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COUPLING MEANS FOR COAXIAL ELECTRICAL LINES

Filed May 21, 1948

2 Sheets-Sheet 1

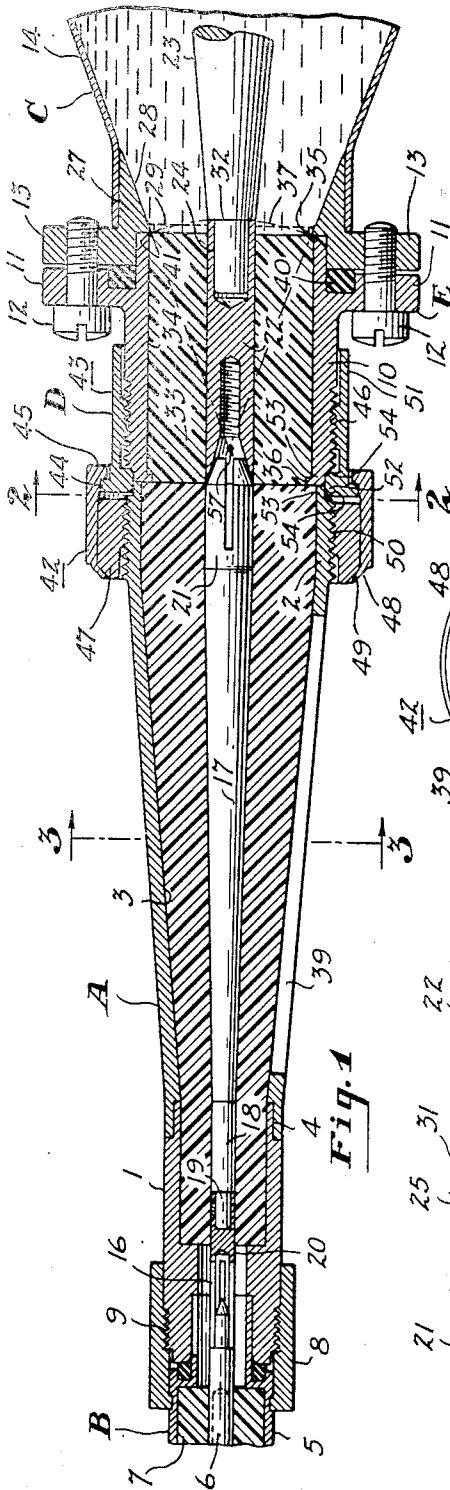


Fig. 1

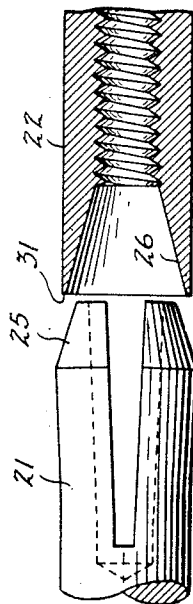


Fig. 4

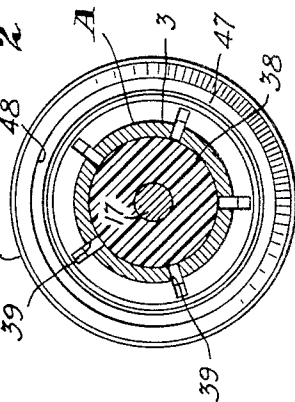


Fig. 3

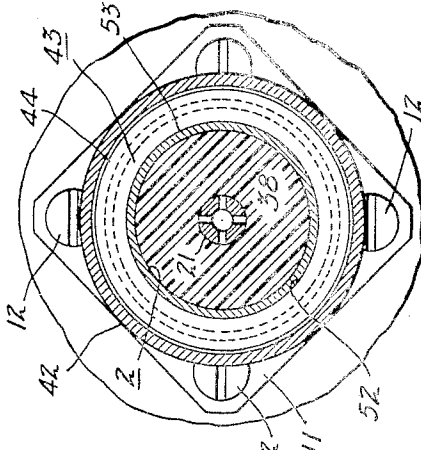


Fig. 2

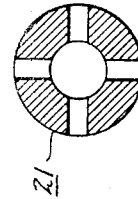


Fig. 6

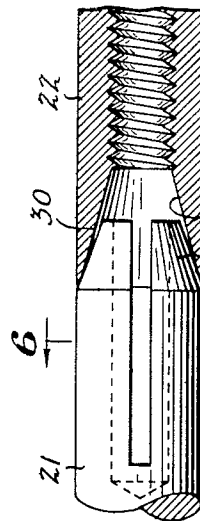


Fig. 5

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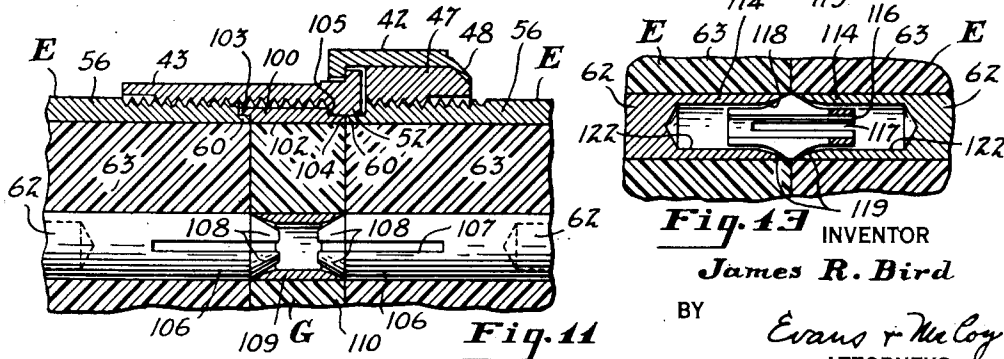
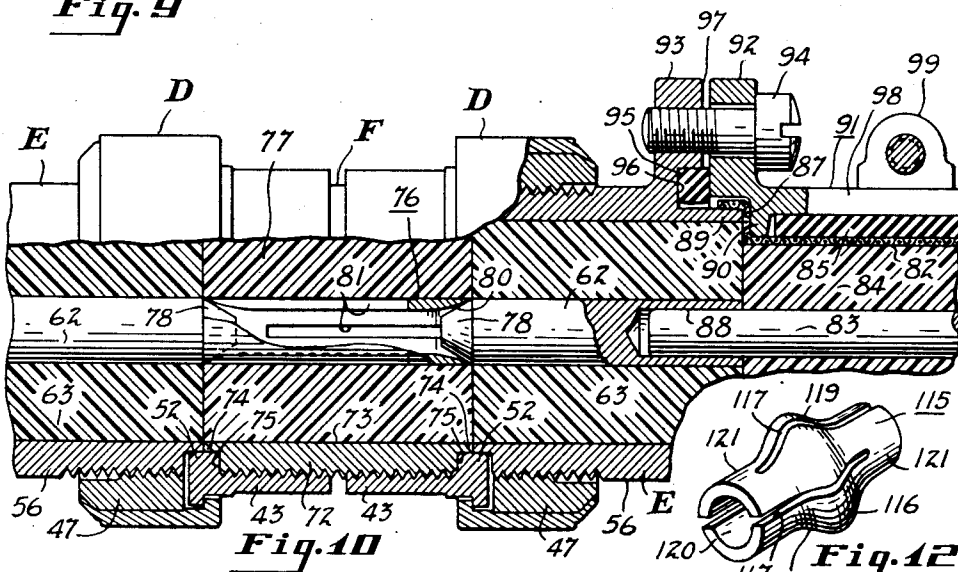
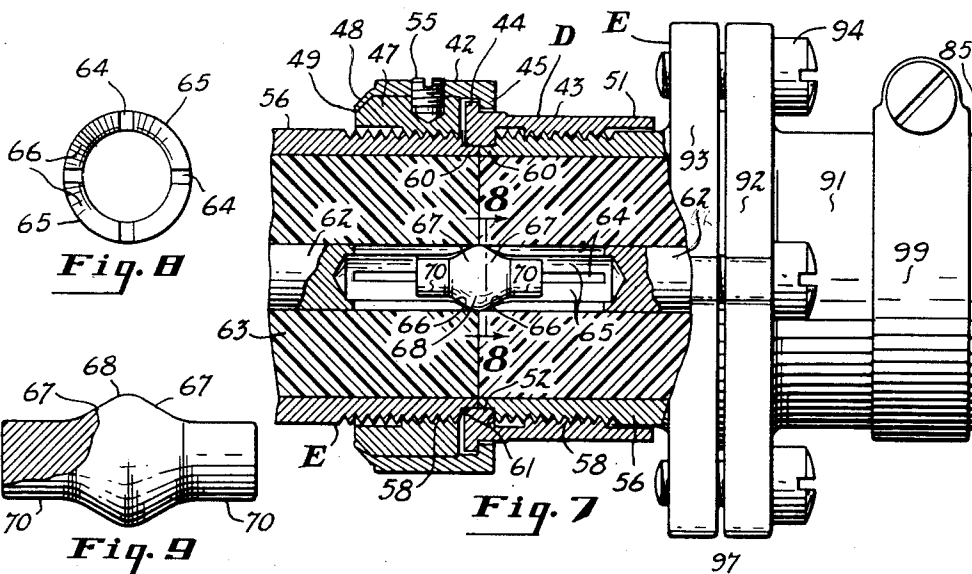
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COUPLING MEANS FOR COAXIAL ELECTRICAL LINES

