Aug. 23, 1932. D. A. QUARLES 1,873,477

COAXIAL CONDUCTOR TRANSMISSION LINE

Filed March 30, 1929

FIG. 1

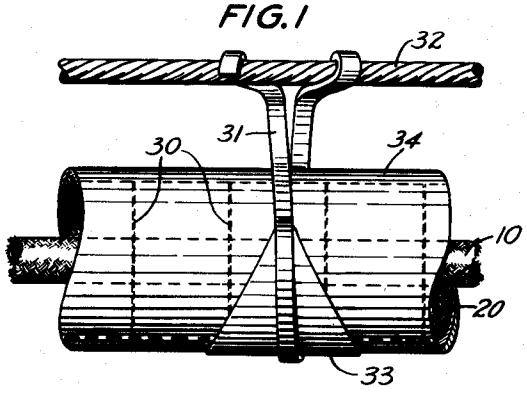


FIG. 2

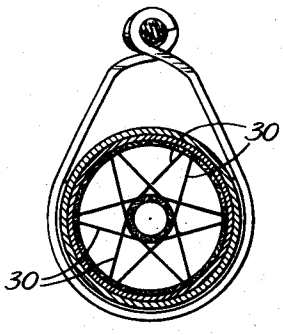


FIG. 4

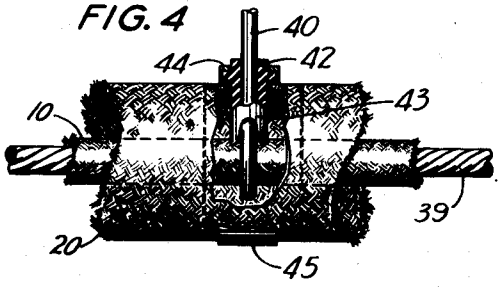


FIG. 5

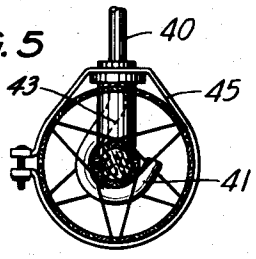


FIG. 7

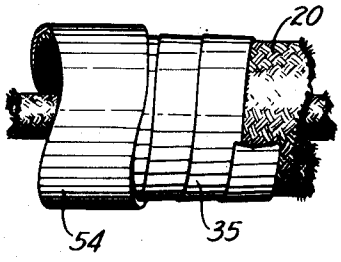


FIG. 6

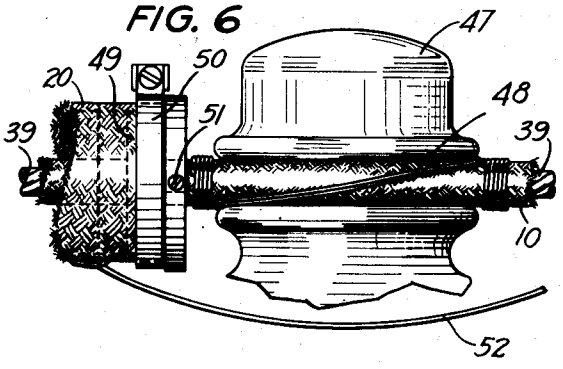


FIG. 3

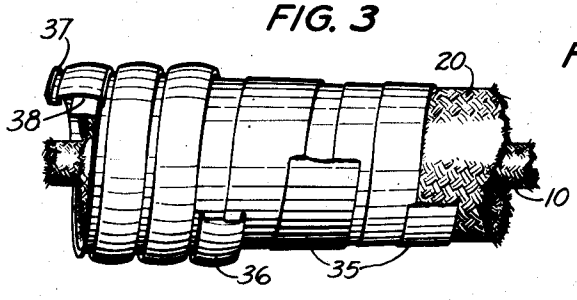
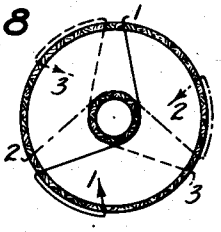


FIG. 8



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UNITED STATES PATENT OFFICE

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COAXIAL CONDUCTOR TRANSMISSION LINE

Application filed March 30, 1929. Serial No. 351,304.

