Oct. 6, 1959 S. D. ROBERTSON 2,907,959

FINLINE PHASE SHIFTER

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FIG. 1

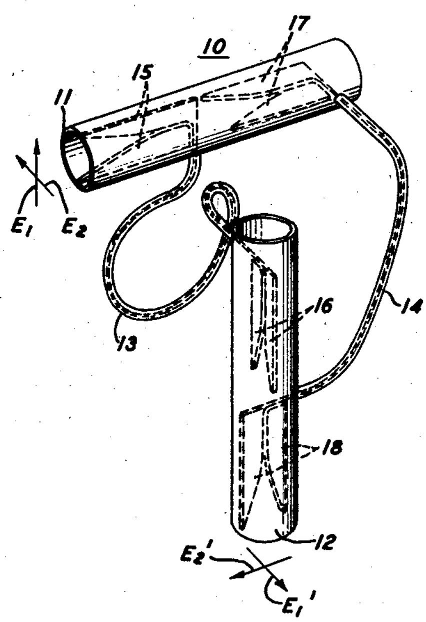

FIG. 1A

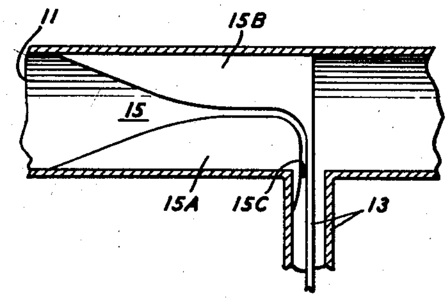

FIG. 2

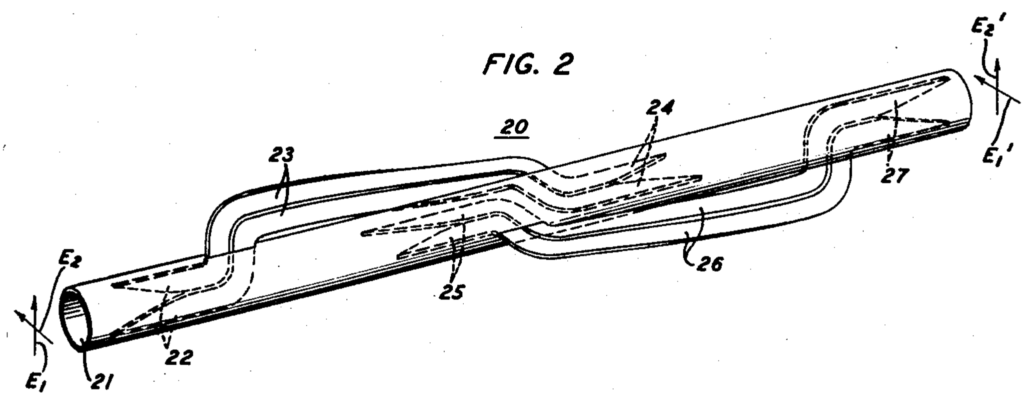

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FIG. 3

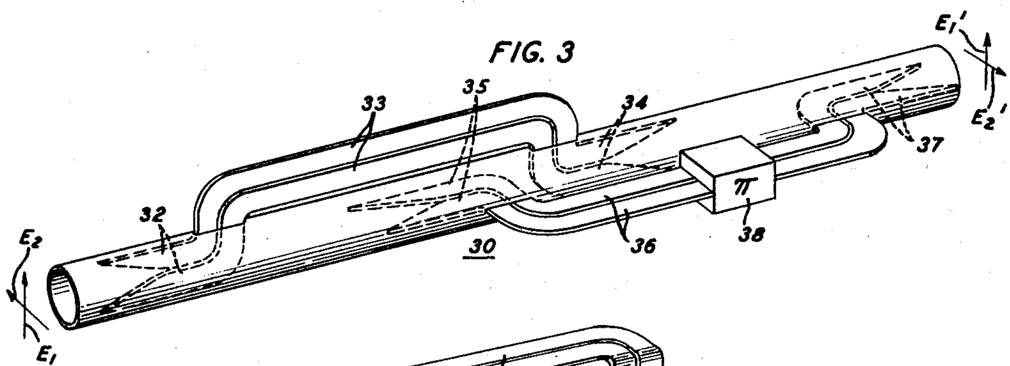

FIG. 3A

