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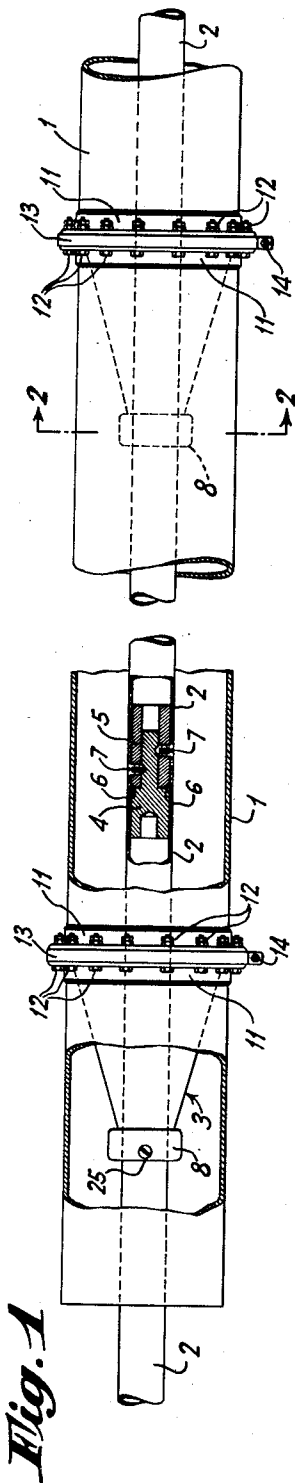
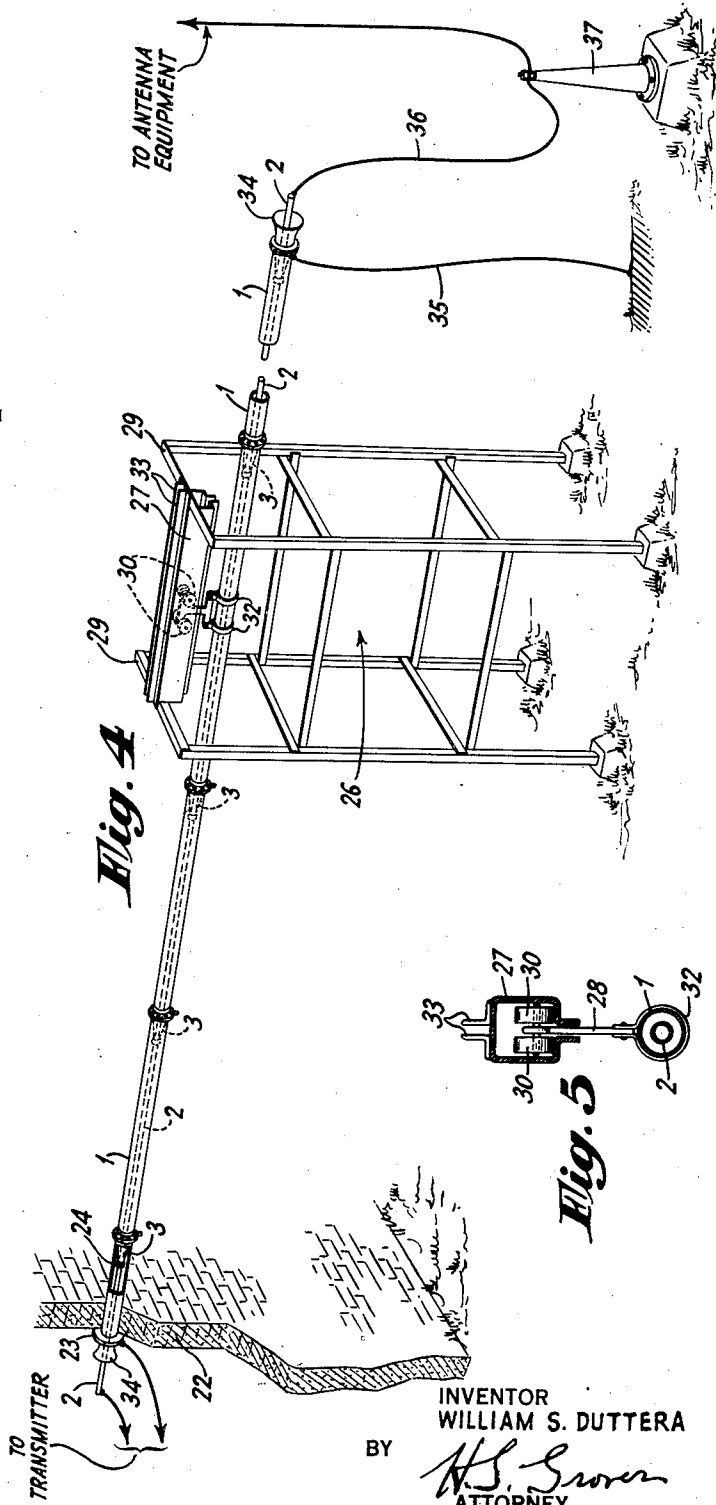
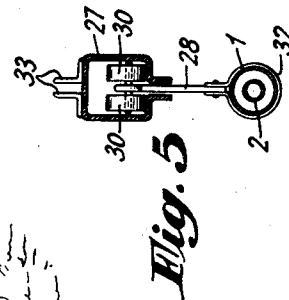
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2,191,071

