PLATED PLASTIC ELECTRICAL CONNECTOR AND TERMINAL DEVICE

Filed July 8, 1965 3 Sheets-Sheet 1

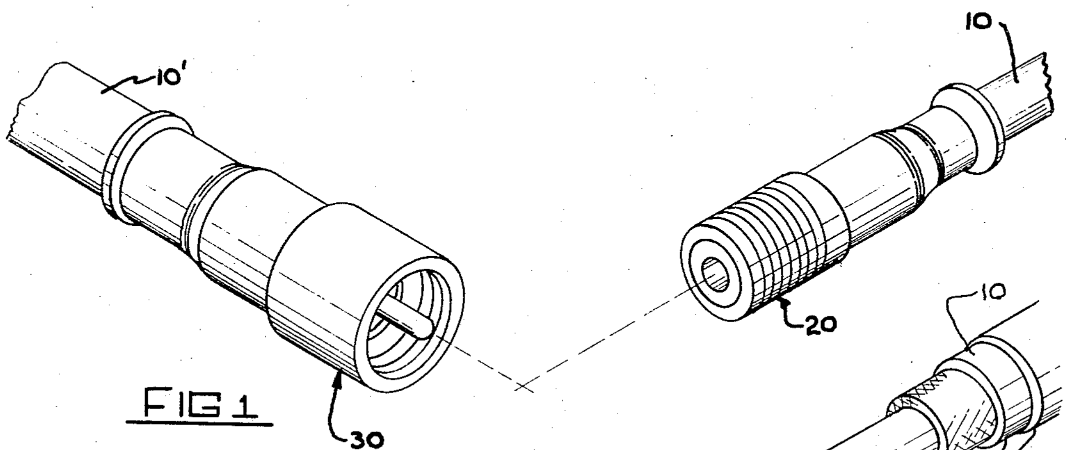
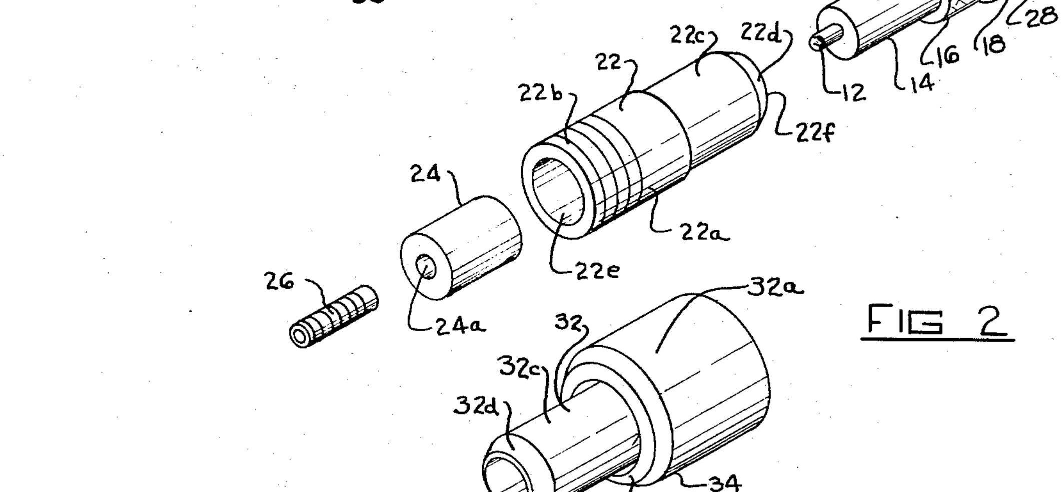


