Aug. 8, 1961 J. D. MURPHY 2,995,718

CONSTANT-IMPEDANCE CABLE CONNECTOR

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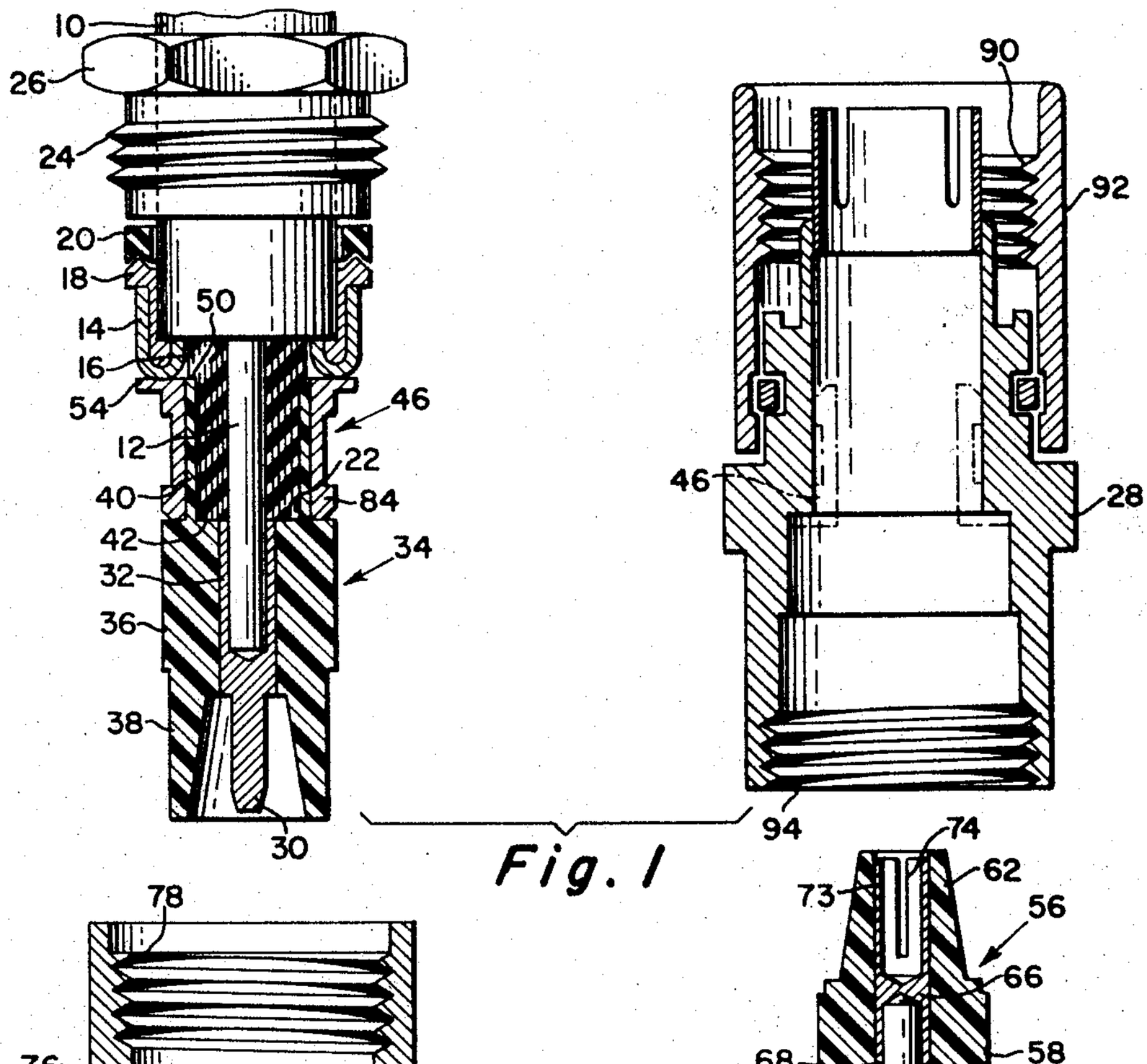