The present invention relates to wave transmission systems and a conductor construction therefor.

An object of the invention is a restricted or closed-field wave transmission system employing a construction well adapted for use on pole lines or in conduits.

The invention employs a conductor of the coaxial type comprising an outer cylindrical shell and an inner core spaced therefrom.

Where attempt is made to accomplish successfully long-distance high-frequency wave transmission by means of such a conductor, the following important considerations arise:

If the conductor is to be suspended on poles it must possess considerable flexibility.

To avoid too costly suspension, it should not be too heavy.

It must be adapted to exposure to weather, including wet, freezing, sleet, etc.

If the conductor is to be used only in conduits, it should likewise possess considerable flexibility to facilitate handling. Weight and resistance to exposure are not however in this case so important.

Whatever manner of supporting the conductor is adopted, a prime consideration is the dielectric loss. This should, of course, be kept to the lowest value consistent with other requirements.

In accordance with the present invention, applicant has provided a braided or woven type of construction for one or both the outer and inner conductors. This makes for flexibility and light weight. By this construction also, applicant is enabled to keep the solid dielectric at a minimum in the space between the inner and outer conductors, practically all of this space containing only air. The supporting or spacing means between the inner and outer conductors consists preferably of cords of suitable textile material which are preferably impregnated with a water-proof compound. These not only provide strong, light-weight supporting means, but are well adapted to the woven or braided construction of the conductors, since they may be interwoven with the conductor strands and thus can be incorporated in the structure during the braiding process, if desired.

A more complete understanding of the invention and its mode of construction may be had from the following specification taken in connection with the accompanying drawing, in which Figs. 1 and 2 show plan and sectional views respectively of one type of construction which the invention may take; Fig. 3 illustrates a type of armoring that may be applied to the cable in accordance with the invention; Figs. 4 and 5 are similar views respectively of one type of suspension in accordance with the invention; Fig. 6 illustrates another type of suspension in accordance with the invention; Fig. 7 illustrates another form of armoring for the conductor; and Fig. 8 is a diagram to show one method of suspending the inner conductor from the outer.

Referring first to Figs. 1 and 2, the preferred form of construction for the coaxial conductor cable will first be described, this being the construction which is illustrated in each of the figures of the drawing. Thereafter different typical modes of suspending the conductor as illustrated in the different figures will be described.

The inner and outer conductors, 10 and 20 respectively, may be similarly constructed and each preferably is formed by braiding relatively fine gauge copper wire to form cylinders which have the requisite flexibility for handling, but at the same time are not easily collapsible but possess a high degree of mechanical resistance to crushing. A suitable size for the copper wire is 22 to 26 B and S gauge. The inner conductor 10 is supported centrally relative to the outer cylinder 20 by suspension rather than by compression members, one means of accomplishing this being to thread a cord of suitable material such as silk, cotton, hemp, etc. back and forth from the outer to the inner cylinder through the braiding process. Such suspension members or cords are indicated at 30. These cords should be placed near enough to one another to afford the necessary support for one conductor relative to the other, but the number used should not be greatly in excess of what is needed for mechanical requirements in order not to provide too great a tendency to-

ward electrical leakage or losses by dielectric capacity. A practical dimensioning of the two conductors is to have the inner diameter of the outer cylinder about four times the outer diameter of the inner cylinder.

One manner in which the supporting strands may be braided into the structure is shown in Fig. 8. The insulating supporting strand numbered 1, for example, is shown as projecting inwardly from the outer cylinder at the top of this figure, passing around about ⅓ of the circumference of the inner cylinder and extending to the outer cylinder in a direction about 120° from the direction of entering, after which it may be braided into a suitable portion of the outer conductor and may project inwardly again as shown by the arrow to engage the inner conductor at another point. The same rule is followed for supporting strands 2 and 3, respectively. In this way the strands are made substantially tangential to the inner conductor. The point at which each of the supporting strands in Fig. 8 enters the space between the conductors a second time (as indicated by the arrow) will be spaced along the conductor a suitable distance from the point where it last emerged so as to provide suspension systems at points along the cable as indicated in Fig. 1.