COAXIAL CONDUCTOR SYSTEM FOR TRANSMISSION OF ELECTRICAL POWER

Filed April 15, 1937

2 Sheets-Sheet 1



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Fig. 3

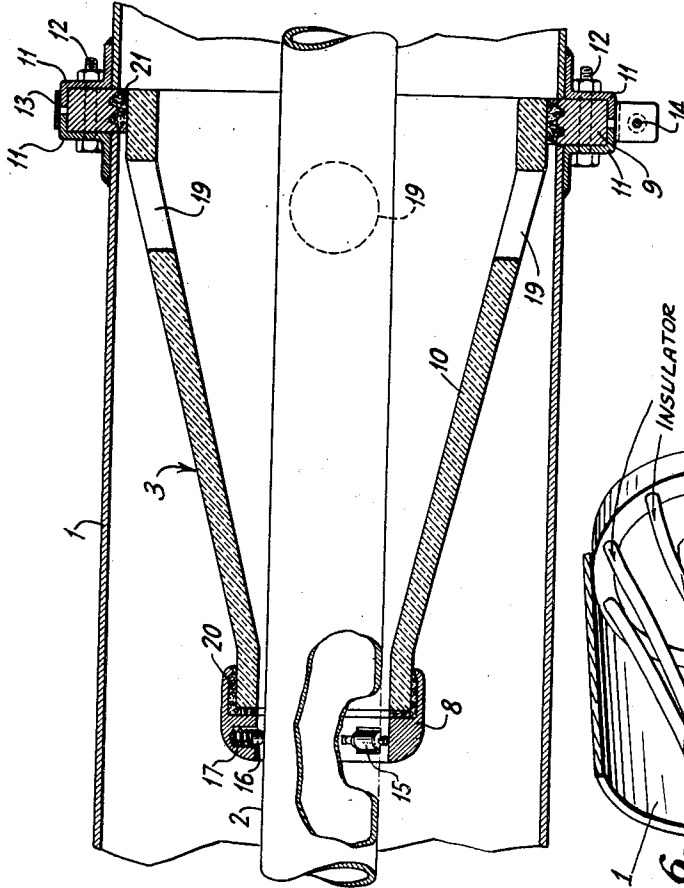
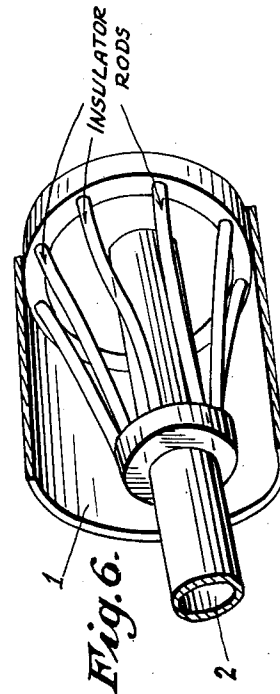
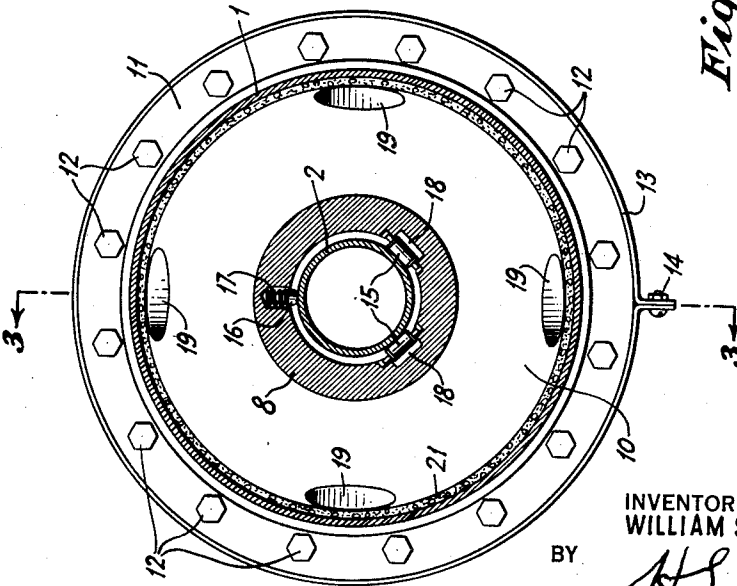