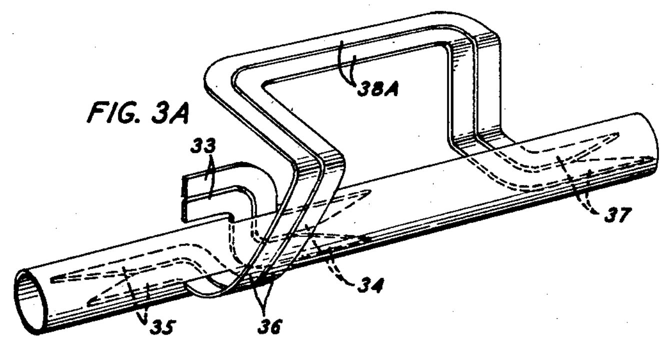

FIG. 3B

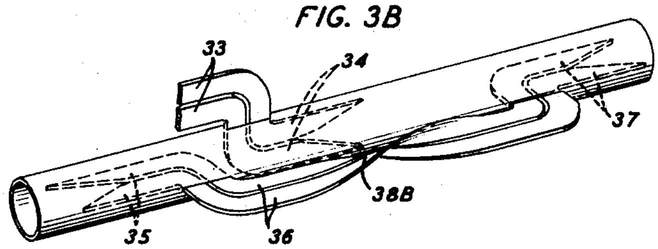

FIG. 3C

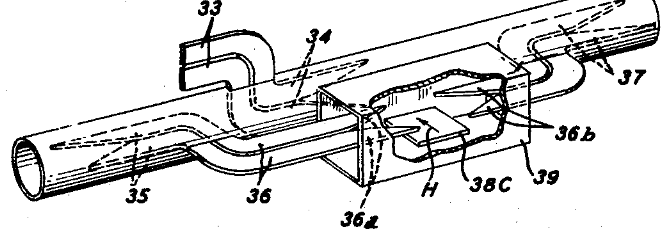

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FIG. 5

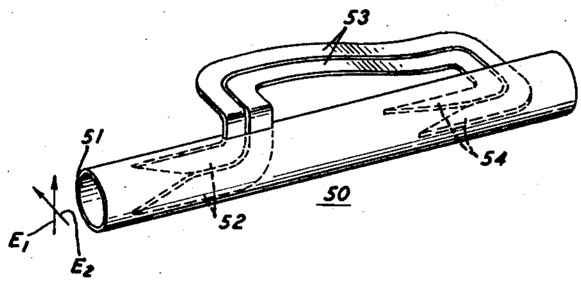


FIG. 4

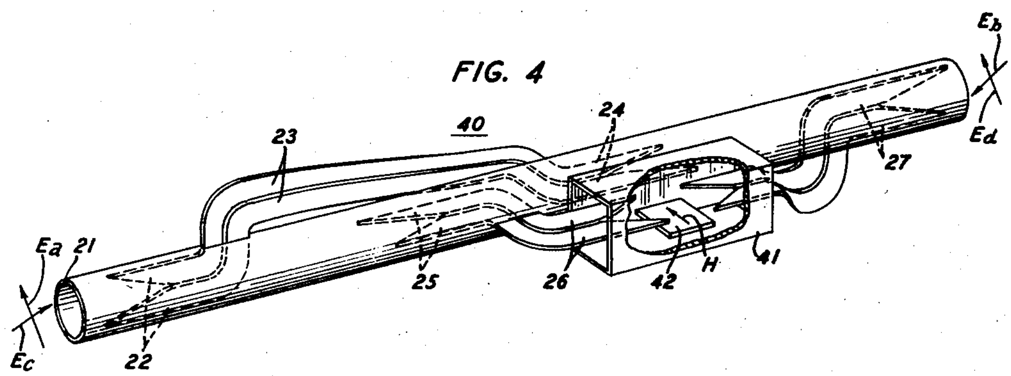


FIG. 6

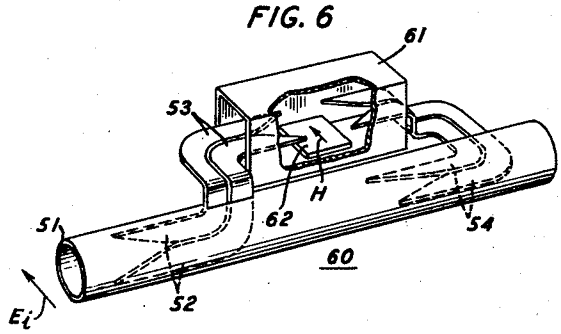
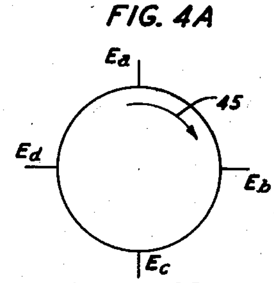