FIG 1



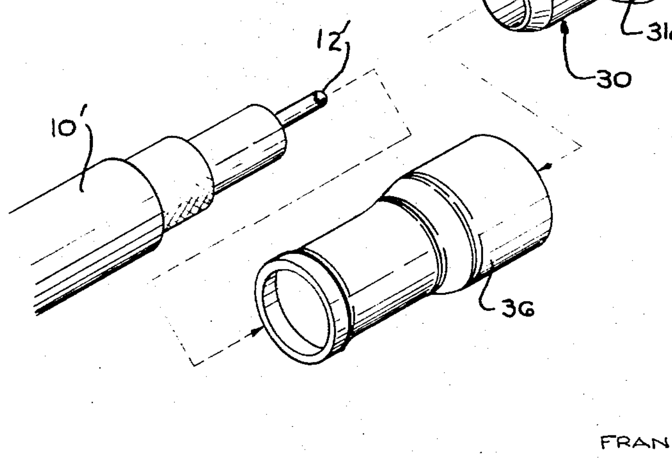


FIG 2

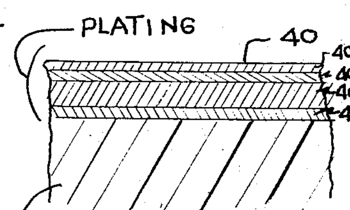


FIG 3

INVENTOR.
FRANK BENJAMIN STARK
BY Curtis, Morris & Safford

PLATED PLASTIC ELECTRICAL CONNECTOR AND TERMINAL DEVICE

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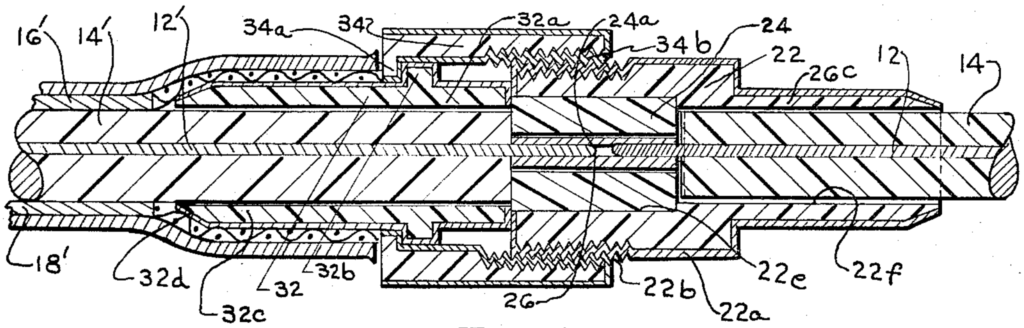

