

May 20, 1969

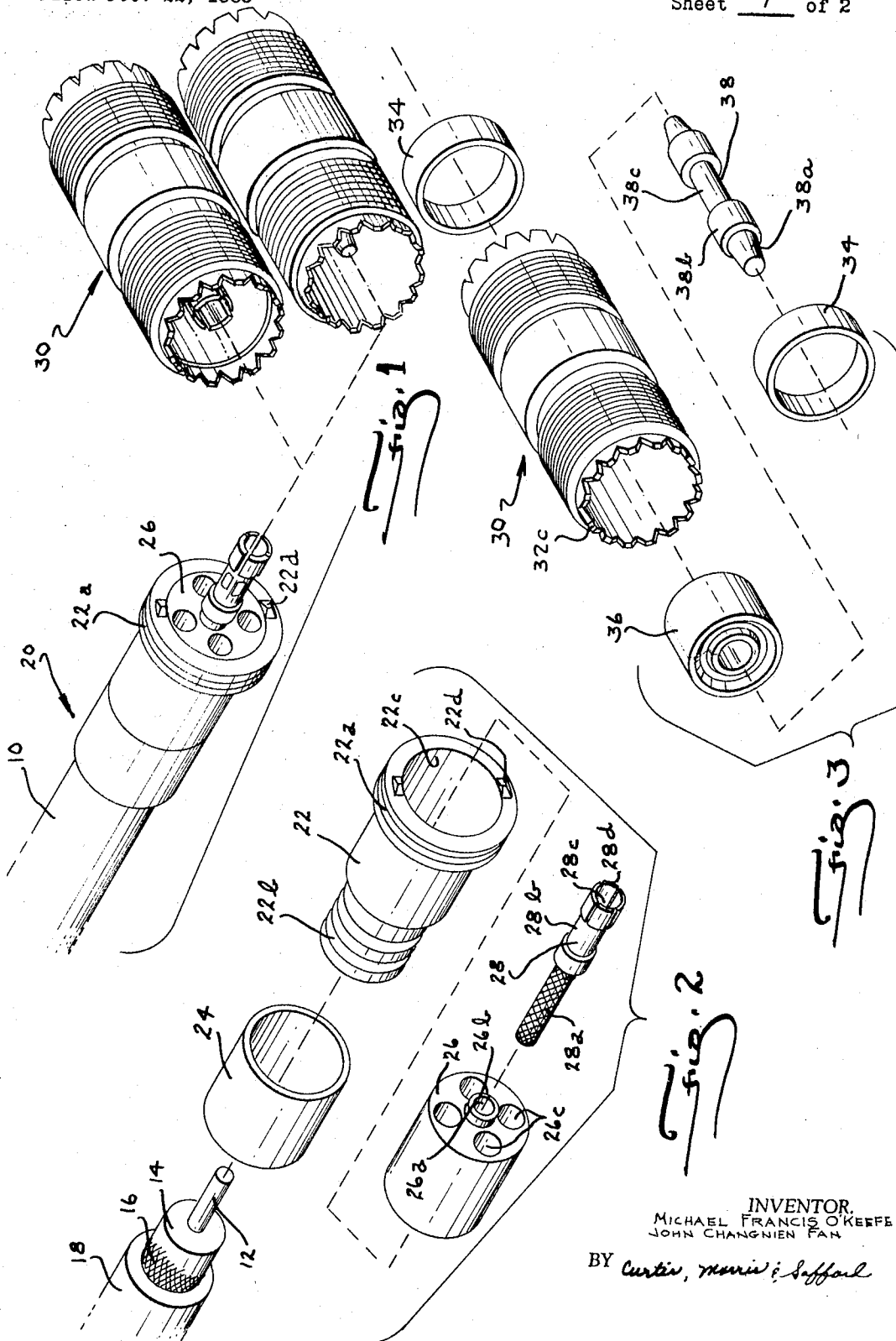
M. F. O'KEEFE ET AL

3,445,794

COAXIAL CONNECTOR PLUG AND RECEPTACLE ASSEMBLY

Filed Dec. 22, 1965

Sheet 1 of 2



INVENTOR.
MICHAEL FRANCIS O'KEEFE
JOHN CHANGNIEN FAN

BY *Curtin, Morris & Safford*

May 20, 1969

M. F. O'KEEFE ETAL

3,445,794

COAXIAL CONNECTOR PLUG AND RECEPTACLE ASSEMBLY

Filed Dec. 22, 1965

Sheet 2 of 2

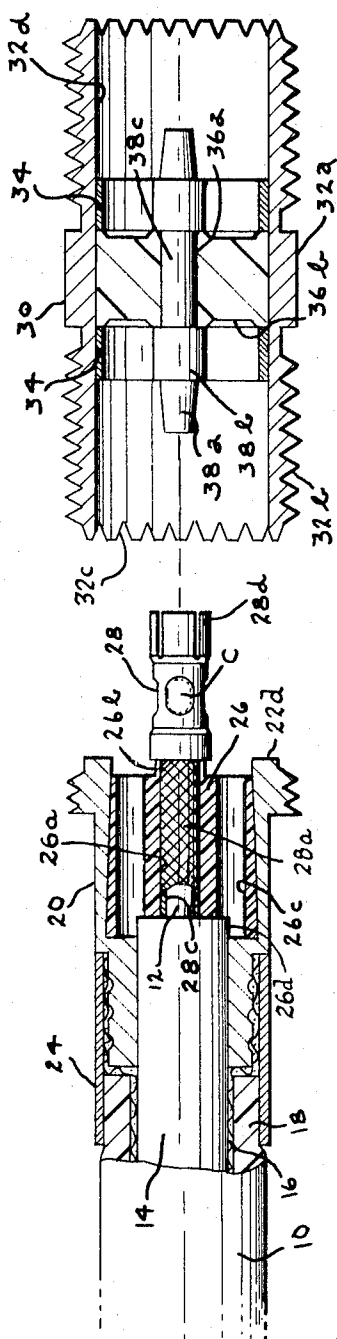


Fig. 4

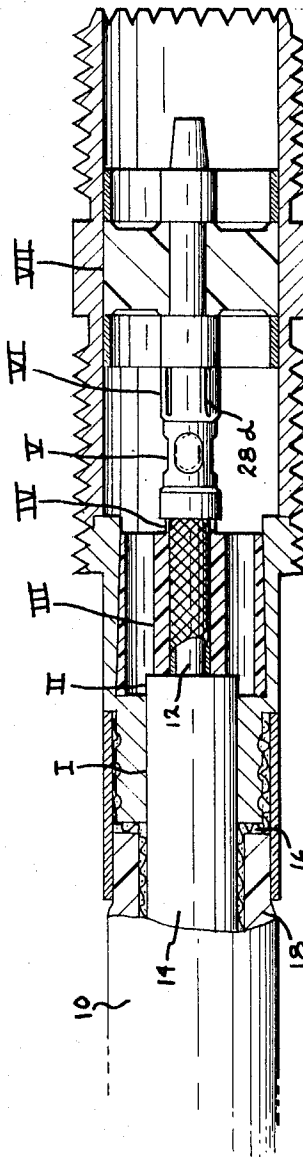


Fig. 5

INVENTOR.
MICHAEL FRANCIS O'KEEFE
JOHN CHANGNIEN FAN
BY *Curtis, Morris & Lafford*

1

2

3,445,794

COAXIAL CONNECTOR PLUG AND RECEPTACLE ASSEMBLY

Michael Francis O'Keefe, Mechanicsburg, and John Changnien Fan, New Cumberland, Pa., assignors to AMP Incorporated, Harrisburg, Pa.

Continuation-in-part of application Ser. No. 486,360, Sept. 10, 1965. This application Dec. 22, 1965, Ser. No. 515,572

Int. Cl. H01p 1/24

U.S. Cl. 333—97

3 Claims

ABSTRACT OF THE DISCLOSURE

A connector device for coaxial cable is taught which features a coaxial plug for use with coaxial receptacles, the plug including a center contact member having an outer diameter and an outer contact surface to be engaged within a center contact member of a receptacle and also including means yieldable in a radial sense and an inner contact surface to alternatively receive inserted therein a center contact member of a different complementary receptacle. The plug includes an outer conductive shell and a center contact member held therein by a dielectric insert with the plug being dimensioned to provide a match to the characteristic impedance of a given cable and also dimensioned to make the plug mateable with a receptacle of a different and lesser characteristic impedance.

This invention is a continuation-in-part of our earlier filed application Ser. No. 486,360 filed Sept. 10, 1965, now U.S. Patent No. 3,372,364.

