COAXIAL CABLE CONNECTOR

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This invention relates to electrical connectors and is particularly concerned with connectors for use on coaxial cables commonly used for the transmission of radio frequencies.

Flexible coaxial cables are widely used, and usually consist of a central conductor surrounded by a dielectric insulating layer which in turn is surrounded by a conductive shield. The shield commonly consists of a cylindrical metallic braid which is covered by an outer insulating flexible material. It is well known that when the characteristic impedance along a coaxial cable system abruptly changes, reflections of the signal occur which set up standing waves of voltage and current along the propagation path of the signal. Thus, an electrical connector for use in a coaxial transmission line should present an impedance as close as possible to the characteristic impedance of the coaxial line in order to avoid reflections.

Further, an electrical coaxial connector should also consist of a minimum number of parts, be easily assembled, and have characteristics of construction which minimize movements of the connector components even during varying mechanical stresses on the connector or the cable connected thereby.

The electrical connector of the present invention provides an element of independent design freedom for equalizing or compensating impedance characteristics within the connector at the dimensional transition from the line to the main body of the connector. This marks the geometrical enlargement of the solid insulation within the outer cable system conductor elements where the line dielectric abuts the connector dielectric. The element comprises a counterbore in the connector dielectric larger than the outer diameter of the line dielectric to provide in combination with the annular air gap. The radial and axial dimensions of the air gap may be selected by the design engineer independently of other parameters to achieve the desired operation of the transmission line system at a desired frequency or over an extremely broad range.

The utility of a coaxial connector depends, however, on many factors in addition to its electrical design. Diminution of cost and rapidity of assembly are essential. More important than these is to achieve a construction which maintains its manufacturing dimensions under use and abuse. The present invention combines remarkable achievements in all these areas.

Diametral dimensions of coaxial connectors are easily controlled and stable in use. Longitudinal positioning of individual parts, however, has only been accomplished by complexity and at added expense. Connectors of the present invention characteristically employ resilient solid dielectric components radially interfitted with mating metallic conductor elements to prevent axial displacement in any direction. Such dielectric components transiently deform in the manufacturing or assembly operation during implantation and lock permanently in axial design position against the stresses of practical use.

According to the invention, resilient solid dielectric elements may be radially interfitted in axially locked position with either or both the central conductor element and the outer annular conductor shield. Longitudinal positional stability is especially important in avoiding variable air gaps under application conditions.

It is thus a principal object of this invention to provide a coaxial electrical connector which provides for a substantial reduction of V.S.W.R. and a consequent improvement in electrical transmitting characteristics.

An object of the invention is to provide a coaxial connector presenting constant impedance to the line over a desired frequency band through the use of an independently designed impedance section at the abutment of the cable dielectric with the connector dielectric.

Still another object of the present invention is to provide an electrical connector for coaxial cable with the electrical characteristics are stabilized because the mechanical components of the connector are securely interconnected to prevent relative movements and are so dimensioned as to substantially eliminate air gaps between abutting dielectric members.

Yet another object of the present invention is to provide an electrical connector with improved coaxial cable retention characteristics.

A further object of the instant invention is to provide a coaxial connector which has a small number of parts to be assembled, thereby facilitating assembly as well as assuring uniformity in the electrical characteristics of the connector.

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

FIGURE 1 is a central cross-sectional view of the connector jack subassembly prior to assembly;
FIGURE 2 is a partially cross-sectional view of a mating plug prior to assembly with the connector jack of FIGURE 1;
FIGURE 3 is an enlarged view partly in cross-sectional view of the assembled electrical coaxial connector;
FIGURE 4 is an enlarged sectional view of a portion of FIGURE 1 showing a part of the dielectric insert including the novel retention means.

