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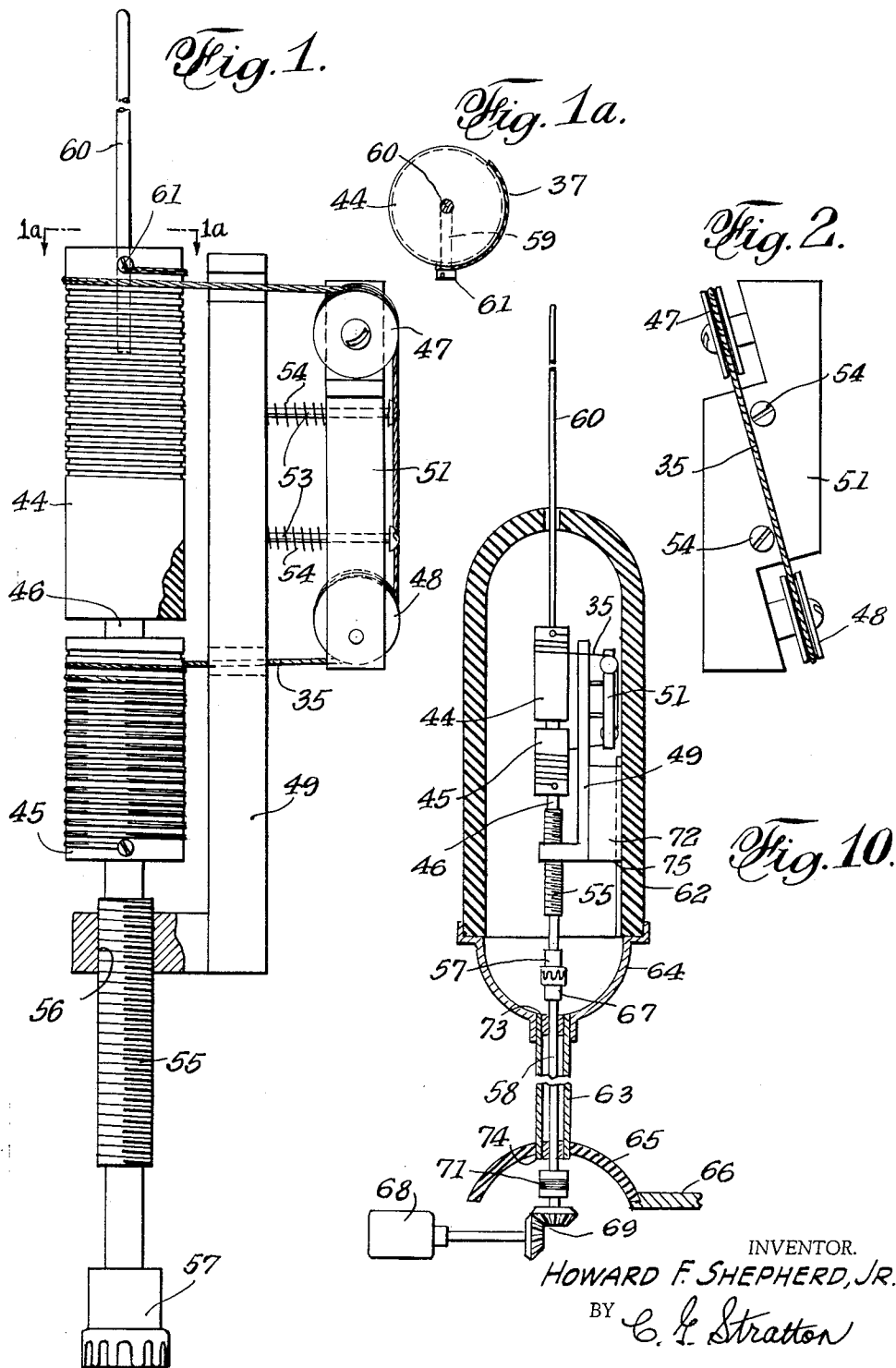
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PRECISION VARIABLE WINDING IMPEDANCE