FIG 4

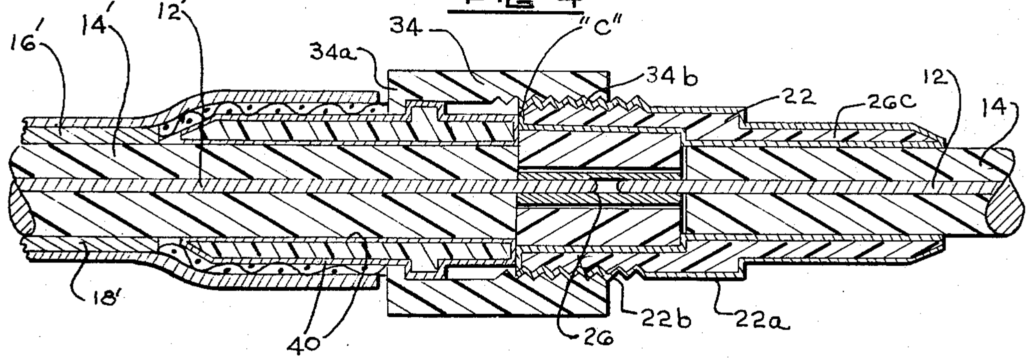

FIG 5

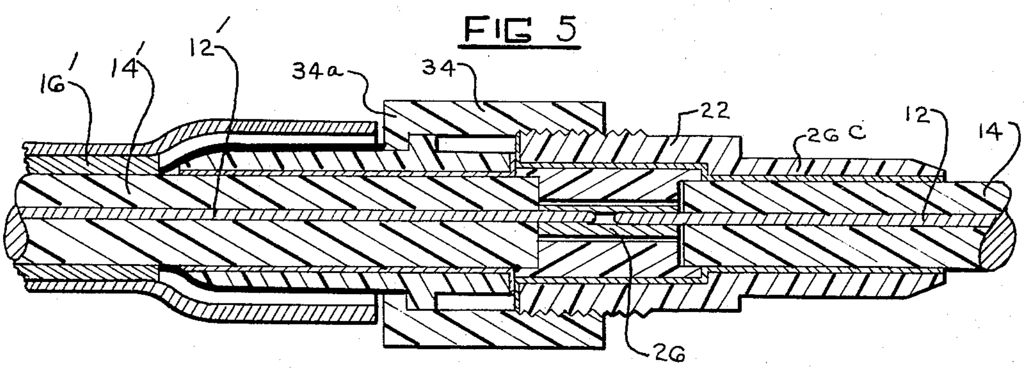

FIG 6

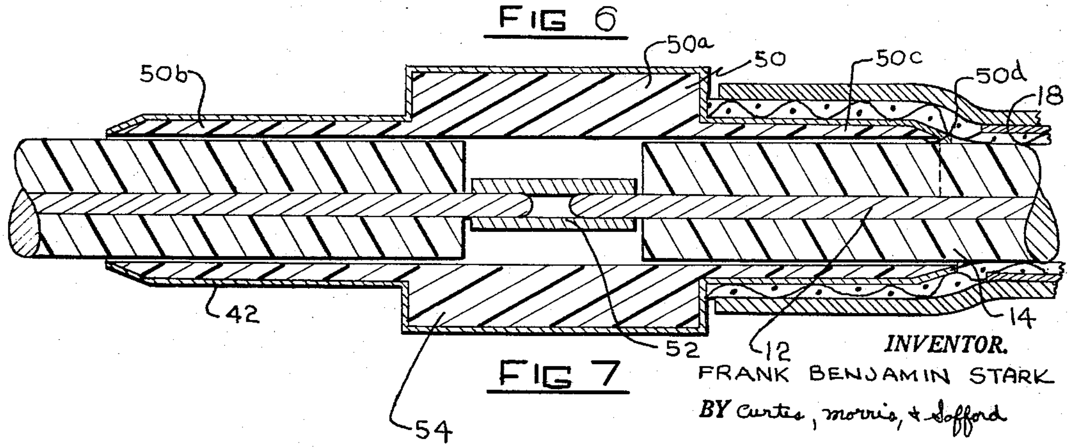

FIG 7

INVENTOR.
FRANK BENJAMIN STARK
BY Curtis, Morris, & Safford

PLATED PLASTIC ELECTRICAL CONNECTOR AND TERMINAL DEVICE

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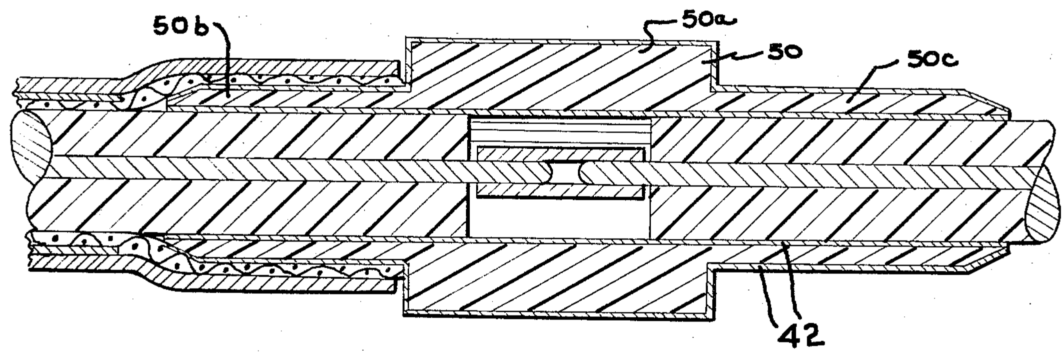

FIG 8

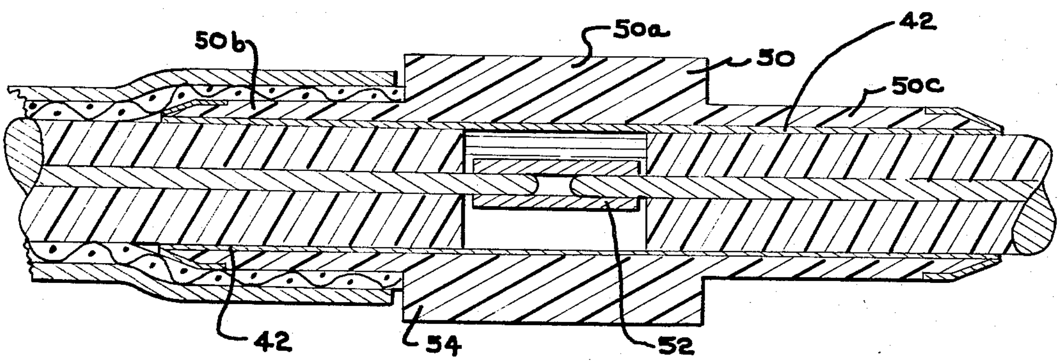

FIG 9

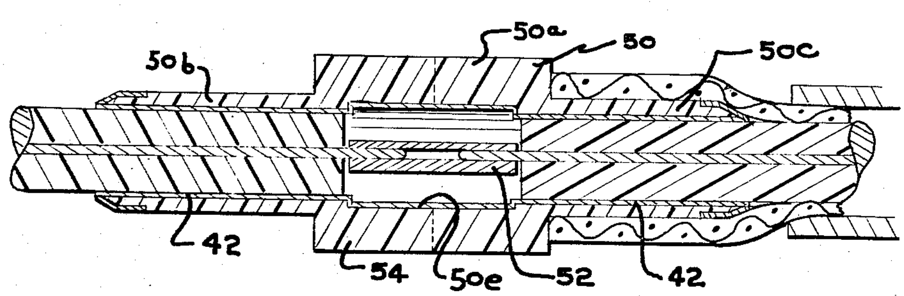

FIG 10

INVENTOR.
FRANK BENJAMIN STARK
BY Curtis, Morris, & Safford

United States Patent Office

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3,363,221

PLATED PLASTIC ELECTRICAL CONNECTOR AND TERMINAL DEVICE

Frank Benjamin Stark, Wormleysburg, Pa., assignor to AMP Incorporated, Harrisburg, Pa.

