Jan. 20, 1959 | J. V. MALEK | 2,870,420

ELECTRICAL CONNECTOR FOR COAXIAL CABLE

Filed April 5, 1955

FIG. 1

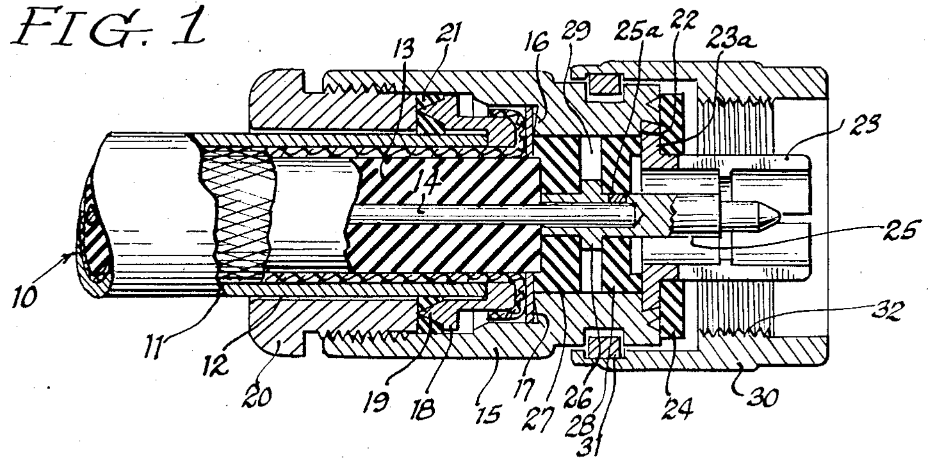


FIG. 3

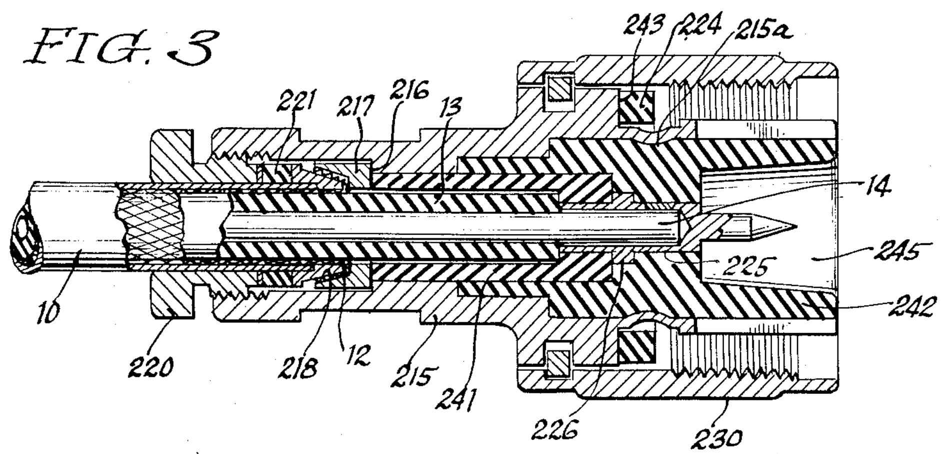
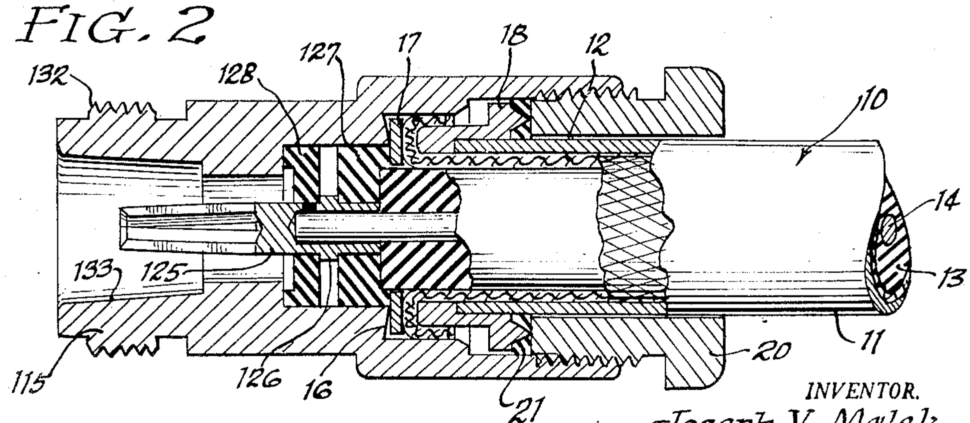


