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2,793,352

CONNECTOR FOR ELECTRICAL TRANSMISSION LINES

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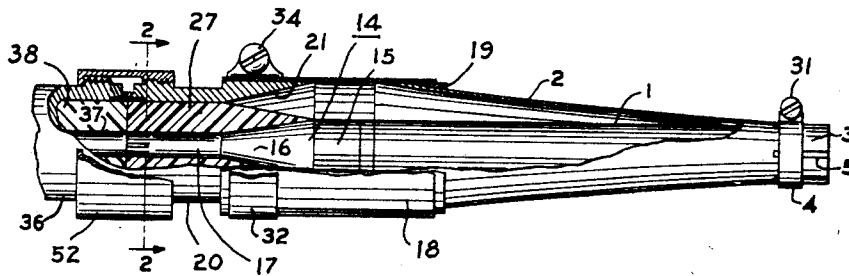


FIG. 1

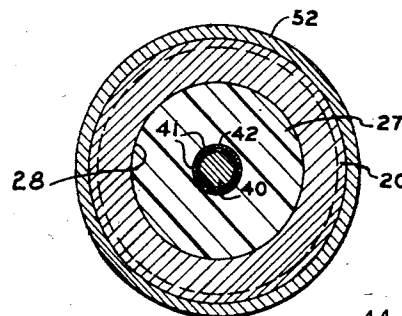


FIG. 2

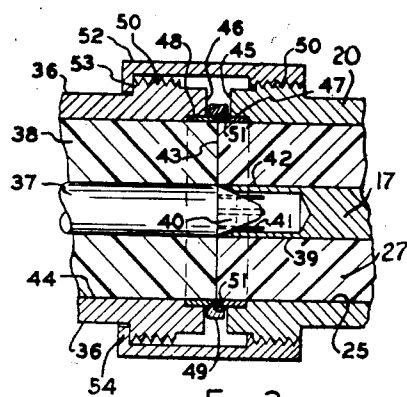


FIG. 3

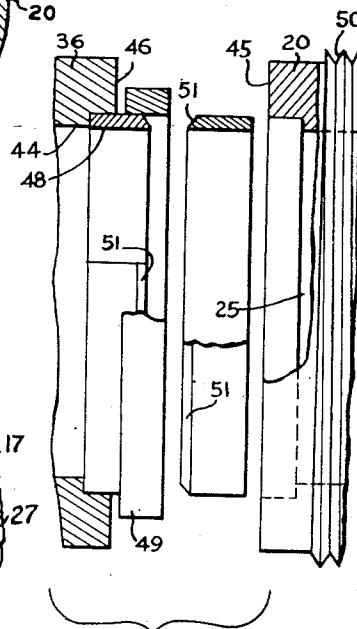


Fig. 4

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1

2,793,352

CONNECTOR FOR ELECTRICAL TRANSMISSION LINES

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Original application August 21, 1946, Serial No. 692,116. Divided and this application March 8, 1951, Serial No. 214,523

10 Claims. (Cl. 339-177)

This invention relates to high frequency electrical devices and more particularly to an improved connector for joining conductors, lines and other components of high frequency circuits.

In the transmission of high frequency energy as by means of a coaxial line, it is important that all portions of the line conform to certain principles or laws, now well known, pertaining to diameter ratios of the inner and outer conductors, dielectric constants of the medium disposed in the spaces between the conductors, and avoidance of obstructions and surface irregularities on the conductors. Practical considerations require that components of high frequency systems be joined by disconnectable couplings which permit removal and insertion of elements at will for test, repair and replacement. Such couplings or connectors must embody the design principles referred to in order that objectionable reflections and other effects will be avoided.

It is, therefore, one of the principal objects of the present invention to provide a high frequency connector structure that maintains the characteristic impedance of the lines connected thereby and that is substantially free from objectionable reflections.