Filed Feb. 15, 1960

2 Sheets-Sheet 1



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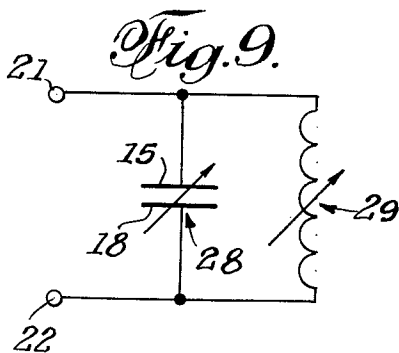
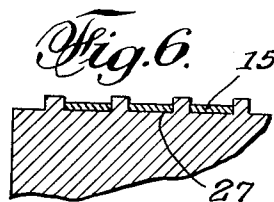
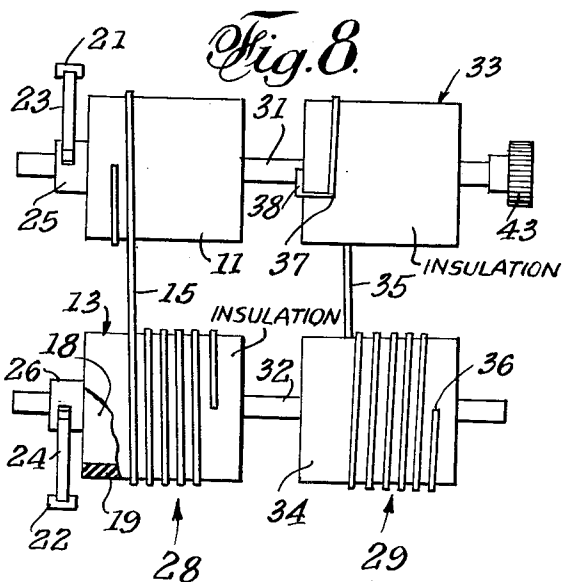
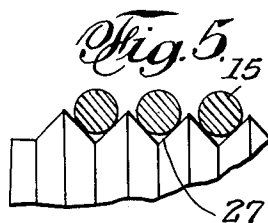
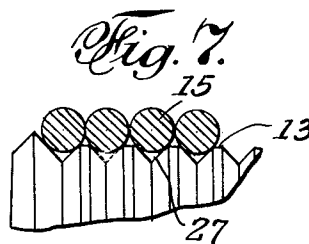
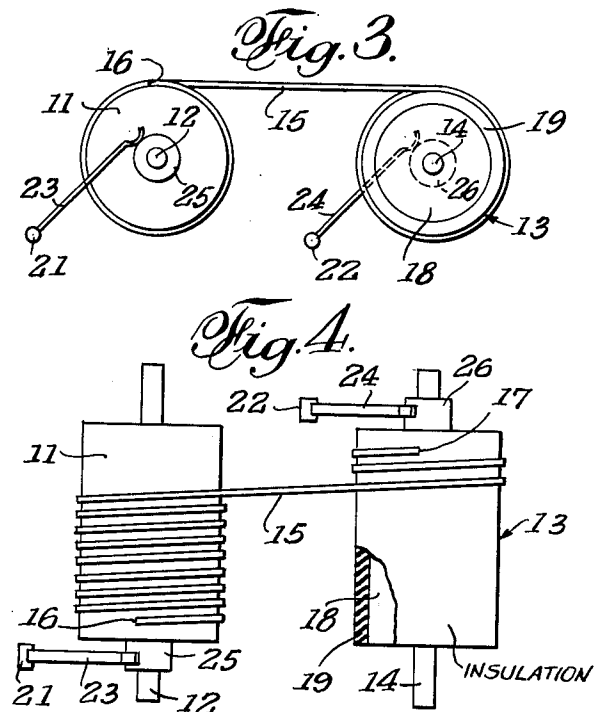
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PRECISION VARIABLE WINDING IMPEDANCE

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2 Sheets-Sheet 2



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PRECISION VARIABLE WINDING IMPEDANCE
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1 Claim. (Cl. 336-15)

This application is a continuation-in-part of my co-pending application, Serial No. 1,612, filed January 11, 1960, and relates to variable impedances.

An object of the present invention is to effect very minute changes in impedance with changes in setting by employment of a micrometer effect.