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Application May 21, 1948, Serial No. 28,428

23 Claims. (Cl. 174—88)

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This invention relates to electrical line coupling devices and more particularly to means for coupling coaxial components or lines of high frequency electrical circuits. In high frequency electrical devices the various components or parts are frequently connected by coaxial cables or lines comprising outer tubular conductors and inner conductors insulated from and concentrically supported with respect to the outer conductors. Considerable difficulty has been experienced in making satisfactory electrical connections between the ends of coaxial lines or cables that are to be joined or coupled together and between the various electrical components and the connecting coaxial cables or lines therefor.

The development of the art has provided line coupling devices in which threaded plugs on tubular outer conductors or devices are received in threaded collars or sockets on the ends of other components or lines and the parts are thus secured together. Such arrangements are not entirely satisfactory since it frequently occurs that a coaxial line having a threaded plug end must be connected to another line or electrical component also having a threaded plug end.

The present invention has for one of its principal objects the provision of a coupling structure for coaxial lines which is of universal application, permitting the ends of lines to be connected to one another interchangeably and alternatively to the ends of different coaxial electrical components without regard to the matter of mating internal and external threads or the like.

Another difficulty encountered in the coupling of coaxial lines and components is axial misalignment of outer tubular conductors. Such misalignment, resulting in radial shoulders at the joints, is apt to give rise to objectionable reflections during the functioning of the circuit. The invention therefore contemplates as another of its objects the provision of coupling means which insures axial alignment of the adjacent ends of the outer conductors of coaxial lines at the coupling. As a preferential arrangement it is sought to provide pilot means for guiding the ends of tubular conductors of cable end fittings into predetermined coaxial alignment as they are drawn together into abutting relation in a coupling structure.

Another acute problem encountered in the construction of high frequency electrical devices is the connecting of coaxial components or lines having conductors of different diameters. To avoid reflections and other objectionable phe-

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nomena, certain diameter ratios are maintained between the inner and outer conductors of a coaxial line, the ratio varying with the dielectric constant of the insulating material separating the conductors. While it may appear that conductor diameters and dielectric material can change abruptly so long as basic theoretical ratios and relations are adhered to, superior results are obtained in high frequency coaxial circuits in which changes in conductor diameters are effected gradually. Therefore a further object of the invention is concerned with the provision of coupling means for connecting one coaxial line or cable to another such line or cable or to a coaxial electrical component having conductors of different diameters. More particularly, this aspect of the invention contemplates the provision of a tapered coaxial line coupling in which the transition from one diameter is effected gradually, preferably over tapered conductors that are several times longer than their maximum diameters.

A still further object is to provide a coaxial line coupling device which incorporates improvements in the means for electrically connecting the inner conductors. More specifically, this aspect of the invention seeks to provide inner conductor connecting means which effect electrical connections of the inner conductors at a substantially uniform or constant diameter across the connection. As a further refinement of this phase of the invention the inner connector provides for limited axial movement of the inner conductors toward and away from one another while maintaining the electrical connection therebetween. Such an arrangement permits the coupling together of coaxial lines or components with the outer conductors thereof in rigid or non-yielding abutment, slight irregularities and tolerances in length being compensated for by the longitudinal adjustment provided in the connector structure joining the ends of the inner conductors.

The above and other objects and advantages of the invention pertaining to details of construction and arrangements of parts which will become apparent as the following detailed description proceeds are embodied in coupling structures which are simple and inexpensive to manufacture and which incorporate a minimum number of parts. The description is made with reference to the accompanying drawings forming a part of the specification. Like parts throughout the several views are indicated by the same letters and numerals of reference.

In the drawings:

Figure 1 is a longitudinal sectional view, with parts broken away and removed, showing a coupling for connecting a high frequency coaxial component to a coaxial line of different or smaller diameter;

Fig. 2 is a transverse sectional view, with parts broken away and removed, taken substantially on the line indicated at 2—2 of Fig. 1;

Fig. 3 is a transverse sectional view with parts removed, taken substantially on the line indicated at 3—3 of Fig. 1;

Fig. 4 is an expanded fragmentary elevational detail, partly in section and with parts removed, showing the meeting ends of the inner conductors in separated relation and on an enlarged scale with respect to Fig. 1;

Fig. 5 is an elevational detail partly in section and similar to Fig. 4, showing the meeting ends of the inner conductors in assembled relation;

Fig. 6 is a transverse sectional detail taken substantially on the line indicated at 6—6 of Fig. 5;

Fig. 7 is an elevational view partly in longitudinal section and with parts broken away and removed showing the meeting ends of a universal coupling structure of the present invention, the conductors being of uniform diameter;

Fig. 8 is a detail showing an end view of one of the inner conductors of the preceding figure, this view being taken along the line indicated at 8—8 of Fig. 7 and enlarged with respect to that view;

Fig. 9 is an elevational view partly in section, showing the connector element or plug for the inner conductors of Fig. 7 on an enlarged scale with respect to that figure;

Fig. 10 is an elevational view partly in section and with parts broken away and removed, showing a universal coupling structure of modified form employing a splice insert;

Fig. 11 is a fragmentary sectional detail taken longitudinally through another universal coupling structure which employs a modified form of splice insert;

Fig. 12 is a perspective view of a plug type connector element for joining the ends of the central conductors of a coaxial line; and

Fig. 13 is a fragmentary sectional detail taken longitudinally through a coupling structure such as that of Fig. 7 showing a modification employing the connector plug of Fig. 12.

Coupling structures such as shown in Figs. 1 through 6 are useful in connecting high frequency coaxial components to lines or other components having different diameters. For example, it might connect the high frequency electrical device or resistor of my copending application for patent Serial No. 777,516, filed October 2, 1947, now Patent No. 2,556,642, issued June 12, 1951, to a coaxial line having an outer conductor of relatively small diameter. In the illustrated structure a transition device A is connected at its small diameter end to the connector B of a coaxial line and at its other or large diameter end to resistor device C which is the high frequency electrical device disclosed in the copending application referred to above.

The transition member or device A comprises an outer tubular conductor of metal such as brass, copper or bronze, of substantially circular cross section from end to end, and formed with cylindrical end portions 1 and 2 and a tapered or frustoconical central portion 3. The major portion of the length of the transition member is embodied in the tapered portion 3, the length of which is several times its maximum diameter,

being at least about twice as long as its maximum internal diameter and preferably about three or more times as long as its maximum internal diameter. The tapered portion 3 is also longer than either of the cylindrical portions 1 and 2 and may be integral with such portions or formed separately and joined thereto in coaxial relation as by telescopic joints, one of which is indicated at 4. Such joints are secured by brazing or soldering.

