Dec. 27, 1966 K. KRAUS 3,295,076

ELECTRICAL CONNECTOR MEANS FOR COAXIAL CABLES AND THE LIKE

Filed Aug. 17, 1964

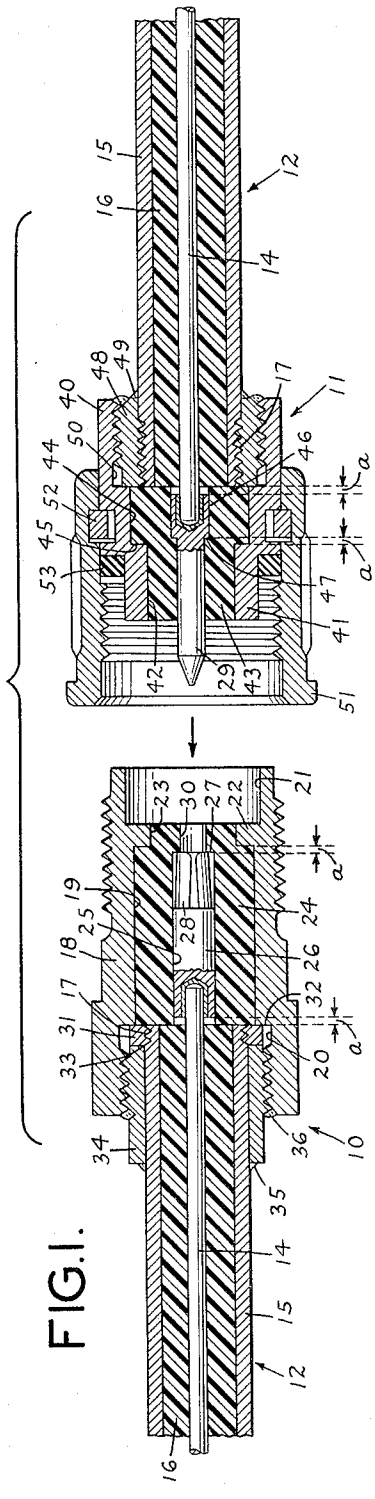


FIG. 1.

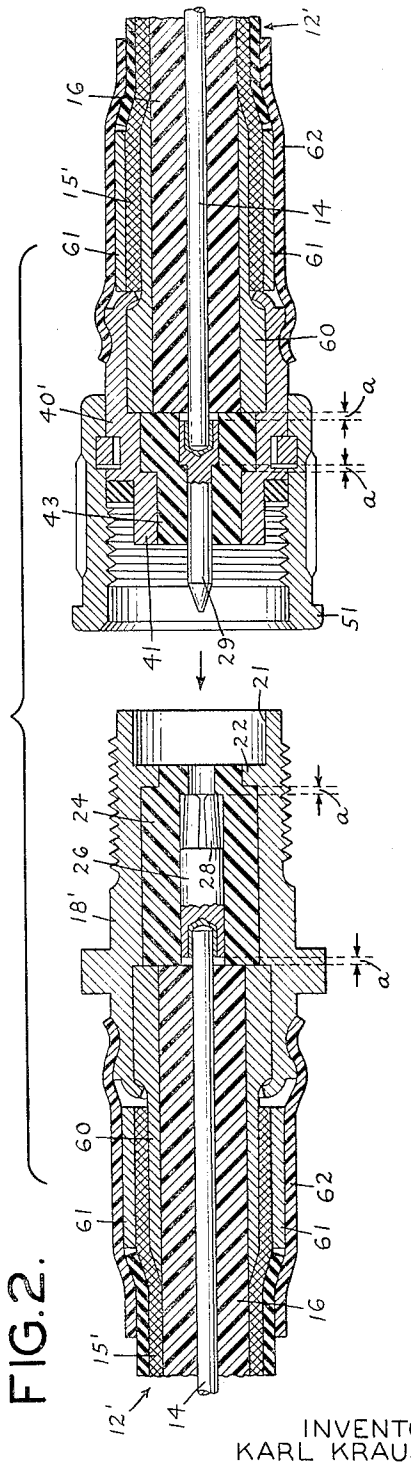


FIG. 2.

