

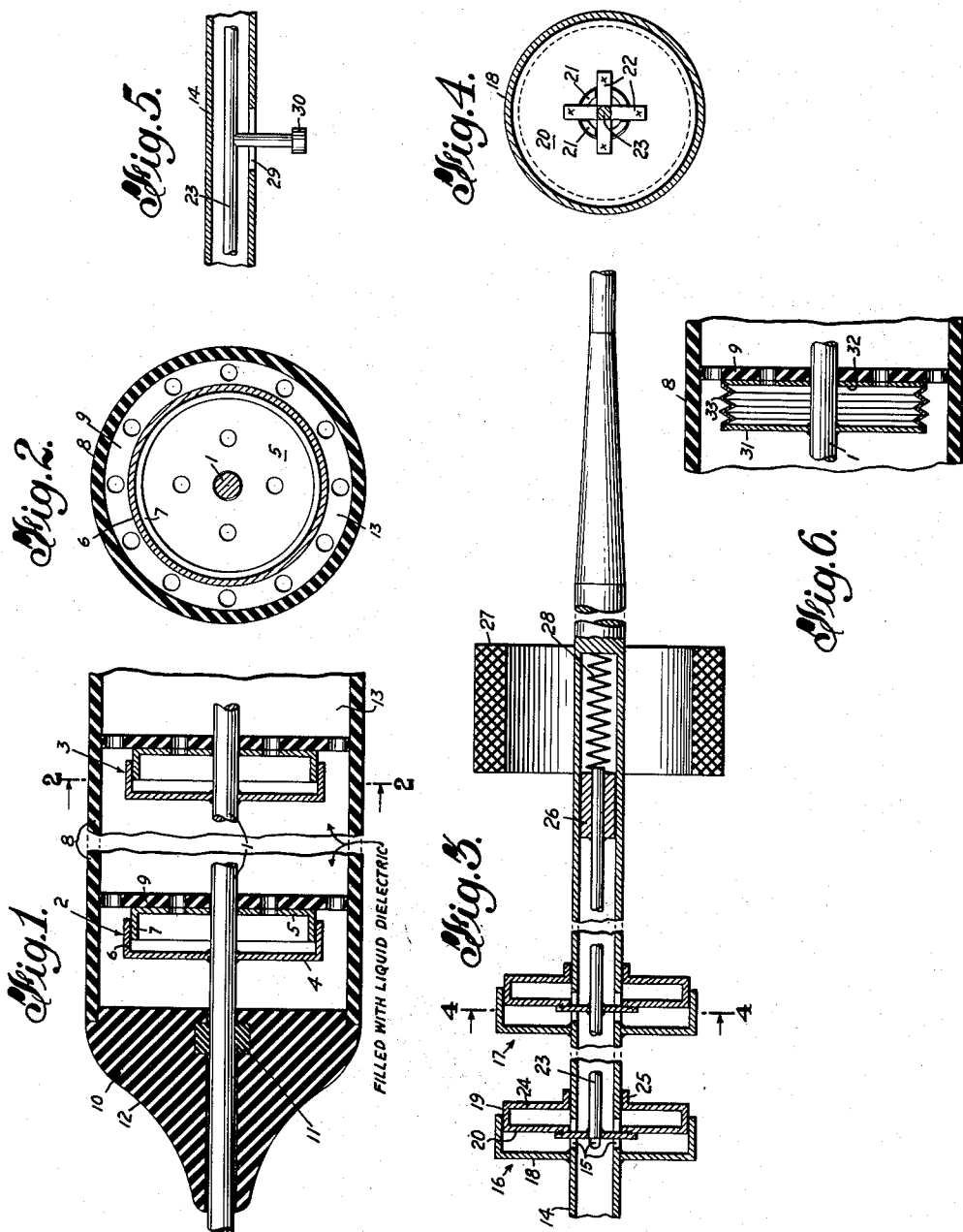
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PHASE CHANGER

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PHASE CHANGER

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5 Claims. (Cl. 333—31)

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This invention relates to microwave transmission systems employing surface wave propagation and more particularly to phase shifters for such systems.