Fig. 1

Fig. 2

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Fig. 3

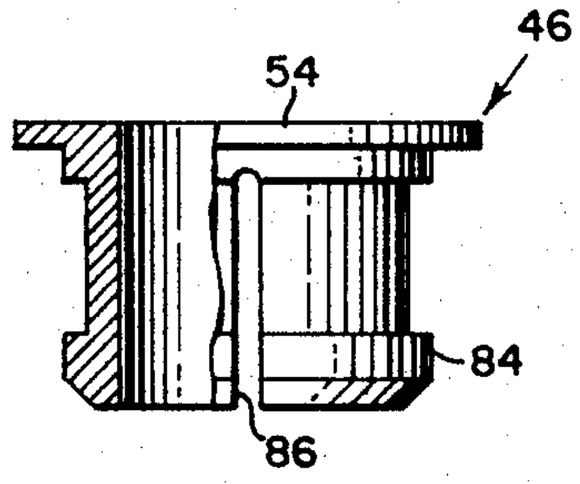


Fig. 4

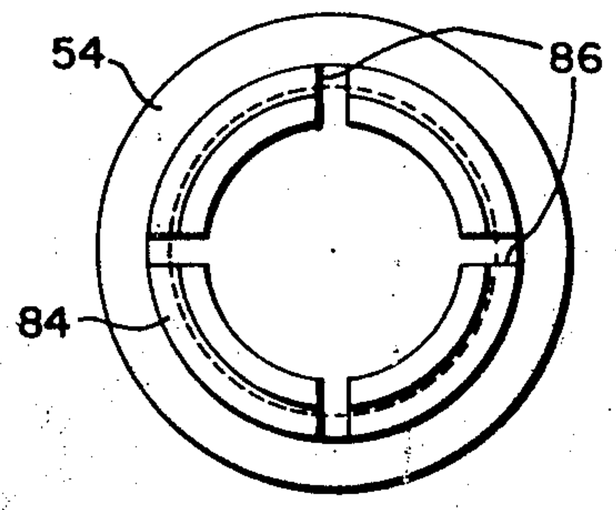
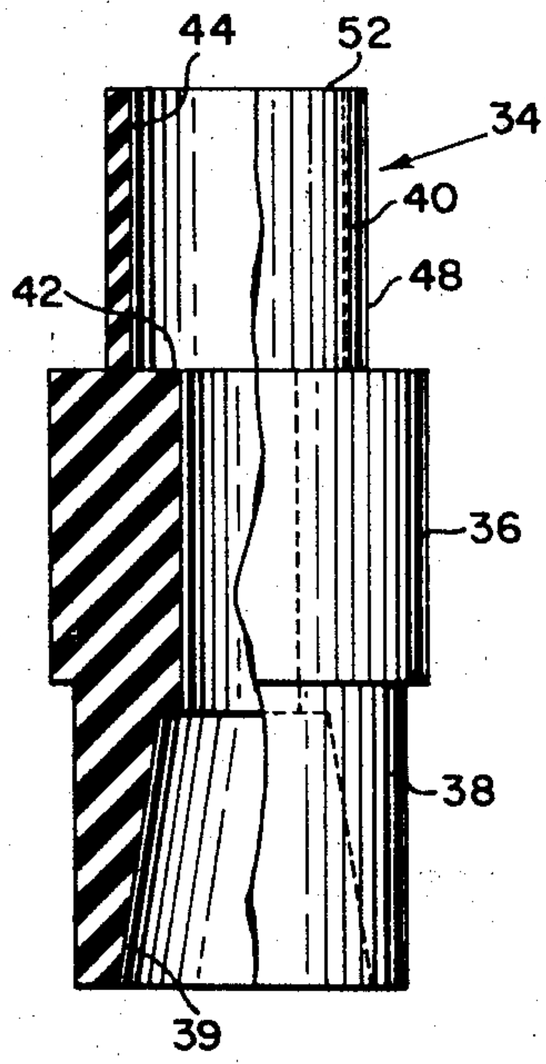


Fig. 5



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CONSTANT-IMPEDANCE CABLE CONNECTOR

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The present invention relates to an improved connecting device for coaxial cables of the type in which the insulating material disposed between the cable conductors, rather than being formed as a homogeneous solid, is instead composed of a plurality of layers of some substance having suitable dielectric properties.