FIG. 4A



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2,907,959

FINLINE PHASE SHIFTER

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Application May 21, 1956, Serial No. 586,103

18 Claims. (Cl. 333—33)

This application is a continuation-in-part of my copending application Serial No. 485,671 filed February 2, 1955, and this invention relates to coupling arrangements for use in signal wave transmission, and more particularly to such coupling arrangements of the so-called differential phase shift variety.

A signal wave propagating along a transmission path, such as a circular hollow wave guide, may be viewed as comprising two mutually perpendicular components, for example a vertical and a horizontal component. Various techniques have been proposed for shifting the phase of one of these components with respect to the other, for certain well known purposes to be discussed hereinafter. Coupling arrangements for achieving this have been called differential phase shifters or delta sections. The most useful phase shifters of this type are those which introduce a phase difference of 90 degrees or 180 degrees, so-called delta 90 degree or delta 180 degree sections.

The differential phase shifters proposed heretofore operate to separate the two components of a wave so that they propagate for a time along different paths. Then they are recombined. The electrical lengths (i.e., the distances measured in radians of the propagating wave) of the two paths are adjusted to be different so that, at recombination, one component of the wave is retarded with respect to the other. Disadvantageously, the phase shifters proposed heretofore are not broad band devices since the electrical lengths of their two wave paths vary differently with frequency. Hence the difference in their electrical lengths cannot readily be maintained constant as the frequency varies.

Accordingly, a principal object of the present invention is to achieve a broad band differential phase shifter.

A further object is to provide a differential phase shifter that is flexible in nature and so can be readily adapted for a wide variety of circuit applications.

In accordance with the present invention, there is provided a differential phase shifting arrangement which comprises a first pair of finlines which are disposed in mutually perpendicular planes along one region of the signal wave path, a second pair of finlines which are also disposed in mutually perpendicular planes along a different region of the signal wave path, and a pair of waveguiding members whose electrical lengths differ by a predetermined amount, the difference being achieved in a manner which is independent of frequency, each interconnecting one finline of the first pair with a finline of the second pair. Each of the finlines comprises two thin coplanar conductive fins having thicknesses no more than several percent of a wavelength at the cut-off frequency of the wave guide. The two fins of each finline are spaced apart along their entire length and the space between them forms a wave path bounded by their opposing edges. The transverse dimension of the path thus formed is extremely small over the central portion of its length and is tapered at least at one end for matching the characteristic impedance of that central portion to the characteristic impedance of the hollow wave guide. Finlines of this type are also disclosed in a copending application Serial No. 485,672 of H. T. Friis and S. D. Robertson, filed February 2, 1955.

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Differential phase shifters have been proposed heretofore employing a single finline, rather than one or more pairs of finlines, but such phase shifters have not been broad band devices. Such phase shifters provide two paths of different electrical lengths for the two mutually perpendicular components of a wave. But the electrical lengths of those two paths vary differently with changes in frequency, and so it is difficult to maintain the difference in their lengths constant over a broad frequency band. Moreover, couplers using only one finline are not characterized by the flexibility that is exhibited by the differential phase shifters of the present invention.

In one embodiment, the present invention comprises first and second sections of hollow conductive wave guide, a pair of finlines extending along mutually perpendicular axial planes within each of the wave guides, and a pair of waveguiding members each interconnecting one finline of the first wave guide section with one finline of the second wave guide section. There is thus formed a separate continuous wave path between the two wave guide sections for each of two mutually perpendicular components of a wave propagating along the first section of wave guide. Any desired difference in phase shift between the two components can be achieved by adjusting the two wave paths to have different electrical lengths.

In the preferred embodiment of the invention, the two wave paths provided are similar physically except that in one there is introduced a phase shift that is independent of frequency, such as is achieved by interchanging the two elements of a parallel pair transmission line. Hence the electrical lengths of the two paths vary with frequency in the same fashion and so the difference in their electrical lengths remains constant over a wide frequency band.