A further object of the invention is to avoid step-wise variations in impedance and to enable an impedance adjusting dial or shaft to be employed in such a manner as to obtain continuous variations in impedance with fractional turns of the adjusting shaft or dial.

A further object of the invention is to enable variations in impedance to be effected over a wide range with a large ratio between minimum and maximum impedance, without sacrifice of precision of fine adjustment.

Still another object of the invention is to enable inductive, capacitative or resistive variations in impedance to be effected.

A further object is to provide a tuned circuit with fine-adjustment impedance elements correlated to achieve simultaneous variation in capacity and inductance.

Still another object of the invention is to provide a loading coil or tuned circuit having a single shaft, carrying rotatable adjustment elements.

Still another object of the invention is to provide a whip-type of antenna with adjustable impedance having an adjustable loading coil in the center thereof, so that center loading is accomplished, or top or base loading may be accomplished.

Other and further objects, features and advantages of the invention will become apparent as the description proceeds.

In carrying out the invention in accordance with a preferred form thereof, rotatable means are provided having a pair of cylindrical surfaces, one of which is conducting and the other insulating, and a flexible conductor is provided, adapted to be wound helically upon one cylindrical surface while being unwound from the other. Electrical terminals are connected to the ends of the flexible conductor. The impedance between the terminals depends upon the proportionate amounts of the flexible conductor on the conductive and insulating cylindrical surfaces. For achieving compactness in an adjustably loaded antenna, the antenna may be coaxially mounted with the insulating cylindrical surface and connected to one end of the flexible conductor.

For producing variable capacity instead of inductance, the insulating cylindrical surface is provided with a conductive core.

A better understanding of the invention will be afforded by the following detailed description, considered in conjunction with the accompanying drawing, in which:

FIG. 1 is an elevation of an adjustable-impedance whip antenna unit having a whip antenna mounted coaxially with the shaft of a single-shaft, rotatable, helically-wound variable inductance.

FIG. 1a is a fragmentary cross-sectional view of the apparatus of FIG. 1, illustrating the electrical and mechanical connection of the whip antenna.

FIG. 2 is a fragmentary side view of the apparatus of FIG. 1, illustrating the arrangements for guiding flexible conductor means from one cylindrical surface to another.

FIG. 3 is an end view of a parallel-shaft variable impedance unit in accordance with the invention.

FIG. 4 is a plan view of the apparatus of FIG. 3.

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FIG. 5 is a fragmentary sectional view of the apparatus of FIGS. 3 and 4, illustrating the use of helical grooves in the cylindrical surface for carrying the flexible conductor when variable inductance or resistance is desired.

FIG. 6 is a view corresponding to FIG. 5, in which a tape form of flexible conductor is employed instead of the circular cross-section form of flexible conductor.

FIG. 7 is a fragmentary sectional view, illustrating the relationship between groove pitch and diameter of circular cross-section flexible conductor when variable capacity, free from inductance, is desired.

FIG. 8 is a diagram corresponding to FIG. 4, illustrating a parallel-tuned adjustable-frequency circuit in accordance with the invention.

FIG. 9 is a schematic diagram illustrating the equivalent electrical elements of the apparatus of FIG. 8.

FIG. 10 is a view in longitudinal section of an adjustable wave-length whip antenna having adjustable center loading.

Like reference characters are utilized throughout the drawings to designate like parts.

In the parallel-shaft form of the invention illustrated in FIGS. 3 and 4, there is a spool or cylinder 11 having a conductive cylindrical surface composed of copper, brass, or the like, carried rotatively upon a shaft 12. There is a second cylinder or spool 13 having an insulating cylindrical surface mounted upon a second shaft 14 parallel to the shaft 12. Arranged to be carried by the spools 11 and 13 is a flexible conductor 15 in the form of metallic wire, such as copper wire, for example, which may be solid, of circular or flat cross-section, or, if desired for greater flexibility, in the form of braid or cable.