Many forms of connecting devices for coaxial cables are known in which both the electrical and mechanical requirements of the assembly are met by removing a portion of the inner dielectric material and arranging the conductive portions of the assembly so as to preclude any leakage of energy between the conductors and also to avoid any sharp mechanical discontinuities which might result in an undesirable increase in the standing wave ratio.

When coaxial cables of the type formed with a solid dielectric between the inner and outer conductors are to be interconnected, the problem of maintaining the electrical characteristics of the cable is not too difficult of solution. One expedient in common usage is to counterbore the dielectric surrounding the center conductor, and then to employ a relatively long pin or sleeve surrounding the respective terminal portions of the center conductor. However, such a process is not practicable in cases where the coaxial cables to be joined are manufactured with a dielectric in the form of an insulating tape which is wrapped around the center conductor so as to create a plurality of layers filling the space between the latter and a braided metal outer conductor. With such cable constructions, it is apparent that the wrapped dielectric of the cable cannot be bored out by the same operation used in modifying a cable having a solid dielectric. Consequently, previously-known methods of interconnecting coaxial cables are not suitable for employment under these particular conditions. Furthermore, it is highly desirable that any resulting alteration of the respective terminal portions of two cables to be interconnected be such that each subassembly is capable of being quickly and easily inspected for mechanical uniformity prior to the time that the two units are joined together. Still further, each subassembly should be so arranged that tightening of the connector housing will not result in any change in the physical relationship of the elements of the connector assembly or in their electrical characteristics.

In accordance with a feature of the present invention, there is provided a constant-impedance high-voltage connector especially designed for use with wrapped-dielectric cables of the coaxial type, in which the electrical path between the respective conductors of each cable possesses a very low resistance factor, while at the same time mechanical discontinuities are eliminated which, when present, are undesirable in the sense that they have an adverse effect on the standing-wave ratio of the assembly. In addition, the present invention contemplates the employment of a dielectric bushing designed so that it replaces a portion of the original wrapped dielectric material of the cable and thereby maintains the resistance characteristics of the connector assembly to high-voltage breakdown. This bushing is so configured as to carry thereupon a generally annular collar composed of conductive material and which enters into electrical engagement both with the outer tubular

conductor of the cable and with the inner surface of the sleeve or housing which encloses the connector components. The presence of such a collar at each cable terminal portion establishes a low-resistance electrical path between the respective outer conductors of the two cables to be interconnected, so that the loss factor of the assembly compares very favorably with many connectors conventionally employed to join together cables of the solid-dielectric type.

One object of the present invention, therefore, is to provide an improved connector for coaxial cables which are so designed that the insulation lying between the inner and outer cable conductors is made up of a plurality of wrapped layers.

A further object of the invention is to provide a cable connector of the above nature which acts to maintain the high-voltage breakdown characteristics of the cable, while at the same time precluding any appreciable increase in the standing-wave ratio thereof.

An additional object of the invention is to provide a connector for wrapped-dielectric coaxial cables in which the connector components associated with each cable terminal portion may be quickly and easily assembled, inspected, and then the two cable terminal portions joined together without the interconnecting operation causing any significant alteration in the cable's electrical characteristics.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a partly sectional view (with the housing member disengaged) of a connector subassembly designed in accordance with the principles of the present invention and intended for use at the terminal of one of two cable portions the interconnection of which is desired;

FIG. 2 is a partly sectional view (also with the housing member disengaged) of a connector subassembly constructed somewhat along the lines of FIG. 1, but intended for use at the terminal of the remaining cable portion to be interconnected;

FIG. 3 is a side view of one of the components of the connector subassembly of FIG. 1;

FIG. 4 is an end view of FIG. 3; and

FIG. 5 is a side view of a still further component of the connector subassembly of FIG. 1.