INVENTOR
KARL KRAUS
BY
Bauer and Seymour
ATTORNEYS

United States Patent Office

3,295,076

Patented Dec. 27, 1966

3,295,076

ELECTRICAL CONNECTOR MEANS FOR COAXIAL CABLES AND THE LIKE

Karl Kraus, Sidney, N.Y., assignor to The Bendix Corporation, Sidney, N.Y., a corporation of Delaware

Filed Aug. 17, 1964, Ser. No. 389,965
10 Claims. (Cl. 333—97)

This invention relates to electrical apparatus and more particularly to separable connections for cables in electrical transmission lines.

An object of the present invention is to provide novel mating jacks and plugs for connecting coaxial cables.

It is also an object of the invention to provide novel means for electrically and mechanically connecting both rigid and flexible types of cables and particularly coaxial cables which may be of small diameter.

Another object of the invention is to provide novel electrical connector means for detachably connecting the ends of the cables of a coaxial transmission line without appreciably disturbing the characteristic impedance of the line across the connection.

A further object is to provide novelly constructed coupling means for coaxial cables wherein the so-called discontinuities resulting from variations in conductor diameters are compensated for and thus minimized.

In coaxial cable transmission lines including known types of separable connections, conductor discontinuities at the connector interposed between the ends of the cables create electrical disturbances which result in an undesirable increase in the VSWR (voltage standing wave ratio) of the line. These disturbances interfere with the electrical signals transmitted by the line and prevent the efficient and accurate transmission of such signals, particularly in the higher frequency ranges.

It is accordingly another object of the invention to provide a readily separable connection between the cables of a coaxial transmission line wherein the VSWR closely approaches ideal value.

Still another object is to provide novel connector means for connecting the cables of coaxial transmission lines wherein conductor-step type discontinuities are compensated for in a simple manner to maintain the characteristic impedance of the line and to minimize or eliminate undesirable electrical disturbances resulting from such discontinuities.

A still further object is to provide novelly constructed coaxial electrical connectors which are satisfactory for use in the transmission of electrical energy having a wide or broad range of frequencies, including radio and microwave frequencies.

The invention contemplates a simplified combination of parts of simplified construction which may be mass produced and assembled with facility at low cost to have an exceptionally low VSWR that may be maintained within a narrow range in mass production.

The above and further objects and novel features of the invention will more fully appear from the following detail description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is an exploded longitudinal or axial sectional view illustrating one form of separable connector means for a semi-rigid coaxial transmission line with the mateable female and male parts in uncoupled relation; and

FIG. 2 is a similar cross sectional view illustrating a modified form of connector means for flexible coaxial cables.

The invention is illustrated in FIG. 1, by way of example, in the form of a cable-to-cable connection comprising a jack 10 and a plug 11, each securely connected in a novel manner to the end of a rigid or semi-rigid coaxial cable 12. Each of the latter has an inner or center cylindrical conductor 14 separated from an outer tubular conductor 15 by suitable electrical insulation 16. The outer conductor may, for example, consist of an impervious cylindrical copper tube which is bendable but relatively rigid and preferably capable of having shallow threads 17 cut in the outer surface thereof.