Background of the invention

In our previously mentioned application there is given a detailed description of a variety of problems with prior art connectors in applications wherein the signals to be transmitted are of a frequency which makes connector dimensions and proportions critical with respect to electrical performance. Our prior invention is directed to a solution to certain of these problems through a structure which can be easily manufactured and easily applied to coaxial cable. As mentioned in our previous application, the basic and underlying difficulty with present connector design lies with military and commercial specifications written sometime ago in an attempt to standardize designs so that the connector products of various manufacturers will be intermateable. These specifications were most limiting with respect to purely physical dimensions, threading and other such structural features backed up by a general electrical performance specification. Over the years signal frequencies have continued to increase and the specification has of necessity been altered to achieve an improved performance with respect to the higher frequencies. The overall dimensional specification, however, has not changed. This means that the underlying problem of improving coaxial connectors is one of attempting to deal with dimensional limitations where the principal means of achieving improved operation is by change in dimension.

Summary of the invention

This invention relates to a coaxial connector plug and receptacle assembly.

In our parent application S.N. 486,360 a coaxial connector plug and receptacle assembly for ultra high frequency use is disclosed in a configuration to solve the problem of mateability with standardized connector devices and at the same time provide low VSWR performance. The device of our earlier filed application is useful

in a substantial range of sizes and particularly for an embodiment of a UHF connector for 50 ohm cable.

The present invention purports to solve the foregoing problem with respect to a UHF connector line for 75 ohm cable and additionally to provide improved structural features applicable to a wide variety of connector designs.

It is then an object of the present invention to provide a connector and receptacle assembly for coaxial devices which is capable of handling higher frequency signals within a structure dimensionally limited to be compatible with the prior art devices. It is another object of the invention to provide a coaxial connector and receptacle assembly capable of improved performance. It is a further object of the invention to provide a coaxial connector and receptacle assembly having a contact structure capable of use with different contact structures of existing connector and receptacle devices. It is a still further object of the invention to provide a coaxial connector having a novel dielectric bead structure and interior configuration to provide high frequency performance in a connector and receptacle configuration restricted in overall size.

The foregoing problems are solved and the foregoing objects are attained in the present invention in one aspect through the use of a connector center contact structure which is capable of mating by insertion within a female contact receptacle or serving as a female receptacle to receive a male contact member inserted therewithin. In a further aspect the present invention connector and receptacle assembly includes a specialized shaping of dielectric and conductive paths of the inner and outer conductive portions of the connector to maintain substantially a constant characteristic impedance throughout the connector over a broad range of signal frequencies. This specialized shaping includes a dielectric insert having a longitudinal recess of a controlled size extending through such insert. Other parts of the signal path within the connector and receptacle assembly are dimensioned so as to continue the characteristic impedance or to compensate for changes in conductor spacing so as to maintain the characteristic impedance substantially constant throughout the assembly. These various features are provided in the invention in addition to a mechanical assembly of parts adapted to rigidly lock the connector and receptacle components against radial or axial displacement in a proper relationship to maintain a desired characteristic impedance for the transmission path formed by the assembly.

In the drawings:

FIGURE 1 is a perspective showing the invention in the preferred embodiment including a plug half terminated to a cable and a pair of mating receptacles for such plug half;

FIGURE 2 is an exploded view of a plug half of the connector of the invention showing the various components thereof;

FIGURE 3 is an exploded view of the receptacle half of the connector of the invention showing the components thereof;

FIGURE 4 is a longitudinal section of the plug and receptacle of the assemblies of the invention showing the center contact structure and the compensation insert thereof in detail; and

FIGURE 5 is a longitudinal section of the plug in half portions of the connector as shown in FIGURE 4, and intermated.

Description of preferred embodiment

Turning now to FIGURE 1, the invention as shown in the preferred embodiment for a UHF connector plug and receptacle assembly. The plug is shown as 20 and the receptacle is shown as 30. The plug is terminated to a coaxial cable 10, which has a composition as shown in

FIGURE 2, including a center conductor 12 surrounded by a dielectric sheath 14, an outer conductor 16 which may be braid, and an outer protective sheath 18. It is an overall objective of the connector and receptacle assembly to mechanically and electrically connect the cable 10 in a union which is mechanically as strong as the cable itself with respect to tensional and torque forces, and which is at least as good in terms of signal transfer characteristics as that of the cable. The receptacle 30, as shown, is adapted to a double ended use so that another plug like 20 could be connected to the end opposite that facing the plug in FIGURE 1. It is contemplated that one half of the receptacle may be employed in a connection to equipment wherein there is no need for a connection on the inner end and further that other types of connectors could be applied to the end opposite that which is adapted to engage the plug 20 in FIGURE 1. It is also contemplated that the receptacle 30 may include as a part of its exterior structure some flange member enabling the receptacle to be used in a bulkhead application. With respect to the specific embodiment shown, it may be assumed that plugs such as 20 would be utilized at each end of the receptacle 30. Additionally, there would be provided a nut (not shown) for each plug 20 which would be fitted over the outside of the forward end thereof and would include threads suitable to engage the threads of 20 and the threads of 30 so as to draw the plug into engagement with the receptacle and hold such during use of the plug and receptacle.