The coaxial line or cable (not shown in Fig. 1) is conventional and terminates in a conventional end connector which includes outer conductor 5 and inner conductor 6 separated by a tube 7 of suitable dielectric material. A knurled collar 8 is formed at one end with a radial flange received with a running fit in a circumferential groove in the outer conductor 5 of the cable end connector. The other end of the collar is internally threaded and received over the externally threaded small diameter end portion 1 of the transition member as indicated at 9.

The large diameter end portion 2 of the transition device A is externally threaded and connected by universal coupling assembly D to end connector or fitting E of a coaxial line or component. The connector E comprises a tubular outer conductor element 10 having at one end a square flange 11 secured by cap screws 12 to a matching flange 13 of a metal member 27 attached as by solder to the coaxial electrical component or structure C. The member 27 corresponds to the connector 27 described in the above referred to copending application and the metal cone or outer member 14 corresponds to the connector 14 disclosed in the same application.

The inner conductor 6 of the coaxial line connector B terminates in a reduced diameter portion which is received within a longitudinal split sleeve portion 15 of a contact element 20 on the small end of tapered inner conductor 17 of the transition device. The tapered inner conductor 17 has an integral cylindrical portion 18 at its small diameter end disposed coaxially within the cylindrical end portion 1 of the transition outer conductor. The contact element 20 is of the same diameter as the conductor portion 18 and is telescoped over and soldered to a reduced diameter end of the conductor portion 18.

Within the large diameter cylindrical portion 2 of the transition outer conductor the inner conductor 17 is formed with an integral cylindrical end 21 electrically connected to a cylindrical inner contact element 22 disposed coaxially in the tubular outer conductor element 10. The element 22 is received as by telescopic fit 24 and soldered on the small diameter end of tapered inner connector 23 of the electrical component C terminating the coaxial line.

The inner conductor 17 or at least the cylindrical end 21 thereof is formed of resilient spring-like conductive material such as beryllium-copper or bronze and the end 21 is axially drilled and longitudinally split along diametric intersecting planes, forming a plurality of parallel spring-like tines (Figs. 4-6). Conical or tapered surfaces 25 on the ends of the tines are slidably received within a tapered socket 26 on the end of the contact element 22. The tines on the end 21 of the inner conductor are initially sprung apart as shown in Fig. 4 so that, as the parts are drawn together in assembly, the tapered surfaces 25 on the ends of the tines contact and bear against the tapered surface 26 of the receiving socket and are radially compressed,

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thereby effecting positive electrical connection between the parts which, by reason of the resiliency of the tines, is maintained for slight axial shifting or movement of the conductors.

Preferably the slopes of the tapered surfaces 25 and 26 are such that in assembled relation (Fig. 5) the tips or small ends of the tines on the conductor portion 21 are separated from the surrounding socket walls 26 by an annular space 30. The angle of the conical socket 26 is less than the angle or slope of the conical or tapered tine ends 25. Electrical contact between the tines of the conductor end 21 and the element 22 is thus established and maintained substantially at thin, knife-like tip end 31 of the contact element. By this arrangement electrical connection between the component parts of the inner conductor is effected substantially at the maximum diameter of the conductor, thus obtaining improved transmission characteristics in high frequency electrical applications.

Supporting the inner conductor 17 within the tubular outer conductor of the transition member A is an insulating body 33 of solid dielectric material such as polyethylene or other thermoplastic composition. This insulating dielectric is continuous substantially from end to end of the transition device A including the cylindrical end portions 1 and 2. The insulating dielectric 33 has a coefficient of thermal expansion different from that of the bronze, copper, or brass, of which the conductors 3 and 17 are made and provision is made for differential expansion and contraction in the form of elongated axially extending slots 35 cut in the tapered portion 3 of the outer conductor. These slots permit radial expansion and contraction of the insulating dielectric 33 and minimize any tendency of the dielectric to shift or expand axially under temperature changes. Thus axial shifting of the inner conductor is eliminated.

Another insulating body 33 of solid dielectric material fills the annular space between the tubular conductor element 10 and the inner element 22 and supports the latter in coaxial relation to the former. The insulating dielectric 33 being subject to the heat of the oil filled electrical component or resistor device C is of heat resistant composition such as polytetrafluoroethylene and serves as a liquid sealing plug to retain the oil or other liquid dielectric within the resistor device. Since the dielectric plug 33 has a dielectric constant which differs from and is lower than that of the insulating body 33 in the transition device the internal diameter of the successive outer or tubular conductors may differ as shown. If, however, the same insulating material, or insulating materials having the same dielectric constants, are used for the tubular plugs or bodies 33 and 38 the internal diameters of the cylindrical end portion 2 of the transition device A and conductive surface 34 of the element 10 are made equal or substantially so, to satisfy the fundamental principles or formulas governing the design of coaxial electrical lines.

Circumferentially extending flanges 35 and 36 of relatively shallow radial depth are provided at the ends of the conductive surface 34 on the inside of the outer conductor 10 to engage the ends of the dielectric plug 33 so as to locate the latter and resist axial shifting thereof. The flange 35 is formed on one end of the conductor element 10, the dielectric plug 33 being initially inserted through the opposite end of the conductor element in assembly. The flange 35 is

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formed internally on the member 27 at the small diameter end of the tapered or conical surface 28 thereof. To prevent leakage of oil or other liquid dielectric from the chamber in the resistor device C, a resilient deformable O ring 40 is interposed between the flanges 11 and 13, a suitable annular groove being formed in the flange 11 to receive the O ring. The flange 11 is located inwardly from the end of the conductor element 10 providing an axial extension 41 on the latter which projects beyond the meeting plane of the flanges 11 and 13 and is received slidably within a mating socket formed in the connector member 27. Thus the conductor element 10 and the flanged member 27 are piloted together during assembly to provide positive concentricity and establish the desired electrical characteristics.

In a coaxial line structure involving a transition from cylindrical conductors to tapered or conical conductors, it has been found advantageous to arrange parts so that the plane of the circle of intersection between the cylindrical and conical outer conductors is offset axially with respect to the plane of the corresponding junction or circle of intersection of the inner conductors. An application of such an arrangement is illustrated in Fig. 1 in the transition between the cylindrical conductors of the connector B and the conical conductors of the coaxial component or device C. The inner conductive surface of the tubular element 10 and the inner conical face 28 of the member 27 intersect in a plane indicated at 29. This plane contains the end face of the solid dielectric or insulating plug 33 and is the meeting plane of the liquid and solid dielectrics.

The plane of intersection between the surface of the conical inner conductor 23 and the cylindrical conductive face of the conductor 22 is indicated at 32, coinciding with the shoulder against which is abutted the end of tubular portion 24 of the cylindrical conductor. The intersecting plane 32 of the inner conductors is offset axially with respect to the intersecting plane 29 of the outer conductors in the direction of the large ends of the conical conductors. The amount of such offset varies with the cone angle or taper of the conical conductors and with the diameters of the cylindrical conductors. It has been found that a satisfactory approximation is realized in laying out the design of the line by describing a circular arc 37 representing a spherical surface with center 57 thereof substantially at the apex of the cone defined by the elements of one of the tapered conductive surfaces and with the ends of the arc crossing the intersection between the cylindrical conductive surface 34 and the conical conductive surface 28. Thus the spherical surface of the arc 37 contains the circle of intersection between the tapered and cylindrical conductive surfaces. The offset between the plane 29 and the plane 32 is such that the spherical surface generated by a radius from the common center 57 contains the circles of intersection between the cylindrical and conical portions of both the inner and the outer conductive surfaces.

The center point 57, shown as the center of the cone of the outer tapered surface, also coincides with the apex of the cone defined by the surface elements of the inner conical conductor 23. Thus, in designing tapered transition devices for connecting coaxial lines or components of different diameters, the tapers or slopes of the inner

and outer conductive surfaces and also the axial offsets of the several planes of intersection between the conical and cylindrical surfaces are readily determined by employing this point intersection method.

