

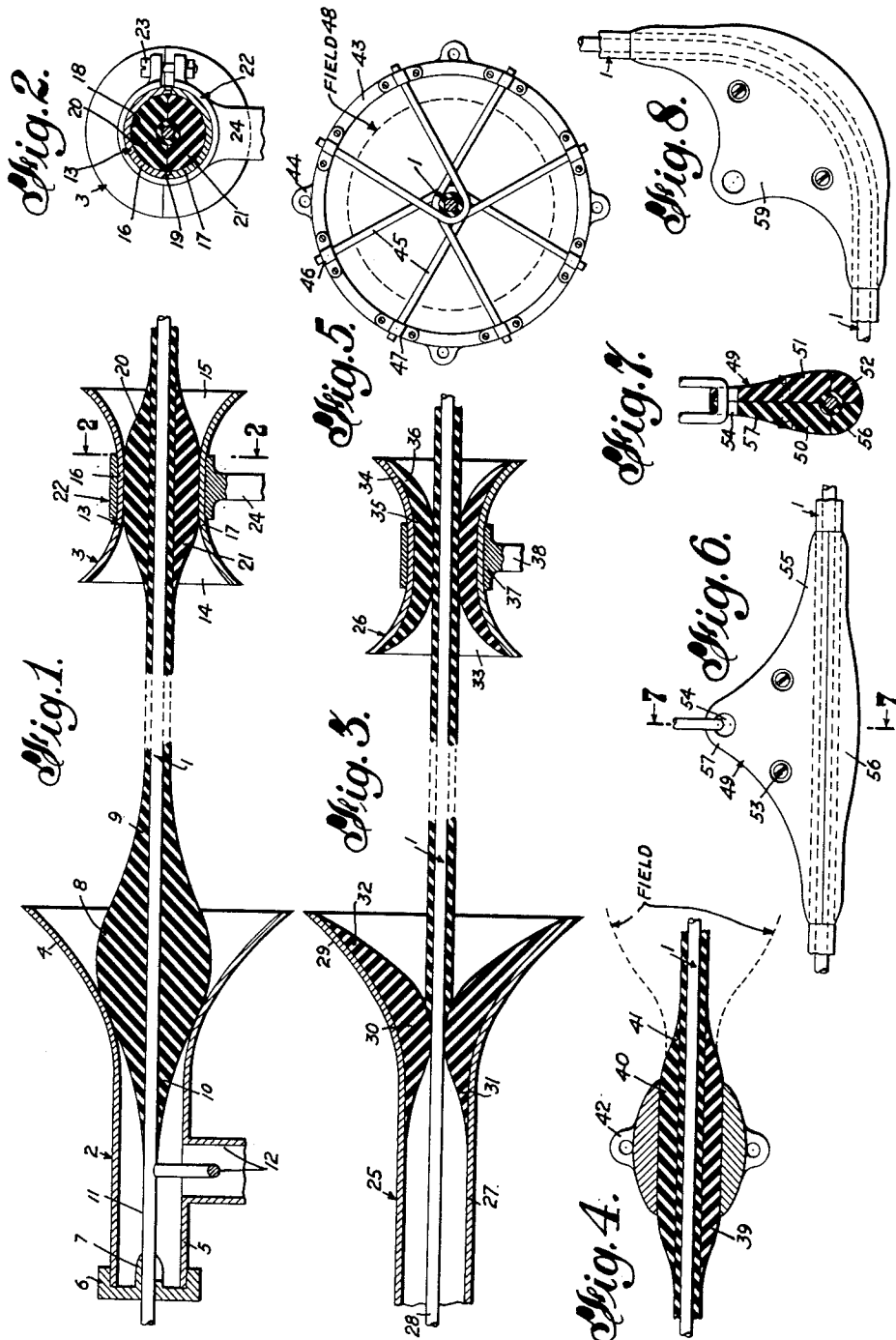
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SUPPORTS FOR TRANSMISSION LINE

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SUPPORTS FOR TRANSMISSION LINE

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This invention relates to microwave transmission apparatus and more particularly to means for supporting a conductor for microwave propagation.

In addition to the transmission of microwave energy over radio links, coaxial cables and dielectric waveguides, it has recently been discovered that such high frequency energy covering a very wide band may be transmitted by means of a single wire properly insulated, the transmission of energy being confined closely adjacent the wire in the electric and magnetic fields formed thereabout. It has been recognized that when a wire had electric energy applied thereto that electric and magnetic fields formed about the wire but it was believed that the fields extended outwardly without any definite limits or boundary. It has recently been discovered that if the conductor is coated with a given thickness of insulation the electromagnetic fields are concentrated and substantially confined within a cylindrical volume of a given radius about the conductor, the given radius being determined by the size of the conductor and the quality and thickness of the insulating coating. By way of example, an ordinary No. 12 enameled copper wire was found to have an electromagnetic field concentrated within a three to four inch radius about the wire and that the high frequency energy flowed in this field. This manner of propagation now referred to as the "surface wave" transmission presents very small loss and is substantially free from electrical and other disturbances where this confined cylindrical field is substantially unobstructed.

