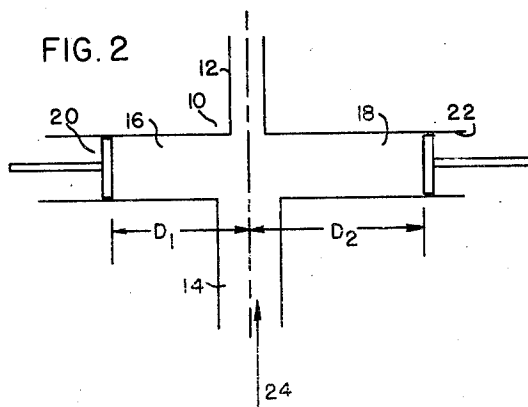


FIG. 2



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PHASE SHIFTING DEVICE

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This application relates to electrical circuit components and more particularly to devices for producing a phase shift in signals in the ultra-high and microwave frequency regions.

In radio and electronic devices, or systems, in which the frequency of oscillation of the energy involved is in the ultra-high or microwave regions, sections of open wire transmission line, coaxial line, or wave guide are often used as inductors, capacitors, transformers, etc. For example, short-circuited or open-circuited sections of transmission line or wave guide may be used as inductive or capacitive reactance components. To produce a desired amount of phase shift in any circuit, there may be inserted in the circuit a section of line, the electrical length of which may be varied. Such a section of line is commonly known as a line stretcher. In radio frequency systems which employ wave guides, line stretchers used heretofore have included U-shaped sections of line cumbersome in size and operation, and utilizing sliding contacts which often prove unsatisfactory.

It is an object of the present invention, therefore, to provide a unique phase shifting device or line stretcher which may be used in radio frequency systems employing wave guides.

It is a further object of the present invention to provide a unique phase shifting device in which the phase shift introduced may be easily adjusted.

For a better understanding of the invention together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing in which:

Fig. 1 is an isometric view of the preferred embodiment of the present invention; and

Fig. 2 is a schematic illustration of the embodiment shown in Fig. 1.

Referring now to the drawing and more particularly to Fig. 1 thereof, there is shown a wave guide assembly here termed a magic-T, denoted generally by 10, comprising arms 12, 14, 16 and 18. The arms 12, 14, 16 and 18 are sections of rectangular wave guide designed to propagate the desired signal, operating preferably in the dominant mode. The arms 16 and 18 are preferably co-linear and the arms 12 and 14 are joined to arms 16 and 18 at right angles. The longitudinal axis of the component wave guides intersect at a common point, hereinafter termed the electrical center of the magic-T. The arm 12 is joined to the arms 16 and 18 in what is commonly called a series connection. The arm 14 is joined

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to the arms 16 and 18 in what is commonly known as a parallel connection.

The magic-T has several unique properties or characteristics which include:

5 (1) If arms 16 and 18 are terminated in their characteristic impedances and a signal is supplied to the arm 14, energy will be present in arms 16 and 18 in equal magnitude and in phase at points equidistant from the center of the magic-T. No energy will be present in arm 12.

10 (2) If energy of equal magnitude and in phase is supplied to arms 16 and 18, energy will be present in arm 14. No energy will be present in arm 12.

15 (3) If the arms 16 and 18 are terminated in their characteristic impedances and energy is supplied to arm 12, energy will be present in the arms 16 and 18 in equal magnitude and out of phase at points equidistant from the center of the magic-T. No energy will be present in arm 14.

20 (4) If energy of equal magnitude and in 180° phase opposition is supplied to arms 16 and 18, energy will be present in arm 12. No energy will be present in arm 14.

25 (5) If energy enters either arm 16 or 18, energy will be present in arms 12 and 14, but no energy will be present in the remaining arm 18 or 16.

Any four-terminal network which exhibits the properties 1 through 5, listed above, may be termed a magic-T. For example, a section of circular wave guide designed to operate in the dominant mode, having two coupling terminals physically displaced 90° about the periphery of the wave guide at one position along the axis thereof, and having two more coupling terminals physically displaced 90° from each other at a second position along the axis of the wave guide and respectively displaced 45° from the first two coupling terminals, possesses the unique properties listed above and is therefore another embodiment of a magic-T.

Referring again to Fig. 1, mounted for axial movement within arms 16 and 18 of the magic-T 10 are plungers 20 and 22, respectively, which effectively provide short circuit terminations for the arms 16 and 18. Certain mechanical structure and refinements, well known in the art, may be provided in the magic-T shown in Fig. 1 to adapt it for association with a wave guide transmission line and to produce displacement of plungers 20 and 22 in a manner to be described. Fig. 1 illustrates an embodiment of the basic structure of the invention, and the manner in which it operates as a line stretcher will become

apparent from the description of Fig. 2 which follows.