Referring now specifically to the plug half of the assembly of the invention, FIGURE 2 shows the components thereof to include an outer sleeve 22, a ferrule member 24, a dielectric insert 26 and a center contact member 28. The sleeve member 22 includes at its forward end an outer flange portion threaded as at 22a. At the rear of 22 is a sleeve portion 22b of reduced diameter which is adapted to receive the outer conductor 16 of the cable 10 fitted thereover as indicated in FIGURE 4. The inner portion of 22b has a diameter approximating that of the cable dielectric 14 to support such within 22. The exterior surface of 22b is roughened so as to provide a good mechanical connection between the metal of the sleeve and the metal of the outer conductor. The outer diameter of 22b is held to be only slightly larger than the inner diameter of 16 so as to reduce the transition necessary to fit the outer conductor over 22b.

The forward face of 22 includes a pair of V-shaped projections 22d adapted to cooperate with complementary V-shaped slots in the receptacle to hold the plug against twisting movement within the receptacle during installation.

There is provided an interior large bore 22c in the forward portion of 22 which preferably has a slight outward taper, as indicated in a somewhat exaggerated showing in FIGURES 4 and 5. The purpose of this taper of 22c as explained in detail in our previously mentioned application is utilized to lock the dielectric insert 26 within the plug and thereby hold the center contact against axial displacement.

The ferrule 24 is a thin, malleable sleeve which is cylindrical. Ferrule 24 is made to have an interior diameter slightly larger than the diameter formed by the outer conductor 16 when fitted over 22b. In use the ferrule is placed back over the cable 18 and after the cable is inserted within the plug it is pushed forward to the position shown in FIGURE 4 and crimped downwardly to lock the cable outer conductor to the plug. The ferrule is made to be of a length to extend out over the cable sheath 18 and to be crimped inwardly to grip the cable and support such to protect the mechanical and electrical interfaces terminating the cable outer conductor and inner conductor to the components of the plug. A crimp of the type preferred for use with the invention is taught in U.S. Patent Re. 25,847, Aug. 31, 1965, to Edgar J. Forney, Jr. It is contemplated that while the crimp version is preferred, other means may be employed for ter-

minating the cable outer conductor to the plug. For example, a split ring and wedge structure may be incorporated into the rear end of the plug for this purpose.

The insert 26 is of a dielectric material formed into the configuration shown to include a center bore 26a extending therethrough which is of a diameter to receive in a force fit the center contact member 28. At the forward end of the insert 26 is a projection 26b adapted to position the center contact member relative to plug 26 in the manner shown in FIGURES 4 and 5 so that the enlarged diameter portion thereof is outside of the bore 22c. At the rear of 26 is a recess 26d which extends into 26 to receive and support the dielectric sheath 14 of the cable in the manner shown in FIGURES 4 and 5. Extending axially through 26 are a plurality of bores 26c which are provided for compensation purposes. In the particular embodiment shown four bores 26c are employed in the symmetrical pattern extending around bore 26a between the inside and the outside of the insert 26. In the design of a UHF connector for 75 ohm characteristic impedance application it was found that a restriction against dimensional change of the plug diameter precluded the use of known dielectric materials which were available on a production basis and which had a dielectric constant permitting a use of a solid insert member. The four bores 26c provide a net dielectric constant seen by the signal transmitted through the connector assembly which results in a proper characteristic impedance for low-loss transfer. It is contemplated that the recess represented by the bores may be in a number of configurations to achieve an equivalent result. It is also contemplated that the recess may be filled with dielectric material other than air as shown.

In the 75 ohm characteristic impedance application the insert is made of polypropylene material to an outer diameter approximately 0.441 inch. The diameter of bore 26a is approximately 0.065 inch. The bores 26c have a diameter of approximately 0.108 inch and are positioned from the center of the insert 0.132 inch. For reasons not fully appreciated, the resulting structure serves to provide a low-loss signal transfer through the connector assembly. It is thought that the resulting electric field disposition effected by the complex dielectric shape must be in some energy mode which is approximately as efficient as the mode of transfer in the cable.