Another object is to provide a connector of the character mentioned which incorporates means for effecting circumferential line contact between the conductors joined substantially at the effective diameter of such conductors. More specifically, the invention contemplates an arrangement wherein circumferential line contacts each substantially completely circular in extent are established by the connector components at the outside diameter of the inner conductor of a coaxial line and at the inside diameter of the outer conductor of such line.

Another object is concerned with the provision of a non-polar connector structure for tubular lines, the connector components being alike on each line end so that such line ends may be joined indiscriminately.

A further object is to provide a connector composed of a minimum number and kind of parts and that can be quickly and easily assembled and disassembled without special training or instructions.

A suitable connector arrangement for tubular conduits may take the form of thin flange means on one, though preferably both of the conduits, in combination with a pilot element engageable with the thin flange means to guide the flange means into proper position during drawing together of the conduits. The flange means may take the form of a thin shell which, in the case of a circular sectional conduit, is in the nature of a ring of cylindrical shape, or substantially so. Likewise with a circular conduit, the guide or pilot may take the form of a ring which embraces the shell flange and makes contact therewith around substantially the entire circumferential extent of the shell. By making the inside diameter of the shell the same as that of the tubular conduit on which it is formed or mounted, the shell end and the companion shell or conductor end against which the shell is abutted in assembly, make circumferential line

2

contact, substantially completely circular in extent at said inside diameter. In a coax connector, one of the center conductor ends is formed or provided with a circumferentially extending shell flange which terminates in a tapered or knife-like edge that makes circumferential line contact with an axially tapered plug end on the other center conductor. The knife edge, in the case of a circular sectioned center conductor, has substantially the same diameter as the conductor so that the circular line contact has the same diameter as the conductor, or substantially so. The plug or the embracing shell flange, preferably the latter, is axially slotted so as to yield radially during assembly, the slotted element being formed of suitable resilient metal that has good electrical properties. When a solid dielectric is used between the inner and outer conductors of the connector parts in a coaxial arrangement, the knife edged shell tube or flange is axially slotted so as to be compressed by the embracing solid dielectric and thereby held with the knife edge pressed firmly against the plug. Initial contact between the center conductor tube shell and the tapered plug occurs on the tapered portion of the plug at a diameter somewhat less than the center conductor diameter, the resilient fingers formed by the slitting of the shell tube preferably being slightly pinched together radially before assembly and deformed so that the circle of the knife edge is slightly less in diameter than the center conductor. The parts are so arranged that when the conductor is fully assembled, the circular line contact of the knife edge is on the tapered portion of the plug at a diameter substantially equal to that of the inner conductor.

The principles of the invention as briefly outlined above are illustrated in a connector structure used to join one component of a high frequency electrical circuit to a coaxial line. Other applications of the invention are intended and will be apparent. The particular circuit component illustrated is a termination including a tapered horn embracing a cylindrical resistance, as disclosed in my copending joint application for United States patent Serial No. 692,116, filed August 21, 1946, now Patent 2,552,707 dated May 15, 1951, of which the present application is a division. Reference is also made to United States Patent 2,663,753 dated December 22, 1953, entitled "Coupling Means for Coaxial Electrical Lines," which describes and claims similar subject matter, such patent having been issued on a copending application.

The device of the present invention provides connecting means of separable parts between the conductors of a high frequency coaxial line and, by way of example, the members or parts of the line termination structure of the application referred to. Objects and advantages in addition to those outlined above will become apparent from the following detailed description of a suitable embodiment of the invention made in connection with the accompanying drawings forming a part of the specification.

In the drawings:

Figure 1 is an elevational view partly in section and with parts broken away, showing a line terminator or dummy antenna attached to a coaxial transmission line;

Fig. 2 is a section taken substantially on the line 2-2 of Fig. 1 and enlarged with respect thereto;

Fig. 3 is a sectional detail showing the structure of the connector device between the line termination and the coaxial transmission line; and

Fig. 4 is a fragmentary expanded elevational view partly in section, with parts broken away and with parts removed, showing the interfitting arrangement for mounting the connector shells in the ends of the tubular outer conductors and the guide ring that embraces the meeting ends of the shell connectors, this view being enlarged with respect to the other figures.