Referring first to FIG. 1 of the drawings, there is shown one terminal portion of a coaxial cable **10** fabricated to include a center conductor **12**, a braided metal outer conductor **14**, and a series of layers of wrapped dielectric material **16** filling the space between the cable conductors. This dielectric material **16** may be of any suitable type which possesses both thinness and high insulating properties. For example, it may be in the form of tape made from some plastic such as Teflon. Surrounding the outer tubular conductor **14** in conventional fashion is a layer of suitable insulation.

As shown in FIG. 1, the two conductors **12** and **14** at the extremity of coaxial cable **10** are rendered accessible by removing a portion of both the inner and outer insulating material of the cable. This permits the present invention to be practiced by the employment of means which will be set forth hereinafter. The outer cable conductor **14** is first stripped back and then bent in reverse fashion to encircle a clamp **18** adjacent to which is positioned an O ring, or rubber gasket, **20**. All of the layers of insulating material **16** are then cut away for a short distance back from the end of the cable to allow the center conductor **12** thus exposed to project outwardly from a shoulder indicated in the drawing by the

reference numeral 22. As will be seen from the drawing, the rubber gasket 20 lies between the cable clamp 18 and the inner shoulder of a threaded sleeve 24 which is formed integrally with a nut 26, the sleeve 24 being designed for engagement with the threaded inner surface of a more or less conventional housing member 28.

As above stated, the center conductor 12 of cable 10 is initially exposed for a short distance back from the end thereof. A male pin 30, composed of electrically-conductive material, is designed with a sleeved portion 32 adapted to slip over the exposed end of conductor 12 in such a manner as to establish a tight-fitting relation therebetween, or, preferably, to permit these two elements to be soldered together. As shown in the drawing, the rear surface of the sleeve pin portion 32 abuts the shoulder 22 formed by removal of a portion of the cable dielectric material 16.

Encircling the pin 30 is a generally cylindrical bushing 34 which may be formed of the same dielectric material as that of the cable insulation 16 except that it is in one piece rather than of tape form. As an illustration, the bushing 34 may be fabricated of Teflon which has been molded or machined to the configuration best shown in FIG. 5 of the drawings. That is, it possesses a central portion 36, of maximum outer diameter, having an axial opening in which the sleeved pin portion 32 is receivable. Longitudinally offset from this central bushing portion 36 is a second section 38, of reduced outer diameter, and possessing a conical recess 39 the axis of which coincides with the principal axis of the bushing as best shown in FIG. 1. This recess 39 in the bushing section 38 is configured to receive a conical projection formed as part of a further bushing to be hereinafter described in connection with FIG. 2.

Lying on the opposite side in a longitudinal sense of the central bushing portion 36 from that of bushing section 38 is a still further bushing section 40 which is of minimum outer diameter, this construction being again best shown in FIG. 5 of the drawings. This bushing section 40 is in the form of a tubular sleeve, and forms with the central bushing portion 36 a shoulder 42 designed to be in contact with the shoulder 22 of the dielectric material 16 when the components are assembled as shown in FIG. 1. The inner surface of the bushing section 40 (shown in FIG. 5 by the reference numeral 44) is adapted to fit tightly over the outer surface of the cable's wrapped dielectric material 16. To position a collar 46 so that it encircles the outer surface 48 of the bushing portion 40, several layers of the wrapped dielectric material 16 are removed in this region to form a still further shoulder 50, the end surface 52 of the bushing sleeve 40 abutting this shoulder 50 in the manner brought out in FIG. 1. The collar 46 mentioned above is designed to fit snugly over the bushing section 40 and to lie between the mid-portion 36 of the bushing and the turned-back outer cable conductor 14 in the manner illustrated.

