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L. A. BONDON

2,589,328

COAXIAL TRANSMISSION LINE SPACING ASSEMBLY

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FIG. 1.

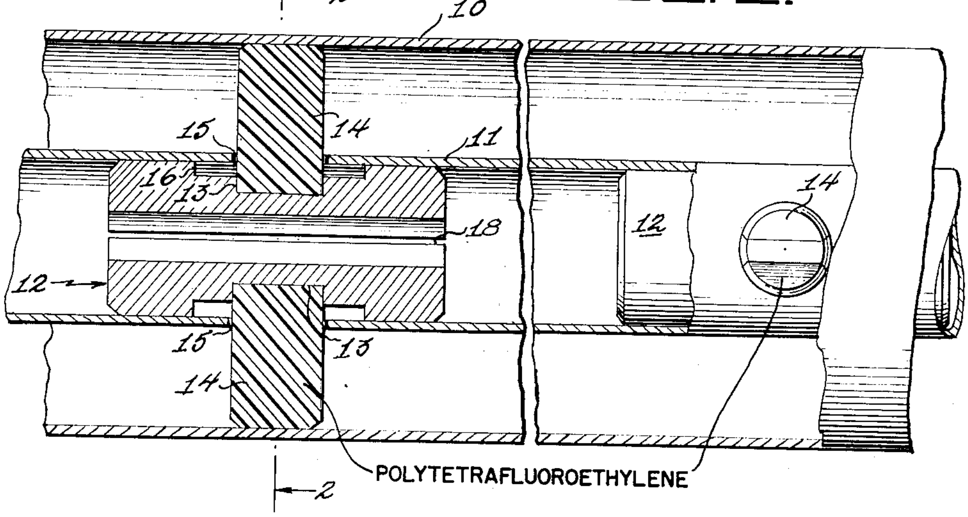


FIG. 2.

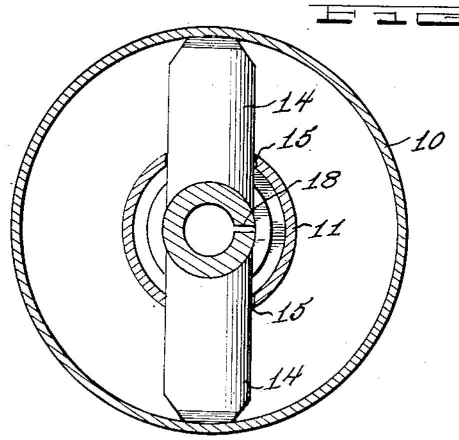


FIG. 3.

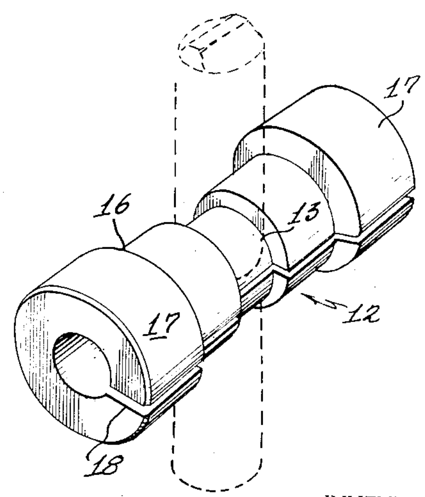


FIG. 4.

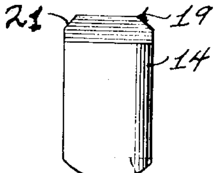
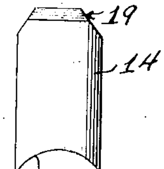


FIG. 5.



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COAXIAL TRANSMISSION LINE SPACING ASSEMBLY

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8 Claims. (Cl. 178—44)

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This invention relates to electrical coaxial transmission lines and has more particular reference to insulating assemblies for maintaining the conductors of such lines in concentric relation.

Conventional forms of coaxial transmission lines usually comprise a tubular inner conductor disposed in a tubular outer conductor and spaced concentrically therefrom by uniformly spaced insulators between inner are outer conductors. With such a known construction there are relatively abrupt changes in the characteristic impedance of the line where the insulators occur and electrical reflection effects accordingly occur at these places.