The main jack assembly may be clearly seen in FIGURE 1 where metallic outer body member consists of rearwardly extending ferrule which is completely filled with grooves in order to better grip the conductive shield of the coaxial cable when finally assembled. Instead of employing grooves, the ferrule may be externally knurled. The forward extending contact portion includes locking studs which are utilized during the final connector engagement. Cylindrical portion extends through the ferrule portion to a counterbore whose diameter is increased at shoulders, the inclined wall, and beveled end in order to provide for easy connection with the plug assembly. A cylindrical dielectric sleeve is dimensioned to fit tightly within counterbore and is secured by lock washer which is press fitted into shoulder Insulating insert is provided with a central bore which extends from the compensating air gap counterbore through the forward extending mating portion and includes the locking shoulder extension. Counterbore is not completely filled with coaxial cable dielectric in the final assembly, as subsequently explained, which provides impedance compensation for the overall connector. Locking shoulder may be seen with greater clarity in an enlarged sectional view in FIGURE 4, where a portion of the annular edge of chamfered end is shown with end which is perpendicular to the central bore.

In FIGURE 1 as tightly secured in insulating insert is the female inner contact which for the sake of clarity in the illustration is not shown attached to the central conductor of a coaxial cable. Contact may be seen to include a conductor-receiving bore and solder port through which solder may be applied to secure
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the central conductor of a coaxial cable before final assembly of the connector. Shown in an interlocking relationship, the locking shoulder extension 27 is an annular locking groove 33 in inner contact 30. FIGURE 4 shows in detail how perpendicular edges 34 and 35 of the contact 30 fit closely with the respective ends of the locking shoulder extension 27. The female contact portion 36 in FIGURE 1 is designed to receive a male contact portion in mating relationship and may also be seen to taper slightly toward the forward end of the contact. This taper enables the elongated contact 30 to be easily inserted into the central bore 29 and to ride or climb up chamfer 28 during insertion. Dielectric 22 is commonly made of a deformable plastic such as Teflon, or a polypropylene composition available as Avisum grade 1044, which enables the rigid contact pin 30 to deform locking shoulder extension 27 during insertion. The pin is pushed through the central bore until the forward perpendicular edge 35 of the annular locking groove 33 snaps into place over the perpendicular edge 29 of the locking shoulder extension 27. The rearward edge 34 of the elongated contact 30 tightly fits against the base of chamfered end 28, and therefore it may be seen that the elongated contact pin 30 is locked into position in the insulating insert 22. Whereas prior art devices provided means only to lock a contact pin in one direction, the present invention may be used in locking action in both forward and backward directions. The locking edge 29 of insert 22 is utilized to prevent the contact from being withdrawn from the connector because of forces applied upon the coaxial cable. However, it is just as important to provide for the retention of the elongated contact 30 in the forward direction by edge 28, as a forward movement of the central contact 30 can occur as the center conductor of the cable expands because, for example, of an ambient temperature rise. This longitudinal positioning of the central contact by interfitted radial variations is quite important in reducing relative movement between the various parts of the connector and thereby substantially eliminating changes in V.S.W.R. characteristics.

Referring to FIGURE 2, plug assembly 11 is shown in cross-section with the contact pin position, without the coaxial cable for simplicity of description. Rotatable outer mating cover 37 may be seen to enclose the metallic main body 38, which is held in rotatable relationship with mating cover 37 by means of restraining sleeve 39 which is forced into a suitable groove 40 in the main housing 37. Sleeve 39 fits loosely around main plug body 38 thus allowing the outer mating cover 37 to be easily rotated during final assembly. Main plug body 38 is further supported by flexible gasket 41 which fits in audible relationship with the outer mating cover 37. Spring washer 42 provides a biasing force to compress gasket 41 to firmly seat main plug body 38 when the connector is finally assembled. The main plug body 38 consists of an intermediate coupling portion 43 which joins flexible outer contact member 44 with rearward extending ferrule portion 45 to form a unitary body construction. Ferrule portion 45 may be seen to be provided with grooves or notches 46 which provide a strong gripping force to the metallic braid of the coaxial cable when the connector is fully assembled. Main plug body 38 also has a cylindrical opening 47 through ferrule 45 to a counterbore 48 which extends the length of the flexible outer contact 44. Contact 44 is constructed with an outward flaring annular contact 49 to provide a good electrical contact when the plug assembly is mated with jack 10. Contact 44 may be preformed and machined in body 43, soldered therein around the outer juncture, and the assembly plated with a suitable covering. Then insert 51 may be pressed into position. The indented retention means 50 of the flexible outer contact is used to secure the dielectric insert 51 at the annular rounded groove 62, thus providing permanent positioning of the insert in the plug body.