One of the objects of this invention is to provide means for supporting a conductor adapted for surface wave propagation in a manner such that a minimum of obstruction or distortion is presented to the electromagnetic field confined about the conductor.

Another object is to provide means for supporting the wire conductor in coupling relation with respect to coaxial lines and dielectric waveguides.

One of the features of the invention is to provide supports for the wire conductor which are so shaped and disposed with respect to the wire conductor that a minimum amount of perturbation occurs in the propagated wave. The supporting structure according to the invention includes a supporting member disposed adjacent the wire conductor to be supported and dielectric means carried by the supporting member supports the conductor in spaced relation with respect to the supporting member so that the supporting member is located beyond the concentrations of the electromagnetic field. Further, certain supporting members and dielectrics are so designed as to constrict the electromagnetic field into a very small volume close about the conductor at the support. The supporting member in one form, for example, may comprise an annular member of conducting material disposed in spaced relation about the conductor with the dielectric means either in the form of a conductor enclosing a body of insulating material or as strands of insulating material arranged to support the wire conductor in spaced relation, usually coaxially, of the annular member. The annular

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member may have the ends thereof flared outwardly or tapered inwardly depending on the shape of the dielectric body disposed between the annular member and the wire conductor. The dielectric body, for example, may be tapered from the central portion thereof to points closely adjacent the wire conductor which passes through the center of the dielectric body or the insulating characteristic of the body may be reduced by flaring the body outwardly from the wire conductor, the spacing between the wire and the dielectric body progressing in proportion to the amount of flare.

As a further feature of the invention, the supporting structure may comprise a part of the coupling means for anchoring the wire to an energy feeding or receiving structure such as a coaxial line or dielectric waveguide. As still another feature the dielectric body may be curved in accordance with a desired bend to be provided in the direction of the wire conductor and the wire conductor secured along the curvature of the dielectric body or a passageway formed therein.

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 longitudinal sectional view showing a line coupling device and an associated line support for the surface wave conductor in accordance with the principles of this invention;

Fig. 2 is a view in cross-section of the line support taken along line 2—2 of Fig. 1;

Fig. 3 shows a longitudinal sectional view of a modified form of line coupling device and an associated line support for the conductor;

Fig. 4 is a longitudinal sectional view of another modification of the line support;

Fig. 5 is a side elevation of a line support of modified construction, the view showing the conductor in cross-section;

Fig. 6 is a view in elevation of a line support adapted for suspension;

Fig. 7 is a cross-sectional view taken along line 7—7 of Fig. 6; and

Fig. 8 is a view of still another form of line support similar to that shown in Figs. 6 and 7 with the exception that this form provides a predetermined bend in the conductor at the support.

In Fig. 1 an insulation coated conductor 1 is shown supported by a line coupling device 2 and a line support 3. The device 2 which may be used for either launching or receiving microwave energy, not only supports the conductor 1 at one end thereof but also provides for the transfer of microwave energy between either a coaxial line or waveguide structure and the surface of conductor 1. As shown in Fig. 1, the device 2 comprises a tubular element, one end 4 of which is flared outwardly in the form of a horn and the opposite end 5 of which is in the form of a matching stub. The conductor 1 is supported coaxially of the tubular element by the "open circuit" quarter wave stub 5 which has an end cap 6 with wire gripping means 7, the conductor being anchored by suitable tensioning means (not shown). The conductor 1 is supported by a body of dielectric material 8, which may comprise glass, polystyrene, polyethylene, ceramic or other material of suitable insulating quality, disposed in the flared portion 4. While the body 8 is shown of a size and shape sufficient to close the mouth of the horn, it may be of a size substantially smaller than the inner dimensions of the horn. The ends of the body 8 are tapered down, as indicated at 9 and 10, to closely adjacent the surface of the conductor. The tapered portion 9 in fact is tapered into the insulating

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coating carried by the conductor 1, while the portion 10 is tapered to the very surface of the conductor. The end portion 11 of the conductor 1 beyond the tapered portion 10 provides for transformer coupling with a waveguide connection 12 located adjacent stub 5.

