

CONCENTRIC CONDUCTOR TRANSMISSION LINE

Filed March 24, 1938

2 Sheets-Sheet 1

FIG. 1

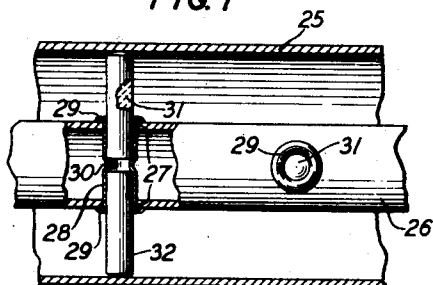


FIG. 2

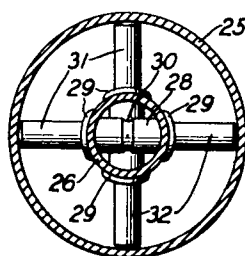


FIG. 3

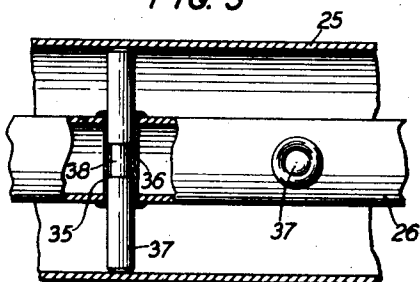


FIG. 4

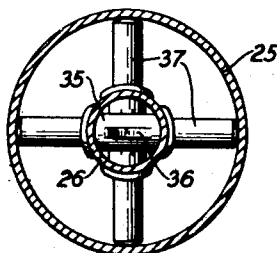


FIG. 5

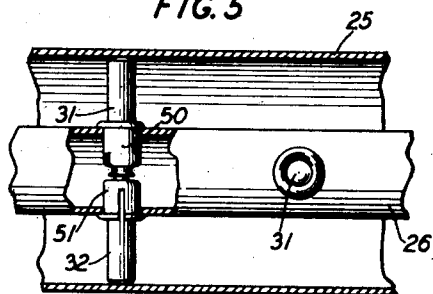


FIG. 7

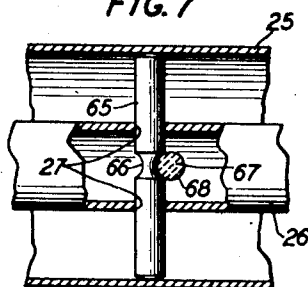
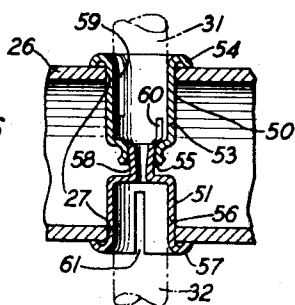


FIG. 6



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Oct. 22, 1940.