The center contact 28 includes a rear portion 28a adapted for insertion within 26a. The outer diameter of 28a is such as to provide a force fit within 26 and to be locked thereto when 26 is forced within 22c in the manner described in our previous application. The outer surface of 28a is shown to be roughened as by knurling to increase the locking action holding the center contact against axial displacement. The forward portion of 28 shown as 28b is of a very slightly larger diameter relative to 28a. A bore 28c extends through 28a up within 28b to accommodate the insertion of the center conductor 12 of the cable. The portion 28b is preferably crimped inwardly, as indicated in FIGURE 4 by the letter C, to terminate the cable center contact to 28. The forward end of 28 is split as at 28d to form a plurality of resilient spring fingers. The outer diameter of the various portions of 28 are held to maintain their desired characteristic impedance relative to the dielectric material surrounding such portions and the inner diameter of the outer conductive portions of the plug and receptacle. The outer diameter of 28d is in accordance with the invention made to be such that the center contact 28 may be plugged into a female receptacle of the type shown in our previously mentioned application. In such application 28 serves as a male member. The inner diameter of 28d is made so as to receive the insertion of a male member carried in the receptacle shown in the present application. In accordance with the invention this member is slightly tapered in the manner shown relative to member 38 in FIGURES 3, 4 and 5, which results in an engagement leaving the outer diam-

eter of 28d constant along the length of such portion for the purpose of maintaining characteristic impedance. As a result of the foregoing the invention plug 20 can be used for high performance applications with the receptacle 30 and in applications where only physical mating and electrical continuity are important. For example, the plug 20 can be used with the 50 ohm UHF receptacle of our previous application. This is of considerable advantage.

With respect to plug 20, as assembled in the manner shown in FIGURES 4 and 5, the outer shell 22 serves as the connector outer conductive path and shielding structure. The center contact 28 is locked therewithin coaxial thereof by the dielectric 26 to form the center conductive path of the plug. When the ferrule 24 is crimped down upon the cable the cable dielectric 14 is fitted within the plug in the manner shown in FIGURE 5 into the rear recess 26d of the insert to be supported thereby and to in turn support the cable center conductor within portions of the plug. Loads applied to the cable tending to pull the center conductor and contact structure of the plug back axially along the shell 22 are resisted by means of the engagement of the slightly enlarged diameter portion 28b engaging the forward edge of 26b extended out of 26. Loads tending to displace the center conductor and contact structure of the plug in the opposite sense are resisted by engagement of the dielectric 14 with the rear of the dielectric insert in recess 26d.

The receptacle 30 is comprised of an outer conductive sleeve 32 having a center portion 32a and on either side thereof a threaded portion 32b. A plurality of V-shaped grooves are disposed around each end of 32 as shown by 32c to engage the projections 22d of plugs in the manner shown in FIGURE 1. The sleeve 32 includes a bore of constant diameter shown as 32d extending therethrough. In the center of 32 there is provided an insert 36 and a center contact structure 38 locked in position by a pair of rings 34 which are force fitted within 32d. These rings are typically comprised of brass, are cylindrical and are thin walled. The rings are made to be of a length approximating the length of the enlarged portions of the center contact structure shown as 38b. The dielectric insert 36 includes an inner bore 36a adapted to receive the center contact member 38 and hold such coaxial of the receptacle. The insert 36 includes a split extending along the length thereof in the manner shown in FIGURE 3 to permit insertion of the center contact 38 prior to insertion of 36 within the receptacle. The preferred assembly calls for the insertion of 38 within 36, followed by the insertion of 36 within the receptacle and the insertion of the rings 34 to lock 36 and 38 therewithin in the position shown in FIGURES 4 and 5. The shaping on the end faces of 36 is for the purpose of adjusting and compensating the dielectric paths in such zones to achieve a characteristic impedance for minimum signal distortion and loss. The desired configuration of these faces shown as 36b is more completely taught in U.S. application Ser. No. 395,150, filed in the name of John C. Fan.

The center contact member 38 includes contact portions at each end shown as 38a, which is slightly tapered to fit within the portion 28d of the center contact of the plug. Adjacent such portions are enlarged portions 38b which serve to engage the insert 36 to lock the center contact 38 against axial displacement in the receptacle. The center shown as 38c is of slightly reduced diameter for this same purpose.