Fig. 6.

Fig. 2



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COAXIAL CONDUCTOR SYSTEM FOR TRANSMISSION OF ELECTRICAL POWER

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Application April 15, 1937, Serial No. 137,003

11 Claims. (Cl. 174-28)

This invention relates to a coaxial conductor system for transmitting electrical energy, generally radio frequency energy.

It has been proposed to manufacture a coaxial conductor system by employing spiral insulators, spaced washer discs, or spoked insulators for insulating the two conductors of a coaxial line from each other, and for supporting the inner conductor in proper spaced relation with respect to the outer conductor. These insulators, as heretofore proposed, have a relatively low voltage breakdown in comparison to the breakdown voltage of the line without the insulators.

One of the objects of the present invention is to provide an improved coaxial conductor system for high frequency transmission, having improved insulators between the inner and outer conductors of the line.

Another object is to provide a method of, and means for enabling the coaxial conductor system to expand and contract with variations in temperature.

A further object is to enable the two conductors of the coaxial conductor system to expand and contract independently of each other with variations in temperature.

A feature of the invention comprises the conical-shaped insulator located within the outer conductor for providing an insulated support for the inner conductor. This insulator permits an operating voltage on the line which approaches more closely than heretofore possible the breakdown voltage of the line without the insulator. A further characteristic of this conical-shaped insulator is the minimization of the losses normally engendered in the insulator.

Another feature lies in the roller arrangement included in the cap of the insulator for enabling the inner conductor to move freely relative to the insulator.

A further feature of the invention is the movable carriage on wheels and the track arrangement for enabling the coaxial line to move with changes in temperature.

One advantage of the present invention lies in the fact that any one insulator, or any section of the transmission line, can be removed without completely disassembling the line.

Other objects and features will appear in the following detailed description taken in conjunction with the drawings, wherein like parts are indicated by like reference numerals:

In the drawings:

Fig. 1 is a side view, partly in section and partly cut away, of a coaxial transmission line

constructed in accordance with the principles of the present invention;

Fig. 2 is a cross section of the coaxial line of Fig. 1, along the line 2-2, in the direction of the arrows, and shows an end view of the improved insulator;

Fig. 3 is a cross-section of Fig. 2, along the line 3-3;

Fig. 4 is a perspective view of a complete coaxial line system showing one of the movable carriage supports;

Fig. 5 is a cross-sectional view showing the manner in which the movable carriage, which supports the coaxial line, moves over the track; and

Fig. 6 shows a modification of the insulator of the invention, wherein rods are employed instead of a single conical surface of revolution.

Referring to Fig. 1 of the drawings, there is shown a coaxial conductor system comprising an outer conductor 1 and an inner conductor 2, these conductors being insulated from one another and maintained in spaced relation by a plurality of conical insulators 3, 3. The inner conductor is composed of a plurality of sections which are joined together by male and female coupling elements. Each of these sections has a male member 4 secured to one end and a female member 5 secured to the other end of the section. The sections are assembled so that the male member of one section is joined with the female member of the adjacent section and held tightly together by a pair of set screws 7, 7 which are countersunk in the outer surface of the inner conductor in such a manner as to provide a smoothly continuous outer surface for the inner conductor. Member 4 is a solid, metallic, cylindrical male element and is secured to the inner conductor 2 by a continuous circular weld 6. Female member 5 is a hollow metallic cylindrical element fitting snugly over the male element 4 and also secured to the inner conductor 2 by a continuous circular weld 6. This combination provides an easily removable joint as well as a smooth continuous outer surface for the inner conductor.