The line support 3 associated with the device 2 is constructed in a similar manner. The support comprises a tubular conductor 13, the ends of which are flared outwardly as indicated at 14 and 15. The member 13 is preferably made in two parts 16 and 17 secured together to form a continuous inner surface 18 to correspond to the inner surface of a waveguide. The parts 16 and 17 are preferably interconnected by a lap joint 19 to insure continuity of the surface 18. The dielectric body is also made up of two parts 20 and 21 and retained within the members 16, 17 which are clamped together by a clamping ring 22 and one or more bolts 23. The ring 22 may be integral with a supporting arm 24 as shown, or it may be provided with means for securing it to other supporting structure.

The ends of the dielectric body 20, 21 are tapered down to the insulation of the conductor 1, the tapered portions extending preferably throughout the flared portion of the member 13. This tapering of the dielectric body may extend out beyond the ends of the flared portions 14 similarly as indicated for the dielectric body 8 of the device 2. This tapering of the dielectric body and the flaring of the conductive ends of devices 2 and 3 serves to constrict the electromagnetic field closely about the wire as it approaches and enters the flared portions thus reducing the electromagnetic energy in radius to the dimensions of the waveguide sections of devices 2 and 13. Since the insulating material on the conductor 1 serves to confine the electromagnetic field closely adjacent the surface of the conductor, the increased thickness of the coating at the device 2 and the support 3 serves to constrict the field even more closely to the surface of the conductor so that the microwave energy passes into the surrounding metallic horn structures without undue perturbation of the wave. The dielectric bodies 8 and 20, 21 thus permit the use of horn and metallic supports of smaller dimensions than would otherwise be permissible.

In Fig. 3 an alternative terminal support 25 and line support 26 are shown. The line coupling device 25 is shown as a continuation of a coaxial line comprised of an outer conductor 27 and an inner conductor 28. The end portion of the outer conductor 27 is flared outwardly into a horn shape as indicated at 29. A body of dielectric material 30 is disposed within the end portion of the outer conductor 27 with the inner surface thereof in engagement with conductor 1 to center it coaxially of the horn portion. The inner conductor 28 may comprise a continuation of the conductor 1 with or without the insulation removed therefrom. The inner and outer ends 31 and 32 of the body 30 are reduced in insulating quality by flaring the body outwardly. The end portion 31 is thus gradually spaced outwardly from the inner conductor 28 until the thickness thereof is thinned down to the surface of the outer conductor. The end portion 32 is likewise decreased in thickness and is disposed along the surface of the horn portion 29.

The line support 26 comprises in conjunction with the conductor 1 a short coaxial line section with the ends of the outer conductor flared, as indicated at 33 and 34. The ends of the dielectric body 35 are likewise flared outwardly from the conductor, as indicated at 36, the flared portions being reduced to an edge adjacent the ends of the flared portions 33, 34. The member 26 may be made in two parts similar to the construction of the support shown in Fig. 2 and clamped together by a clamping ring 37 to which a support 38 may be connected.

In the devices 25 and 26 the flaring outwardly of the dielectric body serves similarly to the tapered forms of Fig. 1 to constrict the electromagnetic field closely about

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conductor 1 at and within the cylindrical conductors of the two line supporting structures.

In Fig. 4 a variation of the line support is shown, the support comprising a metallic cylindrical member 39 and a dielectric body 40. The inner surface of the member 29 is preferably cylindrical although it may be rectangular or oval in cross-section, the inner cross-sectional dimensions throughout the length thereof being constant for waveguide propagation of microwave energy. The dielectric body 40, however, is extended an appreciable amount beyond the ends of the member 39, the ends as indicated at 41 being tapered gradually down to the normal insulation coating contained on the conductor 1. The outer surface of the end member 39 may be of any desired shape and arrangement. The member 39 as shown is provided with ear-lugs 42 by which it may be supported.

In Fig. 5, a variation of the line support of Fig. 4 is shown wherein an annular member 43 in the form of a ring or hoop is adapted to be supported by ear-lugs 44 concentric about conductor 1. A plurality of insulation fibers, such as nylon, are secured at spaced points along the ring and looped around the conductor 1 for retention of the conductor axially of the ring 43. As illustrated, one of the fibers 45 has its ends clamped or otherwise secured to the ring 43 at 46 and 47. Each fiber may be looped one or more turns or only a partial turn about the conductor 1. By this construction the electromagnetic field 48 which is smaller in diameter than ring 43, is unhindered by obstructions other than the few fibers required to support the conductor axially of the ring.