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2,218,921

CONCENTRIC CONDUCTOR TRANSMISSION LINE

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FIG. 8

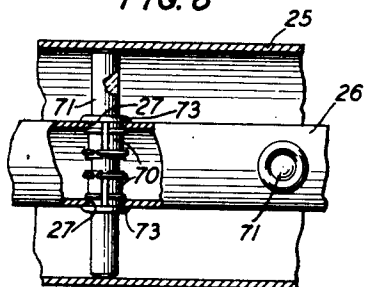


FIG. 9

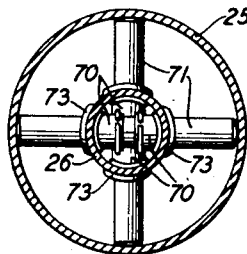


FIG. 12

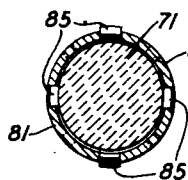


FIG. 10

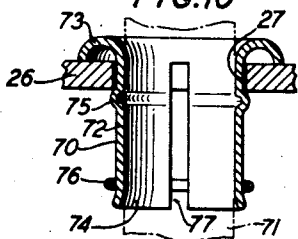


FIG. 11

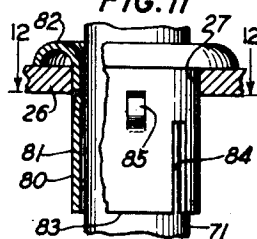


FIG. 13

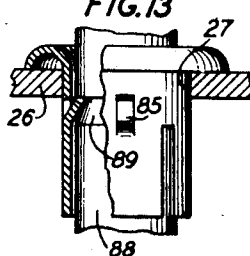


FIG. 14

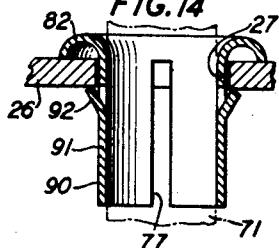


FIG. 15

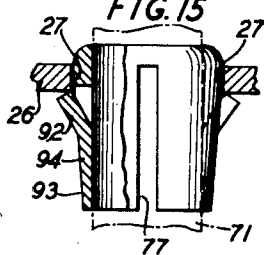


FIG. 16

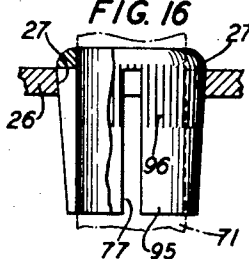


FIG. 17

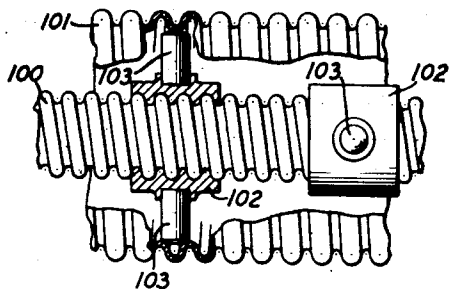
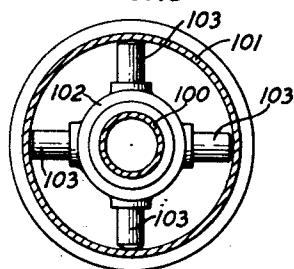


FIG. 18



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CONCENTRIC CONDUCTOR TRANSMISSION
LINE

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Application March 24, 1938, Serial No. 197,786

4 Claims. (Cl. 174—28)

This invention relates to concentric conductor transmission lines, and more particularly to arrangements for retaining concentric spacing between the conductors of such lines.

5 One form of concentric conductor line known heretofore comprises a tubular inner conductor disposed in a tubular outer conductor and spaced concentrically therefrom by insulating rings or the like mounted on the periphery of the inner conductor at intervals therealong. In such arrangement, insulating rings are held in place on the inner conductor in one of the following ways, (a) friction, (b) crimping the inner conductor on both sides of the insulating ring, (c) soldering 10 metal rings on the inner conductor on both sides of the insulating ring and (d) springing resilient wires on the inner conductor on both sides of each insulator.

Accordingly, these insulating rings create gaps 20 extending between themselves and the inner conductor along a radial from the center of the line and also introduce between the inner and outer conductors a relatively large mass of material which has a high dielectric constant compared to air or gas surrounding it and which, in addition to increasing dielectric losses that are proportional to the mass of this material, alters the distribution of the voltage gradient on the outer surface of the inner conductor. This distribution would 30 be uniform for a line assumed to have a uniform air or gas dielectric intervening exclusively between the inner and outer conductors, or a line provided with insulators having a dielectric constant equivalent to that of the surrounding air or gas, if such were possible. However, since a solid material having a dielectric constant equivalent to that of air or gas is physically non-existent, the nearest approach to the desired condition of a uniform air or gas dielectric is realized with an insulator having minimum mass.

40 These alterations in the distribution of voltage gradient cause substantial increases of voltage gradient in the vicinity of the insulating rings and frequently result in the production of relatively steep voltage gradients on the outer surface of the inner conductor, particularly if any gaps intervene between the inner conductor and the insulating rings. Consequently, there may be produced in the vicinity of the insulating rings, 50 corona and flash-over by signaling voltages applied to the line and having magnitudes substantially less than those that would be transmitted by a concentric line of the same dimension and having air or gas dielectric intervening exclusively 55 between the inner and outer conductors.