Collar 46 is composed of material having high conductive characteristics, such, for example, as beryllium copper, and is shown in detail in FIGS. 3 and 4 of the drawings. It is designed with a flanged inner portion 54 which makes electrical contact with the outer cable conductor 14, this flanged inner portion 54 also making direct electrical contact with the inner surface of the shell or housing element 28 when the latter is brought into such position that the threaded inner surface thereof engages the threaded surface of the sleeve 24. When the components of FIG. 1 are assembled, the collar 46 will assume the position within the housing element 28 indicated by the broken lines, the outer, or forward, end of the collar 46 being designed to lie in abutting relation with the central portion 36 of the bushing 34.

The preceding description of the components shown in FIG. 1 covers one of two subassemblies which together comprise the connector of the present invention. The

remaining subassembly is illustrated in FIG. 2. Many of the elements of this latter figure are similar both in structure and function to those of FIG. 1, and consequently only those which possess significant variations will be discussed hereinafter. Such variations are found primarily in the surface configuration of a second bushing which mates with that of the bushing 34, and in the provision of a female pin associated with the center cable conductor, this female pin being designed to receive the male pin 30 of FIG. 1.

The bushing element of FIG. 2 is generally identified in the drawing by the reference numeral 56. This bushing incorporates a central section 58 substantaially identical to that of the central bushing section 36 of bushing 34. Bushing 56 also includes an inner sleeved portion 60 corresponding to the sleeved bushing portion 40 of FIGS. 1 and 5, and an outer conical section 62 the surface of which is configured to fit within the conical recess 39 formed in the bushing section 38. When the two subassemblies of FIGS. 1 and 2 are brought together and fastened in a manner to be later described, the recessed bushing section 38 of FIG. 1 will receive therewithin the conical outer bushing section 62 of FIG. 2 to form a solid dielectric mass extending between the collar 46 of FIG. 1 and a similar collar 64 associated with the assembly of FIG. 2.

To accommodate the male pin 30 of the unit illustrated in FIG. 1, there is shown in FIG. 2 a female pin 66 having an inner sleeved portion 68 which fits over the center conductor 70 of the cable 72 in the same manner that the sleeved pin portion 32 of pin 30 fits over the center conductor 12 of coaxial cable 10. This pin 66, however, is formed with a tubular terminal portion 73 which is split longitudinally by the slot 74 to thereby permit a tight fit to be established when the male pin 30 is received therewithin. It will be noted from the drawing that the length of the tubular terminal portion 73 of the female pin 66 is chosen to create a large area of electrical contact between the pins 30 and 66 and thus prevent any loss of energy which would cause the transmission efficiency of the connector to be adversely affected.

In a manner similar to that in which the component assembly of FIG. 1 is receivable within the shell or housing element 28, the device of FIG. 2 is intended for insertion in a housing 76 having an innner threaded surface 78. The latter is designed for engagement with the outer threaded surface 80 of a sleeve which is associated with the terminal portion of cable 72 in the same manner that threaded sleeve 24 encircles the terminal portion of cable 10. Following such engagement, a tightening of nut 82 completes the subassembly of FIG. 2 and brings the collar 64 into a position as shown by the dotted lines.

It has been stated above that the collars 46 of FIG. 1 and 64 of FIG. 2 act as media by which the respective outer cable conductors are electrically joined through the connector unit. To perform this function with maximum efficiency, the collars 46 and 64 are arranged not only to have excellent contact with their respective cable conductors, but also with the inner surface of their respective housing members. To achieve this result, each of the collars 46 and 64 is designed with a configuration best illustrated in FIGS. 3 and 4 of the drawings. Referring now to these latter figures, it will be seen that collar 46, for example, not only incorporates the previously-mentioned flanged inner portion 54, but is also provided with a beveled outer flange 84 one surface of which contacts the inner surface of the housing unit 76 when each subassembly is in condition for a final interconnection of the two cable portions 10 and 72.