The jack 10 and plug 11 are novelly constructed and assembled from a minimum number of simplified parts and may be readily and permanently assembled with and connected to the ends of coaxial cables 12. The jack 10 as illustrated comprises a tubular metallic shell 18 having a central bore portion 19 of uniform diameter, a somewhat enlarged counterbore 20 at one end with internal threads and an enlarged counterbore 21 at the other end separated from central bore 19 by an internal flange 22. Slidably received within and filling the central bore 19 and the reduced bore 23 within flage 22 is a tubular electrical insulator 24. The latter has a stepped bore therethrough, the enlarged portion 25 of which accommodates a cylindrical socket contact 26 positioned axially by the internal shoulder 27. The end of contact 26 adjacent said shoulder may have circumferentially arranged spring fingers 28 arranged to form a socket for receiving a pin contact 29, hereinafter described, through the reduced bore portion 30 of insulator 24. The other end of socket contact 26 is preferably recessed to receive an exposed end of center conductor 14 of cable 12. The contact and said conductor are preferably soldered togther, but the same may be crimped or otherwise suitably connected. The relationship of the diameters of socket contact 26 and pin contact 29 to the inner diameters of bores 19 and 23, respectively, is so calculated in a manner understood in the art of coaxial transmission lines that the characteristic impedance of these sections of the coaxial line will be the same as the characteristic impedance of the cables 12.

The end of the outer tubular conductor 15 of cable 12 is mechanically and electrically connected to shell 18 in a novel manner to provide a moisture-tight sealed connection and to facilitate assembly as well as compensation for the electrical disturbances which would result from the step in the center conductor necessitated by the difference in the diameters of wire 14 and contact 26 and the corresponding step in the surface of the outer conductor 15, 18. As shown, the end portion of outer cable conductor 15 is threaded to receive an internally threaded ring flange 31. The transverse end surfaces of the latter and conductor 15 are flush and abut the flush transverse end surfaces of insulator 24 and annular shoulder 32 in shell 18. Ring 31 is preferably annularly soldered at 33 to tube 15. An externally threaded sleeve nut 34 surrounds tube 15 in abutment with ring 31 and engages the internal threads in bore 20 of shell 24. If it is desired to provide greater assurance of moisture tightness, annular seals 35 and 36 may be effected at the outer ends of sleeve 34 and shell 18 by suitable means, such as an epoxy resin.

The plug 11 shown at the right in FIG. 1 for mating with the above-described jack 10 comprises a metallic shell 40 having a stepped internal bore. A reduced end portion 41 of the shell has a sliding telescopic fit within bore 21 of shell 18 to engage and make electrical contact with flange 22. The bore of end portion 41 has the same diameter as the bore 23 through flange 22, in order to maintain the characteristic impedance of the line.

A tubular insulator 43 having stepped inner and outer

diameters surrounds and supports contact pin 29 and has a sliding fit in the bore 42 and the enlarged central bore portion 44 of shell 40, said insulator being axially positioned by a shoulder 45. Contact pin 29 has an enlarged portion 46 within bore 44, the diameters thereof being calculated to maintain the characteristic impedance of the line. The enlarged portion of the pin contact is recessed to receive the bared and tapered end of center conductor 14 of cable 12. Contact 29 is axially positioned by shoulder 47 in insulator 43 and may be soldered or otherwise suitably secured to the end of conductor 14.

The connection between cable 12 and shell 40 may be effected in the same manner as described above for cable 12 and shell 18. As shown, however, a single internally and externally threaded sleeve 48 is substituted for the parts 31 and 34. Sleeve 48 is threaded onto conductor 15 and terminates flush with the inner end thereof. The parts 15 and 33 may also be solder connected at 49 if desired.

The external threads on sleeve 48 cooperate with threads in an enlarged bore portion 50 in shell 40. The shell is screwed onto sleeve of ferrule 48 until the latter firmly and electrically engages the shoulder at the inner end of bore 50. The bared end of conductor 14 is received in and soldered or otherwise suitably secured to the enlarged portion 46 of pin contact 29.

When plug 11 is telescoped with jack 10 to bring pin 29 and shell 40 into electrical engagement with socket 26 and shell 18, respectively, the same may be detachably secured together in any suitable manner known to the art. As shown, a nut 51 is rotatably mounted on shell 40 by a split ring 52 engaging opposed grooves in the nut and shell and is adapted for threaded engagement with shell 18. A sealing gasket 53 of yieldable material may be provided between shells 18 and 40 if desired.