Also, it may happen that either in slipping the outer conductor onto the inner conductor or in handling an assembled concentric conductor line in the field the insulating rings would be subjected to longitudinal displacement on the inner conductor. Such movement tends to change the concentric relation between the inner and outer conductors, thereby causing disturbances producing further variation in the distribution of the voltage gradient on the outer surface of the inner 10 conductor.

Concentric conductor lines may be used in the transmission of radio-frequency signals in the manner disclosed in the patent of L. Espenschied et al. No. 1,835,031, issued December 8, 1931. 15

It is an object of the invention to provide a concentric conductor system, which for a given cross-section and conductor diameter ratio, allows the efficient transmission of maximum signaling voltages, substantially equivalent to those 20 that would be transmitted by a concentric conductor system of the same dimensions and embodying ideal insulating arrangements.

It is another object of the invention to provide a concentric conductor transmission line having 25 high efficient insulation for the transmission of signaling currents embracing a wide band of frequencies.

It is still another object of the invention to provide a concentric conductor transmission line that 30 is capable of facile assembly in both factory and field, and therefore one that is relatively inexpensive to manufacture.

It is a further object of the invention to provide a concentric conductor transmission line in which there is a minimum disturbance of the air or gas dielectric intervening between the inner and outer conductors. 35

It is a still further object of the invention to provide a concentric conductor line in which concentric spacing is substantially maintained at all points thereof. 40

In a preferred form the invention comprises a concentric conductor line in which the inner conductor is provided with a plurality of pairs of diametrically aligned openings spaced therealong in such manner that adjacent pairs are angularly disposed relative to each other. Extending between the associated openings of each pair are tubular members adapted to firmly engage the 50 inner conductor and simultaneously therewith to immovably grasp elongated insulators adapted to provide concentric spacing between the inner and outer conductors.

The invention will be more readily understood 55

from the following description taken together with the accompanying drawings in which:

Fig. 1 is a sectional view of a concentric conductor line illustrating one form of the invention;

Fig. 2 is an end view of Fig. 1;

Fig. 3 is a sectional view of a concentric conductor line delineating another form of the invention;

Fig. 4 is an end view of Fig. 3;

Fig. 5 is a sectional view of a concentric conductor line showing still another form of the invention;

Fig. 6 is an enlarged sectional view illustrating assembly of insulator supports on inner conductor;

Fig. 7 is a sectional view of a concentric conductor delineating a further form of the invention;

Fig. 8 is a sectional view of a concentric conductor showing a still further form of the invention;

Fig. 9 is an end view of Fig. 8;

Fig. 10 is a sectional view of an insulator support embodied in Fig. 8;

Figs. 11, 13, 14, 15 and 16 are partial sectional views of insulator supports that may replace the one shown in Figs. 8 and 10;

Fig. 12 is a plan view taken along lines 12-12 in Fig. 11;

Fig. 17 is a sectional view of a concentric conductor line comprising spirally corrugated inner and outer conductors; and

Fig. 18 is an end view of Fig. 17.

In the following description the same reference numerals are used to indicate the same elements appearing in the several views.

Fig. 1 shows a concentric conductor comprising outer conductor 25 and inner conductor 26. In the latter is provided a plurality of pairs of diametrically aligned openings 27, 27, the openings being of the same diameter and spaced at intervals along the inner conductor. As shown in Fig. 2 adjacent pairs are angularly disposed at 90 degrees, although it is understood that the angular disposition may also be 120 degrees or any desired amount. Positioned in each pair of openings 27, 27 is a tube 28, preferably of the same electrically conductive material as the inner conductor. The opposite ends of the tube 28 are formed with annular beads 29, 29 shaped to assume the contour of the inner conductor so as to provide an autogeneous union therewith. This is, of course, desirable for the purpose of providing satisfactory electrical conductivity in the vicinity of the openings 27, 27.

Also, at substantially the mid-point of the tube 28 is formed an internal circumferential bead 30. Serving to retain concentric relation between the inner and outer conductors is an insulator comprising complementary members 31 and 32 each of which is so disposed in the tube 28 that one end rests on the internal bead 30 and the opposite end engages the inner surface of the outer conductors, the complementary members 31 and 32 engaging diametrically opposite points on the inner surface of the outer conductor. The ends of the members 31 and 32 engaging the outer conductor are preferably rounded so as to substantially provide a point-contact therewith.