For example, in laying out the transition device of Fig. 1 the relationship between the conical inner surface of the tapered portion 3 of the outer conductor and the conical surface of the inner conductor 17 is established by arranging these surfaces so that extensions of their elements intersect at a common point. Such point is the apex of the cone of the inner conductor and also the apex of the cone of the outer conductor. This point of intersection, or common apex, is the center from which are struck the arcs of the spherical surfaces which contain the circles of intersection between the tapered surface of the inner conductor 17 and its cylindrical ends 18 and 21. These arcs also intersect the outer conductor of the transition device at the intersections between the conical conductive surface of the tapered portion 3 and the conductive surfaces of the cylindrical end portions 1 and 2. In this connection it is to be noted that the single point intersection or common cone apex provides the center for the arc or spherical surface establishing the axial offsets, not only as between the tapered and cylindrical surfaces at the small diameter end of the transition device, but also as between the tapered and cylindrical surfaces at the relatively large diameter end of the device.

The universal coupling structure or assembly D which draws the transition device A and the resistor device C axially together into end to end abutting relation includes a pair of sleeves 42 and 43 which are interlocked against axial separation but are relatively rotatable for turning about a common axis. For example, the sleeve 43 may be formed at one end with a circumferentially extending outwardly directed radial flange 44 which is received behind and is overlapped by a circumferentially extending inwardly directed radial flange 45 on one end of the sleeve 42, the flanges and sleeves being sized to provide running fits.

The cylindrical end portion 2 of the transition member A and the abutting end portion, also cylindrical, of the conductor element 10 are formed with external threads that are identical and of the same diameter. The coupling sleeve 43 is formed with matching internal threads so as to be receivable on either the transition member A or the conductor element 10. An outer portion 51 of the sleeve is unthreaded and serves as a guide in screwing the sleeve onto the tubular member of the coaxial line or component being assembled therewith. In the arrangement illustrated the threaded connection of the coupling sleeve on the conductor 10 is indicated at 46. An internally threaded collar 47 is received as by a press fit within the coupling sleeve 42 and serves as a stop for engagement with the flanged end of the sleeve 43 to hold the coupling sleeves in assembled relation. A thin axial flange 48 formed on the end of the coupling sleeve 42 remote from the flange 45 is rolled or pressed radially inwardly against a tapered or conical end face 49 on the collar 47 to retain the latter on the sleeve. Suitable means such as soldering or brazing may also be used to supplement the press fit between the parts to resist relative movement of the coupling sleeve 42 on the collar 47.

The internal threads on the collar 47 are

identical to the threads formed on the interior of the coupling sleeve 43 and are received on the threaded end of the transition member A, the threaded connection between the parts being indicated at 50. An outer portion of the internal face of the collar 47 is without threads and serves to guide the parts into correct alignment during assembly. Thus while the coupling sleeve 43 is shown screwed on to the conductor element 10 and the threaded collar of the coupling sleeve 42 is shown threaded on to the transition member A the parts are so designed and constructed that they may be reversed with the sleeve 43 on the transition device and the sleeve 42 on the conductor element 10 of the resistor device terminal. Furthermore, the provision of the externally threaded end on the terminal element 10 permits the resistor device (or electrical component) C to be connected to conventional coaxial lines of the proper size having attaching collars corresponding to the collar 8 described in connection with the coaxial line B. The external threads on the cylindrical end portion 2 of the transition device enable the latter to be connected to coaxial devices, components, or lines other than the resistor shown, either directly or by using the universal coupling D of the present invention.

In the coupling of coaxial lines and devices it is vital to maintain concentricity and also to maintain positive electrical connection between the abutted outer or tubular conductors around substantially the entire circumferential extent of the latter. It is especially important that the electrical connection between the outer or tubular conductors be established at the inner diameter thereof so as to eliminate diameter changes along the length of the transmission line. Otherwise, objectionable wave reflections are apt to occur in the transmission of high frequency current and perfect transmission cannot be obtained. In the universal coupling structure of the present invention, accurate alignment of the abutted ends of the outer or tubular conductors is obtained by a circular pilot ring 52 carried by one of the coupling sleeves, the sleeve 43 in the embodiment illustrated. This pilot may take the form of an integral circumferentially extending inwardly directed radial flange of relatively short axial length which spans the gap between the ends of the outer conductors to serve as a guide as the inner conductors 21 and 22 are initially engaged and drawn together by the screw action of the coupling sleeves.

At the extreme ends of the externally threaded portions of the transition device and the conductor element 10 are thin shell-like cylindrical flanges 53 which are drawn into circumferential abutment with one another as the line structure is assembled. The shell flanges 53 have inner surfaces which extend as continuations of the respective conductive inner surfaces of the tubular conductors on which they are formed. By reason of the thin section of the shell flanges 53 they effect positive electrical contact under the contractive pressure applied to the joint by the coupling sleeves 42 and 43, the electrical contact being established around substantially the entire circumferential extent of the joint.

In assembling the universal coupling structure of the present invention the sleeve 43 is initially screwed onto one of the tubular outer conductors until the pilot flange or guide 52 is received on the shell flange 53 and is disposed against a shallow radial limiting shoulder 54 of the con-

ductor. Thereafter the end fitting of the other line or electrical component being connected is manually brought into registry and the collar 47 of the sleeve 42 is threaded onto the second tubular conductor. As the times of the cylindrical end 21 of one of the inner conductors are received within the tapered socket 26 of the other inner conductor, the shell flange 53 of the second outer conductor is received within the pilot flange 52 and is guided thereby into accurate alignment with and abutment against the shell flange 53 of the first outer conductor. To facilitate assembly the leading edge corners of the inside face of the pilot flange or guide 52 are beveled or relieved to provide the chamfers shown.

In Fig. 7 is illustrated an application of the principles of the present invention to a universal coupling structure for connecting the ends of coaxial lines or cables. The coupling sleeve assembly D is of substantially the same construction as that described in the preceding figures. A set screw 55 is shown as an alternate means for locking the threaded collar 47 against relative rotation or movement in the sleeve 42.

A pair of substantially identical rigid tubular outer conductors 56 (corresponding parts of coaxial component, line or cable connectors E to be connected) are formed on their ends with identical external threads 58 which receive alternatively the internally threaded collar 47 of the sleeve 42 and the internally threaded sleeve 43. At their extreme meeting ends the conductors 56 are formed with thin shell-like axially directed flanges 60 corresponding to the flanges 53 described in connection with Fig. 1. The inner cylindrical surfaces of the flanges 60 are the same diameter as and extend as continuations of the inside faces of the tubular conductors. The shell flanges are brought into abutment with one another under relatively high localized pressure and a relatively smooth substantially unbroken conductive surface is provided across the joint for the transmission of electrical current.

In assembling the ends of coaxial components, lines or cables the coupling sleeve 43 is first screwed onto the rigid outer tubular conductor of one of the cable end connectors E until the pilot flange or ring 52 of the coupling sleeve is abutted against circumferential shoulder 61 of such conductor. This shoulder corresponds to the shoulders 54 previously described and is present on both of the tubular outer conductors 56 so that the coupling sleeves 42 and 43 are reversible on the conductors. After the sleeve 43 is assembled on the outer conductor of one of the cable end connectors with the shell flange 60 of the latter embraced by the guide ring 52, the other cable end connector is brought into registry and the threaded collar 47 of the coupling sleeve 42 is screwed into position. This action draws the shell flanges into abutment, piloted by the guide ring or flange 52.

The inner conductors of the coaxial lines connected to the cable connectors E terminate in inner conductor elements 62 which are in the form of round or cylindrical metal rods or bars concentrically supported within the outer conductors by annular bodies of solid insulating or dielectric material 63. The meeting or confronting ends of the inner conductors 62 are axially drilled or bored to form tubular tips which are slit longitudinally at 64 (Fig. 8), forming a number of axially extending resilient tines 65. The extreme ends of the tines 65 are internally beveled providing inside tapered or conic faces 66. A plug type connector element 68 (Fig. 9)

is received between the ends of the inner conductor elements to effect an electrical connection therebetween. The outer or maximum diameter of the bulbous or biconic central portion of the connector 68 is substantially equal to that of the inner conductors 62 and the ends of the tines 65 are tapered out to thin wedge shaped or knife-like edges which ride up conical faces 67 of the central portion of the connector element during assembly of the coaxial lines, thereby effecting electrical connection between the parts substantially at the maximum diameter of the connector element. The conductor tines 65 are sprung inward slightly before assembly so as individually to bear strongly against the conical faces 67 of the connector element and effect a positive electrical connection therewith which is substantially continuous about the entire circumferential extent of the connector plug.