FIG. 2



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2,870,420

ELECTRICAL CONNECTOR FOR COAXIAL CABLE

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Application April 5, 1955, Serial No. 499,291

4 Claims. (Cl. 333—33)

This invention relates to the broad field of electrical connectors and is particularly directed to improved connectors for use with flexible coaxial cables.

The coaxial cables of the type with which the connectors of the present invention are used consist of a central conductor, of solid or stranded construction, covered by a cylindrical layer of dielectric material such as polyethylene or Teflon, such dielectric being in turn covered by a cylindrical metallic braid which forms the outer conductor of the cable. The outer conductor, in turn, is usually covered with an outermost cylindrical layer of insulation, usually made of a material having good mechanical and weather-resistant properties, such as one of the polyvinyl plastics.

Such coaxial cables are in very extensive use today, and many types of connectors have been designed for use therewith. The connectors most extensively used for the purpose in recent years have all embodied some means for clamping the braid of the outer conductor within the body of the connector proper, and, in many instances, have also included means for achieving a weatherproof seal between the body of the connector and the outer surface of the coaxial cable.

The connectors of that type have all necessarily been designed in such manner that certain elements of the connector could be separated from the main body thereof during the course of mounting the connector on the end of the cable, the clamping action for holding the outer conductor being accomplished during the process of re-assembly of the connector after insertion of the cable. All such connectors of which I have knowledge have employed contact members for the center conductor which were secured, by means of soldering, a set screw, crimping, or other fastening means, to the central conductor of the cable, the junction between the center contact and the central cable conductor providing the only mechanical support within the connector for such center contact.

While connectors of that sort have been very widely used, they have all been subject to the disadvantage that forces applied to the connector contact, whether axial forces or shearing forces, have been primarily taken up by the junction between the center conductor of the cable and the center contact of the connector.

This state of affairs is undesirable. For one thing, it has meant that the solder joint relied upon for good electrical contact between the center conductor of the cable and the center contact of the connector has also been required to provide mechanical support for the center contact. This violates a basic principle in the design of electrical equipment.

It is the object of the present invention to provide a coaxial connector having all the advantages of the prior-art connectors with respect to weather-proofing and clamping of the braid while providing for the first time means whereby the center contact of the connector is held firmly anchored in the desired axial position, despite rough use.

Another object of the present invention is to provide a coaxial connector of the type described wherein axial and transverse forces applied to the center contact of the connector are taken up entirely within the rigid body of the connector proper and without transmission of either axial or transverse force to the center conductor of the cable.

Still another object of the present invention is to provide, in a coaxial connector having the structural advantages just mentioned, a construction wherein the structural advantages are achieved without introduction of any significant electrical discontinuity.

In some applications, on the other hand, the structure of the present invention can be used to introduce a compensating impedance discontinuity which will tend to cancel reflections produced elsewhere in the connector structure and thus improve the over-all impedance characteristics of the connector.

Other objects and advantages of the invention will be apparent from the detailed description which follows of certain illustrative embodiments thereof.

In the appended drawing, I have shown in Figure 1 a sectional view of a typical connector plug embodying my invention and having the property of substantially constant characteristic impedance throughout the length of the connector. Fig. 2 shows in section a connector adapted for cooperation with the connector of Fig. 1, having the same structural characteristics but being designed as a jack—that is, as a female counterpart of the male connector of Fig. 1. Fig. 3 is a sectional view of another coaxial connector embodying the features of my invention and being particularly designed for use in high-voltage applications.