The flexible conductor 15 is so arranged as to be wound helically upon the spools 11 and 13 and to unwind from one spool as it is wound upon the other. Suitable means, not shown, are provided for causing the spools 11 and 13 to rotate together. In order that the flexible conductor 15 will take helical form as it is transferred from one spool to the other during rotation thereof, one end 16 is mechanically secured to the surface of the conductive spool 11 at one end thereof, and the other end 17 of the flexible conductor 15 is mechanically secured to the opposite end of the insulating-surface spool 13. For assuring uniform guiding of the flexible conductor 15 along the surfaces of the spools as they are rotated, the surfaces may be grooved, as illustrated in FIGS. 5, 6 or 7.

When a variable capacity is desired, the insulating-surface spool 13 is provided with a conductive core 18. In FIG. 3 the thickness of the insulating shell 19 between the conductive core 18 and the insulating surface 13 is exaggerated for the sake of clarity. It will be understood, however, that for the sake of providing as large a value of capacity as possible, the thickness of the insulating shell 19 is, in practice, reduced to a minimum consistent with mechanical strength and requisite voltage-rating. For making electrical connections to terminals 21 and 22, brushes 23 and 24 are provided. The brush 23 cooperates with a slip ring 25, electrically and mechanically connected to the conductive cylinder 11 which, in turn, is electrically and mechanically connected to the end 16 of the flexible conductor 15. The brush 24 cooperates with the slip ring 26 mechanically and electrically connected to the conductive core 18 of the spool 13.

Where pure variable capacity is desired, free from inductive effects, a spool surface is employed such as illustrated in FIG. 7 in connection with the use of circular cross-section flexible conductor 15. The spacing between successive grooves in the insulating surface 13 corresponds to the diameter of the flexible conductor 15 so that successive turns thereof are in contact. The portion of the flexible conductor 15 wound upon the insulating-surface spool 13, in this case, constitutes a conductive layer which

is electrically continuous in the axial direction of the shaft 14, as well as being continuous around the periphery of the cylindrical surface.

On the other hand, if it is desired to provide a variable inductance instead of a variable capacity, the conductive core 18 is omitted. On the insulating-surface cylinder 13, at least, grooving such as illustrated in FIG. 5 or FIG. 6 is then employed to make sure that adjacent turns of the flexible conductor 15 are insulated from each other. The end 17 of the flexible conductor 15, in this case, is connected electrically to the slip ring 26.

Where variable resistance instead of variable reactance is desired, the flexible conductor 15 may be composed of a material having a relatively high resistivity, such as a nickel-chromium alloy wire or braid, for example. The electrical resistance between the terminals 21 and 22 then depends upon the relative amounts of the flexible conductor which have been wound upon the insulating surface and upon the conducting cylindrical surface. The flexible conductor may also be a dielectric tape means as in FIG. 6, having a deposited resistive material, as for example carbon, on the side of such tape that rolls in contact with the conductive surface of spools 11 and 13.

The combination of a variable capacity unit and a variable inductance unit to form a tuned circuit is illustrated in FIG. 8. There is a variable capacity unit 28 and a variable inductance unit 29, employing common shafts 31 and 32. The variable capacity unit 28 comprises a metallic cylinder 11, insulating spool 13 with a conductive core 18, and flexible conductor 15, as in FIGS. 3 and 4.

The variable inductance unit 29, on the other hand, comprises an insulating cylinder 33 carried on the shaft 31 and a conductive cylinder 34 carried on the shaft 32, with a flexible conductor 35 arranged to wind back and forth between the cylinders 33 and 34 as the shafts 31 and 32 are rotated. In order to avoid other means for causing the shafts 31 and 32 to rotate in unison, the conductor 15 is wound on one side and the conductor 35 on the other side, so that the conductor 15 rewinds upon the cylinder 11 as the conductor 35 unwinds from the cylinder 33 for rotation in a given direction of the shaft 31. Corresponding results take place with respect to the shaft 32 and the cylinders 13 and 34.

