Sept. 18, 1962 J. V. MALEK ETAL 3,054,981

COAXIAL CONNECTORS

Filed July 28, 1959

Fig. 3.

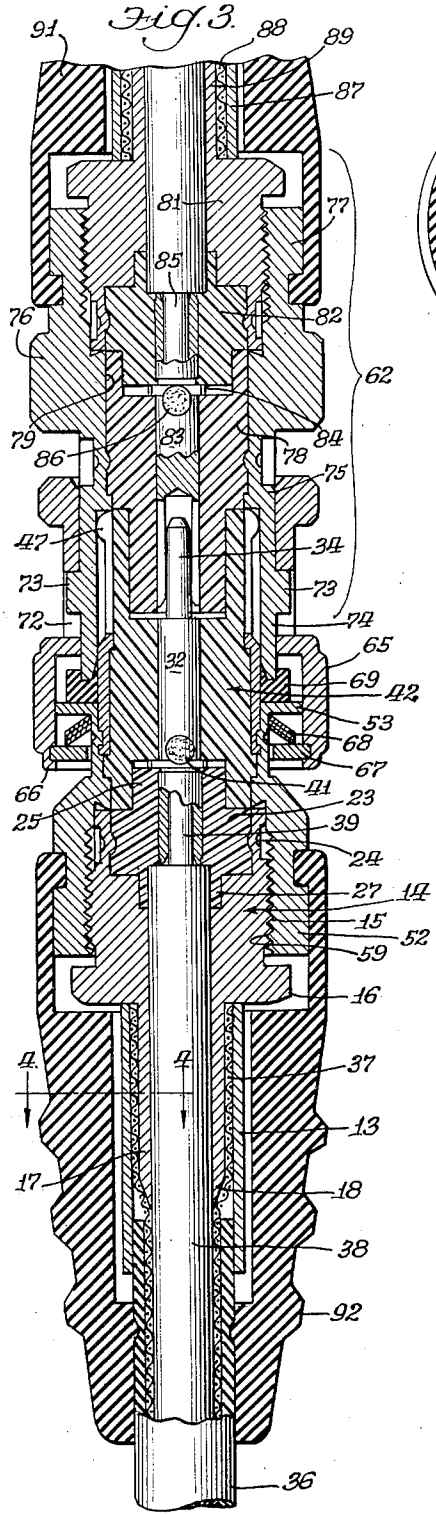


Fig. 4.

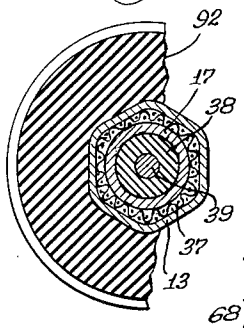
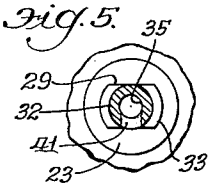


Fig. 5.



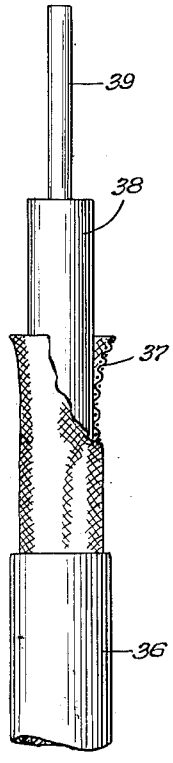
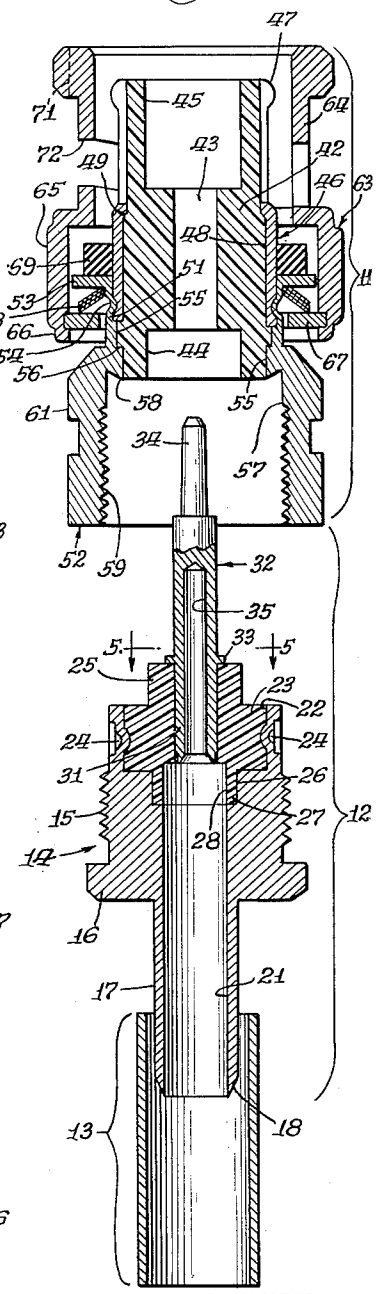


Fig. 2.