Filed July 8, 1965, Ser. No. 471,508
5 Claims. (Cl. 339—177)

This invention relates to an electrical connector and terminal device for coaxial and shielded cable and particularly to a connector construction wherein the connector body is comprised of an insulating plastic material having a conductive plating positioned thereon to serve as the medium of continuity, shielding or in high frequency applications, channeling the signal energy through the connection made with the connector.

The objective of any electrical connection is to provide a transmission path having mechanical and electrical characteristics as close as possible to related characteristics of the electrical cable of use. In DC or low frequency AC applications the cable of use usually consists of solid or stranded wire of a cross-sectional area and conductivity sufficient to handle the power requirements involved. The wire employed is surrounded by an insulating medium which may range from air in the case of power transmission lines, to a plastic insulating coating applied to the wire in the case of low power supply and communication lines. As the frequency of signal increases or as its power level decreases, it is necessary to add a further conductive and shielding medium surrounding the signal carrying conductor in order to protect the signal against degradation caused by outside signal sources.

These requirements must, of course, be carried into the design of connectors used to terminate and connect signal paths having these characteristics. A widely used cable construction employs a metallic sheath of either round or flat wires interwoven into a cylindrical configuration and fitted over a solid insulating and dielectric sheath which carries coaxially therein a solid or stranded center conductor. As signal frequencies are extended up into the megacycle and kilomegacycle range, the mode of energy transfer changes from one of simple conduction in a conductive medium to one conduction in the skin of the cable conductors and of electric and magnetic field propagation in the insulating medium between the conductive surfaces of the cable. The outer conductive material then becomes more than mere shielding and in many applications must be made to have a solid and smooth surface. Thus, in the case of microwave transmission the cable frequently takes the form of a relatively rigid conductive structure formed of a solid or hollow smooth center conductor surrounded by a dielectric material and a solid outer conductor formed of conductive tubing.

Connectors and terminals for use in these various applications have a structural complexity which proportionally increase with the complexity of the cable of use; both being roughly proportional to the frequency and/or power level of the signals transmitted. Most of the conductor and terminal parts are metal and are formed by either casting or screw-machining with numerous secondary operations being required. Most of the resulting connectors and terminals are thus relatively heavy, although very little of the conductive material of which they are comprised is utilized for the purposes of conductivity, shielding or channeling of the signal energy transmitted. In addition, since the main body of the connector is formed of metal, considerable effort has been required to provide compensating dielectric and insulating inserts to isolate the center conductive portions of the connector or terminal from the outer conductive portions thereof.

Thus, the typical prior art device winds up with an assembly of metal and dielectric material in parts carried to close production and assembly tolerances. The meaning of this is that the cost of connection or termination with present structures is quite high. The opportunity for failure of such devices, being related to the number and configuration of the parts thereof is also considerable.

It is an object of the present invention to provide a connector or terminal assembly wherein electrical and insulating and dielectric portions are comprised of an integral structure. It is another object of the invention to provide a connector and terminal assembly for coaxial, shielded and microwave transmission lines which has fewer parts than devices heretofore available. It is still another object to provide a connector and terminal assembly wherein the principal assembly body is formed of an insulating and/or dielectric plastic material and the conductive portions are comprised of a specialized plating bonded to the plastic portions. It is still another object of the invention to provide a connector and/or terminal assembly for coaxial cable which is essentially of plated plastic material, but includes features permitting crimping to join the connector or terminal to the cable. It is still a further object of the invention to provide a plated plastic coaxial connector and/or terminal device having an arrangement of conductive plating in various embodiments to serve various cables, or transmission lines and various signal requirements.

It is a general object of the invention to provide an improved coaxial connector and terminal device which is capable of being inexpensively produced by molding to a degree of tolerance adequate for low, medium and high frequency signal transmission and which is capable of being easily installed on the cable of use.

The foregoing objectives are attained in a structure wherein the mechanical connection of cable is carried by an insulating plastic member and the electrical connection is carried by a specialized conductive plating bonded to the plastic material. The plating has characteristics to provide wear under frictional contact, adequate conductivity for power requirements, shielding or channeling.