The flexible conductor 35 has an end 36 electrically and mechanically connected at one end of the cylinder 34 to the surface thereof, the cylinder 34 being electrically connected to the shaft 32 which, in turn, is electrically connected to the shell 18 and the slip ring 26. The opposite end 37 of the flexible conductor 35 is mechanically connected to the surface of the insulating cylinder 33 near the end thereof, and is electrically connected to the shaft 31 by means of a conductor 38, or the like. The shaft 31, in turn, is electrically connected to the conductive cylinder 11 and the slip ring 25. Consequently, there is an inductive electrical circuit from the terminal 21, through the slip ring 25, the shaft 31, the conductor 38, the flexible conductor 35 from its end 37 to the metallic cylinder 34, the shaft 32, and the slip ring 26 to the terminal 22. There is also a parallel electrical capacity across the terminals 21 and 22. There is a circuit from the terminal 21 through the brush 23, slip ring 25, conductive cylinder 11, flexible conductor 15 to an outer layer or electrode of a capacitance having a dielectric consisting of the insulating shell 19. Likewise, there is an electrical circuit from the terminal 22 through the brush 24, the slip ring 26, to the conductive core 18 serving as the opposite electrode of the capacitance having the dielectric 19. In the circuit diagram of FIG. 9, the variable inductance 29 represents the portion of the flexible conductor 35 which is wound upon the insulating cylinder 33 and the variable capacity 28 represents the capacity between the conductive core 18 and the portion of the flexible conductor 15 lying upon the cylindrical surface 13. It will be understood, however, that the ar-

range of FIG. 8 may also be employed to form a series-resonant circuit instead of the parallel-resonant circuit, by connecting the lead 38 from the end 37 of the flexible conductor 35 to a separate slip ring, instead of the slip ring 25, and insulating such slip ring from the shaft 31. In this case, the series-resonant circuit would be between the terminal 21 and the terminal lead 38 of the flexible conductor 35.

The variable-frequency tuned circuit of FIG. 8 may be used as a tuner in variable-frequency communication equipment, as the resonant element in absorption wave meters where high precision of adjustment and wide dynamic range are required, and in other similar applications. An adjusting knob 43 may be provided which is connected to one of the shafts 31 or 32, and may be arranged to cooperate with a calibrated dial, not shown. In the arrangement of FIG. 8, either shaft 31 or 32 may be driven and the shafts will rotate in unison because the flexible conductor 35 is wound oppositely to the flexible conductor 15. Consequently, one flexible conductor or the other serves as mechanical connection between the shafts to cause them to rotate together.

The invention is not limited to the arrangement of FIG. 8, however, for causing rotation of the cooperating cylinders or spools in unison. For example, as illustrated in FIG. 1, cooperating cylinders or spools may be mounted upon the same shaft to bring about rotation in unison, and provide a construction taking up relatively little space laterally. In the adjustable-inductance antenna-loading coil of FIG. 1, there is an insulating spool 44, and a conductive or metallic spool 45, cooperating, as in the case of the spools 33 and 34 of FIG. 8, to carry a flexible conductor 35 adapted to be wound or unwound from one spool to the other to vary the number of inductance turns of the conductor and, thereby, vary the inductance of the loading coil unit. Where the spools carrying the same flexible conductor are mounted coaxially, as upon a common shaft 46, suitable means are provided for causing the flexible conductor 35 to travel tangentially to and from appropriate portions of the surface of the spools 44 and 45. For example, as shown, a pair of idler pulleys 47 and 48 is provided. Further, these may be mounted directly upon a support 49 extending along the spools 44 and 45, or upon a separate pulley block 51 resiliently mounted upon the support 49. In the arrangement illustrated, the pulley block 51 is provided with apertures loosely fitting studs 53 secured in the support 49.

Compression coil springs 54 surrounding the studs 53 are provided for biasing the pulley block 51 away from the support 49 for maintaining the flexible conductor 35 in tension, and promoting orderly winding and unwinding of the conductor 35 as the spools 34 and 45 are rotated.

Suitable means are provided for guiding the flexible conductor 35 axially along the length of the cylindrical surfaces of the spools 44 and 45 as they are rotated, by causing relative axial movement of the idler pulleys 47 and 48 with respect to the spools 44 and 45. For example, in the arrangement illustrated, the shaft 46 is provided with a threaded portion 55 mating a threaded socket 56 in the support 49, the pitch of the thread 55 corresponding to the pitch of conductor-carrying grooves on the spools 44 and 45 and the desired spacing between the turns of the flexible conductor 35 on the spools 44 and 45.