At some point in the construction, preferably after the braiding process, the whole structure including the conductors and the supporting strands are impregnated with a suitable stiffening and water-proofing compound.

A coaxial conductor of the type described is suitable for use as a two-wire circuit for currents of very high frequencies, or of a very wide rang of frequencies from any desired low frequency value up to in excess of 100 kilocycles per second. As stated above, it is desirable particularly where very high frequencies are used to avoid an unnecessarily large number of suspension points and this in turn may be achieved by adopting a light-weight construction. The weight of the conductor as a whole may be carried from either the inner or the outer cylinder. In the interest of using as few suspension points as possible it is preferable to support the inner conductor from the outer since the former can be made of much lighter weight than the outer on account of its much smaller dimensions. At very high carrier frequencies the principal dielectric losses would be due to current through the dielectric as distinguished from leakage along the surface. Where water-proofing is not essential, therefore, it is preferable not to impregnate the conductor, but in the interest of light-weight construction to make it by the simple braiding operations above described and to suspend the outer cylinder at suitable points, suspending the inner cylinder from the outer by the requisite number of tensioning cords.

One type of suspension is shown in Figs. 1 and 2 where a metal band 31 of suitable construction is merely passed around the outer cylinder and secured to any suitable suspension means such as the messenger cable 32. Where the light-weight construction above referred to is used it is not necessary to employ a messenger cable 32, but the supporting bands 31 may be secured at rather distant intervals as, for example, from the cross arms of an ordinary telephone pole system. The band 31 may be provided with a suitable cradle 33 to provide a larger bearing surface for the outer cylindrical conductor 20. While Figs. 1 and 2 show the conductor provided with an outer protective sheath 34, it will be understood that this may be omitted where lightness of weight is of paramount importance.

Where it is not practicable to employ the conductor using as a protection merely the impregnation above referred to, or no protection at all, various types of protective armor may be used. The suspension of the conductor on an open-wire telephone pole lead where it is exposed to all kinds of weather conditions would probably require armoring the cable by some such process as that known to the electrical trade as "BX" cable. With such a construction the conductor with its armoring could be made self-supporting so that an additional messenger strand such as 32 of Fig. 1 would not be necessary for supporting the cable. Such a construction is shown in Fig. 3 and a type of suspension that may be used is shown in Figs. 4, 5 and 6.

In Fig. 3 the outer cylinder 20, preferably after the whole conductor has been suitably impregnated, is given one or more servings of hard drawn copper tape 35 and over this is the armoring 36 of the BX cable type above referred to. This armoring may, for example, be made of steel or other high tensile strength material provided with an interlocking groove construction illustrated generally at 37 and 38.

One means of suspending the cable as a whole may be by providing a central core 39 (Fig. 4) of high tensile strength material which passes through the inner cylinder and which bears the weight of the entire structure. The outer cylinder and armoring are supported by the tensioning means 30 between the supporting points of the cable, while at the supporting points the weight is divided between the central strand and the outer armor.

In Figs. 4 and 5, for example, the central strand 39 is supported at each one of the supporting points, for example, at each telephone pole, by means of a rod 40 which is bent at its lower end into a hook 41 passing partly around the inner conductor. A bushing of insulating material 42 is slipped over the shank 40 of the hook member and is pro-

vided at its lower end with a saddle portion 43 which bears on the upper surface of the inner conductor. This bushing 42 has a shoulder 44 for supporting a band 45 which may pass around the armor of the outer conductor so as to take its weight. It will thus be seen that the weight of the outer conductor is supported directly from the shoulder of the bushing which since it rests on the inner conductor is in turn supported by the suspension rod 40 which may be secured to the crossarm and any other suitable point.

Figs. 4 and 5 are intended to show in general a type of suspension which may be used in any type of armoring and the armoring therefore is not specifically shown in these figures. It will be obvious, however, particularly in view of the other figures, to employ any type of suitable armoring with the type of construction shown in these figures for the supporting means.