In our copending application, Serial No. 163,581, filed May 23, 1950, we disclose various forms of guide lines together with associated launching and receiving devices for surface wave propagation of microwave energy. The guide line may comprise either a bare conductor having a finite resistivity or a conductor with dielectric material distributed therealong, either as a continuous coating or as spaced sections or beads. The larger part of the electromagnetic field for such lines is confined in the form of a cylindrical volume closely adjacent the surface of the conductor thereby resulting in efficient transmission of high frequency energy. By way of example, an ordinary No. 12 enameled copper wire has been found to have for high frequencies the major portion of the electromagnetic field concentrated within a 3 to 4 inch radius about the wire. The high frequency energy has been found to flow in this field along the surface of the wire with very low loss and to be substantially free from electrical and other disturbances where this confined cylindrical field was substantially unobstructed.

One of the objects of this invention is to provide a phase shifter for guide lines capable of surface wave transmission; and a further object is to provide a phase shifter for such lines which is easily adjustable.

The phase shifters according to our invention comprise a line conductor along which conductor sections of cross-sectional size greater than the cross-sectional size of the line conductor are periodically disposed. These conductor sections are similar to the conductor sections of the filters disclosed in our copending application, Serial No. 152,132, filed March 27, 1950, except that the sections in the present invention are adjustable in size. These periodically disposed conducting sections increase the delay of propagation of high frequency energy, the degree of delay depending upon the ratio between the size or thickness axially of the sections and the spacing between the sections. By altering this ratio without changing the periodicity of the sections, wide band phase change is obtainable.

One of the features of the invention is the structural arrangement of the conducting sections. Each section preferably comprises a pair of disc-like elements at least one of which is provided with a peripheral flange disposed concentrically about the line conductor in over-lapping

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contact relationship with the peripheral edge of the other element of the pair. By adjusting one of the elements relative to the other differences in phase may be obtained.

Another feature of the invention is the manner by which the conductor sections may be adjusted in axial size. In one embodiment of the invention a corresponding element of each pair is connected together so that the connected elements may be moved in unison relative to the other elements which are carried by the line conductor. The connecting means for the movable elements may comprise a hollow cylinder of insulating material disposed about the sections and mounted for axial movement relative to the line conductor. One element of each section is connected by insulating means to the hollow insulating cylinder so that movement of the hollow cylinder will produce variation in the size of the conductor sections. To minimize undue perturbation of the high frequency energy the ends of the cylinder are closed about the line conductor by bodies of insulating material which preferably are tapered from the outer cylinder to substantially the surface of the line conductor. A liquid dielectric is also preferably contained within the cylinder, the dielectric coefficient of the liquid being substantially the same as the dielectric coefficient of the insulating bodies.

In still another embodiment, the corresponding elements of each section are shifted by means of an axial connector disposed within the line conductor which in this embodiment is made hollow.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood, by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a view in longitudinal section illustrating a phase changer embodying a plurality of phase changer sections together with an enclosing insulating cylinder by which the sections may be adjusted in axial size;

Fig. 2 is a cross-sectional view taken along line 2—2 of Fig. 1;

Fig. 3 is a longitudinal sectional view of a modified form of phase changer which includes an electrical control for effecting adjustment of the sections;

Fig. 4 is a sectional view taken along line 4—4 of Fig. 3;

Fig. 5 is a fragmentary sectional view illustrating a manual control which may be substituted

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for the electrical control illustrated in Fig. 3; and Fig. 6 is a longitudinal sectional view of a modified form of phase changer section.

In Fig. 1, the phase changer shown comprises a length of conductor 1 which may correspond to the conductor of the guide line although it may be of different size if desired. Periodically spaced along the conductor is a plurality of sections 2, 3, etc., each of which comprises a pair of disc-like elements 4 and 5. One element of each pair such as 4, is mounted on the conductor 1 so that it is relatively fixed thereto. This may be accomplished by brazing or by a tight sliding engagement. The other element of each pair such as 5, is mounted for sliding engagement with respect to the conductor 1 so as to provide electrical connection therewith. The outer periphery of each element is provided with a laterally disposed flange which is concentric with respect to the conductor 1. The two elements 4 and 5 are preferably made of different size radially so that the flange 6 on one will overlap in sliding engagement the flange 7 on the other. If desired, the flange on one of the elements may be eliminated entirely by having the flange of the other overlap in sliding contact the peripheral edge of the one element.