The connector plug or element, shown enlarged in Fig. 9, includes a central portion substantially biconical in shape, having a relatively long axis approximately coincident with the axes of the coaxial line end connectors being joined in the coupling structure. Substantially cylindrical extension portions 70 on the ends of the connector element are received within the bores in the ends of the inner conductors 62 and are surrounded by the tines thereof. Prior to assembly of the coaxial lines, one of the extensions 70 of the connector element 68 is inserted within the socket or bore of one of the central conductors and the resilient grip of the tines retains the connector element during assembly. As the coaxial lines are drawn together and the tines 65 ride up the conical or tapered faces 67 of the connector element the extensions 70 are released by the tines and the connector element is then centered and held solely by the frictional grip of the tip or thin wedge-like end edges of the resilient tines 65 which center the plug between the conductors and permit limited axial shifting of the conductors without breaking or interrupting the electrical connection. The diameter of the biconical connector plug is substantially equal to the diameter of the inner conductors 62 so that the plug acts as a limiting pilot in assembly to distend the sprung in tines 65 to the normal diameter of the conductors.

The several elements of the cable end connectors E of Fig. 7 terminate in a common plane which is the plane of abutment of the coupling structure. That is, the end face of each of the insulating dielectric bodies 63 is substantially flush with the end edge of the corresponding shell flange 60 and with the thin, knife-like edges of the inner conductor tines 65. Accordingly, a relatively rugged cable end structure or connector is provided which resists deformation and injury in use though repeatedly connected and disconnected in making various hook-ups of apparatus and electrical components using the device. In the coupling assembly the space between the inner and outer conductors is sealed off by the dielectrics 63 which are abutted against one another, excluding dust, dirt, and other foreign material, and by the meeting edges of the thin shell flanges 60 which are held together under relatively high unit pressure.

In Fig. 10 is illustrated a universal coupling structure in which the end connectors E of coaxial electrical lines are joined by a splice connector F, the latter being retained between the end connectors E by one of the coupling assemblies D. In this embodiment of the invention the threaded sleeves 43, without pilot extensions,

are threaded onto opposite ends of externally threaded metal tube 72 of the splice F. This tube has an internal cylindrical face 73 of the same diameter as the inner faces of the tubular conductors 56 of the end connectors and serves as an electrical connection between the latter. Reduced external diameter portions or circular shell flanges 74, formed on the ends of the tube 72, as by turning in a lathe, receive the cylindrical pilots 52 of the sleeves 43, the pilot flanges being drawn up snugly against radial shoulders 75 on the ends of the connector tube 72.

The threaded collars 47 of the coupling devices D are screwed onto the external threads of the outer tube conductors 56 of the connectors E. As the parts are drawn together by the threaded connections the pilot rings 52 of the sleeves 43 receive the shell flanges on the ends of the tubular conductors 56 and guide them into abutting engagement with the mating axial shell flanges 74 of the splice tube 72.

A tubular inner conductor 76, disposed in the center of the connector tube 72 in coaxial relation thereto, is of substantially the same axial length as the outer splice tube. This inner conductor is formed of resilient spring metal having good electrical conductivity, such, for example, as beryllium copper, and is supported by a surrounding body of insulating dielectric material 77 such as polyethylene or polytetrafluoroethylene, as used for the insulating dielectrics 63. During assembly the inner tube 76 receives in its ends tapered or conical ends 78 on the inner conductors 62 of the cable end connectors E.

To establish electrical connection between the conductor element 76 and the inner conductors at or adjacent their maximum diameter, the inner face of the connector 76 at its ends is tapered to form conic sockets, indicated at 80. The angle or slope of each of the internal faces 80 is less than that of the mating external conical faces 78 of the inner conductors so that electrical connection is made between the parts at the maximum diameter of the tubular connector 76. The chamfering at the ends of the tubular connector provides thin knife edges, the extreme tips of which make electrical contact with the inner conductors 79 around substantially the entire circumferential extent of the latter. A number of axial slits 81 are formed in circumferentially spaced relation about the tubular inner conductor 76 and open alternately through the opposite ends of the latter, providing for expansion and contraction of the connector during assembly and disassembly. The tubular connector 76 is initially slightly collapsed or sprung together so that the tapered socket ends make substantially circular line contact with the tapered cones 78 of the inner conductors 62 in the initial stages of assembly and ride up the conical contact surfaces as the threaded outer collars 47 draw the parts firmly together in the final stages of assembly. In the assembled coupling structure the diameter of the inner conductor remains substantially constant across the splice, there being no objectionable diameter changes in the electrical connections between the splice connector 76 and the inner conductors 62.

The construction of the end connectors E for attachment to coaxial cables is illustrated in Figs. 7 and 10. The outer tubular conductors 56 are similar in design to the conductor element 10 previously described in connection with Figs. 1 and 2, the internal flange 36 for retaining the dielectric plug being omitted. Conventional coaxial lines

or cables on which the end connectors E are assembled each comprise an outer conductive shield 82 formed of diagonally woven or braided conductive metal wires or tapes, an inner conductor 83 in the form of a copper rod or wire, a tubular insulating body 84 which may be of the same material as that used for the insulating dielectrics 63 and 77 of the couplings and connectors, and an outer protective tubular jacket 85 of tough abrasion resistant insulating material such as a suitable vinyl compound.

An end portion of the jacket 85 is stripped away and end 87 of the braided shield 82 is expanded to expose the insulation 84, which is cut away from the end of the inner conductor 83. The inner conductor 62 of the end connector E is withdrawn from its supporting dielectric 63 and telescoped over the exposed end of the inner conductor 83 of the coaxial cable. The conductor 62 is formed with an axial bore 88 that slidably receives the cable conductor and the parts are secured together as by solder. The conductor 62 is then inserted into the central bore in the supporting dielectric 63 and the latter is forced snugly against the insulating dielectric 84 of the cable. In this operation the expanded end 87 of the woven shield 82 is guided over axial extension 89 of the tubular conductor 56. The woven shield is clamped between the conductor extension 89 and a radial shoulder of a flange 90 formed on the inside of a collar 91 previously placed over the coaxial cable.

The collar is formed with a circumferentially extending square shaped radial flange 92 which matches a corresponding flange 93 on the tubular conductor 56. The flanges 92 and 93 may correspond in shape to the flanges 13 and 11 respectively, previously described in connection with the device illustrated in Figs. 1 and 2. Cap screws, one of which is indicated at 94, extend through apertures in the flanges 92 and are threaded into aligned openings in the flanges 93 to hold the parts together. A seal is provided by a rubber O ring 95 received in an annular channel 96 in the end face of the flange 93. Clearance 97 between the flanges 92 and 93 assures positive gripping of the woven or braided shield or outer conductor 82 of the coaxial cable between the tubular extension 89 of the end fitting conductor 56 and the shoulder of the flange 90 of the connector collar 91. The collar 91 is split longitudinally as indicated at 98 so as to be contracted by an embracing device of the hose clamp type indicated at 99. For holding the coaxial cable within the connector collar the latter may be of any desired length, the design shown in the drawings being relatively short. Longer collars may employ more than one of the clamps 99 thereby obtaining a stronger grip on the sheath 85 of the coaxial cable.

In Fig. 11 is illustrated a modified coupling of the universal type in which the tubular outer conductors 56 of the connectors E are held together by a coupling assembly D like that previously described, the internally threaded sleeve 43 being relatively long so as to accommodate a relatively short splice insert G between the pilot flange 52 of the sleeve and the shell flange 60 of the outer conductor 56.

The splice insert includes a metallic tubular shell 100 which has an internal cylindrical face 102 of approximately the same diameter as the internal faces of the outer conductors 56 of the cable connectors being joined. One end of the splice tube 100 is provided with locating means

in the form of a circular axially directed integral flange 103 which overlaps the shell flange 60 of one of the conductors 56, the flange 103 being shorter than the shell flange 60 of the conductor so that the end of the latter is forced snugly against the circular radial shoulder on the end of the shell 100 to effect a positive electrical connection between the parts which extends around substantially the entire circumferential extent of the conductor at the diameter of the inner faces.