Referring to the drawings by numerals of reference which indicate like parts throughout the several views, the illustrative embodiment of the present invention is shown as a connector between a coaxial transmission line of conventional character and the termination of the application referred to. The termination includes a hollow cylindrical resistor member indicated generally by the numeral 1, enclosed in or surrounded by a tapered metal housing or shell 2. The housing, of circular cross section throughout its length, is concentric to the resistor 1 and is of trumpet or horn shape.

The small diameter end of the housing may be formed with a relatively short cylindrical portion or throat 3 which embraces one end of the resistor 1. A circular split clamping band 4 embraces cylindrical portion 3 of the housing adjacent the juncture of the housing and the inner resistor member. Longitudinal slots 5 in the cylindrical portion 3 of the housing, which permit limited expansion and contraction of the housing to accommodate slight variations in diameter of the resistor 1, facilitate assembly in production.

An inner connector member 14 is formed at one end with a tubular cylindrical element 15 which is telescopically received over the reduced diameter end portion of the resistor 1. The tubular element 15 has a relatively tight sliding fit over the end of the resistor so as to make electrical connection therewith and the parts may be soldered together. The diameter of the smooth outer surface of the tubular connector element 15 is substantially equal to that of the carbon film or other resistive coating on the resistor, thus effecting an electrical connection while maintaining substantially constant diameter, it being understood that in soldering the tubular element onto the reduced diameter end portion of the resistor any cracks and crevices between the end of the tubular element and the shoulder are filled.

The inner connector 14 may be formed of copper, brass or similar metal of high conductivity and has a tapered central body portion with an outwardly directed smooth conical face. At the end of the connector opposite the tubular element 15 is a cylindrical conductor element 17 of less diameter than the tubular connector 15. The connector member 14 may be formed in one piece by casting or by turning from bar stock, the cylindrical tubular end portion 15 and the conductor element 17 being integral with the tapered body portion.

The large diameter end of the housing or horn 2 is telescopically received within a conductive cylindrical shell 18 which may be in the form of a brass or copper tube of uniform circular cross section. A tapered wedge sleeve 19 embraces the large diameter end of the horn casing 2 and is received in the angle between the horn and the cylindrical sleeve 18 to guide the latter in longitudinal or axial sliding movement over the horn and to maintain the parts in correct alignment.

Disposed about the connector member 14 in concentric relation thereto and telescopically received in one end of the conductive shell 18 for sliding engagement therewith is an outer connector member 20. This outer connector 20 is formed with an internally tapered conical end element or portion 21 which is disposed concentrically about the tapered body of the inner connector 14 in confronting relation to the conical face 16 of the inner connector.

A solid dielectric tube 27 fills the annular space between the cylindrical element 17 of the inner connector member and the confronting cylindrical face of the outer connector member. This tubular dielectric may be polyethylene or such other compound having known dielectric properties as is customarily employed in making solid dielectric coaxial cables.

In the transition zone of the connector assembly, that is, in the region of the conical faces of the connector members the solid dielectric tube 27 progressively changes or is reduced and tapered in cross sectional area. The dielectric material has its maximum cross section in the

region of the cylindrical conductor elements 17 and 20.

In the assembly of the line structure the horn or casing 2 is placed over the resistor 1 and positioned so that the line of connection between the carbon film and a conductive band painted on the carbon coating of the resistor at one end lies substantially in the plane of the large diameter circular end edge of the casing 2. The resistor 1 and the horn or casing are retained in this adjusted position by tightening screw 31, which locks the clamping ring 4 about the small diameter end of the horn, holding the latter tightly about the end of the resistor 1 and making positive electrical contact between the internal surface of the horn or casing and a band of conductive metal paint on the other end of the resistor.