In FIGURE 5, denominated by Roman numerals are depicted various segments along the transmission path formed by the plug and receptacle of the connector of the invention. Beginning to the left with the segment I, the characterized impedance is, of course, that of the line since the effective diameter of the inner and outer conductive portions are identical to that of the cable. Next in the segment II the center conductive portion is that of the cable center conductor 12 and the outer con-

ductive path is of a diameter substantially enlarged from that of the outer conductor of the cable. The dielectric path "seen" by the electric field of the signal passing through this segment includes the dielectric of the cable 14 and a portion of the dielectric of the insert 26. This composite dielectric structure has a characteristic impedance approximating that of the cable and a net configuration which has been found to introduce little, if any, distortion and reflection to the signal transmitted therethrough.

The next segment is III and it includes the center conductive path slightly enlarged by the presence of 28a and an outer conductor diameter equal to that of 22c. The dielectric in the segment is, however, all together that of the insert 26, including, of course, the air present in bores 26c. This is again made to have a characteristic impedance approximately that of the line of the cable. The next segment IV finds the center conductive path the same, but the outer conductive path of increased diameter, that of 32d. The dielectric path is comprised of a very slight thickness of the material of 26, that of 26b, and a very substantial portion of air. The net characteristic impedance is again made to be that of the cable. The next segment V finds the center conductor increased slightly in outer diameter with the diameter of the outer conductor 32d remaining the same. The dielectric is completely air in this zone and again is approximately equal to that of the cable. The next segment is shown as VI and again there is an adjustment in diameters to approximate to the characteristic impedance of the cable. The same is true with respect to the segment VII.

While the transmission path through the plug and receptacle has been shown to be held to have a characteristic impedance approximately that of the cable of use, it is contemplated that the means shown may be separately used to achieve a characteristic impedance other than that of the line if such is desired. For example, if it is necessary for compensation purposes the insert 26 can be made to yield a characteristic impedance greater than that of the line by increasing the size of the bores 26c.

Having now described our invention in a preferred form in order to enable its practice by those skilled in the art, we now define it through the appended claims.

We claim:

1. In a connector device for coaxial cable of the type having a center conductor surrounded by dielectric material and an outer conductor, a coaxial plug for use with a coaxial receptacle, the said plug including an outer conductive shell adapted to be terminated to the cable outer conductor, a dielectric insert fitted within said shell and at least one center conductive contact member fitted within said insert and adapted to be connected to the cable center conductor, means securing the said center contact member to said insert and means securing the said insert to said shell against axial displacement, the forward portion of said center contact member having an outer diameter and outer contact surface to be engaged within a center contact member of a receptacle for said connector and including means yieldable in a radial sense and including an inner contact surface to alternatively receive inserted therein a center contact member of a different complementary receptacle.

2. The device of claim 1 wherein the said shell has a rear sleeve portion including an inner diameter to receive and support the cable dielectric material inserted therethrough and the insert includes a rear recess to receive and support the end of the cable dielectric material.

3. In a coaxial assembly for cable of the type having a center conductor surrounded by a dielectric sheath and an outer conductor, the combination comprising a connector plug and a connector receptacle, the rear portion of the said plug having means including a conductive shell to receive and be terminated to the outer conductor of a cable, a bore through said plug shell to receive and support the cable dielectric inserted within said plug, a dielectric insert in said bore locked to said plug shell including a rear recess adapted to receive the forward end

of the dielectric sheath of said cable and support such against transverse and axial displacement relative to said plug, a center conductive member secured in said insert and projecting forwardly of said plug for engagement in said receptacle, said receptacle including an outer conductive shell a dielectric insert fixed therein and a center contact member held by said insert coaxial to said receptable shell to project along said receptable shell free of the insert material, the said plug and receptable shells and center contact members of the plug and receptacle in conjunction with the radial spacing therebetween of dielectric material providing a characteristic impedance approximately equal to a given characteristic impedance for a given cable and the dimensions of said plug shell and the center contact including means providing mateability with a receptacle for use with plugs for cable of a characteristic impedance less than the said given characteristic impedance, said last mentioned means including

a center contact of the plug having at the end thereof a contact surface on the interior and on the exterior thereof to receive a receptacle contact member inserted therein and alternatively to be inserted within the center contact member of a receptacle.

References Cited

UNITED STATES PATENTS

1,859,390	5/1932	Green	-----	333—96
3,344,371	9/1967	Sewell	-----	333—96
3,372,364	3/1968	O'Keefe et al.	-----	333—97

HERMAN KARL SAALBACH, *Primary Examiner.*

L. ALLAHUT, *Assistant Examiner.*

U.S. Cl. X.R.

174—88; 339—32