Considered as a terminal of coaxial shielded cable, the invention structure includes an insulating plastic shell which is plated on its inner and/or outer surface and in a preferred embodiment mechanically joined to cable via a malleable ferrule crimped down over the cable outer conductor against the rear of the shell and against plating bonded to the shell. Considered as a connector, two terminal structures of the type mentioned are provided with an additional means for interconnection, such as a threaded nut and a receptacle assembly to join the center conductors. In a splice configuration the terminal portions for each cable half are integrally joined in a unitary assembly of plastic and plating material. For cables which are adapted to handle signals carried by the cable center conductor and shielded by the cable outer conductor or braid, the invention structure contemplates providing a conductive plating only on its outer surface. For cables wherein the signal energy transfer includes modes of propagation between conductive surfaces, the invention structure contemplates a plating provided only on the interior of the shell structure. For uses wherein the cable may be employed to both conduct and channel signals, plating may be provided on the interior and exterior of the invention shell member. It is contemplated that in certain uses with certain plastic and plating materials the plating may additionally be employed as a strengthening medium.

In the drawings:

FIGURE 1 is a perspective of a connector in accordance with one embodiment of the invention including male and female halves as fitted on coaxial cable;

FIGURE 2 is an exploded perspective view of the halves shown in FIGURE 1, removed from the cables;

FIGURE 3 is a fragmentary section considerably enlarged depicting an embodiment of the insulating plastic-plating composition contemplated by the invention;

FIGURES 4–6 are longitudinal sections showing two coaxial cables electrically and mechanically joined through connector embodiments of the invention having different configurations of plating; and

FIGURES 7–10 are longitudinal sections of different splice embodiments joining coaxial or shielded cables having different configurations or plating for different electrical and mechanical applications.

FIGURE 1 shows a connector in accordance with the invention, including mating plug and jack connector halves each terminated to coaxial cable. The cable **10**, **10'** is as shown in FIGURE 2, comprised of a center conductor **12**, surrounded by a dielectric sheath **14**, a metallic outer braid **16** and an outer insulating and protective sheath **18**. Cable of this type may be utilized for a broad range of signal applications from D-C up to a low megacycle range of frequencies with the outer braid serving to shield the signal carried on the cable center conductor. Cable substantially like **10**, **10'** with considerably more care taken in production tolerances and with an outer conductor which is formed of conductive tubing or of solid metallic sheet is used for the kilomegacycle frequency range. The description hereinafter to follow relative to the invention may be taken to be applicable to analogous signal and cable ranges.

The plug and jack halves of the invention connector are identical in their rear portions and in the other portions utilized to terminate the halves to the cable. The forward portions of the halves differ only to provide an intermating for disconnect purposes. Viewing FIGURES 1, 2 and 4, half **20** will be seen to be comprised of but four pieces: a shell body member **22**, an insert **24**, a spring receptacle **26** and a crimping ferrule **28**. Half **30**, in this embodiment, is comprised of but two pieces: shell body member **32** and a crimping ferrule **34**. The body members **22** and **32** and the insert **24** are of an insulating plastic material having characteristics to be hereinafter described. The ferrules **28** and **34** are of relatively thin, annealed copper, sufficiently malleable to be crimped inwardly in a manner to be described. The body members **22** and **32** have a conductive plating **40** thereon extending over the outer surface thereof. This plating is shown in FIGURE 4 additionally, to extend over the outside and inside surface of the nut **34** of the member **30**.

In FIGURE 3, the specialized plating **40** contemplated by the invention is shown in one embodiment to be comprised of a plurality of layers bonded to the base plastic of the various plastic members and to each other. These include a base layer **40*a***, bonded to the surface of the plastic covered by a layer **40*b*** in turn covered by a layer **40*c*** and finally an outer layer **40*d***. These layers are of conductive material having a net thickness sufficient to serve the particular purpose of the connector or terminal device with respect to electrical and/or mechanical requirements.

As one example for general use, the layer **40*a*** is electroless copper, applied to an etched and cleaned plastic surface to a thickness of approximately 0.0002 of an inch with the layer **40*b*** an electro-plated copper to a thickness of 0.0005 of an inch. Layer **40*c*** is electro-plated nickel 0.0003 of an inch and **40*d*** is electro-plated silver to 0.0002 of an inch.

As another example, the plating layer **40*a*** is of electroless nickel approximately 0.0002 of an inch, layer **40*b*** is of electro-plated nickel 0.0005 of an inch. Layer **40*c*** is eliminated and layer **40*d*** is a suitable finish plate of silver. Plating of this type has been found to mechanically strengthen the plastic body members and to provide substantial wear characteristics for frictional engagement of the members and to strengthen the portions thereof which receive crimping forces as well as providing conductivity for power transfer, shielding and the necessary outside conductive surface for microwave applications. The outer layer **40*d*** additionally provides an anticorrosive surface to maintain the appearance of the connector and to resist the formation of contaminating oxides and the like. For higher frequency applications the plating outer layer is preferably made to be quite smooth. For power applications the net plating thickness is increased by increasing one or all of several of the various layers in thickness. As an important point, the plating should be sufficiently hard and tough to provide adequate wear in use. A plating of the type above given was tested under an applied force of 2500 pounds per square inch applied through a point of contact to 25,000 engagement cycles without failure and without developing an inordinate resistance.