Fig. 1.



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COAXIAL CONNECTORS

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This invention relates to coaxial electrical connectors adapted for use with radio frequency transmission lines of the coaxial type. It is the general aim of the invention to provide an improved arrangement of parts capable of reconciling the heretofore conflicting electrical and mechanical requirements of such connectors, to result in an improved line of connectors characterized by (*a*) improved and stabilized electrical continuity, yet with (*b*) increased mechanical strength, and (*c*) particularly by simplified installation procedures, yet so designed and constructed as to be well suited to commercially practicable methods of manufacture and adapted to production at a cost not greatly exceeding the cost of prior types of connectors lacking the advantageous features hereinafter disclosed.

More specifically, it is one of the principal objects of the invention to provide a coaxial connector capable of interconnecting the ends of flexible transmission lines with the electrical continuity through the connector so improved and stabilized that the V.S.W.R. (voltage standing wave ratio) through the connector is more constant than ordinarily achieved heretofore, and is not subject to appreciable variation due to minor changes of position or "floating" of the parts, irrespective of mechanical stresses applied to the connector or to the cables extending therethrough, and irrespective of expansion and contraction of the component parts of the assembly due to temperature changes.

A further object of the invention is top rovide an electrical connector so designed as to achieve maximum strength, particularly in the joint between the outside metal braid of a flexible transmission line and the body of the connector housing, whereby the mechanical weaknesses characterizing many prior types of coaxial radio frequency connectors are to a large extent avoided. This involves improved means for securing the connector fitting to the flexible cable itself, and particularly to an improved means for anchoring the connector fitting to the woven metallic braid ordinarily provided in flexible coaxial transmission lines. It is accomplished in the present invention by a unique arrangement whereby the body of the connector fitting is firmly anchored to the woven metal braid of the cable without the necessity of unbraiding or combing out the wire of the strands of the braid. By this expedient, troubles heretofore encountered due to improperly or bunched wire braid are obviously overcome.

A still further object of the invention is to provide an improved coaxial connector having the mechanical and electrical features noted above, yet so designed as to be suited to preassembly of the principal component parts at the factory, whereby it is capable of quick, easy and convenient attachment to the coaxial lines. It is a particularly important object to avoid the shortcomings of prior types of coaxial radio frequency connectors which are quite subject to incomplete or incorrect assembly by reason of the fact that they involve a relatively large number of small, detached, yet confusingly similar parts which must be assembled in a rather exacting and intricate manner in the field, whenever an individual connector is to be attached to a cable.

In addition to the reduction in the total number of parts to be assembled in the field, it is a further object

of the invention to provide an improved radio frequency connector wherein the total number of parts is not only reduced but wherein the sizes of the individual parts are actually increased, without a corresponding increase in the over-all size of the connector. While this increase in size of the individual parts is of some importance in connection with all of the parts involved, it is a particular object of the invention to provide an assembly wherein the dielectric inserts utilized to support and align the central conductor of the connector are somewhat longer than prior types of comparable sizes. This is of importance both electrically and mechanically. It achieves mechanical advantages in that it imparts greater strength to the dielectric inserts, avoids the possibility of cold flow in response to long continued stresses, and facilitates the assembly of parts with precise, properly calculated, electrical parameters, even by the utilization of parts having practicable mechanical tolerances. It is thus a contributing factor in not only providing a satisfactory voltage standing wave ratio which has been found to be lower than in connectors such as the prior amphenol captivated contact type BNC, but also provides greater uniformity in electrical characteristics.

It may be explained that while much engineering talent has been devoted to development of coaxial connectors having theoretically optimum electrical continuity and V.S.W.R. characteristics, yet practical accomplishment has tended to fall far short of the theoretical results to be obtained; at least partially for the reason that, in the mechanical designs heretofore utilized, vital internal parts have been subject to minor internal movements or variations in position, both as to spacing and alignment. This has been noted to be particularly true in instances wherein the connector contacts attached to the central conductor of the coaxial cable are held against axial shifting only by the conductor itself, so that the parts are necessarily subject to a certain amount of floating movement, giving rise to electrical discontinuities, particularly in the higher frequency ranges. The present design provides better electrical and mechanical isolation of the shoulder of the center contact than heretofore achieved, in addition to providing a firmer mechanical mount for the central contacts with less tendency toward misalignment than in prior types commercially known.