Figs. 3 and 4 are substantially identical with Figs. 1 and 2 except tube 35 is provided with an internal boss or projection 36 located preferably at the mid-point thereof. Disposed in the tube 35 is a unitary electrical insulator 37 of an elongated type and having a peripheral recess 38

formed preferably in the mid-section thereof to accommodate the boss 36. It is, of course, understood that the boss 36 can assume any suitable shape and be located in any desired position internally of the tube 35, and also that the recess 38 can be shaped and positioned correspondingly.

Figs. 5 and 6 illustrate a form of the invention that is substantially the same as that shown in Figs. 1 and 2 except supports 50 and 51 cooperate to hold complementary insulators 31 and 32 in position. Support 50 comprises a cup-shaped member 53 formed on one end with annular flange 54 and on the opposite end with an opening 55. Support 51 consists of a cup-shaped member 56 formed on one end with an annular flange 57 and on the opposite end with a hollow projection 58 of tapered configuration. The member 53 also preferably includes two pairs of slots 59 and 60, the slots 59 being provided in diametrically opposite portions commencing at the flange 54 while the slots 60 are also cut in diametrically opposite portions beginning at the opening 55. It is understood the pairs of slots are angularly displaced from each other on the periphery of the member 53. The member 56 is shown with one pair of diametrically opposite slots 61, although two pairs may be provided similarly as in the member 53, if necessary.

The members 53 and 56 are disposed in the associated openings 27, 27 (Fig. 6) by pressing together the ends embodying slots 59, 60 and 61 until tapered projection 58 is properly seated in opening 55 and flanges 54 and 57 are fitted to the periphery of the inner conductor. It is understood that the pairs of slots 59, 60 and 61 are of a length that serve to facilitate the disposition of the members 53 and 56 in the manner described above; that the mouth of the opening 55 is outwardly tapered to facilitate the insertion of the projection 58 thereto, and that the flanges 54 and 57 are shaped to correspond with the contour of the periphery of the inner conductor. Openings 27, 27 may be formed slightly smaller than the outside dimension of the members 53 and 56, so as to firmly hold the latter therein after the pressing force mentioned above has been relaxed.

Fig. 7 is a modification of Fig. 3 and includes a unitary insulator 65 of elongated type disposed in associated openings 27, 27 in the inner conductor, and formed with a peripherally arcuated groove 66 at preferably the mid-section thereof. A transverse insulating pin 67 is positioned so that a central portion is seated in the groove 66 while the ends are disposed in a pair of diametrically aligned openings 68, 68 provided in the inner conductor and arranged at an angle of 90 degrees relative to the openings 27, 27.

Figs. 8 and 9 show a form of the invention which is similar to that illustrated in Figs. 5 and 6 except supports 70, 70 disposed in the openings 27, 27 in the inner conductor for supporting a unitary insulator 71 are individual. Referring to Fig. 10 each support 70 comprises a tube 72 formed on one end with a flanged portion 73 shaped to conform with the contour of the inner conductor and on the opposite end with a bell-mouth portion 74. Adjacent the flanged portion 73 and externally of the tube 72 is provided a peripheral projection 75. Also, externally of the tube 72 and intermediate bell-mouth portion 74 and projection 75 is a split-ring 76 slidable longitudinally of the

tube 72. In addition, the tube 72 embodies a pair of slots 77 formed in diametrically opposite sections commencing at the bell-mouth portion 74.

Each support 70 is secured in an opening 27 in the inner conductor by inwardly flexing the slotted end and inserting this into the opening 27. Pressure is then applied to the flanged end until a portion of the inner conductor is firmly seated between the flanged portion 73 and the peripheral projection 75 as shown in Figs. 8 and 10. Each opening 27 may be slightly larger in diameter than the outside dimension of each tube 72 so as to facilitate the insertion thereof into the opening. Also, the lengths of the slots 77, 77 are such that the end of each support 70 can be readily flexed for positioning in the manner aforescribed. Each insulator 71 is rigidly held in position by a force due to the two slit-rings 76, 76 being spread apart upon the insertion of insulators 71 into tubes 72. Fig. 9 shows adjacent insulators 71 angularly disposed at 90 degrees, although it is obvious these may also be positioned as described above in connection with insulator arrangement delineated in Fig. 1.