The invention will be explained in greater detail in the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a perspective view of one embodiment of the present invention forming a differential phase shifter between two separate sections of hollow wave guide;

Fig. 1A is a longitudinal sectional view of a finline coupling element of the type used in the differential phase shifter of Fig. 1;

Fig. 2 is a perspective view of a second embodiment of the present invention forming a differential phase shifter in a straight through wave guide;

Figs. 3, 3A, 3B, and 3C are modifications of the differential phase shifter of Fig. 2;

Fig. 4 is a further modification of the differential phase shifter of Fig. 2, for use as a circulator;

Fig. 4A is a schematic representation of a circulator shown for purposes of explanation; and

Figs. 5 and 6 show examples of a third embodiment of the present invention forming reflex-type differential phase shifters.

Referring now more particularly to the various figures of the drawing, Fig. 1 discloses a differential phase shifter **10** comprising first and second sections **11** and **12** of hollow conductive wave guide which are interconnected by coaxial lines **13** and **14**. Coaxial line **13** forms a waveguiding path between finlines **15** and **16**, and coaxial line **14** forms a waveguiding path between finlines **17** and **18**.

For exposition purposes finline **15** is shown in greater detail in Fig. 1A. In this figure the finline comprises two fins **15A** and **15B** which extend in an axial plane within wave guide **11**. The two fins are spaced apart along their entire length for forming therebetween a continuous wave path 15C bounded by the opposing fin edges. The transverse dimension of this finline path initially equals the transverse dimension of wave guide 11, then tapers gradually to a smaller dimension along an intermediate portion of its length, and finally tapers gradually to the transverse dimension of coaxial line 13. The smaller dimensioned intermediate portion of wave path 15C advantageously extends outside the wall of wave guide 11 so that the propagating wave energy is closely confined during traversal through the wave guide wall and hence is not seriously affected by any discontinuity presented by that wall.

In the operation of the finline coupler of Fig. 1A, a wave propagating from left to right along wave guide 11 whose electric field vector is polarized in the plane of finline 15 will pass along the finline wave path 15C to coaxial line 13. Contrariwise, a wave polarized perpendicular to the finline will continue along the wave guide substantially undisturbed by the presence of the finline, as the finline presents an equipotential surface to a wave so polarized. To ensure undisturbed transmission of the perpendicularly polarized wave, the thickness of the fins should be less than one-tenth the guide diameter and preferably approximately one-sixty-fourth of the guide diameter. These dimensions correspond to four percent and less than one percent, respectively, of the cut-off wavelength of the guide. A more detailed discussion of the finlines can be found in my aforementioned copending application and in my copending application Serial No. 549,734, filed November 29, 1955.

Returning now to Fig. 1, a wave propagating from left to right along wave guide 11 may be viewed as comprising two mutually perpendicular components, one in the plane of finline 15 and one in the plane of finline 17. These have been shown in the figure as vectors E_1 and E_2. The component represented by vector E_1 passes from wave guide 11 along finline 15, coaxial line 13, and finline 16, into wave guide 12. There it appears as E_1'. The component represented by vector E_2 continues undisturbed past finline 15 and passes from wave guide 11 along finline 17, coaxial line 14, and finline 18, into wave guide 12 as vector E_2'. It should be noted that E_1 lags E_2 by 90 degrees in space but E_1' leads E_2' by 90 degrees in space. Thus a 180 degree phase shift in space, which is equivalent to a 180 degree phase shift in time, is effected between the components. Accordingly, the coupling arrangement serves as a delta 180 degree section. Additionally, the coupling arrangement provides a convenient technique for circumventing a bend from circular wave guide section 11 to section 12 without the generation of spurious modes.

It will be observed from Fig. 1 that the wave path of each of the two components E_1 and E_2, after their separation and before recombination, consists of a section of hollow wave guide, two finlines, and a section of coaxial line. If the electrical lengths of the corresponding elements of the two paths are made equal, the length of the two paths will remain equal independent of frequency. Hence the phase shift between the two components will remain constant at 180 degrees independent of frequency.