Except where compensation is introduced in a manner to be next described, each axial section or length of line from cable to cable has inner and outer conductors with outer and inner diameters, respectively, which are so calculated and related as to provide a constant or uniform characteristic impedance which matches that of the cables 12. Due to the necessity of varying these conductor diameters at the points of connection between the cables and the separable connector parts, so-called step or conductor discontinuities are introduced which unless compensated, will cause interference with and undesirable disturbances in the electrical signals transmitted by the line. An important advantage of the novel construction contemplated by this invention resides in the fact that suitable compensation may be readily incorporated in the composite transmission line by introducing short longitudinal or axial sections *a* of the line between the transverse planes of adjacent steps in the inner and outer conductors, which short sections have a characteristic impedance that exceeds the desired line characteristic impedance. These short sections *a* of higher impedance function as series inductances which effectively compensate for the capacitative effects of the line conductor discontinuities which create the disturbances. The appropriate axial length of each section *a* for any given transmission line will be dependent upon a variety of parameters, including the composition of the insulation, and may be determined by formula and testing in a manner well understood in the art.

In the embodiment illustrated in FIG. 2, the jack and plug assemblies are substantially the same as those in the embodiment of FIG. 1, except that the shells 18' and 40' are modified to adapt the same for connection to flexible coaxial cables 12'. The latter are the same as cables 12, except that the outer tubular conductor 15' is made of braided wire to permit maximum flexibility. The connection between a cable 12' and each shell 18' and 40' comprises a retainer sleeve 60 closely surrounding insulation 16 and having an end portion of reduced outer diameter wedged between said insulation and the braided conductor 15'. The other enlarged end of sleeve 60 is telescopically received by shell 18' (or 40') and secured therein by spinning the end of the shell inwardly against the external shoulder on the sleeve or by other suitable means, such as soldering. A firm and good mechanical and electrical connection between the telescoping portions of sleeve 60 and braided conductor 15' may be effected by crimping or shrink fitting a metal sleeve 61 around the same. If desired, a heat shrinkable plastic tube 62 of irradiated polyethylene or the like may be applied around the joint.

Although only a limited number of embodiments of the invention are herein illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. For example, it will be apparent that the plug portion of the embodiment of FIG. 2 may be coupled with the jack or socket contact portion of FIG. 1. Likewise, the plug or pin contact portion of FIG. 1 may be coupled to the jack or socket contact portion of FIG. 2. Various changes may also be made, particularly in the detail design and arrangement of the parts illustrated, without departing from the spirit and scope of the invention, as will now be apparent to those skilled in the art.

What is claimed is:

1. The combination comprising a coaxial electrical cable having its inner conductor exposed beyond the end of its outer conductor and the end of the cable insulation between said conductors, a tubular metallic shell having a stepped bore comprising a large diameter bore portion at the rear end thereof and intermediate and small diameter bore portions intermediate the ends thereof adjoining each other and said large diameter bore portion, a tubular insulator slidable into, having an axial length equal to the combined lengths of and accurately filling said intermediate and small bore portions, said insulator having a stepped bore forming an internal shoulder therein, the larger and smaller diameter portions of the bore in said insulator being principally within the intermediate and small bore portions of the shell, respectively, a contact slidably mounted in the bore of said insulator and being axially positioned therein by said shoulder, said contact having a recess in the end thereof to receive the exposed end of said inner conductor and being secured thereto, tubular metallic means comprising a sleeve secured on the end portion of said cable, said sleeve terminating flush with the end of the cable insulation and having a portion telescopically received in said large bore portion of the shell, and means for securing said sleeve within said large bore portion of the shell in end abutment with the shoulder at the inner end of said large bore portion and with said cable insulation in end abutment with said insulator.