As shown in Fig. 1, the sections 2, 3, etc., are enclosed by an outer container of insulating material disposed concentrically about the line conductor 1 in the form of a coaxial cylinder. The movable elements 5 are connected to the outer container 8 by perforated discs 9 of insulated material. The ends of the outer container 8 are closed by bodies of insulating material 10 which are provided with liquid type glands 11 about the conductor 1. The bodies 10 are tapered as indicated at 12 from the outer conductor 8 to substantially the surface of the line conductor 1. Within the outer container 8 is a liquid dielectric 13 which has a dielectric coefficient substantially the same as the dielectric coefficient of the bodies 8 and 10. When it is desirable to adjust the phase changer the outer container 8 may be manually moved along the conductor 1 thereby enlarging or reducing the axial size of the sections 2, 3, etc.

In Figs. 3 and 4, a line conductor 14 is shown as being hollow and as having a plurality of circumferentially spaced slots 15 at intervals therealong to accommodate conductor sections 16, 17, etc., each of which comprises a pair of radially disposed elements, one of which is mounted in the slots for axial adjustment with respect to conductor 14. As shown, the element 18 is preferably of disc shape secured to the surface of the conductor 14 and extending radially outwardly therefrom. At the peripheral edge of the disc is a laterally disposed flange concentric with respect to the conductor 14. The other element 19 of the pair is in the form of a hollow disc, one wall 20 of which is provided with cut-outs 21 to accommodate the conductor 14, the cut-outs being separated by inwardly projecting spokes 22 which are secured to a rod 23 disposed axially of the hollow conductor 14. The opposite wall 24 of the cylindrically shaped disc 19 is disposed radially of the conductor 14 and is provided with lateral flange 25 for sliding engagement with the outer surface of the conductor 14. For adjustment of the movable elements 19 of the sections 16, 17, etc., the rod 23 is disposed along the hollow conductor 14 for a distance at which point it carries an iron slug 26 which may be attracted magnetically by a solenoid 27 disposed in spaced

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relation concentrically about the conductor 14. A helical spring 28 is mounted on the rod adjacent the slug 26 to urge the movable elements toward a given position. When the solenoid 27 is energized it forces the slug 26 in a direction opposed to the action of spring 28 thereby changing the axial size of the sections, 16, 17, etc.

In the place of the electrical control of Figs. 3 and 4, a manual control may be employed such as indicated in Fig. 5. The hollow conductor 14 is provided with a slot 29 through which a slider 30 carried by the rod 23 extends. By manually moving the slider 30 the sections 16, 17, etc., may be changed in size and thereby alter the degree of phase shift accomplished by the assembly.

In Fig. 6 a phase changer section is shown in the form of a siphon bellows comprising two disc-like walls 31 and 32 with a corrugated flexible wall 33 spanning the space therebetween. This flexible wall permits relative movement of the side walls 31 and 32 to effect change in phase.

While we have described above the principles of our invention in connection with specific apparatus, it will be clear to those skilled in the art that the phase changer sections may be varied widely as to their specific construction, also that the end sections of a series of sections may be graduated in size similarly as the filter sections shown in our aforementioned application Serial No. 152,132. Also that various means may be arranged for effecting adjustment of position of the movable elements of the conductor sections. It is to be clearly understood, therefore, that this description is made only by way of example and not as a limitation to the scope of our invention, as set forth in the objects thereof and in the accompanying claims.

We claim:

1. A phase changer for use in conjunction with a guide line capable of surface propagation of high frequency energy by means of an electromagnetic field formed about such line, comprising a line conductor, a plurality of conductor sections of cross-sectional size greater than the cross-sectional size of said line conductor, each of said sections comprising a pair of elements extending radially of said line conductor, each of said elements having an axially disposed flange, the flanges of the elements in said pair being disposed in overlapping relation, and means for simultaneously moving a corresponding element of each pair for changing the size of said sections.

2. A phase changer according to claim 1, wherein said elements comprise discs and the flanges thereof are concentrically disposed with respect to the axis of said line conductor.

3. A phase changer comprising a line conductor, a hollow cylinder of insulating material disposed concentrically and surrounding said line conductor, a plurality of conductor sections disposed periodically along said line conductor, each of said sections comprising a pair of elements extending radially of said line conductor, one of said elements of each pair being electrically connected to said line conductor and the other element of each pair being connected to said cylinder but electrically coupled to said line conductor and supporting means for movably supporting said cylinder with respect to said line conductor.

4. A phase changer according to claim 3, wherein the supporting means includes a body of insulation at each end of said cylinder tapered gradually to the surface of said line conductor

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5. A phase chamber according to claim 4, wherein said supporting means include a liquid tight gland about said line conductor and a liquid dielectric is contained in the space between said line conductors and said cylinder.

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