A second embodiment of the present invention for forming a differential phase shifter 20 in a straight through guide is shown in Fig. 2. In this embodiment a wave propagating from left to right along a hollow conductive wave guide 21 is again viewed as comprising two mutually perpendicular components, represented by vectors E_1 and E_2. Component E_1 lies in the plane of finline 22, which plane will be referred to as a vertical plane, and so is coupled thereby out through the wall of the wave guide to a closely spaced two-conductor line 23, which is shown as an extension of the finline, and then back through the wave guide wall in finline 24 in a horizontal plane. There it appears as vector E_1'. Component E_2, on the other hand, lies in the plane of finline 25, and so is coupled thereby to two-conductor line 26, then to finline 27, and finally appears as vector E_2' at the right-hand end of wave guide 21. As shown by these vectors, E_1 lags E_2 by 90 degrees in space but E_1' leads E_2' by 90 degrees in space; thus a 180 degree phase shift in space, and hence in time, is effected between the two wave components. The operation of the finlines in this embodiment is similar to that of the finlines in Fig. 1. Here, as in Fig. 1, the spacing between the two fins of the finline should be extremely small at the point where the fins pass through the conductive wave guide wall.

It will be noted that the 180 degree differential phase shifter 20 of Fig. 2 may be employed as a rotary joint. In particular, if E_1 represents a wave rather than a component of a wave and its polarity is rotated in a counterclockwise direction, it will be observed that it will appear at the right-hand end of the phase shifter 20 as E_1' having a polarity which rotates in a clockwise direction. Thus it can be appreciated that, if the polarization of wave E_1 is maintained constant but the differential phase shifter 20 is rotated, the polarity of wave E_1' will rotate in a direction opposite to the direction of rotation of the phase shifter and at a speed twice the speed of rotation of the phase shifter. A wave guide coupling arrangement which is characterized by operation of this type is commonly referred to as a rotary joint. It finds particular application in a wave guide transmission path coupled to a rotating or scanning antenna.

Fig. 3 shows a modification of the differential phase shifter of Fig. 2. In this modification, unlike that of Fig. 2, the two finlines 32 and 34 which are joined by two-conductor line 33 are coplanar. Further, finlines 35 and 37 joined by two-conductor line 36 are likewise coplanar. Component E_1 of this modification traverses from left to right through the differential phase shifter 30 without a change in phase, and appears as E_1'. Component E_2, however, experiences a 180 degree phase shift in traversing from left to right through the differential phase shifter and appears as E_2'. The 180 degree phase shift is provided by element 38 shown schematically in two-conductor line 36.

Various techniques for providing the 180 degree phase shift are shown in Figs. 3A to 3C. These figures show portions of a coupling arrangement similar to Fig. 3. Elements of these figures which correspond to those of Fig. 3 have been given similar reference numbers.

In Fig. 3A the 180 degree phase shift in the two-conductor line 36 is provided by a semi-circular rotation 38A of the path.

In Fig. 3B the 180 degree phase shift is provided by a twist 38B in the path, i.e., the interchange of the relative positions of the two elements defining the wave-guiding path.

Finally, in Fig. 3C the phase shift is provided by a section of ferrite material 38C positioned within rectangular wave guide section 39 which is connected between the tapered fins 36*a* and 36*b* to form a part of wave path 36. The ferrite material is in the form of a rectangular slab which extends in the direction of, but displaced laterally from, the axis of the wave guide. Arrangements of this type are disclosed in an article entitled "Behavior and Applications of Ferrites in the Microwave Region" by A. G. Fox, S. E. Miller and M. T. Weiss appearing in vol. 34 of the Bell System Technical Journal, January, 1955. In operation a magnetic field H is provided for magnetically biasing the ferrite material in the direction shown by the arrow in the figure. It is characteristic of this material when suitably magnetically biased that it exhibits a unidirectional or nonreciprocal phase shift, that is, it imparts a substantial phase shift to a wave passing through it in one direction but imparts virtually zero phase shift to a wave passing through it in the opposite direction. In the instant case, the length and properties of ferrite material 38C are selected to provide in the presence of magnetic field H a phase shift of 180 degrees in one direction and virtually zero in the opposite direction. As a result of this, the resulting differential phase shifter 30 would likewise be nonreciprocal in nature, that is, there would be 180 degree differential phase shift action from left to right but no differential phase shift action from right to left. However, if reciprocal differential phase shift action is desired, a rectangular wave guide including a second section of ferrite material characterized by 180 degree phase shift for a wave passing from right to left can be inserted in either path 36 or path 33. Additionally, nonreciprocal or reciprocal differential phase shift of any other desired angle, for example 90 degrees, can be had by suitably choosing one or two ferrite sections to give the desired phase shift. Other arrangements can be devised for particular applications, for example a differential phase shifter can be built having a 90 degree nonreciprocal phase shift in one path and a 180 degree nonreciprocal phase shift in the other path.