The tubular dielectric 27 and the outer connector member 20 are assembled over the inner connector member 14 and adjusted so that the ends of the several conical or tapered surfaces are disposed in a common plane. The sleeve 18 is placed over the horn or casing 2 and the wedging sleeve 19 adjusted to align the parts. A clamping band 32, fitted with tightening screw 34, is applied about the shell 18 to hold the latter in tight embracing relation about the connector member 20. Subsequently, the parts are soldered or brazed together.

The "dummy" antenna or line terminator is assembled to a coaxial high frequency line comprising outer conductor 36 and inner conductor 37. The cylindrical face 25 of the outer connector member 20 and the cylindrical element 17 of the center conductor are designed with internal and external diameters respectively equal to corresponding diameters of the coaxial line elements 36 and 37. Between the conductors 36 and 37 of the line is a solid dielectric tube 38 which is preferably of the same material as the solid dielectric tube 27.

The end of the inner conductor element 17 is formed into a thin sectioned circular shell portion 39 which receives a tapered or conical plug portion 40 formed on the extreme end of the inner conductor 37 of the coaxial line. The shell portion 39 is of the same outer diameter as the conductor 17. A number of axial slots 41 opening through the end of the shell portion 39 provide laterally flexible fingers 42 arranged in a cylinder for simultaneous yielding contact with the tapered plug portion 40 substantially at the maximum diameter of the latter which is the diameter of the inner conductor of the coaxial line. Electrical connection is thus established between the circular knife edge and the tapered plug end substantially at a circular line contact located intermediate the axial limits of the tapered portion 40 of the conductor 37 but substantially at the outer diameter of such conductor. The end of one of the center conductors is resilient and deformable to provide for expansion and contraction thereof so that the line contact between the conductors travels along the tapered end 40 as such tapered conductor plug end moves into and out of the socket of the conductor 17 in assembling and adjusting the structure.

The solid dielectric 27 in the connector assembly compressively abuts the ends of the dielectric 38 of the coaxial line and the line of abutment, indicated at 43, is disposed substantially in the plane of the ends of the flexible fingers 42. The tapered plug portion 40 on the end of the inner conductor of the coaxial line extends beyond the end of the said dielectric tube 38.

In assembling the line termination with the coaxial line, the ends of the flexible fingers 42, formed with knife or tapered edges, make line contact with the inner conductor 37 approximately at the base end of the tapered plug portion 40 thereof and substantially at the diameter of the conductor. Thus the connection provides a substantially continuous conductor of uniform diameter and the transition between the inner conductors 17 and 37 is effected smoothly at a substantially circular line contact and without abrupt diameter change.

The ends of the solid dielectric tubes 27 and 38 project

axially beyond the outer connector member 20 and the outer line conductor 36, respectively, so that confronting end faces 45 and 46 of the outer conductors are disposed in spaced, confronting relation when the solid dielectric tubes are in abutment. At the ends of the outer conductors 20 and 36, thin contact shell elements 47 and 48 of metal such as brass, silver or copper, are received in embracing relation about and substantially flush with the ends of the dielectric tubes 27 and 38 respectively. These shells are fitted into shallow recesses formed in the interior faces of the outer conductors and abut circumferential shoulders interiorly of the conductors. The internal diameter of the shells is approximately equal to that of the conductors so as to provide smooth continuous internal conductive surfaces.

In assembling the line elements the shells 47 and 48 are brought into end-to-end abutting relation to effect a positive electrical connection between the outer conductors of the structure, such connection being substantially continuous throughout the entire circumferential extent of the shells and being made along a line having a diameter approximately that of the internal faces 25 and 44 of the outer conductors. To insure the making of the electrical connection at the diameter of the outer conductors, the meeting end edges of the shells 47 and 48 are beveled at 51 about their outer end edges.

A guide ring 49 embraces the portions of the shells 47 and 48 which are disposed in the space between the confronting faces 45 and 46 of the outer conductors. The ring 49 is of less width than the space separating the confronting faces 45 and 46 of the outer line conductors so as to provide clearances which permit positive abutment of the contact shells. This guide ring is freely slidable on the shells and besides guiding them into contact it serves as a reinforcement to resist collapse of the shells under axial compression.