The connector of Fig. 1 is joined to a conventional coaxial cable **10** comprising an outer jacket **11** of plastic insulating material, a cylindrical outer conductor **12** made of metal braid, a cylindrical layer of insulation **13**, commonly formed from polyethylene, Teflon, or other low-loss flexible plastic, and a center conductor **14** which may be either a solid or a stranded wire.

The connector comprises a main body member **15**, generally cylindrical in shape and substantially larger in outer diameter than the diameter of cable **10**. Body **15** is centrally bored throughout its length, the portion of the bore near the front end being substantially equal in diameter to that of the cable **10**. At the rear portion of the body member **15**, however, the central bore is substantially enlarged, providing an annular shoulder **16**, against which is abutted a metal washer **17** having a central aperture substantially equal in diameter to the diameter of the insulation **13** of cable **10**.

Cooperating with the washer **17** is a cylindrical clamp member **18** having at its forward face a slightly curved surface or lip and having its rear face formed into an annular edge **19** of V-shaped section.

The outermost portion of the enlarged bore of body member **15** is provided with internal threads for cooperation with the external threads on a clamping nut **20**. Received between the forward or leading edge of the nut **20** and the rear edge of clamp member **18** is an annular gasket **21** made of rubber or similar resilient material.

When the connector is assembled on cable **10**, the end of the braid **12** is fanned out, cut off, and folded back over the curved leading edge of the clamp member **18**, as shown. When the nut **20** is screwed into the body member **15**, the clamp **18** is forced against the washer **17**, the braid **12** being thereby securely clamped and locked into position, so that excellent and permanent electrical contact is afforded between the outer conductor **12** of cable **10** and the metallic body of the connector. At the same time, the gasket **21** is compressed tightly into the space between the clamp member 18 and the nut 20, thus effectively sealing the inside of the connector from moisture and other foreign elements which might otherwise enter the connector when the cable and connector are exposed to the weather.

The front face of body member 15 is provided with a short zone of increased diameter, providing an annular shoulder 22 which carries a contact member 23. Contact member 23 is generally cylindrical in shape, but it is slotted along its forward portion to provide a plurality of resilient leaves or fingers, and at its rear end it is provided with an annular shoulder 23*a* which abuts against the ledge 22.

Contact member 23 is held securely in place with respect to body member 15 by a staking or spinning operation performed on the front face of body member 15, whereby the metal of member 15 is caused to overlie the tapered edge of shoulder 23*a*. An insulating washer 24 may be pressed over the outer surface of contact member 23 to provide a seal in cooperation with the forward edge of the jack or female connector with which the plug of Fig. 1 is designed for use.

The connector center contact element 25 is suitably connected, preferably by soldering, to the end of central conductor 14 of the cable 10. The forward end of center contact 25 is suitably tapered and shaped for cooperation with the corresponding center contact of the female connector, and is bored axially at its rear end to receive the central conductor 14. If desired, one or more small side apertures 25*a* may be provided to facilitate soldering of the wire 14 to the contact 25.

A short distance forward of its rear edge contact member 25 is provided with an annular shoulder 26, extending radially outward from the main cylindrical contour of the element 25. An insulating washer or bushing 27 surrounds the portion of the contact 25 which lies between shoulder 26 and the end of the cable insulation 13. If desired, the rear face of the bushing 27 may be slightly undercut as shown to permit the cable insulating 13 to telescope slightly inside the bushing 27. The outer diameter of bushing 27 is proportioned to fit within the bore of body member 15.

Another bushing 28, also made of insulating material, is carried over the shank of contact member 25 between the forward face of shoulder 26 and the rear face of contact member 23.

The annular space 29 between the rim of shoulder 26 and the inner face of body member 15 may be occupied by an insulating material of the type having different dielectric constant from that of the insulating material used for bushings 27 and 28. Such other insulating material may be air, or it may be a different type of solid material.

The connector shown in Fig. 1 is of the type commonly known as the "constant impedance" type—that is, the characteristic impedance of the section of transmission line formed by the connector and its mating counterpart is substantially the same at all points as the characteristic impedance of the cable 10. This design is highly desirable in applications wherein the cable and the connector are called upon to transmit signals of extremely high frequency—that is, signals wherein the wavelength is of the same order of magnitude as the dimensions of the connector.