It should be noted that ferrite section 38C acts to delay the phase of a wave passing therethrough with respect to the phase of a wave passsing through path 33. In this manner a differential phase shift in time between the two components E_1 and E_2 is achieved. But disadvantageously the time delay provided by the ferrite does not remain constant with frequency and so its effective frequency range is limited. On the other hand, phase shift sections 38A and 38B do not act as time delays for a wave component passing through, but rather they provide a spatial phase shift of 180 degrees and this phase shift advantageously is independent of frequency so long as the corresponding elements of the wave paths for the two components of the wave are made to be similar physically.

Fig. 4 shows a modification of the differential phase shifter of Fig. 2 for forming a circulator. Elements of this figure which correspond to elements described with reference to Fig. 2 have been given like reference numerals and will not be redescribed here. In this modification rectangular wave guide section 41 including ferrite material 42 is located in path 26. This ferrite member is advantageously chosen to provide, in the presence of magnetic field H, a 180 degree phase shift for a wave passing therethrough from left to right and approximately zero phase shift for a wave passing from right to left. In this case, a wave whose electric field is polarized as vector E_a, which is at an angle of 45 degrees with each of finlines 22 and 25 will be divided in half. One half will pass along finline 22, two-conductor line 23, and finline 24, and the other half will pass along finline 25, two-conductor line 26 and finline 27, the phase of this latter half being shifted 180 degrees by ferrite member 42. The two halves are then recombined at the right-hand end of wave guide 21 and they appear as vector E_b. But a vector appearing as E_b and traveling from right to left will be divided in half, the two halves traversing the two finline wave paths and recombining at the left-hand end of wave guide 21 as vector E_c. Further E_c, passing from left to right through the differential phase shifter 40, separates into halves and then recombines at the right-hand end as vector E_d, and a wave represented by vector E_d, passing from right to left, separates into halves and then recombines as E_a. This action can be illustrated by the schematic representation shown in Fig. 4A. The arrow 45 indicates the direction of wave energy flow between adjacent terminals of the circulator. Thus wave energy E_a flows to E_b, E_b to E_c, E_c to E_d, and E_d to E_a.

For use as a circulator, finline elements, such as shown in Fig. 1A, are advantageously employed for launching the linearly polarized waves in the desired polarity, for example in the polarity of E_a, and for selectively extracting the wave energy from the ends of wave guide 21 on the basis of its polarity.

Fig. 5 shows a third embodiment of the present invention forming a reflex-type differential phase shifter 50. This embodiment comprises a hollow wave guide 51, and two finlines 52 and 54 joined by a two-conductor line 53. The two finlines extend along mutually perpendicular axial planes within the hollow wave guide. In operation, a wave component entering as vector E_1 at the left-hand end of wave guide 51 passes along finline 52, two-conductor line 53, and finline 54, and is reflected as vector E_2. Similarly, a wave component entering as vector E_2 passes along finline 54, two-conductor line 53, and finline 52, and is reflected as vector E_1. Thus the two components of the wave are differentially phase shifted 180 degrees, as E_1 acquires a 90 degree lag and E_2 acquires a 90 degree lead.

Observing the direction of phase shift acquired by these components, it can be seen that if E_1 represents a wave, rather than only a component of a wave, and its polarization is rotated in one direction, for example clockwise, the polarization of the reflected wave will rotate in the opposite direction or counterclockwise. Additionally, if the polarization of wave E_1 is maintained constant, but the differential phase shifter 50 is rotated, then the polarity of the reflected wave will rotate in a direction opposite to the direction of rotation of the phase shifter and at a speed twice the speed of rotation of the phase shifter.