External threads 50 are formed adjacent the ends of the outer conductors 20 and 36 so that a threaded coupling sleeve 52 may be employed to secure the conductors together. The coupling sleeve 52 is threaded at one end over less than half its axial length and at its other end is formed with a circumferentially extending inwardly directed radial flange 54 which is engageable behind a circumferential shoulder 53 at the end of the threaded portion of one of the outer conductors.

This coupling arrangement, wherein each outer conductor has a threaded end portion terminating at an inwardly directed radial shoulder, provides for interchangeable connectors in coaxial lines. Each threaded line end has a shoulder corresponding to the shoulder 53 and is fitted with a threaded coupling sleeve corresponding to the sleeve 52. In assembling coaxial lines so constructed, the coupling sleeve for either of the line ends may be employed to secure the parts together, the unused sleeve remaining idle and not being shown in the drawings.

During assembly, the parts are initially guided into correct relative position by the interfitting relation of the tapered plug end 40 received in the socket provided by the fingered shell portion 39 of the inner conductor 17. As the parts are moved into final position, the guide ring 49, cooperating with the beveled ends 51 of the contact shells 47 and 48, guides the latter into abutting relation. Tightening of the coupling sleeve 52 draws the parts firmly together, compressing the abutting end faces of the dielectric tubes 27 and 38, the dielectric being confined between the contact shells 47 and 48 and the inner conducting means. The incompressible character of the solid dielectric material acts to force the flexible fingers 42 of the inner conductor 17 tightly against and into positive electrical conducting relation to the inner conductor 37 of the coaxial line.

The principles of the present invention may be utilized in various ways, numerous modifications and alterations being contemplated, substitution of parts and changes in

construction being resorted to as desired, it being understood that the embodiment shown in the drawings and described above is given merely for purposes of explanation and illustration without intending to limit the scope of the claims to the specific details disclosed.

What I claim and desire to secure by Letters Patent of the United States is:

1. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, axially directed substantially cylindrical relatively thin shell flanges being in edgewise abutment with one another and on the ends of the conductors, said shell flanges having substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, and guide ring means received embracingly about the guide surfaces of the shell flanges, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the shell flange surfaces to pilot the conductors into aligned relation as the latter are drawn together.

2. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, axially directed substantially cylindrical relatively thin shell flanges on the ends of the conductors, said shell flanges having substantially circular end faces disposed in confronting relation and substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, and guide ring means received embracingly about the guide surfaces of the shell flanges, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the shell flange surfaces to pilot the conductors into aligned relation and the end faces into abutting relation as the conductors are drawn together.

3. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, axially directed substantially cylindrical relatively thin shell flanges on the ends of the conductors, said shell flanges being in edgewise abutment with one another and having substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, guide ring means received embracingly about the guide surfaces of the shell flanges, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the shell flange surfaces to pilot the conductors into aligned relation as the latter are drawn together, a pair of center conductors, and solid dielectric bodies supporting the center conductors co-axially in the tubular conductors, the dielectric bodies abutting one another substantially in the plane of abutment of the shell flanges.

4. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, axially directed

substantially cylindrical relatively thin shell flanges on the ends of the conductors, said shell flanges having substantially circular end faces disposed in abutting relation and substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, guide ring means received embracingly about the guide surfaces of the shell flanges, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the shell flange surfaces to pilot the conductors into aligned relation and the end faces into abutting relation as the conductors are drawn together, a pair of center conductors, and solid dielectric bodies supporting the center conductors coaxially in the tubular conductors, the end faces of the shell flanges being in abutment in a plane substantially normal to the axis along which the conductors are drawn together and the dielectric bodies being disposed one in each tubular conductor and having substantially flat confronting faces substantially abutting in the plane of abutment of the circular end faces.