Generally speaking, the characteristic impedance of a coaxial transmission line of cylindrical cross section will be governed primarily by the ratio of diameter of the inner and outer conductors and by the dielectric constant of the insulating material which lies between them. To maintain the characteristic impedance of the portion of the connector which includes shoulder 26 from departing substantially from that of the remainder of the connector, the diameter of the shoulder 26 should be so chosen as to provide, in cooperation with the inner bore of body member 15 and the dielectric material which lies between them, the same characteristic impedance as that of the remainder of the conductor. Calculation of characteristic impedance involves well-known formulas familiar to persons skilled in the art, so that it is unnecessary in the present instance to specify the particular dimensions necessary to produce that desired result. Indeed, to give specific dimensions for shoulder 26 would be pointless, since they will be determined in a given case by the impedance desired and by the characteristics of the particular material chosen to fill the annular space 29.

Incidentally, as heretofore mentioned, the radial dimensions and axial position of shoulder 26 can be proportioned if desired to provide a compensating impedance discontinuity which, by cancelling reflections elsewhere produced in the connector structure, will improve the over-all impedance characteristics of the connector.

A coupling ring 30 is secured to the outer surface of body member 15 by means of a split washer 31, carried within appropriate annular recesses formed in the inner surface of ring 30 and the outer surface of body member 15. Ring 30 is provided in its forward portion with internal threads 32 designed for cooperation with the corresponding threads 132 on the body portion 115 of the jack connector shown in Fig. 2.

Fig. 2 shows a jack connector designed to function as a female counterpart of the connector plug shown in Fig. 1 and just described. A detailed description of the Fig. 2 connector will not be necessary, since it corresponds in most respects to the Fig. 1 connector. As will be observed, it is connected to a coaxial cable 10 of similar characteristics to that of the cable 10 of Fig. 1. Similar mechanism is employed in the Fig. 2 connector for clamping the braid 12 within the connector and for providing a weatherproof seal, such mechanism including the annular ledge 16, washer 17, clamp member 18, gasket 21, and nut 20.

The principal differences between the jack connector of Fig. 2 and the plug connector of Fig. 1 lie in the structure of the forward ends of the body member 115 and the central contact member 125. In the Fig. 2 connector, the forward end of the central contact 125 is slotted and squeezed together to provide a resilient electrical contact designed to overlie and grip the forward end of the central contact 25 of the plug connector. Similarly, instead of being provided with a coupling ring 30, the forward end of the body member 115 of the Fig. 2 connector is provided with external threads 132 on its outer surface and is provided on its inner surface with a frusto-conical surface 133 designed to cooperate with the leaves or fingers of contact member 23 of the Fig. 1 plug.

When the connectors of Figs. 1 and 2 are mated together, the two connectors form in cooperation a coaxial line having throughout a characteristic impedance substantially equal to that of the cable 10, the inner and outer conductors of such line consisting, in the junction zone, of the united inner contact members 25 and 125 and the united outer contact members 23 and 133.

A shoulder 126 on the central contact 125 is employed in the Fig. 2 connector, in conjunction with bushings 127 and 128 to anchor the central contact 125 into position in the identical manner used in the Fig. 1 device to anchor the central contact 25.

Fig. 3 shows an alternative form of plug connector designed to employ the structure of my invention while providing exceptionally good voltage-breakdown characteristics. In this form of the invention, I show a body member 215 provided with a stepped central bore adapted to receive insulating sleeves of different sizes. The central bore of body member 215 is internally threaded at its rear end to accommodate a clamping nut 220; an annular clamp element 218, in conjunction with a second clamp element 217, corresponding functionally to washer 17 of Fig. 1, serves to receive and rigidly clamp the braid 12 of cable 10. A gasket 221 provides a seal against the invasion of foreign matter to the interior of the connector.

The clamp member **217** abuts against a ledge **216** formed within the body member **215** of the connector.