Plating of this type has been found to be compatible with a number of plastic materials, including acrylonitrile-butadiene-styrene, made from the Cycolac No. 3510 series, produced by the Marlbon Chemical Co. This plastic has been found to be sufficiently rigid to receive crimping forces and to have insulating and other electrical properties sufficient for most applications.

Referring again to the connector of the invention and to FIGURES 2 and 4, the body member **22** of half **20** includes a forward relatively enlarged shell portion **22*a*** having its forward exterior surface threaded as at **22*b*** to engage with a mating threaded surface of **30**. At the end of the member opposite to such threading is an integral sleeve extension **22*c***, beveled at its outer end as at **22*d***. The body member includes a bore **22*e***, extending through the forward portion **22*a*** and a further bore **22*f*** extending through the sleeve extension **22*c***, the bore **22*f*** has a diameter approximately equal to or slightly larger than the diameter of the cable sheath **14**, so as to receive such and support it along its length. The thickness of the sleeve extension **22*c*** is controlled relative to the particular plastic employed so as to be capable of withstanding crimping forces applied thereover during termination of the connector half to cable. As an additional consideration relating to the choice of material and its thickness, the outer diameter **22*c*** should be sufficiently related to the cable outer conductor so that the cable outer conductor may be fitted thereover. With braid this constitutes no particular problem, since such is expandable.

With outer conductors which are solid metal tubing or stiff metal sheet material, the outer diameter of **22*c*** is made to be equal to or slightly smaller than the outer conductor inner diameter. In this event, the wall thickness of **22*c*** may be made to extend inwardly to directly engage the cable center conductor, the sheath **14** being trimmed off accordingly. This is shown by the dotted line in FIGURE 4 which represents an inward extension of the plastic material. The additional thickness to the plastic material quite adequately provides the additional strength necessary for crimping cable having an outer conductor of tubing.

In a sample tested having an extension like that of FIGURE 4, the extension wall thickness was .065 of an inch with an O.D. of 0.209 of an inch, molded out of Cycolac No. 3510. The ferrule was of soft copper having a wall thickness of 0.010 of an inch, 0.260 of an inch in diameter. This was crimped down over braid on the extension sleeve to a diameter of about 0.220 of an inch and resulted in an excellent mechanical and electrical termination of the cable.

The bore **22*e*** is sized in diameter to receive in a wedging fit the insert **24**, which itself includes a bore **24*a*** adapted to receive the spring receptacle **26**. This receptacle is shown schematically, but may be considered to contain spring members adapted to receive the cable center conductors. As assembled, the insert **24** carrying receptable **26** is fitted within **22*e***, to coaxially position **26** within **22** in alignment with the cable center conductor **12**. The cable is prepared as shown in FIGURE 2, with a portion of 12 extending forwardly and a substantial portion of 14 exposed in length related to the bore 22f, followed by a free length of the outer conductor or braid 16 approximately as long as 22c. The ferrule 28 is normally positioned back on the sheath 18, as indicated. As assembled, then, 22 is inserted on the cable with 22c worked under the braid with the beveled portion 22d facilitating this insertion. Thereafter, ferrule 28 is brought forwardly and crimped radially inwardly to the geometry shown in FIGURE 1 to mechanically and electrically terminate the cable to the connector half. As can be seen from FIGURE 1 the ferrule is made to extend well out over the cable such that when crimped it operates to grip and support the cable apart from the end of 20. The plating 40, which extends over the outside surface of 22 electrically extends the conductive path of 16 up to the end of 22.

Connector half 30 includes a body 32 having a forward extension 32a carrying an outward flange 32b adapted to cooperate with the nut 34 and an inner flange 34a thereof. The body 32 further includes a rear sleeve extension 32c beveled as at 32d in the same manner and for the same purpose as described with respect to half 20. The member is positioned on cable 10′, as previously described with respect to half 20 and the ferrule 36 is crimped inwardly to terminate 10′ to half 30.

With the halves 20 and 30 thus terminated to the cables 10 and 10′, 20 may be inserted within 30 with the center conductor 12′ fitting into one end of 26 and the center conductor 12 fitting into the other end of 26 to complete an electrical connection of the cable center conductors; the outer electrical connection extending from the outer conductors 16 and 16′ through the plating 40 on the surfaces of 22c and 32c, across the surfaces of the body members in the respective threading of the halves. The plating 40 is thus continuous over the outside surfaces of the halves and will also shield the signal carried by the center conductive paths.