The conical insulators each include a non-ferrous metallic cap 8 at one end and a non-ferrous metallic ring 9 at the other end (note Fig. 3), the ring serving as a fastening means for the insulator 3 to the outer conductor, both cap and ring being cemented at 20 and 21, respectively, to the insulating material 10 of the insulator. The insulator 3 is supported from the outer conductor 1 by the ring 9 which is positioned between a pair of circular flanges 11, 11,

these flanges being welded to the outer surface of the outer conductor 1 and fastened together by means of a plurality of bolt and nut arrangements 12 regularly spaced around the continuous flanges, as shown. A circular cover plate 13 overlaps the adjacent edges of the flanges 11, 11 for preventing water from entering into any open space which might exist between the flanges and the ring. This circular cover plate is held in position by means of a machine screw and nut arrangement 14 which fastens together the two ends of the cover plate.

Figs. 2 and 3 show the details of the insulator more clearly. Located in the cap 8, there is provided a pair of rollers 15 symmetrically positioned under the inner conductor 2 for supporting same, so as to enable the inner conductor to move freely within the cap. The contact pin 16 and spring arrangement 17 is provided to insure good electrical contact between the inner conductor 2 and the metal cap 8, thus preventing any voltage difference between the cap and the inner conductor. In assembling the line, the rollers are first placed in machined grooves 18 in the cap 8 and the inner conductor 2 rolled over the rollers. The contact pin and spring arrangement 16 and 17 is placed in position before the inner conductor is inserted in the cap, but displaced in position and held in such manner as not to interfere with the insertion of the inner conductor during the process of assembling. For purposes of ventilation in the line, there are provided suitable vent holes 19 in the insulating material 10. Both the cap 8 and the ring 9, at opposite ends of the insulator 3, are fastened to the insulating material 10 by means of layers of cement 20 and 21. At the large end of the insulator 3, the ring 9 is grooved on the inner surface to enable the cement 21 to obtain a very firm hold on the ring. All surfaces of the insulator which actually contact the cement are sanded to provide a good gripping surface. Although the insulator has here been shown as being conical in shape, and such general configuration is preferred, it will be understood that, if desired, the insulator may consist of a plurality of separate insulating rods generally conforming to the shape of a cone. Putting it another way, the form of rods may be obtained by lengthening the vents 19 lengthwise of the conical insulator. Such an arrangement is illustrated in Fig. 6. Similarly, the conical insulators shown in the drawings may take slightly different forms, the surfaces bulging or tapering to a more or less gradual or pronounced extent, as desired.

Fig. 4 indicates, among other things, the manner in which a complete coaxial transmission line system is assembled, such that the conductors of the line are free to expand in one direction with increase in temperature, and conversely, to contract in the opposite direction with decrease in temperature. In this system the outer conductor 1 is rigidly fastened to the wall 22 of the transmitter building by means of a flange 23, while the inner conductor 2 is fixedly attached, from a mechanical standpoint, at one point 24 near the flange 23, to the outer conductor 1 by means of the insulator 3 nearest said flange. In this particular instance, the two conductors 1 and 2 are mechanically connected together by one or more pins 25 extending through the cap at the small end of the insulator 3 and through the inner conductor 2. The rollers 75 which are normally present in the other insula-

tors, as described above, are here omitted from this last insulator nearest the building, and packing is provided between the inner conductor and the cap 8 to properly center the inner conductor. This is more clearly illustrated in Fig. 1, wherein the left hand insulator 3 indicates the manner of mechanically connecting the conductors 1 and 2 together, while the right hand insulator designates the general arrangement described above utilizing rollers for permitting the inner conductor to move relative to the outer conductor. It should be understood, at this time, that the two conductors of the coaxial transmission line are mechanically connected together at only this point 24 by means of the insulator nearest the transmission wall, while the inner conductor is maintained in spaced relation to the outer conductor but free to move with respect thereto by means of the many other insulators located at intervals along the length of the transmission line.

For enabling the line to move with changes in temperature, there are provided, along the length of the line, numerous supporting frameworks 26, each having across the top thereof struts 29 extending transversely of the transmission line, for supporting a stationary track and movable carriage arrangement. The track consists of a substantially completely enclosed rectangular shaped hollow sheet steel element 27 which is bent inwardly at the bottom and open at this particular location for permitting a downwardly extending rod 28 to support the outer conductor 1. Rod 28 connects at its upper portion with two pairs of wheels 30 which are movable along the length of the track 27 with movement of the line. At the lower end of the rod 28, there are provided two spaced straps 32 which are firmly clamped around the circumference of the outer conductor. It will thus be seen that any movement of the outer conductor 1 will cause a corresponding movement of the rod 28 and the wheels 30 attached to the pin, over the track 27. Although the track arrangement 27 is here shown supported on a pair of angle irons 33 resting on the transverse struts 29, it will be understood that, of course, these angle irons may be omitted and the track supported in any other suitable way to the struts; for example, by means of a bolt arrangement extending from the strut 29 through the element 27. The track and movable carriage arrangement is clearly shown in detail in Fig. 5, which illustrates a cross-sectional view of the track, carriage and supporting pin.