Fig. 11 delineates an insulator support 80 that may be substituted for supports 70, 70 shown in Fig. 8. Support 80 comprises a tube 81 formed on one end with a peripheral flange 82 shaped to correspond with the periphery of the inner conductor and a plain opposite end 83. In diametrically opposite sections of the latter are provided at least two longitudinal slots 84, 84 that serve to facilitate inward flexing of the tube 81 for the purpose of insertion into the openings 27, 27. Also, provided in the tube 81, preferably on the same circumference, are four inwardly projecting tongues 85, 85 spaced 90 degrees apart and pressing against insulator 71 to hold the latter in place, Fig. 12. As each opening 27 may be made with diameters slightly smaller than the outside dimension of the supports 80, the latter are firmly secured therein by frictional engagement with the inner conductor. It is, of course, understood that the slots 84, 84 and tongues 85, 85 are so angularly disposed relative to each other that no interference therebetween will be encountered.

Fig. 13 illustrates an insulator support that may also be substituted for supports 70, 70 shown in Fig. 8, and more particularly a modification of insulator support 80 delineated in Fig. 11. An insulator 88 is provided with a circumferential groove 89 of beveled configuration in which tongues 85 are seated as the insulator 88 is inserted into the support 80. This serves to firmly hold insulator 88 in position. It is understood that either one of the two supports associated with the two openings of each aligned pair of openings may be provided with tongues 85, or that both supports may be provided with tongues 85 thereby necessitating the provision of two grooves 89 in the insulator 88. In the latter case, it is evident that the tongues 85 and grooves 89 may be so disposed as to either removably or permanently hold the insulators 88 in position.

Fig. 14 shows an insulator support that may also be substituted for supports 70, 70 shown in Fig. 8, and more particularly a modification of Fig. 11. Support 90 comprises a tube 91 formed with two externally projecting tongues 92, 92 in diametrically opposite portions thereof together with a pair of longitudinal slots 77 disposed at

90 degrees relative to the tongues 92, 92. After tube 90 is inserted into opening 27, the tongues 92, 92 pressing the inner surface of the inner conductor against the flange 82 serve to hold the support 90 in position. Frictional engagement between the inner surface of the support 90 and the periphery of insulator 81 serves to retain the latter in position.

Fig. 15 illustrates an insulator support that may also be substituted for supports 70, 70 shown in Fig. 8, and more particularly is a modification of Fig. 14. Support 93 comprises a tube 94 having a tapered outer surface. Tube 94 is seated in opening 27 by pressing until tongues 92, 92 engage the inner surface of the inner conductor. Due to the tapered configuration of support 93 in its finally seated position, insulator 71 will be firmly wedged therein.

Fig. 16 is a simplification of Fig. 15 in that the tongues 92, 92 of the latter are omitted and further in that slots 77 are substituted therefor. Consequently, support 95 will include four slots 77 angularly disposed 90 degrees relative to each other. In addition, support 95 embodies a knurled portion 96 that serves to bite into the inner conductor thereby assuring a firm seating of each support 95 in each opening 27. It is obvious that any ridged, corrugated, or roughened surface that would bite into the inner conductor could be substituted for the knurled portion 96 mentioned above.

Figs. 17 and 18 show an arrangement for use with a concentric conductor line comprising a spirally corrugated inner conductor 100 and a spirally corrugated outer conductor 101, both of which are of a type well known in the art as Reflex conductor. On the inner spiraled conductor 100 is disposed a carriage 102 of suitable insulating material which is adapted on its inner surface to ride the corrugations and on its outer surface to support diametrically aligned insulators 103. As seen in Figs. 17 and 18 adjacent carriages are so arranged that aligned pairs of insulators are angularly disposed at 90 degrees relative to each other, although it is evident that this disposition can be any desired amount. Reflex conductor is used at points where a line abruptly changes direction, and also to compensate for expansion as it takes care of the expansion of the outer conductor as well as differential expansion.