The other end of the splice tube 100 is formed at its inner diameter with an axially directed circular flange 104 which corresponds to the shell flanges 60 of the tubular conductors 56. The flange 104 is received within the pilot flange 52 of the coupling sleeve 43, the pilot flange being drawn snugly against a circumferential shoulder 105 of the splice tube 100 so that the latter is retained firmly between the pilot flange and the end of the tubular conductor 56 onto which the coupling sleeve is threaded. The shell flange 104 of the splice tube is of less axial length than the pilot flange 52 of the threaded coupling sleeve so that the latter also receives and guides the shell flange 60 of the other connector tube 56, the latter being held in place by the threaded collar 47 of the coupling assembly.

The inner conductors 62 of the cable connectors of the embodiment of Fig. 11 are similar to those described in connection with Fig. 10, but have longitudinal slots 107 opening through their ends, forming tines 106 which correspond to the tines 21 of the inner conductors shown in Figs. 1 through 6. Tapered or conic tips 108 on the conductor tines 106 are received within the internally coned ends of a tubular metal splice element 109 coaxially supported within the splice tube 100 by means of an annular body of insulating dielectric 110 similar to the insulating body 71 described in connection with Fig. 10. As the inner conductors 62 are drawn together in assembling the coupling, the metal tines 106 of the tube 109, previously distended or sprung apart, are drawn together by the action of the tapered tips 108 sliding within the conical end sockets of the splice element or tube 109.

Each of the conductor tips 108 has a greater angle of taper than the receiving socket therefor in the tube 109 so that electrical contact is effected between the parts at the extreme tips or knife edges of the splice tube at the maximum diameter of the latter. The resiliency of the tines 106 maintains positive electrical connection between the parts for slight axial or longitudinal shifting of the inner conductors. A splice insert having a tubular inner conductor with longitudinal slots opening through one end only is employed to join cable connectors one of which has an inner conductor like that of Fig. 10 and the other of which has an inner conductor like that of Fig. 11.

Figs. 12 and 13 illustrate a compressible biconic plug 115 for electrically joining inner conductors 62 of cable end connectors similar to those of Fig. 7. In this modification the longitudinal slots 64 of Fig. 7 are omitted, the conductor ends having tubular or hollow ends 114 providing opposed sockets 122. The plug is in the form of a hollow metal tube having a bulbous or enlarged central portion 116 corresponding to the lozenge shaped central portion of the plug 70 previously described in connection with Fig. 7.

Longitudinally extending slots 117 are formed in the tubular plug and open alternately through

the opposite ends thereof so that the plug is adapted to be compressed radially as it is circumferentially squeezed by conical or tapered end portions 118 on the inside of the conductor tube ends 114. The enlarged central lozenge portion 116 of the connector plug has tapered or conical surfaces 119 which correspond to the tapered sides 67 of the plug 70. One method of forming the compressible plug 115 is to turn it to shape on a lathe from brass, bronze, or beryllium copper stock, after which axial bore 120 is drilled and the slots 117 are made by saw cuts from opposite ends.

One of the cylindrical portions 121 on the ends of the plug is forced into the end socket 122 of one of the inner terminal conductors 62 prior to assembly of the coaxial lines being joined. The diameter of each of the cylindrical end portions 121 of the plug is greater than the internal diameter of each of the sockets 122 so that the plug is received in the sockets with a snap or friction fit which holds the parts together until assembly is effected.

Reference is made to applicant's United States Patent 2,552,707, dated May 15, 1951, for High Frequency Coaxial Coupling Device, disclosing certain features of the present invention, the application for which was copending with the present case. Reference is also made to copending application for United States Patent Serial No. 214,523, filed March 8, 1951, for Connector for Electrical Transmission Lines, describing and claiming subject matter related to that of the present case.

In accordance with the patent statutes 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 embodiments shown in the drawings and described above are 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 co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and conductors having interfitting screw threads for retaining the sleeves on the conductors and for drawing the conductors together, said screw threads permitting facile removal of the sleeves from the conductors, a circular guide ring carried by one of the sleeves and projecting axially beyond the end of the conductor carrying said one sleeve, said guide ring being formed with a substantially cylindrical inwardly directed face of less diameter than the root diameter of the threads on the conductor carrying said one sleeve, and means on the other conductor providing a substantially cylindrical outwardly directed face of less diameter than the root diameter of the threads on such other conductor, said outward face being receivable telescopically within the guide ring to pilot the conductors into aligned relation as they are drawn together.

2. In a co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and con-

ductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, a circular guide ring carried by one of the sleeves as a part thereof and projecting axially beyond the end of the conductor carrying said one sleeve, said guide ring being formed with a substantially cylindrical inwardly directed face, and means on the ends of the conductors providing substantially cylindrical outwardly directed guide surfaces receivable telescopically within the cylindrical face of the guide ring, said guide surfaces and the inwardly directed face of the ring being of less diameter than the minimum diameter of all other parts of said one sleeve and the guide surfaces being slidable against the guide ring face to pilot the conductors into aligned relation as the latter are drawn together.

3. In a co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, a circular guide ring carried by one of the sleeves as a part thereof and projecting axially beyond the end of the conductor carrying said one sleeve, said guide ring being formed with a substantially cylindrical inwardly directed face, and an axially directed substantially cylindrical shell flange on the other conductor receivable telescopically within the guide ring and having an outwardly directed substantially circular face in sliding relation to the inward face on the guide ring, to pilot the conductors into aligned relation as the latter are drawn together, said shell flange face and said guide ring face being of less diameter than all other parts of the sleeves.

4. In a co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, a circular guide ring carried by one of the sleeves as a part thereof and projecting axially beyond the end of the conductor carrying said one sleeve, said guide ring being formed with a substantially cylindrical inwardly directed face, and axially directed substantially cylindrical relatively thin shell flanges on the ends of the conductors, said shell flanges having substantially cylindrical outwardly directed guide surfaces receivable telescopically within the guide ring, the shell flanges being circumferentially embraced by the guide ring and slidable relative to and axially of the guide ring face to pilot the conductors into aligned relation as the latter are drawn together.

5. In a co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the

conductors together, said formations permitting facile removal of the sleeves from the conductors, a circular guide ring carried by one of the sleeves as a part thereof and projecting axially beyond the end of the conductor carrying said one sleeve, said guide ring being formed with a substantially cylindrical inwardly directed face, and axially directed substantially cylindrical relatively thin shell flanges on the ends of the conductors, said shell flanges having substantially cylindrical outwardly directed guide surfaces receivable telescopically within the guide ring, the shell flanges being circumferentially embraced by the guide ring and slidable relative to and axially of the guide ring face to pilot the conductors into aligned relation as the latter are drawn together, the shell flange guide surfaces and the face of the guide ring being of less diameter than the minimum diameter of all other parts of the sleeves, and said shell flanges having confronting radially narrow and substantially circular end faces receivable abuttingly against one another upon said drawing together of the conductors.

6. In a co-axial line coupling structure or the like, tubular conductors disposable in end to end relation, sleeves embracing the conductors, means interlocking the sleeves and permitting relative rotation thereof, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, a splice tube disposed between the ends of the conductors in axially aligned abutting relation to the conductors and wholly within the axial limits of the sleeves, and pilot means having substantially cylindrical interfitting surfaces at the adjacent ends of the splice tube and the conductors for guiding the parts together during assembly and for holding the splice tube in predetermined co-axial relation to each of the conductors, said pilot means including a circumferentially extending radially inwardly directed flange on the inside of one of the sleeves, said flange being in engagement with the splice tube and also with one of the conductors and being disposed substantially in the plane of abutment of the splice tube and said one conductor.