An alternative means of supporting the cable is shown in Fig. 6. In this construction a short section, of a few inches at the most, of the outer conductor is removed exposing the inner conductor which, as shown, may be suitably secured to an insulator 47 by means of the wire 48, or in any other suitable manner. A plug 49 of suitable insulating material such as bakelite is then fitted to fill the otherwise open end of the cylinder 20 and a clamping ring 50 may be passed around the cylinder 20 so as to secure the latter firmly to the insulator plug 49. This plug may be made in halves with a central aperture to accommodate the conductor 10 and may be secured against movement lengthwise of the cable by clamping it firmly to the inner conductor 10. A general means of clamping is indicated by the screw 51 which may be made to bear firmly against the inner conductor and the inner supporting strand 39. Suitable electrical bonds, one of which is indicated at 52, may then be used to connect the sections of the outer cylinder 20 on opposite sides of the insulator 47. Armoring (not shown) may be employed over the outer conductors, as shown in the other figures.

Another type of armoring is shown in Fig. 7. The outer conductor 20 after impregnation is wrapped as before with a hard drawn copper tape 35 after which the whole cable is passed through a lead press to cover the exterior with a lead sheath 54. This construction is particularly suitable where complete protection against the elements is necessary. With this type of construction it is preferable to use messenger and cable ring suspension such as is indicated generally in Fig. 1 and such as is employed in present types of aerial cable construction.

It will be obvious from the examples given that other types of armoring and of suspension may be used, the types that have been shown and described being considered as illustrative rather than as limiting the invention. The claims are to be interpreted, therefore, as broadly as the prior art permits and to include within their scope equivalent constructions as well as those specifically disclosed.

What is claimed is:

1. A transmission line comprising inner and outer coaxial conductors, the outer conductor comprising braided strands of metal and means partly braided with said strands for supporting one of said conductors from the other.

2. A two-conductor line one conductor of which surrounds the other, said conductors being spaced from each other by tension members.

3. A two-conductor line one conductor of which surrounds the other, said conductors being braided of conducting material and having insulating cords spacing said conductors.

4. A two-conductor cable one conductor of which surrounds the other, and means for suspending one conductor from the other at numerous points along the cable.

5. A long transmission line comprising a reticulated metallic cylinder surrounding and spaced from a coaxial conductor, and suspension members at intervals extending between said cylinder and said conductor.

6. A transmission line comprising an inner conductor and a cylindrical outer conductor surrounding the inner conductor, means for supporting said conductors to serve as a line for transmission between distant stations, and means in the form of tensioned strands of insulating material at points along the line for spacing the inner conductor from the outer conductor.

7. A transmission line as defined in claim 6 in which the tensioned strands extend between the inner and outer conductors in various angular directions about the inner conductor.

8. A braided cylindrical conductor including strands of electrically conducting material and strands of insulating materials, and an inner conductor coaxial with said cylindrical conductor, said strands of insulating material extending inwardly at intervals along and around the structure and engaging the inner conductor to hold the two conductors in spaced relation to each other.

9. A transmission line comprising coaxial cylinders each formed of braided conductors spaced apart by cords of textile material, the entire structure being impregnated with a protective insulating substance.

10. A transmission line comprising a high tensile strength core over which is braided a cylinder of electrically conducting strands, another cylinder similarly constructed surrounding the first-mentioned cylinder and spaced therefrom, tension members for securing the two cylindrical conductors in

spaced relation to each other, and means spaced at intervals along the line and engaging said core for supporting said line.

11. A line as defined in claim 10 in which an additional support for the outer cylindrical conductor is provided.

12. A two-conductor line one conductor of which surrounds the other, to defined in claim 4 and a protective armor surrounding the outer conductor.

13. A two-conductor line one conductor of which surrounds the other, the outer conductor being formed by braiding metallic strands, insulating strands separating said conductors, a layer of hard-drawn copper tape over the outer conductor, and a lead sheath over said layer of tape.

14. A coaxial electrical transmission cable comprising inner and outer conductors and insulating spacing members between them, all formed as a woven structure consisting of conducting and non-conducting strands, the space between said inner and outer conductors comprising substantially air dielectric.

In witness whereof, I hereunto subscribe my name this 29th day of March, 1929.

DONALD A. QUARLES.