The collar 46, as hereinabove stated, is receivable over the sleeve portion 40 of the bushing element 34, as shown in FIG. 1. To ensure a proper fit between these two components, the iner diameter of the collar 46 is essentially identical to the outer diameter of the

bushing portion **40**. To allow for manufacturing tolerances, and to permit these elements to enter into slidable engagement with one another, and to permit positive contact between flnage **84** of the collar and the inner surface of housing unit **76**, the collar **46**, which is of generally tubular design, is provided with a plurality of longitudinal slots **86** which extend from the outer, or forward, portion of the collar **46** toward the flanged inner portion **54**. This permits a limited degree of flexing of the electrically-conductive material of which the collar is composed. The number of slots which are thus formed in the beveled outer flange **84** (see FIG. 4) will depend both on the diameter of the collar and upon the flexibility of the material used in its manufacture.

As an important feature of the invention, the diameter relationship of the inner and outer conductors are maintained throughout the connector subassemblies in the same ratio as they possess in cables **10** and **72** thus providing constant impedance throughout the entire length of the cables and the connector. For this purpose, and as will be seen in FIG. 1, the inner diameter of collar **46** is so dimensioned that the ratio of that diameter to the diameter of center conductor **12** is equal to the ratio between the diameter of the inner surface of the outer conductor to the diameter of the central conductor in cable **10**. The same ratio relationship is held between the diameter of sleeve pin portion **32** and the inner diameter of housing **28**, and also between the diameter of male pin **30** to the inner diameter of housing **28**. Similarly, the same ratios are held between the corresponding parts in the subassemblies shown in FIG. 2 as are held between the inner and outer conductors of cable **72**.

It will be noted that only a minimum number of operations are required to complete the connector assembly of the present invention. After the cable has been properly trimmed to expose the center cable conductor **12** (for example) and the braided metal outer conductor **14** has been turned back in the manner shown by FIG. 1, approximately three layers of the wrapped dielectric material **16** are removed in the region where the sleeved bushing portion **40** will be received. The male pin **30** (in the assembly of FIG. 1) is then secured, preferably by soldering, to the center cable conductor **12**. The collar **46** is positioned to encircle the sleeved bushing portion **40**, and then the latter is slipped over that portion of the cable insulation which has been stripped away. In so doing, it follows that the central bushing portion **36** is caused to overlie the sleeved portion **32** of pin **30**, and the outer bushing portion **38** positioned so that the terminal portion of pin **30** lies in the conical recess **39**. The outer surface **48** of the sleeved bushing portion **40** consequently carries the collar **46** thereon, the inner surface **44** of this sleeved bushing portion **40** lying over and contacting that portion of the wrapped dielectric material **16** which had been previously stripped back.

All of the parts of each subassembly are inspected to ensure that they conform to the mechanical and electrical specifications laid down for the apparatus, and then the threaded portion **94** of shell or housing element **28** is brought into contact with the threaded sleeve **24** following which the nut **26** is tightened to complete this phase of the operation. In a similar fashion, the elements shown in FIG. 2 are assembled and inspected and then the housing unit **76** moved into a position which permits engagement between the threaded inner surface **78** of the housing unit **76** and the threaded outer surface **80** of the cable sleeve. Tightening of the nut **82** then completes this subassembly.

The two units thus assembled are brought into proximity with one another and then the male pin **30** inserted in the tubular terminal portion **73** of female pin **66**. At the same time, the recess **39** in bushing section **38** receives the conical projecting portion **62** of bushing **56**, while the threaded outer surface portion **88** of housing **76** comes into engagement with the threaded inner portion **90** of end portion **92** of the housing **28**. As shown in FIG. 1, end portion **92** is rotatable relative to the balance of housing **28**. In the above assembled position, rotation of end portion **92** will engage threaded portions **88** and **90** to result in a tight fastening of housing element **28** to housing element **76**, together with good electrical contacting engagement of their corresponding elements as described above.