7. In a line coupling structure, a pair of substantially rigid tubular conductors disposable in end to end relation, a pair of sleeves embracing the conductors, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, means interlocking the sleeves and permitting relative rotation thereof and of the conductors retained thereby, one of the conductors being formed with a circumferentially extending external radial shoulder spaced axially from the conductor end, and a radially inwardly directed circumferential flange on one of the sleeves, said flange projecting axially beyond the end of the conductor embraced by the sleeve having such flange and being engageable with said shoulder to locate the sleeve on the conductor, the ends of the drawn together conductors abutting one another in a plane spaced axially of the structure from the engaged shoulder and flange.

8. In a line coupling structure, a pair of substantially rigid tubular conductors disposable in end to end relation, sleeves embracing the conductors, the sleeves and conductors having in-

terfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, means interlocking the sleeves and permitting relative rotation thereof and of the conductors retained thereby, a radially disposed circumferential shoulder formed on and adjacent an end of one of the conductors, means on one of the sleeves projecting both axially beyond such end of the one conductor and radially inward and formed with a radial shoulder in confronting relation to the shoulder on the conductor, the sleeve shoulder being engageable against the conductor shoulder to locate the sleeve on the one conductor, and means on the other conductor receivable within the shouldered locating means and engageable against the end of the one conductor, whereby the locating means acts to engage the other conductor as the conductors are drawn together to pilot the conductors into axial alignment.

9. In a line coupling structure, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeves embracing the threaded portions of the conductors, means interlocking the sleeves and permitting relative rotation thereof in screwing the sleeves onto the conductor ends to draw the latter together into said relation, means on one of the sleeves and engageable with the extreme ends of both conductors simultaneously for piloting the conductors together in aligned axial relation, and one of the sleeves and one of the conductors being formed with radial shoulders engageable with one another for locating the shouldered parts in predetermined axial relation when they are screwed together, the shoulder on the conductor being spaced axially from the end of the latter whereby the drawn together conductors abut one another in a plane spaced axially of the structure from the engaged shoulders.

10. In a line coupling structure, a pair of substantially rigid tubular conductors disposable in end to end relation and having externally threaded end portions, internally threaded sleeves embracing the threaded portions of the conductors, means interlocking the sleeves and permitting relative rotation thereof in screwing the sleeves onto the conductor ends to draw the latter together into said relation, pilot means on one of the sleeves and projecting beyond the end of the conductor having such sleeve screwed thereon, said pilot means being formed to embrace the other conductor as the conductors are drawn together to guide the conductors into axial alignment, and one of the sleeves and one of the conductors being formed with radial shoulders engageable with one another for locating the shouldered parts in predetermined axial relation when they are screwed together, the shoulder on the conductor being spaced axially from the end of the latter whereby the drawn together conductors abut one another in a plane spaced axially of the structure from the engaged shoulders.

11. In a line coupling structure, a pair of substantially rigid tubular conductors of circular section disposable in end to end contacting relation, sleeves embracing the conductors, the sleeves and conductors having interfitting formations for retaining the sleeves on the conductors and for drawing the conductors together, said formations permitting facile removal of the sleeves from the conductors, means interlocking the sleeves and permitting relative rotation thereof and of the

conductors retained thereby, the conductors being formed with reduced diameter end portions providing conductor ends of relatively thin radial section and radially disposed circumferential shoulders on the conductors spaced axially from the ends thereof, and an internal radially directed circumferential flange on one of the sleeves receivable between the shoulders on the conductors and in embracing sliding contact relation to the reduced diameter thin section end portions of the conductors.

12. In a line coupling structure, a pair of tubular conductors one of which has on one end a circumferential axially directed shell of relatively thin section, the conductors being of circular section, the shell having an internal diameter substantially the same as and an external diameter less than the corresponding diameters of the respective conductors, a pair of sleeves interlocked against axial separation and rotatable one relative to the other, each sleeve embracing one of the conductors, interfitting means on the conductors and sleeves permitting facile removal of the sleeves from the conductors for drawing the conductors together axially and holding them in end to end relation with the conductor end shell abutting the end of the other conductor, and pilot means carried by one of the sleeves for guiding the conductors into axial alignment as they are drawn together, said pilot means being substantially circular and having an internal diameter less than the external diameter of either of the conductors and embracing the end shell to reinforce the latter.

13. In a line coupling structure, a pair of substantially identical tubular conductors having on their ends relatively thin circular shells extending the internal conductive surfaces of the conductors, the conductors being of circular section, the shells having an internal diameter substantially the same and an external diameter less than the corresponding diameter of the respective conductors, a pair of sleeves interlocked against axial separation and rotatable one relative to the other, each sleeve embracing one of the conductors, interfitting means on the conductors and sleeves permitting facile removal of the sleeves from the conductors for drawing the conductors together axially and holding them in end to end relation with the circular shells in edgewise abutment providing substantially continuous internal conductive surfaces of substantially constant diameter through the structure, and pilot means carried by one of the sleeves and embracing the end shells to reinforce the latter and to guide the conductors into axial alignment as they are drawn together, said pilot means being substantially circular and having an internal diameter less than the external diameter of the conductors.

14. In a coaxial line coupling structure having outer tubular conductors and means for drawing the conductors together axially and progressively and for holding the same in end to end axially fixed assembled relation, an inner conductor element coaxially disposed in each outer conductor, insulating means connecting the inner conductor elements to the respective outer conductors and constraining the inner conductor elements to axial movement with the outer conductors, the elements having axially aligned spaced confronting ends, and a connector element disposed between the ends of the inner conductor elements, the inner conductor elements and the connector element being of circular cross section and having substantially the same maximum diameter,

the ends of the conductor elements and the connector element being arranged in interfitting relation in the provision of plug and socket connections between the inner conductor elements and the connector element at each end of the latter, the inner plug end of each such connection having an external tapered surface and the outer socket end of each such connection making substantially circular line contact with the tapered surface of the inner plug interfitting therewith to establish electrical contacts between the elements, at least one of the elements having a resilient and radially yieldable end for expansion and contraction thereof in permitting slight axial movement of one element relative to another while maintaining the line contact electrical connections, and the outer surface of the connector element at said maximum diameter constituting the electrical conductive surface between the axially spaced ends of the inner conductors.

15. In combination in a coaxial line structure, a pair of rigid tubular conductors disposable in end to end axially fixed relation and having substantially smooth internal surfaces, coupling means for drawing the conductors into and holding the conductors in said relation, a pair of inner circular sectioned equal diameter conductor elements disposed within the tubular conductors and axially aligned with one another, the inner conductor elements having confronting axially spaced ends when the tubular conductors are so held, insulators of solid dielectric material substantially completely filling the annular spaces between the tubular conductors and the respective inner conductor elements and serving to support the latter in the tubular conductors, a connector element disposed between the inner conductor element ends, the ends of the conductor elements and the connector element being arranged in interfitting relation in the provision of plug and socket connections between the inner conductor elements and the connector element at each end of the latter, the inner plug end of each such connection having an external tapered surface and the outer socket end of each such connection making substantially circular line contact with the tapered surface of the inner plug interfitting therewith to establish electrical contacts between the elements, at least one of the elements having a resilient and radially yieldable end for expansion and contraction thereof in permitting slight axial movement of one element relative to another while maintaining the line contact electrical connection, and the outer surface of the connector element including a portion of substantially the same diameter as the inner conductor elements and constituting the electrical conducting surface between the inner conductor elements, the solid insulator supporting each inner conductor extending axially along such supported conductor substantially to the plane of the circular line contact between such conductor and the connector element.

16. In a coaxial line coupling structure having outer tubular conductors and means for drawing the conductors together axially and holding the same in end to end axially fixed assembled relation, inner conductor elements coaxially disposed one in each outer conductor, and a connector element disposed between the ends of the inner conductor elements, the ends of the elements being formed with connections which include tapered surfaces in the provision of interfitting self-centering portions in the connections between the connector element and the inner con-

ductor elements, the inner conductor elements and the connector element all being of circular cross section and having substantially the same maximum diameter, and the connections including another interfitting connection portion between the connector element and at least one of the inner conductor elements for holding the connector element in assembled relation to the one inner conductor element during assembly and disassembly of the coupling structure, said other connection portion comprising a plug and socket combination in which an axially extending plug on one element is received in and frictionally restrained against withdrawal from a socket in another of the elements.