Insulating insert 51 utilizes several features of the utmost importance in providing satisfactory electrical connector characteristics. For example, impedance compensating air gap 52 consists of a counterbore whose depth and diameter are determined by calculation based upon the amount of impedance compensation desired in order to obtain flat line voltage conditions. Further, it should be noted that the forward end 53 of the insulating insert 51 extends axially beyond the end of the flaring annular contact 49. This extension has been found to provide markedly improved results in the V.S.W.R. of the assembled electrical coaxial connector, as it enables the insulating insert 51 to be firmly under the projecting action of spring member 42 with its mating component insert 22 upon assembly, thus preventing variable air gaps from forming in the assembled connector. The forward end 53 of insert 51 defines a counterbore with a depth equal, within manufacturing tolerances, to the length of the forward extending mating portion 55 of the dielectric insert 22 of the jack assembly shown in FIGURE 1. During final assembly of the connector pair, the jack insulating insert 22 fits into the counterbore formed by the forward end 53 of insert 51 until the inserts firmly abut, as subsequently to be shown.

An important feature of the plug previously described with relation to the jack assembly is provided by the locking shoulder extension 55 which projects from central bore 54 and includes a chamfered end 56. When elongated contact pin 57, consisting of a forwardly extending mating portion 58, annular locking groove 59, and central conductor connection bore 60, is inserted through the cylindrical opening 47 into the central bore 54, the contact meets chamfered edge 56. The forward portion 58 of contact pin 57 is provided with a bevel 61 which rides inside chamfer 56, thereby temporarily deforming the flexible insulating material of the dielectric insert 51. Finally, the locking shoulder extension 55 snaps into the annular locking groove of contact 58 and the contact is firmly seated within the insulating insert 51 in a manner similar to that shown in FIGURE 4. Both forward and backward movement of the elongated contact 58 is thus prevented when the connector is fully assembled, thereby reducing changes in the electrical characteristics of the connector due to outside forces or expansion because of ambient temperature changes. Connecting bore 60 is provided in combination with port 63 whereby solder may be inserted to attach the central conductor of a coaxial cable before inserting the elongated contact 57 into the plug 11.

As FIGURE 3 shows the fully assembled electrical coaxial connector assembly, the same numbers have been used for like components previously described. The coaxial cable 64 is prepared in a manner known in the prior art by stripping back the outer insulating cover 65, the metallic braid 66, and the dielectric 67 in a stepped manner to expose central conductor 68. Before final assembly, both ends 64 and 69 of the coaxial cable are thus prepared and are soldered to elongated inner contacts 30 and 57, respectively. These completed subassemblies are then inserted into the ferrule portions of the plug 11 and the jack 10, with the braid 66 being slightly flared in order that the rearward extending ferrules 13 and 45 may be slipped under the braid.

As the prepared coaxial subassemblies are inserted into the connector means, respective chamfered edges 48 and 56 of the locking shoulders in the dielectric inserts 22 and 51 ride up the beveled surfaces of the contact pins 30 and 57, slightly deforming the elastic insulating inserts until the locking shoulder extensions snap into place in the annular locking grooves of the contacts as previously described. Thus, the novel contact locking means of this instant invention provides a connector apparatus which may be assembled in swift operation, but which provides precise contact positioning and retention in two directions. The central bore in the integral section of the dielectric
insert has a radial variation in diameter which interfits with a corresponding variation in diameter of the central connector to lock the parts against relative axial displacement in either direction.