5. In a coupling assembly for a high frequency electrical line comprising separable parts each having inner and outer coaxial conductors separated by solid dielectric material and means for holding the parts in assembled end to end relation, the combination of a tapered end portion on one of the conductors of one part, a plurality of fingers on the end of the corresponding conductor of the other part, the fingers having extreme end edges positioned to yieldingly engage the said tapered end portion substantially in a circular line contact surrounding the latter upon drawing together of the parts in assembly, one side of each finger being disposed compressively against the dielectric material, and thin cylindrical ring means carried by the other conductors of the parts, said ring means being arranged to be brought into aligned end to end abutting relation in assembly for establishing the electrical connection therebetween, and said ring means also being disposed to embrace and confine the solid dielectric material in the annular space between the inner and outer conductors of the assembled coupling.

6. In a high frequency electrical line coupling assembly of separable parts the combination of means for drawing and holding the parts together in assembled relation, a relatively thin sectioned substantially cylindrical contact ring carried by one part and having a circular edge face disposed in edgewise abutment with the other part in the establishment of a circular contact in a plane normal to the axis of the assembly, the contact ring being positioned on the one part to be drawn axially into said edgewise abutment during assembly, and means having centering connection with the other part and disposed on the outside of and embraced about the contact ring in sliding relation for holding the contact ring and the other part in axial alignment.

7. A high frequency electrical line coupling assembly comprising separable parts each having inner and outer coaxial conductors, means for drawing and holding the parts together in assembled relation, a tapered plug end on one and a recessed socket on the other of the inner conductors, the plug end being received within the socket end to serve as primary centering means during initial assembly, ring contact means carried by the outer conductors and adapted to establish a substantially circular end to end abutment contact between the outer conductors of the parts, and means engaging the ring contact means for relative axial sliding movement and adapted to guide the parts into said end to end abutment to serve as secondary centering means during final assembly.

8. In a coaxial line coupling structure or the like, tubular conductors disposed in end to end relation and having spaced confronting end faces, at least one of the conductors having at its end a circumferentially extending axially directed shell of relatively thin sectioned con-

ductive material, the shell being of greater length axially of the structure than thickness radially and being generally of less radial thickness than either of the conductors, said shell and at least one of the conductors having inside surfaces of substantially the same curvature radius, sleeve means embracing and having connection with the conductors for drawing the latter together endwise in assembly to compress the shell axially therebetween and to hold the conductors in said end to end relation with the shell abutting the other shell or the end of a conductor, and guide ring means substantially surrounded by the sleeve means and embracing the shell to reinforce the latter against collapse, the ring means being held against radial shifting relative to the conductors and disposed in the space between the confronting end faces of the conductors and having a substantially cylindrical inside surface slidable axially over and relative to the shell for guiding the conductors together in assembly.

9. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, means on the ends of the conductors providing substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, said guide surface means being formed with radially narrow circular end faces contiguous to the surface generated by the internal surfaces of the conductors and arranged to be brought into axial abutment when the conductors are drawn together to establish circular abutment contact between the conductors, and guide ring means receivable embracingly about the guide surfaces of the conductors, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the conductor guide surfaces to pilot the conductors into aligned relation as the circular end faces are drawn together into abutment.

10. In a coaxial line coupling structure or the like, a pair of substantially rigid tubular conductors disposable in end to end relation, said conductors being formed with internal cylindrical coaxial conductive surfaces and having externally threaded end portions, internally threaded sleeve means embracing the threaded portions of the conductors for relative rotation, the sleeve means being arranged upon such relative rotation to draw the conductors together, means on the ends of the conductors providing substantially cylindrical outwardly directed guide surfaces of less diameter than the root diameter of the threads on the respective conductors having such guide surfaces, said guide surface means on the conductors being formed with substantially circular end faces contiguous to the internal conductive surfaces of the conductors, the end faces being radially narrow and disposed in abutment in a plane substantially normal to the axis of the cylinder defined by the guide surfaces, and guide ring means receivable embracingly about the guide surfaces of the conductors, said ring means having a substantially cylindrical inwardly directed face slidable telescopically over the conductor guide surfaces as the conductors are drawn together to pilot the conductors into aligned relation and the end faces into abutment.

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