A still further advantage achieved by the construction and arrangement of parts as disclosed in the present specification is that the portions of the connector which have exhibited electrical discontinuity in prior designs have been redesigned so that electrical reflections are minimized. Notwithstanding the foregoing advantages, it is still worthy of note that the connectors designed and constructed in accordance with the present specification are nevertheless compatible with prior types; that is, they are physically interchangeable with connectors of corresponding types heretofore commercially manufactured.

The manner in which the present invention achieves the foregoing objects is best described in connection with the drawings attached to and forming a part of the present specification, wherein:

FIGURE 1 is a greatly enlarged central sectional view through the unassembled components of a connector plug according to the present invention, ready for attachment to a flexible coaxial radio frequency transmission line;

FIGURE 2 is a side elevational view of the end of a typical flexible coaxial line, partly broken away and showing the line stripped back in the proper manner for attachment to the connector;

FIGURE 3 is a central sectional view of the plug shown in FIGURE 1 after attachment to the end of the coaxial line and in engagement with a mating jack;

FIGURE 4 is a detail sectional view taken on the plane of the line 4—4 of FIGURE 3; and

FIGURE 5 is a detail sectional view taken on the plane of the line 5—5 of FIGURE 1.

The principles of the present invention, while of general application, will be described in connection with a connector designed to interconnect the ends of flexible coaxial radio frequency transmission lines of the type having a solid or stranded wire as the central conductor, surrounded by dielectric, which is in turn enclosed by an outer conductor of woven flexible wire or metal ribbon braid and covered by a tough insulating sheath of suitable plastic or fabric. Cables of this type are well-known and quite conventional for transmission of radio frequency energy and signals.

The unassembled plug, best shown in FIGURE 1, is made of two principal sub-assemblies which may be conveniently referred to as a body **11** and a core **12**. These sub-assemblies coact with a simple tubular ferrule **13** for attachment to the cable.

As will be observed from the drawings, the core **12** includes a tubular metal shell **14** threaded exteriorly at **15** and provided with a hexagonal nut **16** at its rearward (lower) end, and terminating in a thin cylindrical coupling sleeve **17** tapered to a thin feather edge **18** at its end. A central bore **21** extends through the shell, with a large diameter counterbored cavity **22** arranged to receive the cylindrical central portion of a dielectric insert **23**, held in place by crimps **24** in the walls of the metal shell. The dielectric has a forwardly projecting pilot portion **25** at its upper end, and the lower end of the counterbored cavity **22** has a smaller counterbore **26** dimensioned to receive a rearwardly (downwardly) extending pilot sleeve **27** of the dielectric.

The dielectric insert **23** has a central bore **28** in alignment with the bore **21**, with the shank portion **31** of the tubular central contact **32** press-fitted therein to bring the partially annular shoulder **33** of the contact into abutting relation with the forward face of the pilot **25** of the dielectric. As best shown in FIGURE 5, the shoulder **33** may have flats **29** on its opposite sides to improve the V.S.W.R. of the connector and, if desired, the shank of the contact may be provided with exterior knurling to anchor it firmly in the bore of the dielectric **23**.

The central contact **32** has a tapered pin **34** at its forward end and a central bore **35** slightly tapered at the rearmost end to receive the central conductor of a flexible coaxial line which has its extreme forward end prepared in the manner shown in FIGURE 2, by cutting back the insulating sheath **36**, the metal braid **37**, and the dielectric **38** in stepped fashion to expose the end of the central conductor **39**. Prior to assembly, the prepared end of the coaxial line is slipped through the ferrule **13**. The prepared end of the coaxial line is then attached to the core **12** by inserting the stripped end of the line into the core subassembly **12**, loosening the end of the braid layer **37** and telescoping it over the tapered edge **18** at the end of the tubular sleeve **17** on the metal shell **14** of the core until the dielectric layer **38** enters the bore **28** and seats against the end of the bore **28**. Simultaneously, the woven wire braid **37** of the transmission line will be spread by the tapered edge **18** of the sleeve **17** and will be telescoped over substantially the entire length of the sleeve. The ferrule **13** is then drawn over the outside of the braid **37** until it is in a position to abut the hexagonal portion **16** of the core, where it is crimped to clamp the expanded braid **37** against the outer surface of the sleeve **17**. It is to be noted, however, that while the braid layer is somewhat loosened and expanded to fit over the sleeve, it is not unravelled nor combed out and is clamped in braided condition, thus effecting a strong, uniform, mechanical joint with good electrical conductivity and without the faults encountered in many prior connectors due to unevenness or bunching of the braid. The clamping of the ferrule on the sleeve may be accomplished in any approved manner, but excellent results are obtained by clamping it into generally hexagonal form, as best shown in FIGURE 4. The joint is then completed by soldering the bare end of the central conductor **39** within the bore **35** of the center contact through the solder port **41** provided for the purpose. It is to be noted that the solder port **41** is located in a position intersecting the shoulder **33** and as close as practicable to the dielectric, so that when the soldering operation is accomplished, it effects an electrical junction between the center conductor **39** and the connector contact **32** as close as possible to the bored end **35** of the contact **32** for reasons of electrical excellence.