It will be noted that tubular bushing section **40** lies within collar **46** and serves to close the minimum distance path between the upper end of sleeve **32** and the conductor collar **46** at the joint between bushing **34** and insulating material **16**. With the bushing section **40** in place in the assembled condition, the electrical leakage path between conductive sleeve **32** and conductive collar **46** is lengthened appreciably to a course from the upper end of sleeve **32** along the joint at shoulder **22**, thence upwardly along the inner surface of upstand-bushing section **48** and along the joint at shoulder **50** to conductive collar **46** thus providing minimum electrical energy loss. This characteristic is of particular importance since it enables my invention to be used as a connector on high-voltage cables. Thus, the high-voltage, constant-impedance connector described above is superior to other constant-impedance connectors now available which do not have the high-voltage characteristic described above.

While operating results will depend at least in part on the dimensions of the connector components and on the materials used in their construction, it may be mentioned purely as an example that in one particular assembly, designed in accordance with the above teachings, voltage standing wave ratio measurements were made over a range of 400 to 6000 megacycles, with the highest reading being 1.5:1 at 5000 mc.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A connecting device for coaxial cables of the type in which the insulating material disposed between the cable conductors is made up of a plurality of layers of a dielectric substance, and in which such dielectric substance is stripped back from the terminal portion of each of the cable sections to be connected, said device comprising a pair of connector subassemblies respectively associated with the said terminal cable portions, one of said subassemblies incorporating a pin having a sleeved extension encircling the teminal portion of the center conductor of the cable section with which the said subassembly is associated, a dielectric bushing composed of homogeneous material and having three sections the intermediate one of which is adapted to encircle the sleeved extension of said pin and one end section which is adapted to encircle the multilayer insulation of said cable in the region where one or more layers of such insulation have been stripped back, this particular end section of said bushing thus being of tubular configuration, the remaining end section of said bushing substantially enclosing the outer portion of said pin and having a conical recess axially formed therein, a collar of electrically-conductive material and of generally annular shape designed to encircle that particular bushing section which overlies the stripped-back portion of said cable dielectric, said collar having a rearwardly-positioned shoulder for electrical engagement with the tubular outer conductor of said cable and a forwardly-positioned shoulder for engagement with the mid-section of said bushing, a housing for said subassembly one portion of which is secured to said cable and a further portion of which is adapted for threadable engagement with said one portion, whereby threadable engagement between the two said housing portions results in the

establishment of electrical contact between said collar and the inner surface of said housing, the second of the two said connector subassemblies including a pin having inner and outer sleeved portions, the former being designed to encircle the terminal portion of the center conductor of the cable section with which such second subassembly is associated, the remaining sleeved portion of said pin being adapted for electrical engagement with the outer portion of the pin incorporated in said first subassembly when the connecting operation is carried out, a bushing of electrically-insulating material having a mid-portion designed to encircle the inner sleeved portion of said pin and an end portion of tubular configuration designed to encircle that region of said cable dielectric which has been stripped back, the remaining end portion of said bushing being of conical shape and adapted to be receivable in the conical recess formed in the bushing member of said first subassembly, a collar of electrically-conductive material encircling the tubular portion of said bushing, said collar being of annular configuration and having a pair of shoulders the rearward one of which is adapted for electrical engagement with the outer conductor of said cable and the forwardly-positioned one of which is adapted to engage the mid-portion of said bushing, a tubular housing for said second subassembly, said

housing having a portion secured to said cable and a further portion adapted for threadable engagement therewith and also for threadable engagement with the housing of said first subassembly, whereby such a threadable engagement of the housings respectively associated with the two said subassemblies will establish electrical contact between the respective inner cable conductors through the two said pins and between the outer cable conductors through their respective housing portions and through the collars respectively associated with each of the two said subassemblies.

2. A connecting device in accordance with claim 1, in which the collars respectively associated with each of the two said subassemblies are each designed with a plurality of longitudinal apertures permitting a limited degree of flexing of said collar when the latter is brought into a position where it encircles that tubular portion of its respective bushing which is designed to overlie the stripped-back region of said cable dielectric.

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