As the shaft 46 is rotated, the spools 44 and 45 rotate and simultaneously travel axially the requisite distance for causing the flexible conductor 35 to unwind radially from one spool and rewind on the other spool in turns of the desired spacing. The antenna-loading or inductance of the unit is determined by the number of turns, including fractional turns, of the conductor 35 upon the insulating spool 44 since the turns upon the conductive

spool 45 are short-circuited by the electrical conductivity thereof.

Suitable means are provided for rotating the shaft 46, which may take the form of a knob where manual adjustment is desired. Where remote control is desired, a coupling 57 is provided which is adapted to mesh with a corresponding coupling element of a remote control shaft such as shaft 58 shown in FIG. 10. In order to provide a compact, self-contained, adjustably loaded antenna unit, of the whip antenna type, a rod 60 of the desired length to serve as a whip antenna is mounted coaxially in the end of the insulating spool 44. For connecting the end 37 of the flexible conductor 35 to the base or the feed end of the antenna 60, a set screw 59 is provided which bears against the antenna rod 60 and has a head 61 under which the conductor end 37 is clamped.

One of the useful applications of the variable-inductance loading coil arrangement of FIGS. 1, 2 and 1a, is in providing remote control of center, top or base loading of a whip-type antenna. As illustrated in FIG. 10, a variable inductance unit of the type illustrated in FIG. 1 may be mounted within a ferrule 62 used at the center top or base of a whip antenna, such as used on motor vehicles, for example. Such ferrules are in the form of hollow insulator cylinders mounted at the center, top or base of a whip antenna to receive a loading coil. When remote control of the inductance of the center loading of such an antenna is desired, the lower portion of the whip antenna is in the form of a hollow conductor tube 63 having a fitting 64 at the upper end for receiving the insulator ferrule 62 and secured at the lower end to a hollow insulator 65, which is secured to a flange 66 for bolting the antenna assembly to an appropriate portion of the vehicle. The inductance-adjusting remote control rod 53 is mounted within the conductor tube 63 and carries a coupling 67 at the upper end meshing with the coupling 57 of the shaft 46 to enable the shaft 46 to be rotated by a drive motor 68 mechanically connected to the control rod 53 through bevel gearing 69 and insulator coupling 71. The support 49 of FIG. 1 is held against rotation during rotation of the shaft 46. Due to the threads 55 of said shaft, said support moves longitudinally relative to the ferrule 62. A sliding key connection 75 between the support 49 and said ferrule guides a support block 72 on the support 49 during such longitudinal movement. In any case, the conductive cylinder 45, at all times, maintains electrical connection, through

the connected couplings 57 and 67, with the upper end 73 of tube 63. A suitable transmission line (not shown) is connected to the lower end 74 of the conductive tube 63.

While I have illustrated and described what I now contemplate to be the best mode of carrying out my invention, the constructions are, of course, subject to modification without departing from the spirit and scope of my invention. Therefore, I do not wish to restrict myself to the particular forms of construction illustrated and described, but desire to avail myself of all modifications that may fall within the scope of the appended claim.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

A variable impedance comprising: a dielectric cylinder; a conductive cylinder having an axis of symmetry common with said dielectric cylinder, said conductive cylinder being mounted in a fixed position relative to said dielectric cylinder with one end of said conductive cylinder disposed adjacent one end of said dielectric cylinder; a flexible elongated conductor having one end fixed to the other end of said dielectric cylinder, said conductor having its other end fixed to the other end of said conductive cylinder; fixed support means; guide means to take up said conductor from one of said cylinders and deposit it on the other of said cylinders in the shape of a helix; a support carrying said guide means, said guide means support being keyed to said fixed support means for movement relative thereto in the direction of said common axis of symmetry; a shaft having an axis identical to said common axis of symmetry and fixed with said cylinders, said guide means support having female helical type screw threads, said shaft having male helical type screw threads threaded into the female type screw threads of said guide means support; and means to rotate said shaft about said common axis of symmetry.

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