2. The combination defined in claim 1, wherein the recessed end of the contact terminates in said intermediate diameter bore portion in a transverse plane spaced axially a short predetermined distance from the transverse plane of said shoulder at the inner end of said large diameter bore portion, said distance being calculated to compensate for electrical disturbances which would result from the steps in the inner and outer conductors of the coaxial line at said planes.

3. In a separable connection for coaxial electrical cables, the combination of a tubular metallic shell constituting an outer conductor and having a stepped bore including adjoining large, intermediate and small diameter bore portions, a tubular insulator accurately filling and having the same axial length as said intermediate and small bore portions and having a stepped bore therethrough forming an internal shoulder therein, a contact member constituting an inner conductor slidably received in the bore of said insulator and positioned axially therein by said shoulder, a coaxial cable having its inner conductor or exposed beyond the end of its outer conductor and the end of the cable insulation between the inner and outer cable conductors, means for electrically and me-

chanically securing said contact to the exposed end of said inner cable conductor, and means for securing the end of said cable in said large bore portion at the rear end of the shell in end-to-end abutment with said insulator, said last-named means comprising tubular fitting means secured on the end of the cable and extending into said large bore portion into end abutment with an annular shoulder at the inner end of said large bore portion and means for securing said fitting means in said shell.

4. A separable connection as defined in claim **3**, wherein the contact is a socket contact having the forward pin receiving end thereof abutting said shoulder in the insulator.

5. A separable connection as defined in claim **3**, wherein the contact is a stepped pin contact having a portion slidably fitting the larger portion of the stepped bore in said insulator and abutting said internal shoulder and a reduced portion slidably projecting through the smaller portion of the stepped bore of the insulator.

6. A separable connection as defined in claim **3**, wherein the steps at the forward ends of said intermediate and large bore portions of the shell and insulator, respectively, are in parallel transverse planes spaced a short predetermined distance apart, said distance being calculated to compensate for electrical disturbances which would result from the steps in the inner and outer conductors of the coaxial line at said planes.

7. A separable connection as defined in claim **3**, wherein the fitting means comprises a metallic sleeve secured around the end of the cable outer conductor and having external threads cooperating with internal threads in said large diameter bore.

8. A separable connection as defined in claim **3**, wherein said fitting means comprises a metallic ring threaded onto the end of said cable outer conductor and a sleeve surrounding said cable outer conductor in end abutment with said ring and having external threads cooperating with internal threads in said large bore portion of the shell.

9. The combination comprising a coaxial electrical cable having the inner and outer conductors separated by insulation, the inner conductor being exposed beyond the end of the outer conductor and the end of insulation, a tubular metallic shell having a stepped bore, a tubular insulator slidable into said shell from the rear and positioned by a rearwardly facing first shoulder in the shell, a contact slidable into the bore of said insulator and against a rearwardly facing shoulder in said insulator, tubular metallic means comprising a sleeve mounted on the end portion of the cable and means for securing the end of said sleeve within the rear end of said shell with said sleeve in end abutment with a rearwardly facing second shoulder in said shell and with said cable insulation in end-to-end abutment with said insulator.

10. The combination defined in claim **9**, wherein the shoulder in the insulator and the first shoulder in the shell are in transverse planes spaced axially a predetermined distance calculated to compensate for electrical disturbances which would result from the steps in the inner and outer conductors of the combination at said planes.

References Cited by the Examiner

UNITED STATES PATENTS

2,540,012	1/1951	Salati	333—97
2,870,420	1/1959	Malek	333—97
2,981,920	4/1961	Jackson	339—177
3,022,482	2/1962	Waterfield et al.	333—97
3,054,981	9/1962	Malek et al.	333—97

OTHER REFERENCES

AMP Incorporated, publication 429–5M–C–58, copyright 1958.

HERMAN KARL SAALBACH, *Primary Examiner.*

L. ALLAHUT, *Assistant Examiner.*