Fig. 6 shows a reflex-type differential phase shifter 60 which is a modification of the one shown in Fig. 5. This phase shifter differs from the one in Fig. 5 in that it includes in the two-conductor line 53 a rectangular wave guide section 61 having therein a slab of ferrite material 62. This ferrite member is advantageously chosen to provide, in the presence of magnetic field H, a phase shift of 90 degrees in one direction and approximately zero in the other for effecting a 90 degree differential phase shifter. In such a case, a wave inserted at the left-hand end as vector E_1, which is 45 degrees from the plane of each of the finlines 52 and 54, will be divided in half. One half will pass first along finline 52, then two-conductor line 53, and then finline 54, and the other half will pass first along finline 54, then two-conductor line 53, and then finline 52. Only one of these halves will be phase shifted 90 degrees by ferrite section 61 and so they will recombine with a differential phase shift of 90 degrees. Such a 90 degree differential phase shift is known to transform a linearly polarized wave into a circularly polarized wave. Accordingly, a wave entering the differential phase shifter 60 linearly polarized as vector E_1 will be reflected as a circularly polarized wave.

It is understood that the foregoing specific embodiments are merely illustrative of the general principles of the present invention. In the light of these embodiments, various other arrangements will appear to one skilled in the art without departing from the spirit and scope of this invention. In particular, other techniques besides the use of ferrite may be employed for obtaining a desired time delay for a wave or for a component of a wave. These other techniques include conventional phase-shift sections such as known arrangements of lumped or distributed inductive and capacitive elements. Additionally, when a particular phase shift is desired, for example of 90 degrees, it is not essential that one path provide a 90 degree delay and the other a zero delay. Rather, it is possible to make the delay in one path any physically realizable value and merely have the delay of the other path differ by 90 degrees. With such an arrangement any change in electrical length with frequency of one path might advantageously be compensated by a change in electrical length of the other path and thus the difference in electrical length maintained constant over a broader frequency band.

What is claimed is:

1. A differential phase shifter comprising first and second sections of hollow conductive wave guide, first and second pairs of finlines extending axially within said first

and second wave guide sections, respectively, the two finlines of each pair being positioned in mutually perpendicular planes within the respective wave guide sections and extending out through the conductive wall of the respective wave guide sections, each one of said finlines comprising two conductive fin elements spaced apart along their entire length for forming along the interspace therebetween a continuous wave path bounded by opposing fin element edges, the transverse dimension of said continuous path initially being equal to the transverse dimension of the respective sections of hollow wave guide, then being tapered therefrom to a smaller dimension for passage out through the conductive wall of the wave guide section, and waveguiding means for coupling each finline of the first pair exclusively with a different finline of the second pair.

2. The combination of elements set forth in claim 1 wherein said waveguiding means comprises a pair of two-conductor transmission lines.

3. The combination of elements set forth in claim 1 wherein said waveguiding means comprises a pair of coaxial lines.

4. A coupling arrangement comprising first and second sections of hollow conductive wave guide, the axis of the first wave guide section being displaced from that of the second, first and second pairs of finlines extending axially within said first and second hollow wave guide sections, respectively, the two finlines of each pair being located in mutually perpendicular planes within the respective wave guide sections, and waveguiding means for coupling each finline of the first pair exclusively to a different finline of the second pair.

5. A coupling arrangement comprising first and second sections of hollow conductive wave guide, the axis of said first hollow conductive wave guide section is aligned with said second hollow conductive wave guide section and the two sections are joined to form component parts of a continuous wave guide, first and second pairs of finlines extending axially within said first and second hollow wave guide sections, respectively, the two finlines of each pair being located in mutually perpendicular planes within the respective wave guide sections, and waveguiding means for coupling each finline of the first pair exclusively to a different finline of the second pair.

6. A differential phase shifter comprising first and second sections of hollow conductive wave guide, a first pair of finlines extending along mutually perpendicular axial planes within the first section of hollow wave guide, each finline being responsive to one of two mutually perpendicular components of a wave propagating along said first hollow conductive wave guide, a second pair of finlines extending along mutually perpendicular planes within the second section of hollow wave guide, means forming a first continuous path between said first and second hollow wave guide sections including a first waveguiding means in energy transfer relation exclusively with one finline of each of said finline pairs, means forming a second continuous path between said first and second wave guide sections including a second waveguiding means in energy transfer relation with the second finline of each of said finline pairs, the electrical phase shift of one of said continuous paths being different from that of the other for effecting a differential phase shift between the two components of said propagating wave.

7. The combination of elements set forth in claim 6 wherein the differential phase shift between the two components of the propagating wave is provided by a section of ferrite material located in one of said continuous paths between said first and second wave guide sections.