In the above arrangements it is obvious that the insulators are prevented from longitudinal displacement on the inner conductor in the operations of (a) slipping the outer conductor onto the inner conductor and (b) handling of an assembled concentric conductor line in the field. Consequently, concentric relation between the inner and outer conductors will be retained at all points thereof.

In addition, pin-type insulators with their minimum mass of high dielectric material intervening between the inner and outer conductors tend to cause minimum dielectric losses and also minimum disturbances in the distribution of the potential gradient on the outer surface of the inner conductor. This together with the elimination of gaps between the insulators and the inner conductor extending along a radial from the center of the line, as existed in the case of insulators of the ring type, and the substantial reduction of air or gas dielectric between the inner conductor and the individual pin-type insulators, due to tight fit of insulators in associated openings in inner conductor, obviates the pro-

duction of relatively steep voltage gradients on the outer surface of the inner conductor in the vicinity of the insulators. Consequently, signaling voltages that are substantially equivalent in magnitude to voltages that would be allowed by a line of the same cross-section and having air or gas dielectric intervening exclusively between the inner and outer conductors, or an air or gas dielectric line of the same cross-section provided with ideal insulators for maintaining concentric spacing therebetween, may be applied to the line without causing the production of corona or flash-over, and therefore may be transmitted thereover with increased efficiency.

Furthermore, it is evident that a pin-type insulating arrangement of the character described above lends itself to the facile assembly of a concentric conductor line or the expeditious replacement of defective insulators. In the latter event a defective insulator can be removed and replaced without disturbing the other insulators which is not so in the case of ring-type insulators as all insulators leading to the defective one must be removed before the latter can be replaced.

While the invention is particularly described in connection with a concentric conductor line having a tubular inner conductor, it is obvious that it is equally well suited to concentric conductor lines provided with solid inner conductors.

It is understood that the invention is capable of modifications other than those disclosed herein, and further that the scope thereof together with such modifications is defined in the appended claims.

What is claimed is:

1. In a concentric conductor transmission line comprising tubular inner and outer conductors, said inner conductor having a plurality of pairs of diametrically aligned openings spaced at intervals therealong, tubular means disposed in each pair of said openings and secured to the inner conductor, said tubular means having an internally inclined portion, and insulating means positioned in said tubular means such that one section engages said internally inclined portion and another section engages the outer conductor for retaining concentric relation between said conductors.

2. In a concentric conductor transmission line

comprising tubular inner and outer conductors, said inner conductor having a plurality of pairs of diametrically aligned openings spaced at intervals along the longitudinal axis thereof, means extending between opposite openings in each of said pairs, said means comprising oppositely disposed compartments fastened to the inner conductor, and insulators comprising complemental members having adjacent ends disposed in said compartments and opposite ends engaging the outer conductor for retaining concentric relation between said conductors.

3. In a concentric conductor transmission line comprising tubular inner and outer conductors, said inner conductor having a plurality of pairs of diametrically aligned openings spaced at intervals therealong in such manner that adjacent pairs are angularly disposed relative to each other, hollow means secured to the inner conductor and extending between opposite openings in each of said pairs, said means being provided with an internal projection at substantially the mid-point thereof, and insulators for retaining concentric relation between said conductors comprising complemental members so disposed in said means that one end of each member engages said projection and the opposite end engages the inner surface of the outer conductor.

4. In a concentric conductor transmission line comprising tubular inner and outer conductors, said inner conductor having a plurality of pairs of diametrically aligned openings spaced at intervals therealong in such manner that adjacent pairs are angularly disposed relative to each other, tubular means secured to the inner conductor and extending between opposite openings in each of said pairs, the opposite ends of said tubular means being formed with annular beads to engage the outer surface of the inner conductor, said tubular means being also formed with an internal circumferential bead at substantially the mid-point thereof, and insulators for retaining concentric relation between said conductors comprising complemental members so disposed in said tubular means that one end of each insulating member engages said internal bead and the opposite end engages the inner surface of the outer conductor.

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