17. In combination in a coaxial line structure, a pair of rigid tubular conductors disposable in end to end axially fixed relation and having substantially smooth internal surfaces and threaded external surface portions adjacent their ends, means providing a radially disposed circumferential shoulder on at least one of the conductors, a pair of inner conductor elements disposed within the tubular conductors and axially aligned with one another, the inner elements having ends in spaced confronting relation, a conductive element disposed between the confronting ends of the inner conductor elements, the ends of the conductor elements and the connector element being arranged in interfitting relation in the provision of plug and socket connections between the inner conductor elements and the connector element at each end of the latter, the inner plug end of each such connection having an external tapered surface and the outer socket end of each such connection making substantially circular line contact with the tapered surface of the inner plug interfitting therewith to establish electrical contacts between the elements, at least one of the elements having a resilient and radially yieldable end for expansion and contraction thereof in permitting slight axial movement of one element relative to another while maintaining the line contact electrical connection, a first internally threaded sleeve embracing the threaded portion of one of the tubular conductors, a second internally threaded sleeve embracing the threaded portion of the other tubular conductor, radial flange means on one of the sleeves engageable with the radial shoulder on said one conductor in axial bearing relation to locate the one sleeve in screwing the same onto the one conductor, and means interlocking the internally threaded sleeves to permit relative rotation thereof in screwing the sleeves on the respective tubular conductors to draw the latter together axially and to hold the conductors assembled in said axially fixed relation.

18. In combination in a coaxial line structure, a pair of substantially rigid tubular conductors disposable in end to end axially fixed relation and having substantially smooth internal surfaces, a pair of central conductor elements disposed coaxially within the tubular conductors and aligned with one another, the confronting ends of the central conductor elements being axially spaced from one another and formed with substantially identical tapered surface portions, a conductive element disposed between the central conductor element ends and having substantially identical tapered surface portions on its ends for interfitting with the central conductor element tapered end portions for permissive reversal of the conductive element in assembly,

the angle of the tapered portions on the conductor element ends differing from the angle of the tapered portions on the conductive element ends to provide substantially circular line contacts between the conductor elements and the conductive element, one of the elements being radially yieldable to permit expansion and contraction thereof upon relative axial movement of the yieldable element and another of the elements contacting such yieldable element to maintain said line contact therebetween in the form of a flexible connection, the line contact moving along the tapered surface of the inner of the interfitted elements during said relative axial movement, and means engageable with external portions of the tubular conductors for drawing the latter together and holding them assembled in said axially fixed relation, whereby axial shifting of one of the central conductor elements relative to the axially fixed tubular conductors is accommodated in the flexible connection.

19. In combination in a co-axial line structure, a pair of substantially rigid tubular outer conductors disposable in end to end axially fixed relation and having substantially smooth internal surfaces, a pair of inner conductor elements disposed co-axially within the tubular conductors and aligned with one another, solid dielectric material substantially completely filling the annular spaces between the tubular outer conductors and the respective inner conductor elements and serving to support the latter in the tubular conductors, the confronting ends of the inner conductor elements being axially spaced from one another and formed with substantially identical tapered surface portions, a conductive element disposed between the inner conductor element ends and having substantially identical tapered surface portions on its ends for interfitting with the conductor element tapered end portions for permissive reversal of the conductive element in assembly, the angle of the tapered portions on the conductor element ends differing from the angle of the tapered portions on the conductive element ends to provide substantially line contact between the conductor elements and the conductive element, the solid dielectric material supporting each inner conductor extending axially along such supported conductor substantially to the plane of the circular line contact between such conductor and the connector element, one of the elements being radially yieldable to permit expansion and contraction thereof upon relative axial movement of the yieldable element and another of the elements contacting such yieldable element to maintain said line contact therebetween in the form of a flexible connection, the line contact moving along the tapered surface of the inner of the interfitted elements during said relative axial movement, and means engageable with external portions of the tubular conductors for drawing the latter together and holding them assembled in said axially fixed relation, whereby axial shifting of one of the conductor elements relative to the axially fixed tubular conductors is accommodated in the flexible connection.

20. In combination in a co-axial electrical line structure, tubular outer conductors in end to end axially fixed relation, center conductor elements disposed in end to end relation, means supporting the center conductor elements within the tubular outer conductors in co-axial relation, the ends of the center conductor elements being of tubular form, opening toward one another and

having confronting substantially circular substantially knife edges, and a connector element between the ends of the center conductor elements, said connector having tapered end portions located within the tubular ends of the conductor elements in interfitted relation, each knife edge making substantially circular line contact with the connector element on one of the tapered end portions, one of the elements being radially yieldable to permit expansion and contraction thereof upon relative axial movement of the yieldable element and another of the elements contacting such yieldable element to maintain said line contact therebetween in the form of a flexible connection, the line contact moving along the tapered surface of the inner of the interfitted elements during said relative axial movement whereby axial shifting of one of the conductor elements relative to the axially fixed tubular conductors is accommodated in the flexible connection.

21. In combination in a co-axial electrical line structure, tubular outer conductors in end to end axially fixed relation, center conductor elements disposed in end to end relation, means supporting the center conductor elements within the tubular outer conductors in co-axial relation, the ends of the center conductor elements being in the form of resilient tubes having axial slots opening through the tube ends in the provision of radially yieldable fingers, said tubes having confronting substantially circular substantially knife edges comprising the ends of said fingers, and a connector element between the ends of the center conductor elements, said connector having tapered end portions located within the tubular ends of the conductor elements, the finger ends comprising each knife edge making substantially circular line contact with the connector element on one of the tapered end portions, the resilient tubes being adapted to expand and contract as the center conductor elements are moved axially toward and away from one another in assembly and adjustment in the provision of a flexible connection maintaining said circular line contacts at the knife edges, whereby axial shifting of one of the conductor elements relative to the axially fixed tubular conductors is accommodated in the flexible connection.

22. In a line coupling structure, a pair of substantially rigid tubular conductors, sleeves embracing the conductors, the sleeves and conductors having interfitted formations for drawing the conductors into the sleeves upon relative rotation, a splice tube disposed between the ends of the conductors wholly within the axial limits of the sleeves, pilot means having a cylindrical surfaces at and embracing the splice tube ends and the ends of the conductors for guiding the parts together during assembly and for holding the splice tube in predetermined co-axial relation to each of the conductors, means resisting axial separation of the sleeves, said drawing of the conductors into the sleeves acting to compress the splice tube axially between the ends of the conductors, inner conductors extending axially through the outer conductors, bodies of solid insulating material embracing the inner conductors and supporting the same in their respective outer conductors, a conductive connector element extending between the inner conductors, and another body of solid insulating material embracing the connector element and supporting the latter within the splice tube.

23. In a co-axial line coupling structure an end fitting for a line cable having an inside conductor surrounded by and insulated from a braided tubular conductor, the end fitting comprising an inner conductor for connection to one end of the inside conductor of the cable, an outer rigid conductor of tubular form and circular cross section internally, an insulating body separating the fitting conductors and supporting the inner one co-axially within the outer conductor, one end of the outer conductor of the fitting being formed to receive coupling means in assembling the end fitting in the coupling structure, the other end of the outer conductor of the fitting being formed with an internal cylindrical chamber and a radially disposed circular shoulder, a clamping sleeve having one end for receiving and embracing the cable and another end receivable telescopically over said other end of the outer conductor, the sleeve having a substantially radially disposed circular shoulder in confronting relation to the radial shoulder of the outer conductor for clamping therebetween a flared end portion of a braided tubular conductor of a line cable received in the sleeve, the insulating body having a radial end face disposed substantially in the plane of the radial shoulder on the outer conductor of the fitting for abutment by the insulation of a received cable in the provision of an insulation transition substantially in the clamping plane of the shoulders, the sleeve having a circular opening at the sleeve shoulder of less

diameter than the cylindrical chamber and shoulder of the conductor so that the sleeve shoulder projects radially inwardly from the cylindrical walls of the chamber in said other end of the outer conductor in the provision of a diameter increase in the plane of the transition.

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