In Fig. 2 there is shown schematically the magic-T 10 of Fig. 1, in which the arms 16 and 18 contain the shorting plungers 20 and 22. The plungers 20 and 22 are at electrical distances D_1 and D_2 , respectively, from the center of the magic-T 10. The distances D_1 and D_2 are variable, as will appear, but at all times differ by an odd number of quarter-wavelengths. The arms 12 and 14 are to be considered connected in series with the radio frequency line in which it is desired to provide a phase shift or line stretcher. It will be assumed the magic-T is so connected into the radio frequency line that energy enters the arm 14 as indicated by arrow 24. This energy divides equally and in phase into the arms 16 and 18. The energy in the arms 16 and 18 undergoes complete reflection at the short circuits provided by the plungers 20 and 22. However, it will be noted that the energy travels different distances in the two arms 16 and 18. In arm 18, for example, if D_2 is greater than D_1 by an amount equal to one-quarter wavelength, the energy travels one-half wavelength farther than the energy in the shorter arm 16. The energy which reaches the electrical center of the magic-T 10 after having been returned from the short circuits 20 and 22 will therefore arrive in 180° phase opposition. Referring to the characteristic of the magic-T set forth in (4) above, it will be seen that all of the energy reflected from the plungers 20 and 22 will pass into the arm 12 and none will return into the arm 14.

The distances D_1 and D_2 may be increased or decreased by equal amounts, to change the effective electrical lengths of the paths from a given point in the arm 14 to a given point in the arm 12 while maintaining a constant difference (an odd number of quarter-wavelengths) between these lengths. The phase shift in degrees thus introduced is equal to this increase or decrease, multiplied by 360, and divided by the wavelength as measured within the wave guide. The magic-T structure may include suitable mechanism (not shown) to move the plungers equal distances toward or away from the center of the magic-T 10, this mechanism may be calibrated to indicate the length of line or amount of phase shift introduced between two given points in the arms 12 and 14.

It will be realized by those skilled in the art that various refinements in the structure as illustrated in Fig. 1 of the drawing are contemplated. Such refinements have been here omitted for the sake of simplicity. For example, no matching devices have been shown for terminating the wave guide arms 12 and 14 in their characteristic impedances at their junctions with the remaining arms 16 and 18. Such matching devices, and the improved performance of structures in which they are utilized, are well known in the art. Similarly, it may be desirable to utilize some form of choke joint, many of which are well known in the art, between the plungers and the walls of the wave guide, rather than simply a sliding contact as has been illustrated. Arms 12 and 14 may be associated with a wave guide transmission line in any desired manner, for example by means of wave guide elbows and choke joint coupling flanges, or by other means well known in the art.

Although the preferred embodiment of the magic-T 10 is as shown in Fig. 1, there are many

physical forms which a magic-T may take, and the invention is, therefore, not limited to the use of the specific type magic-T shown.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention.

What is claimed is:

1. An apparatus for providing a predetermined amount of phase shift in a radio frequency signal passing therethrough, comprising a magic-T having sections of wave guide intersecting to form first, second, third and fourth arms, short-circuit termination means within said third and fourth arms, said termination means being so positioned along said third and fourth arms that all of the signal entering said first arm is transferred to said second arm, and means for causing equal displacement of said termination means relative to the electrical center of said magic-T, whereby an input signal applied to said first arm causes an output signal in said second arm, said output signal being shifted in phase relative to said input signal by an amount determined by said displacement.

2. An apparatus for providing a predetermined amount of phase shift in a radio frequency signal passing therethrough, comprising a magic-T having a first arm, a second arm, a third arm, a fourth arm, first and second non-dissipating impedance terminations within said third and fourth arms, said first and second terminations being so located with respect to the electrical center of said magic-T that all of the signal entering said first arm is transferred to said second arm, and means for causing equal displacement of said terminations relative to the electrical center of said magic-T, whereby an input signal applied to said first arm causes an output signal in said second arm, said output signal being shifted in phase relative to said input signal by an amount determined by said displacement.

3. An apparatus for providing a predetermined amount of phase shift in a radio frequency signal passing therethrough comprising a magic-T having sections of wave guide intersecting to form first, second, third and fourth arms, said third and fourth arms being colinear, short circuit termination means within said third and fourth arms, the distance between the electrical center of said magic-T and said termination means in said third arm differing by an odd number of quarter-wavelengths from the distance between the electrical center of said magic-T and said terminating means in said fourth arm, whereby an input signal in said first arm causes an output signal in said second arm to be shifted in phase relative to said input signal by an amount determined by the distance of the said terminations from said electrical center.

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