It has been proposed to overcome this defect and make the characteristic impedance of such a line uniform by providing a change in diameter of one or both of the conductors at the points of engagement with the conductors by the insulators. Such constructions, while compensating for the change in impedance at the insulators, do not provide the electrical transparency required for truly broad band transmission performance. This is due to the fact that the deformation of the conductors to provide the change in diameter necessary to compensate for impedance produces a residual capacitive reaction at each insulator, causing electrical discontinuities which did not exist in the line before being deformed.

One object of the present invention is to provide a coaxial transmission line comprising an inner conductor disposed in a tubular outer conductor and spaced therefrom by insulating assemblies, including radially disposed insulating pins, so constructed and arranged as to overcome the aforesaid difficulties so that the transmission line will provide uniform signal transmission through any portion of its length and should not produce harmful reflections due to their insertion at any service up to the cutoff frequency of the line.

Another object of the present invention is to provide a transmission line, as above characterized, in which the effective diameter of the inner conductor is suitably reduced to reduce the capacity of the inner conductor at each insulating assembly in order to keep the characteristic impedance of the line constant.

Another object of the present invention is to provide a transmission line, as above characterized, wherein an air gap is formed around the inner end of each of the insulator spacing pins at the point where they engage the effectively reduced diameter portion of the inner conductor to provide an inductance in series with the the insulator capacity sufficient to compensate for capacitive reactance introduced from the construction employed.

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A further and more specific object of the present invention is to provide a transmission line, as above characterized, wherein the inner conductor is a circular tubular conductor, and wherein the insulating assemblies each comprises a reactance or X-slug slip fitted within the inner conductor and formed as a metallic cylindrical member having a wide, shallow, circumferential channel formed intermediate its ends and a narrow, circumferential channel formed on the bottom surface of the wide channel intermediate its ends; and a diametrically opposed pair of cylindrical insulator pins extending through the walls of the inner conductor with their inner ends saddle fitted within the narrow channel on the X-slug and their outer ends engaging the inner surface of the outer conductor; with the dimensions of the channels being so proportioned that the transmission line is electrically "transparent," thereby permitting it to provide truly broad band performance.

Other objects and advantages of the invention will be apparent in the following specification, when considered together with the accompanying drawings, wherein:

Fig. 1 is an elevational view with parts broken away, of a coaxial transmission line constructed in accordance with the present invention;

Fig. 2 is a vertical sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged perspective view of the X-slug shown in Fig. 1;

Fig. 4 is an end view of one of the insulators shown in Figs. 1 and 2; and

Fig. 5 is an elevational view of the insulator shown in Fig. 4.

The present invention is an improvement over that disclosed in my Patent No. 2,436,284, issued on February 17, 1948, for Coaxial Transmission Line.

The coaxial transmission line disclosed in the aforesaid patent, while giving greatly improved line performance, permitting its use at frequencies beyond the range of the conventional air dielectric coaxial transmission line, does not provide truly broad band line performance, because the insulator structure used to support the inner conductor is not electrically "transparent" to any radio frequency waves within the pass band of operation.

In general, the present invention provides a coaxial transmission line in which the construction of the insulator assemblies is designed to compensate not only for the change in the characteristic impedance, but also for any other flux line discontinuities caused by the design of the assemblage structure, where the insulator structure becomes electrically "transparent" and provides truly broad band line performance.

Referring now to the drawing, there is shown, in Figs. 1 and 2, a coaxial transmission line constructed in accordance with the present invention and comprising an outer circular tubular conductor 10, an inner circular tubular conductor 11. The conductors are held in concentric relationship throughout their length by means of longitudinally spaced, angularly disposed insulator spacing assemblies mounted within the inner conductor.

Each insulating assembly is identical in construction and, as shown, each comprises a cylindrical reactance or X-slug 12, made of conducting material and having a circumferential channel or groove 13 formed thereon intermediate its ends; and a pair of diametrically opposed insulator spacing members 14 extending through diametrically opposed openings 15 in the wall of the inner conductor with their inner ends saddle fitted within the cylindrical groove 13 and their outer ends engaging the inner surface of the outer conductor.