The invention described relative to connector embodiments in FIGURES 1, 2 and 4 may be utilized, of course, as a terminal extending coaxial and shielded cable to or from electronic equipment having the plug or jack half mounted thereon in the standard fashion with the cable having a corresponding half terminated thereto. Alternatively, it is contemplated that jack and plug halves may be terminated in multiple in insulating blocks through the addition of spring members fastened or attached to the bodies of the halves in a standard fashion.

The connector assembly described with respect to FIGURES 1–4 having the conductive surface on the exterior thereof has a contemplated use generally in applications calling for either shielding or continuity of outer conductive paths. In FIGURE 5 there is shown an alternative embodiment having plastic body member portions, ferrules and receptacle recognizably identical to the parts just descussed. In the embodiment of FIGURE 5 the plating 40 has been extended to cover the interior bores of the body members 22 and 32 as well as the exterior so that the entire surface area of each member is covered with the plating material. In this application of the invention the nut 34 is left unplated with continuity being provided through the abutment of the ends of the members in the manner shown at C in FIGURE 5. By providing plating on the interior surfaces of the halves, the spacing between inner and outer conductive portions of the cable is maintained throughout the length of the body members, except in the zone containing the receptacle 26. In this zone there is an increase in the effective diameter of the outer conductive path which serves to adjust or compensate the characteristic impedance of the connector to that of the cable and correct for the enlarged diameter due to the body of the receptacle. This compensation may be in a standard manner. The addition of plating in the interior of the body members also serves to substantially strengthen the connector structure. Accordingly, the required specification for the plastic being used is not quite as rigid as that required in the previous embodiment. Alternatively, the plating may be made thinner. For example, 40a could be 0.0001 of an inch, 40b could be 0.0005 of an inch with 40c and 40d being a composition tin-nickel plating 0.0001 of an inch. The version of the invention shown in FIGURE 5 may be employed rather universally in applications ranging from D-C up to the kilomegacycle frequency range.

FIGURE 6 shows still another embodiment of the invention with the plastic body members, ferrules, insert and receptacle being identical to that previously described but with the plating 40 carried only on the interior of the body members. Connectors in accordance with the embodiment of FIGURE 6 would preferably be utilized in applications of the higher signal frequencies wherein there is a requirement of maintenance of characteristic impedance therethrough. It will be noted that the outer conductor of the cable is shown as solidly formed sheet material rather than braid. This is typically copper foil.

FIGURES 7–10 show embodiments of the invention adapted to serve to splice coaxial or shielded cable. Referring to FIGURE 7, the main body of the connector is shown as 50, including a center enlarged portion 50a with integral sleeve extensions 50b and 50c extending axially therefrom. The extensions 50b and 50c are like the extension 22c previously described. Extending through the body of 50 is a bore of common diameter shown as 50d made to approximate the outer diameter of the cable sheath 14. In the center of 50a there is provided a spring receptacle shown as 52 adapted to receive the center conductors of the cables to be spliced. The receptacle 52 may be supported by a further dielectric insert, not shown, having a diameter to be wedge fitted or bonded within the bore 50d and positioned in the center of the splice or unsupported except by 12, 12′. In the embodiment shown in FIGURE 7 the plating is shown as 42 extending over the outside surface only to provide continuity and shielding of the connection achieved by the splice.

In FIGURE 8 an alternative version of the splice is shown to include plating 42 extending over the entire surface of the body 50. The splice of FIGURE 8 is capable of serving to interconnect a variety of cables for different signal uses and power requirements. Within the center of the body 50a the dielectric material is again shown as air, although it is possible to utilize a dielectric insert of the type previously mentioned.

FIGURE 9 shows still another embodiment wherein the plating 42 is carried on the inside of the body and over the end of the sleeve extensions 50b and 50c, but not over the enlarged portion 50a of the body. This embodiment can alternatively be used for a wide variety of signal cable and uses with continuity being provided through the contact of the outer conductor of the cable through the plating on the exterior of the sleeve extension. The interior portions of the plating 42 serve to conduct and channel energy transmitted by the splice.

If it is desirable to provide a fully compensated splice for kilomegacycle frequencies, the splice may take the configuration shown in FIGURE 10 where there is in the enlarged portion 50a an enlargement of the bore shown as 50e to serve as compensation for the enlargement of the receptacle 52. Again, air or a solid dielectric may be utilized in the space between the receptacle surface and the interior of the body. The plating 42 is carried throughout the inside surface of the body and over the outside surface of the sleeve extension.

While these various plastic portions in FIGURES 1–10 are shown as being comprised of one piece, it is contemplated that they may be made of several pieces bonded together into an integral assembly. This is particularly advisable with respect to the embodiment of FIGURE 10 due to the difficulty inherent in forming in a molded piece the enlarged bore in the center thereof. The dotted line indicated on the plastic body shows a possible configuration in two pieces adapted to be bonded together prior to plating.