At both ends of the coaxial transmission line which connect respectively with the antenna equipment and with the transmitter, the outer conductor is flared as at 34 in order that no voltage gradient will be produced which is greater than that existing throughout the line. If the flares were not provided, there would be an abnormally high voltage gradient at the end of the outer conductor due to the inner conductor extending beyond the end of the outer conductor. This higher gradient would cause premature breakdown. The flared portion thus acts as a sort of shield preventing concentration of flux at the end of the outer conductor. The outer conductor of the transmission line is grounded at every support 26, and at the end of the transmission line, as by a flexible conductor 35. The inner conductor connects through a flexible conductor 36 to the antenna equipment and, if desired, such conductor may be connected to 75

the upper part of a stand-off insulator 37, as shown.

In a coaxial transmission line having a length of about 450 feet, actually constructed in accordance with the principles underlying the present invention, there were employed approximately thirty conical insulators, regularly spaced along the length of the line, and about twenty-one supports. The outer conductor of this line had an inside diameter of about ten inches and the inner conductor had an outside diameter of about two and three-quarter inches. Such a line was designed to excite an antenna having a power rating of 500 kilowatts.

In effect, the coaxial transmission line hereinabove described consists of a plurality of sections which are joined to one another end-on-end at the conical insulators, the flanges 11, 11 serving to mechanically and electrically couple the sections of outer conductor together. Actually, at each of these connecting points, slightly displaced therefrom in a direction toward the antenna equipment, there is also employed a coupling arrangement for the inner conductor of the type illustrated in Fig. 1 comprising male and female members 4 and 5. Thus, if the outer conductor of the line is opened at any one connecting point by removing the bolt arrangements 12 at that point, and pushing the remainder of the outer conductor out toward the free end of the line (it should be remembered that the outer conductor is supported on a movable carriage arrangement), it is possible to gain access to the inner conductor coupling arrangement at that point. By unscrewing screws 7, 7, it is also possible to push the remainder of the inner conductor out toward the free end inasmuch as the inner conductor is movable on the rollers of the insulators. It is then possible to remove the insulator. This arrangement thus permits the removal of any one insulator or section of line without completely disassembling the line.

It should be understood that the invention is not limited to the precise arrangement of parts shown in the drawings, inasmuch as various modifications may be made without departing from the spirit and scope of the appended claims. For example, if desired, the metallic caps at the small ends of the insulators may be dispensed with and a suitable polished, metallized, continuous surface provided only on the inner and outer tip of the small end of the insulator. Such a metallized surface may be achieved by electroplating or hot-spraying copper or aluminum on the surface of the small end of the insulator. Where such a metallized surface is used, the same features of rollers and contact pins may be employed.

What is claimed is:

1. A high frequency coaxial transmission line comprising an inner conductor of high electrical conductivity for radio frequency energy and an outer conductor of high electrical conductivity for radio frequency energy, and a plurality of spaced conical-shaped insulators between said conductors for supporting said inner conductor, one end of each of said insulators being fastened to one of said conductors, while the other end of each of said insulators contains anti-friction means for enabling the other conductor to move relative to said insulators.

2. A high frequency coaxial transmission line comprising an inner conductor of high electrical conductivity and an outer conductor of high electrical conductivity, a plurality of spaced conical-shaped insulators between said conductors for

supporting said inner conductor, the small ends of said insulators being adjacent to and surrounding said inner conductor, means for fastening the large ends of said insulators to said outer conductor, and rollers in the small ends of the insulators for enabling the said inner conductor to move relative to said insulators.

3. A high frequency coaxial transmission line comprising an inner conductor of high electrical conductivity for radio frequency energy and an outer conductor of high electrical conductivity for radio frequency energy, and a plurality of spaced conical-shaped insulators between said conductors for supporting said inner conductor, said conical insulators comprising solid insulating material having a plurality of elongated ventilating openings in the length of said insulators, one end of each of said insulators being fastened to one of said conductors, while the other end of each of said insulators contains anti-friction means for enabling the other conductor to move relative to said insulators.