8. A differential phase shifter comprising first and second sections of hollow conductive wave guide, a first pair of finlines extending along mutually perpendicular axial planes within the first hollow wave guide, each finline of which is responsive to one of two mutually perpendicular components of a wave propagating along said first hollow conductive wave guide, a second pair of finlines extending along mutually perpendicular planes within the second hollow wave guide, means forming a first continuous path between said first and second hollow wave guide sections including a first waveguiding means in energy transfer relation exclusively with one finline of each of said finline pairs, means forming a second continuous path between said first and second wave guide sections including a second waveguiding means in energy transfer relation with the second finline of each of said finline pairs, said first waveguiding means being adjusted to follow a substantially semicircular path for providing a 180 degree differential phase shift between the two components of the propagating wave.

9. A differential phase shifter comprising first and second sections of hollow conductive wave guide, a first pair of finlines extending along mutually perpendicular axial planes within the first hollow wave guide, each of which is responsive to one of two mutually perpendicular components of a wave propagating along said first follow conductive wave guide, a second pair of finlines extending along mutually perpendicular planes within the second hollow wave guide, means forming a first continuous path between said first and second hollow wave guide sections including a first wave-guiding means in energy transfer relation with one finline of each of said finline pairs, means forming a second continuous path between said first and second wave guide sections including a second waveguiding means in energy transfer relation with the second finline of each of said finline pairs, one of said waveguiding means being twisted substantially 180 degrees for providing a 180 degree differential phase shift in the components of the propagating wave.

10. A differential phase shifter comprising first and second sections of hollow conductive wave guide, a first pair of finlines extending along mutually perpendicular axial planes within the first hollow wave guide, each of which is responsive to one of two mutually perpendicular components of a wave propagating along said first hollow conductive wave guide, a second pair of finlines extending along mutually perpendicular planes within the second hollow wave guide, means forming a first continuous path between said first and second hollow wave guide sections including a first wave-guiding means in energy transfer relation with one finline of each of said finline pairs, means forming a second continuous path between said first and second wave guide sections including a second waveguiding means in energy transfer relation with the second finline of each of said finline pairs, the path of both of said waveguiding means being twisted and the sum of the magnitudes of their twists being equal to 180 degrees for providing a 180 degree differential phase shift in the components of the propagating wave.

11. The combination of elements set forth in claim 10 wherein one of the waveguiding paths includes a section of ferrite material for providing a further differential phase shift between the two components of the propagating wave.

12. The combination of elements set forth in claim 10 wherein one of the waveguiding means includes a section of ferrite material for effecting a 180 degree phase shift in a wave propagating therethrough whereby circulator action is achieved.

13. A coupling arrangement comprising means forming a waveguiding path, four finlines longitudinally spaced in a succession within said waveguiding path, the first and second finlines in the succession being disposed in mutually perpendicular axial planes and the third and fourth finlines in the succession likewise being disposed in mutually perpendicular planes, means forming a continuous wave path exclusively between the first and third finlines in the succession including a first transmission line in energy transfer relation with said first and third finlines, and means forming a continuous wave path be-

tween the second and fourth finlines in the succession including a second transmission line in energy transfer relation with said second and fourth finlines.

14. A differential phase shifter comprising a hollow conductive wave guide, a pair of finlines extending along mutually perpendicular planes within the hollow conductive wave guide, means forming a continuous wave path between said finlines including a transmission line independent of said hollow conductive wave guide connected in energy coupling relation between said finlines.

15. The combination of elements set forth in claim 14 wherein the transmission line comprises a parallel two-conductor transmission line.

16. The combination of elements set forth in claim 14 including means located in said continuous wave path for providing a nonreciprocal phase shift for a wave propagating along said continuous path.

17. The combination of elements set forth in claim 16 wherein the phase shift means comprises a section of ferrite material characterized in that it provides a 90 degree phase shift in one direction and substantially zero phase shift in the other direction.

18. A coupling arrangement comprising first and second sections of hollow conductive wave guide, an axially extending finline within said first section supporting energy applied with polarization in a predetermined quadrant, an axially extending finline within said second section, and transmission means independent of said hollow conductive wave guide sections connected in energy coupling relation between said finlines, said transmission means introducing a rotation of the plane of polarization such that said finline within said second section launches energy into said wave guide polarized in a quadrant other than said predetermined quadrant.

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