The invention as thus described contemplates a relatively hard plastic shell with a relatively thick and heavy conductive plating thereon in various configurations to serve as connectors, terminals and splices. It is contemplated that the invention may be carried into L, T and other configurations and into multiple assemblies by an extension of the invention technique to insulating blocks capable of accommodating more than two cables in a disconnect or splice configuration. It is further contemplated that a variety of plastics and platings will adequately serve the purposes of the invention as long as the requirements herein set forth are followed.

Having now described my invention and a preferred mode of practice, I define it through the appended claims.

What is claimed is:

1. In a connector for coaxial shielded cable of the type having a center conductor surrounded by a dielectric material and an outer conductor, a pair of body members each having a rear sleeve extension of a diameter to fit within the outer conductor of a cable and each having a bore extending through each member of a diameter to receive along a substantial portion of the length of each member the cable dielectric material surrounding the center conductor and the center conductor, each body member being comprised of a rigid insulating material throughout with a hard conductive plating bonded to the surface thereof along the length of the member and peripherally therearound and of a sufficient thickness to provide a strengthening of said member with both of said body members being substantially nonflexible along the length thereof to prevent plating separation, means to terminate a cable outer conductor to each member rear sleeve extension, means carried within the bore of at least one of said body members to interconnect the center conductors of cable and means to coaxially hold said body members together with the plating of one member connected to the plating of the other member to interconnect outer conductive paths formed by said plating on said body members without flexing portions of said body members.

2. In a connector for coaxial or shielded cable of the type having a center conductor surrounded by a dielectric material and an outer conductor, a pair of body members each having a rear sleeve extension of the diameter to fit within the outer conductor of the cable and a bore extending through each member adapted to receive the cable dielectric material and center conductor along at least a substantial portion of the length of a member, each body member being comprised of a rigid insulating plastic material throughout with a hard conductive plating bonded to the surface thereof along the length of the member and peripherally therearound at least on the exterior surfaces thereof and of a thickness to provide a material strengthening of said member, a low resistance outer conductive path and a shielding of the center conductor, means to terminate a cable outer conductor to each member rear sleeve extension and the plating thereof, means within the bore of at least one of said body members to interconnect the center conductor of cable and means adapted to engage the forward ends of said body members and mechanically hold such members together to effect a coaxial electrical connection between the platings thereof without substantially flexing said members whereby to form a coaxial connection between cables connected to said members which may be repeatedly used without plating separation therefrom.

3. In a connector for coaxial shielded cable of the type having a center conductor surrounded by a dielectric material and an outer conductor, a pair of body members each having a rear sleeve extension of a diameter to fit within the outer conductor of the cable and a bore extending through each member adapted to receive the cable dielectric material and the center conductor, each body member being comprised of a rigid insulating material throughout with a hard conductive plating bonded to the surface thereof along the length of the member and peripherally therearound along the interior of the bore of each body member with further portion of said plating being continuous with said interior plating and extending around a portion of the exterior surface of said extension and the forward end of each member to provide a material strengthening of said member, an outer conductive path for said connector and a shielding of the center conductor of the cables, means to terminate a cable outer conductor to each member rear sleeve extension and the plating thereon to form an outer conductive path extending along said connector from one of said cables to another of said cables, means within the bore of at least one of said body members to interconnect the center conductor of each of said cables to form an inner conductive path, means within at least one of said body members to insulate said center conductive path including the interior plating from each other, and means to engageably hold said body members mechanically together with the plating thereof at the forward ends of the members forced into an engagement without substantially flexing the said body members whereby to prevent plating separation in repeated use of said connector.

4. A device for interconnecting coaxial or shielded cables of the type having a center conductor surrounded by a dielectric material and an outer conductor including an inner member to interconnect the center conductors of said cables and an outer means surrounding said inner member to interconnect the outer conductors of the said cables, said outer means consisting of a nonflexible body of rigid plastic material having a hard conductive plating bonded thereto along the length thereof and extending peripherally around either the interior or exterior surface thereof with at least a portion extending around the exterior surface of outboard end portions thereof, the outboard end portion thereof forming sleeve members of an outer diameter to be fitted within the outer conductor of said cables and means to terminate the outer conductors of the cables to the outboard end portions of said outer means with the said plating forming an outer conductive path connecting the outer conductors of said cables.

5. The device of claim 4 wherein said cable outer conductors have a given inner diameter and the said device outer means includes a bore extending therethrough with the said bore being plated and of a diameter when plated approximately equal to the said given diameter of said cables whereby to minimize impedance mismatch along at least a substantial portion of said device and means are provided to insulate said plating from the inner conductor of the cables and said inner member.

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MARVIN A. CHAMPION, *Primary Examiner.*

W. DONALD MILLER, *Examiner.*

J. R. MOSES, *Assistant Examiner.*