4. A high frequency coaxial transmission line comprising an outer conductor of high electrical conductivity for radio frequency energy and an inner conductor of high electrical conductivity for radio frequency energy, a plurality of conical-shaped insulators between said inner and outer conductors for supporting said inner conductor, the large ends of said insulators being fastened to said outer conductor, the small ends of said insulators being metallized adjacent to and surrounding said inner conductor, the openings in said small ends of said insulators being larger than the outer circumference of said inner conductor for enabling free movement of said inner conductor along the length of said line relative to said insulators, and means between said inner conductor and the small ends of said insulators for electrically connecting said inner conductor to said metallized small ends for preventing voltage differences therebetween.

5. A high frequency coaxial transmission line comprising an inner conductor of high electrical conductivity and an outer conductor of high electrical conductivity, and a plurality of spaced conical-shaped insulators between said conductors for supporting said inner conductor, said conical insulators each comprising a plurality of spaced insulating rods connected together at the large and small ends of the insulator.

6. A high frequency coaxial transmission line having an inner conductor of high electrical conductivity for radio frequency energy and an outer conductor of high electrical conductivity for radio frequency energy, a plurality of conical-shaped insulators spaced along the length of said line between said inner and outer conductors and surrounding said inner conductor for supporting said inner conductor, said insulators and said line having the same longitudinal axis, means for fastening the large ends of the conical-shaped insulators to said outer conductor, a metal cap attached to and surrounding the small end of each of said insulators and surrounding said inner conductor, and means for providing an electrical connection between each of said caps and said inner conductor.

7. A high frequency coaxial transmission line comprising an outer conductor of high electrical conductivity and an inner conductor of high electrical conductivity, a plurality of spaced conical insulators between said conductors and surrounding said inner conductor for supporting said inner conductor, the large ends of said insulators

- being fastened to said outer conductor, the small ends of said insulators being adjacent to and surrounding said inner conductor, said small ends being larger than said inner conductor for enabling movement of said inner conductor within said insulators along the length of said line, and a plurality of movable carriage supports along the length of said line for supporting same, said carriage supports being connected to said outer conductor, whereby said outer conductor can expand or contract with variations in temperature, and said conductors can also move independently of one another, due to changes of temperature and for purposes of disassembly.
- 15 8. A high frequency coaxial transmission line comprising an inner conductor of high electrical conductivity and an outer conductor of high electrical conductivity, a plurality of spaced conical-shaped insulators between said conductors for supporting said inner conductor, the small ends of said insulators being adjacent to and surrounding said inner conductor, means for fastening the large ends of said insulators to said outer conductor, and a pair of rollers in the small ends of each of said insulators for enabling said inner conductor to move relative to said insulators, said rollers of each pair being located below and on opposite sides of the vertical axis of said inner conductor.
- 20 9. A high frequency coaxial transmission line having an inner conductor of high electrical conductivity for radio frequency energy and an outer conductor of high electrical conductivity for radio frequency energy, a plurality of conical-shaped insulators spaced along the length of said line between said inner and outer conductors and surrounding said inner conductor for supporting said inner conductor, said insulators

and said conductors having the same longitudinal axis, means for fastening the large ends of the conical-shaped insulators to said outer conductor, a metal cap attached to the small end of each of said insulators and surrounding said inner conductor, said cap having a larger internal diameter than said inner conductor for enabling free movement of said inner conductor relative to said conical-shaped insulators, and means for providing an electrical connection between each of said caps and said inner conductor, said last means comprising a resilient contact pin arrangement engaging both said metal cap and said inner conductor.

10. A high frequency transmission line comprising an inner conductor of high electrical conductivity and an outer conductor of high electrical conductivity, a plurality of spaced conical-shaped insulators between said conductors for supporting said inner conductor, the large ends of said insulators being fastened to said outer conductor, said inner and outer conductors being made up of sections, the sections of outer conductor being connected together at the large ends of said insulators, the sections of inner conductor being connected together intermediate the insulators.

11. A high frequency coaxial transmission line comprising sections each having an inner conductor of high electrical conductivity and an outer conductor of high electrical conductivity, and a plurality of spaced conical-shaped hollow insulators between the conductors of said sections for supporting said inner conductor, the large ends of said insulators being fastened to said outer conductor at the junctions of said sections.

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