Fitted over the insulation **13** of the cable **10** is an elongated sleeve **241**, shaped to fit snugly within the bore of body member **215** at its rear end and provided at its forward end with a reduced-diameter aperture adapted snugly to receive the central contact member **225**. Central contact member **225** is soldered to the inner conductor **14** of the cable **10** in the same manner as in the other connectors herein described, and is likewise provided with an annular shoulder **226**, the function of which is similar to that of shoulder **26** of Fig. 1.

The assembly just described, comprising the cable **10**, central contact member **225**, and insulating sleeve **241**, is fitted within the central aperture of an insulating liner **242** of the connector, the insulating material **242** being held tightly within the body member **215** by a spinning operation operative to compress slightly the insulating material and to secure it in place by means of an annular indentation **215***a*. Alternatively, the insulating liner **242** may be held in position within the body member **215** by staking or other suitable means. A coupling ring **230** is secured over the outer surface of body member **215** in the same manner as described with respect to the coupling ring **30** of Fig. 1, and a resilient sealing washer **224** abuts against ledge **243** to provide a seal between the connector of Fig. 3 and its corresponding jack connector.

As will be observed from a study of Fig. 3, the central contact member in that connector will, when the nut **220** is tightly screwed into position, be securely clamped between the elements **241** and **242**, and any force applied to the central contact **225**, whether axial or transverse, will be taken up by the body of the connector rather than by the central conductor **14** of cable **10**.

The same is true of the connectors of Figs. 1 and 2, wherein, when the nut **20** has been screwed tightly into position, the central contact is anchored between the bushings flanking it.

To insure tight anchorage of the central contact, the insulating bushings or sleeves which abut the shoulder portion of the central contact may in any of the embodiments shown be made slightly oversize in the longitudinal direction, in order that they will be slightly compressed when the clamp nut is tightened.

Whereas I have in the present specification described in considerable detail certain specific embodiments of my invention, it is to be understood that this description is merely for purposes of illustration, and that many changes and variations therein may be made by persons skilled in the art without departing from the spirit of my invention.

I claim:

1. In a connector for use with a coaxial electric transmission cable of the type having a filamentary inner conductor, insulating material overlying such inner conductor, and an outer conductor formed of flexible metallic braid, said connector having a generally cylindrical metallic

body member adapted to receive said cable in its rear portion, the improvement which comprises a first centrally apertured insulating element adapted to fit within said body member, means carried by said body member limiting forward movement of said insulating element therewithin, a metallic central contact for said connector of generally cylindrical contour and having a shoulder extending radially outward in a zone axially intermediate the ends of said contact, said contact having also means at its rear end adapted to receive and make electrical contact with the inner conductor of said cable, said shoulder bearing against said insulating element when the front portion of said contact is inserted in the central aperture thereof, a second centrally apertured insulating element adapted to fit over said contact behind said shoulder and within said body member, and clamping means for securing the braid of said cable in intimate contact with the inner surface of said body member, said clamping means being operative in the course of securing said braid to confine said second insulating element and to hold the shoulder of said central contact securely between said first and second insulating elements, thereby fixing said contact against axial and lateral movement within said body member, said first and second insulating elements being formed to terminate substantially flush with the rim of said shoulder, leaving an annular zone between said shoulder and the inner surface of said body member, said annular zone being occupied by a dielectric material of lower dielectric constant than the material from which said first and second elements are formed.

2. Apparatus according to claim 1 wherein the dielectric material occupying said annular zone is air.

3. Apparatus according to claim 1 wherein the radial dimensions of said shoulder are proportioned with respect to the dimensions of the inner surface of said body member directly overlying said shoulder and with respect to the dielectric constant of said material within said annular zone to provide in the portion of said connector comprising said shoulder a characteristic impedance substantially equal to that of said cable.

4. Apparatus according to claim 1 wherein said annular zone is filled with air and wherein the radial dimensions of said shoulder are proportioned with respect to the dimensions of the inner surface of said body member directly overlying said shoulder and with respect to the dielectric constant of air to provide in the portion of said connector comprising said shoulder a characteristic impedance substantially equal to that of said cable.

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