When the prepared contact assemblies have been inserted and secured in the jack and plug assemblies, the coaxial cables 64 and 69 are permanently fastened to the jack 10 and plug 11. With the braid 66 covering substantially all of the rearwardly extending ferrule portions, crimping sleeves 70 which were previously placed on the coaxial lines 64 and 69 are slipped over the outside of the braid and crimped securely into place. The metallic braid 66 will be forced into the knurls or grooves 14 and 46 of the ferrule portions, providing excellent cable retention properties. Outer tubes 72 are then slipped over the crimping sleeves and heat shrunk into place. Now the completed plug and jack assembly may be fitted together to form a completed connector.

As the completed jack 10 and the plug 11 are brought together in a mating relationship, locking stub 16 enters helically disposed groove 76, and outer mating cover 37 is rotated until the stub 16 is firmly seated in the aperture 77. During the insertion of plug 11 into jack 10, beveled end 21 of jack 10 is guided over the outwardly flanged contact 49 of plug assembly 11 until the end of the jack assembly 12 engages flexible gasket 41. The gasket 41 is compressed by end 21 until the forward extending portion 26 of jack insert 22 abuts the plug insert 51 at mating end 74. The combined force of the insertion upon the flexible gasket 41 and the plug insert 51 will force the entire main plug body 38 against spring washer 42, thus maintaining locking stub 16 within the aperture 77 and also holding abutting plug and jack assemblies against each other by a bias. As the forward portion 53 of dielectric insert 51 extends past contact end 49, the portion will fit, within manufacturing tolerances, against insulating insert 22 at mating end 74. Thus variable air gaps found in previous connectors, due to tolerance extremes in their designs, are substantially eliminated by the provision of abutting end surfaces which are held tightly against one another by a novel combination of a resilient gasket and a stiffer blazing spring which, under compression, causes compressing compression in the gasket permitting the insert members to seat axially against each other. Of primary importance is the fact that these intervening air gaps are of substantially zero length which does not vary due to forces in either direction on the cable, and therefore provide and maintain uniform impedance along the insulators. The concept of utilizing a unitary insulating insert which provides precise positioning in all directions of the contact pin and at the same time which may be utilized for predetermined impedance compensation has been found to afford a coaxial connector of greatly improved performance.

It will be apparent from the foregoing description of the invention that an electrical connector embodying the invention has the advantage of providing low V.S.W.R. characteristics, while at the same time maintaining these characteristics in a nonvarying manner even in the presence of outside forces on the cable or ambient temperature changes. Further, these uniform electrical characteristics are obtained by a connector of improved mechanical strength, but which still allows the prepared end of the coaxial cable to be quickly and easily inserted in the basic connector subassembly. The electrical connector of the instant invention has the additional advantage in consisting of relatively few and simple components which permit close mechanical tolerances to be maintained during manufacture and assembly of the connector.

Whereas the present specification has described in considerable detail only one preferred embodiment of this invention, it is to be understood that this description is merely for purposes of illustration, and that changes and variations therein may be made by persons skilled in the art without departing from the true spirit and scope of this invention.

We claim:

1. An electrical connector for a radio frequency coaxial transmission line having an inner conductor encircled by an annular insulating layer and a conductive shield comprising:

- a metallic body member having a forward contact extension and a rearwardly extending ferrule portion, said body having a cylindrical opening extending through said ferrule portion to a larger diameter cylindrical opening coaxial therewith and extending through said contact extension,

- an insulating insert which fits into said larger diameter opening, said insert having a central opening throughout its length with an annular locking shoulder extension radially extending within the central opening of the insert at a point intermediate the ends thereof, said insert also having an impedance compensating counterbore in the rearward end thereof, the diameter of said impedance compensating counterbore being greater than the diameter of the cylindrical opening through said ferrule portion, and

- an elongated inner contact joinable with the inner conductor of a coaxial transmission line, said contact being shaped for insertion through said ferrule portion into the central opening of said insert and having an annularly groove solid portion, said groove being dimensioned to tightly interfit with said shoulder extension to resist axial movement of said inner contact with respect to said insert thereby reducing electrical reflections and stabilizing the electrical characteristics of the connector, the annular insulating layer of the coaxial transmission line extending into said counterbore to the rearward end of said inner contact upon insertion of said inner contact through said ferrule portion into said insert.

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