The X-slug 12 is preferably made of the same material as the inner conductor and is formed to the shape best shown in Fig. 3. As there shown, the X-slug is in the form of a short cylindrical member having a wide circumferential channel or groove 16 formed in its outer surface intermediate its ends, providing shoulders 17 at each end. The shoulders 17 have end walls perpendicular to the longitudinal axis of the member. The narrow circumferential channel or groove 13 engaged by the insulators 14 is formed intermediate the ends of the channel 16. The channels 13 and 16 are rectangular in cross section and their side walls are perpendicular to the axis of the X-slug. The X-slug 12 is provided with a longitudinal slot 18 which gives the member sufficient resilience to permit it to be inserted in the inner conductor with the external surface of the shoulders 17 tightly engaging the inner surface of the conductor.

Each of the insulator pins 14 is identical in construction and may be of any suitable shape; however, in the particular embodiment thereof illustrated, is shown as a cylindrical member having one end wedge-shaped, as indicated at 19, and the other end made concave, as shown at 20, with a surface curvature the same as the outer surface curvature of the channel portion 13 of the X-slug. The insulators 14 are preferably made of a compressible plastic organic insulating material such as polytetrafluorethylene.

In assembling the transmission line, the X-slugs are positioned to bring their grooves 13 in alignment with their corresponding diametrically opposed holes 15 in the inner conductor. Then, the insulator pins 14 are inserted through the holes 15 in the inner conductor and pressed into a tight saddle fit within the grooves 13 on the X-slugs which hold the inner ends of the pins in place (Fig. 1). Then, the inner conductor, with the spacing assemblies in place, is press-fitted into the outer conductor, the plastic material of which the insulator pins 14 are made being slightly compressed to make an intimate physical fit with the inner surface of the outer conductor. To facilitate the insertion of the pin members 14 into the outer conductor, the longitudinal ends of the wedge-shaped ends 19 may be beveled, as indicated at 21.

The insulating assemblies are longitudinally spaced at any desired intervals and may be disposed on the inner conductor in any desired angular relation. In the particular embodiment of the invention illustrated, they are shown as being angularly disposed 90° relative to adjacent assemblies. The circumferential channels 13 on the X-slugs 14 are cut to a depth sufficient to provide a characteristic impedance at each insulator equal to the characteristic impedance of the transmission line in the air space portions between these insulators, or, in other words, to accomplish impedance compensation at the points of support of the inner conductor. The channel 13 of the X-slug produces the same effect as undercutting the inner conductor an amount equal to the dimension of the channel, to reduce its diameter. The width of the circumferential channel 16 in each of the X-slugs is made larger than the diameter of the insulator pins to provide an air gap between the vertical side walls of the insulators and the vertical side walls of the channel. The air gap provides a series inductive reactance which cancels out the residual capacitive reactance of the insulator which causes distortion of flux lines distributed about this local. The interface capacity of the particular construction shown in Fig. 1, is very small, due to the physical relationships of the assembly, as shown, and, therefore, the value of inductance required for cancellation of this capacitive reactance is very small.

It will be seen that with the construction illustrated and above described, it is possible, by suitably proportioning the X-slugs, to decrease the capacitance of the inner conductor at each insulator in order to keep the characteristic impedance constant. Also, the interface capacitive reactance, due to distortion of flux lines at the assembly local and remaining after impedance compensation has been accomplished, is cancelled by introduction of a series inductance as provided by the air gap between the vertical side walls of the channel formed on the X-slug and the vertical side walls of the insulators, thereby accomplishing a coaxial transmission line which is "transparent" to RF waves throughout the frequency range of the size of the line in use.

For example, a 1⅝'' electrical coaxial transmission line as already supplied for commercial and military service and having an impedance of 51.5 ohms is constructed as above described and gives complete broad band performance up to 2100 megocycles. The critical dimensions of the inner and outer conductors, the insulators, and X-slugs of such a line are as follows:

Outer conductor:	
outer diameter	1.625
inner diameter	1.527
Inner conductor:	
outer diameter	.664
inner diameter	.614
Insulator pins:	
diameter	.323
length	.567
X-slug:	
outer diameter	.612
inner diameter	.375
length	.875
Width of wide channel	.620
Depth of wide channel	.041
Width of narrow channel	.333
Depth of narrow channel	.053

From the foregoing it readily will be seen that there has been provided an electrical coaxial transmission line having spacing assemblies so constructed and arranged as to provide the electrical transparency required for RF wave transmission over the entire frequency range of the line size in use.