In Figs. 6 and 7, another embodiment of the invention is shown to comprise a body of dielectric material 49 made of two parts 50 and 51. Adjacent one end of these parts is a channel 52 which may be formed by recesses in one or both of the parts 50, 51. The two parts are secured together by clamping bolts 53 which may be of metal but preferably are of insulation material, such as nylon. At the end furthest from the channel 52 is a transverse opening 54 by which the support may be suspended or otherwise mounted on a supporting structure. The body 49 is tapered outwardly along the channel 52 as indicated at 55, this tapering being for the same purpose as hereinbefore described, that is, to constrict the electromagnetic field closely about the conductor along and through the support. The bottom portion 56 of the dielectric body may be of the same shape as the upper part 57 so that the upper and lower portions may have a balanced effect upon the field. This similarity of the upper and lower halves, however, need not be maintained since the lower half where less insulation is desired, may be made of an insulating material of higher quality than the rest of the body. This difference in quality is indicated by the difference in shading of the upper and lower portions 57 and 56. The two materials are preferably moulded together.

In Fig. 8, the type of support shown in Figs. 6 and 7, is shown of a shape provided with a curved channel 58 for the conductor. It will be obvious that many shapes different from those of the bodies 49 and 59 may be made so that the supporting channels will direct or bend the conductor in the desired directions.

While the various forms illustrated indicate a conductor 1 of circular cross-section, it will be clear that the conductor may have other cross-sectional shapes, that is, rectangular, oval, hexagonal, etc., and also that the cross-sectional shapes of the supporting members may likewise be varied as may be desired. Thus, while I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

What I claim is:

1. In a microwave transmission system having an in-

5 sulation coated conductor capable of surface wave propa-
 gation in an electro-magnetic field formed thereabout,
 said field for a given conductor size and insulating coating
 of given quality being concentrated substantially within
 a given radius about the conductor, an annular support of
 conducting material elongated lengthwise of said con-
 ductor; dielectric means carried by said support for sup-
 porting said conductor in spaced relation with respect to
 said support such that said support is located beyond the
 concentrations of said electromagnetic field, said dielec-
 tric means extending beyond at least one end of said an-
 nular member with the extended portion thereof being
 tapered to a point closely adjacent the surface of said
 coated conductor.

2. In a microwave transmission system according to
 claim 1, wherein the annular member is flared outwardly
 from the central portion thereof toward its ends.

3. In a microwave transmission system according to
 claim 1, wherein the annular member is elongated length-
 wise of said conductor and the dielectric means extends
 beyond both ends of said annular member with the ex-
 tended portions thereof being tapered to a point closely
 adjacent the surface of said conductor.

4. In a microwave transmission system according to
 claim 1, wherein the annular member comprises a part of
 the outer conductor of a coaxial line and said conductor
 extends into said coaxial line as the center conductor
 thereof.

5. In a microwave transmission system according to
 claim 1, wherein the dielectric body has a portion in en-
 gagement with said conductor, said body being flared out
 in one direction from the conductor engaging portion
 thereof, the flared portion of said body being progressive-
 ly spaced from said conductor.

6. In a microwave transmission system having a con-
 ductor capable of surface wave propagation in an electro-
 magnetic field formed thereabout, said field for a given
 conductor size being concentrated substantially within a
 given radius about the conductor, a support for said con-
 ductor located intermediate the ends thereof, dielectric
 means carried by said support for supporting said con-
 ductor in spaced relation with respect to said support
 such that said support is located beyond the concentra-
 tion of said electromagnetic field, said dielectric means

extending beyond at least one end of said support mem-
 ber and being gradually reduced in its degree of insulating
 characteristic towards its end, to confine the electromag-
 netic field to a radius less than said given radius, before
 the field passes through said support.

7. In a microwave transmission system according to
 claim 6, wherein the dielectric means includes a body of
 insulating material extending lengthwise of the conductor
 and gradually reduced in its degree of insulating character-
 istic toward its ends, the reduction being provided by the
 dielectric body being reduced in thickness toward its
 ends, the reduced end portions being spaced from said
 conductor proportionally to the thickness of said portions.

8. In a microwave transmission system according to
 claim 6, wherein the dielectric means includes strands of
 insulating material looped about said conductor and con-
 nected to said annular member at spaced points along
 the periphery of said annular member.

9. In a microwave transmission system according to
 claim 4, further including means terminating said coaxial
 line adjacent the connection to said conductor, means to
 anchor said center conductor and means for coupling a
 second transmission line to said coaxial line.

10. In a microwave transmission system according to
 claim 6, wherein the dielectric means at a central portion
 thereof extends from said support inwardly to said con-
 ductor and then at its ends flares outwardly from said
 conductor.

11. In a microwave transmission system according to
 claim 6, wherein said dielectric means has a curved chan-
 nel therethrough, thereby imposing a predetermined bend
 in said conductor at the support.

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