Obviously, the invention is not restricted to the particular embodiment thereof herein shown and described.

What is claimed is:

1. An electrical transmission line comprising hollow, cylindrical inner and outer conductors and spacing assemblies radially disposed within said outer conductor at spaced points throughout its length for maintaining said conductors in concentric relation, each of said assemblies comprising a short cylindrical conductor member slidably mounted within said inner conductor with its outer surface in engagement with the inner surface of the inner conductor, said member having a circumferential channel formed on its outer surface intermediate its ends and radially disposed insulating pins extending through the wall of said inner conductor with their inner ends projecting into said channel and engaging said member and their outer ends engaging the inner surface of said outer conductor, the depth of the channels formed in the cylindrical members of said insulating assemblies being such as to equalize the transmission line characteristic impedance at an insulating assembly with the characteristic impedance of said transmission line in the air space portions between insulating assemblies, whereby the characteristic impedance of the transmission line will be constant.

2. A transmission line, as set forth in claim 1, wherein said member is made of the same material as said inner conductor and said insulating pins are cylindrical and are made of polytetrafluorethylene.

3. A transmission line, as set forth in claim 1, wherein said insulating pins are cylindrical and have concave inner ends and wedge-shaped outer ends, said concave ends having a curvature substantially the same as the curvature of the bottom of said channel formed on said member to provide intimate physical contact therewith, thereby excluding all air therebetween and said wedge-shaped outer ends provide intimate physical contact with the inner surface of the outer conductor along longitudinal sections thereof.

4. A transmission line, as set forth in claim 1, wherein the side walls of said channel are perpendicular to the longitudinal axis of said member and abut the side walls of said insulating pin thereby preventing longitudinal movement of said member relative to said inner conductor.

5. An electrical transmission line comprising hollow cylindrical inner and outer conductor and spacing assemblies radially disposed within said outer conductor at spaced points throughout its length for maintaining said conductors in concentric relation, each of said assemblies comprising a short cylindrical conductor member mounted within said inner conductor with its

outer surface in tight engagement with the inner surface of the inner conductor, said member having a wide circumferential channel formed on its outer surface intermediate its ends and a narrow circumferential channel formed on the bottom surface of said wide channel intermediate its ends, and radially disposed insulating pins extending through the wall of said inner conductor with their inner ends projecting into said narrow channel and engaging said member and with their outer ends engaging the inner surface of said outer conductor, the depth of the narrow channels formed in the cylindrical members of said insulating assemblies being such as to equalize the transmission line characteristic impedance at an insulating assembly with the characteristic impedance of said transmission line in the space between insulating assemblies, whereby the characteristic impedance of the transmission line will be constant, the depth and width of the wide channels being such as to provide an air gap surrounding the inner ends of said insulating pins of sufficient size to introduce an inductance in series with each of said pins of sufficient value to cancel the residual capacitive reactance due to the particular construction of said insulator assemblies, whereby said transmission line will be electrically transparent and give broad band performance through the usable frequency range of the size line in use.

6. A transmission line, as set forth in claim 5, wherein said member is made of the same material as said inner conductor and said insulating pins are cylindrical and are made of polytetrafluorethylene.

7. A transmission line, as set forth in claim 5, wherein said insulating pins are cylindrical and have concave inner ends and wedge-shaped outer ends, said concave ends having a curvature substantially the same as the curvature of the bottom of said narrow channel formed on said member to provide intimate physical contact therewith, thereby excluding all air therebetween and said wedge-shaped outer ends provide intimate physical contact with the inner surface of the outer conductor along longitudinal sections thereof.

8. A transmission line, as set forth in claim 5, wherein the side walls of said channels are to the longitudinal axis of said member with the side walls of said narrow channel abutting the side walls of said insulating pins to prevent longitudinal movement of said member relative to said inner conductor.

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