The body of the connector plug, generally designated at **11**, FIGURE 1, has its central dielectric insert **42** provided with a central bore **43** of a diameter to fit snugly over the outer cylindrical surface of the central contact **32** and the insert is provided with a counterbore **44** to receive the pilot portion **25** of the dielectric **23** in order to clamp the partially annular shoulder **33** of the contact between the forward face of the pilot portion **25** and the bottom of the counterbore **44**. The forward (upper) end of the dielectric **42** is also counterbored at **45** to clear the contact pin and to provide for reception of a pilot portion of the dielectric on the mating receptacle or jack, as will be described. The dielectric insert **42** of the body **11** of the connector is confined within a metallic casing including two coacting sleeve-like members interlocked with each other. The forward (upper) portion of this casing consists of a thin-walled sleeve **46** having its leading end split into several segments to permit the sleeve to be spread slightly and thus exert an outward spring force tending to hold the contact lips **47** of the sleeve in snug engagement within coacting contacting surfaces of a mating receptacle or jack (see FIGURE 3). The sleeve **42** has a counterbored cavity **48** to receive the enlarged central portion of the dielectric **42** and to form a shoulder **49** restraining the dielectric insert against forward displacement. The rearward end of the sleeve **46** is received within a thin-walled tubular neck **51** of a hollow sleeve-like rear shell portion **52**. As will be observed from the drawings, the rear shell has a flange **53** at its extreme front end, and the parts **51** and **46** are crimped to each other at **54** to hold them assembled.

The rearward shell **52** also has its center bore **55** shouldered at **56** to enage a corresponding rearwardly facing shoulder on the dielectric to prevent rearward displacement thereof. The shell member **52** is internally counterbored at **57** with the end of the counterbore undercut to provide a sharp edge corner **58** arranged to be pressed into intimate electrical contact with the leading end of the core shell **14** when screwed into the body by the coacting threads **15** and **59**. Obviously, the shell **52** may be provided with flats **61** to facilitate assembly.

The elements described above comprise the essential electrical components of the plug assembly, but it is customary to provide connectors of this type with releasable mechanical instrumentalities for locking the plug to a mating jack such as shown at **62** in FIGURE 3, for example. To this end, the plug is provided with an outside rotary coupling collar **63** having a forwardly extending locking sleeve **64** and a knurled finger grip **65** terminating in an inwardly crimped flange **66** encircling a split washer **67** to confine a number of spring washers **68** between the washer **67** and flange **53**. The rotary locking sleeve thus constitutes the forward end of the plug shell and is capable of rotational movement thereon, as well as limited relative axial movement by compression of the spring washers **68**. The forward end of the locking sleeve **64** encloses a sealing gasket **69** and the sleeve is formed with cut-away channels **71** terminated in helically disposed bayonet clamping grooves **72** arranged to engage paired lugs **73** of the jack **62** (FIGURE 3) and to draw the sleeve-like forward end

of the receptacle shell 74 into tight engagement with a resilient gasket 75 fitted on the sleeve 46 ahead of the flange 53. Thus by rotating the collar 63 from the position of FIGURE 3 the plug and jack will be drawn further toward each other to tighten the shell sleeve 74, compress the gasket 69 and seal the joint between the plug and the jack.

As will be best seen in connection with FIGURE 3, the jack, generally designated 62, is constructed in accordance with the same inventive principles described in connection with the plug of FIGURE 1, except that the outer metallic shell member 74 is of unitary rather than two-piece construction. Thus, the forward contact shell 74 is integral with an intermediate neck portion 75, a knurled portion 76 and a circular portion 77, with a dielectric insert 78 crimped in the bore 79. The jack assembly also has an internal core portion comprising the shell 81 and dielectric insert 82. Thus, when the core portion is threaded into the threaded section 77 of the jack shell, the dielectric inserts 78 and 82 coact to confine the female contact 83 of the assembly with its shoulder 84 clamped between the respective faces of the dielectrics.

The transmission line is interconnected with the jack in exactly the same manuner as with the plug by soldering the central conductor 85 through the solder port 86 shown in the drawings, and by crimping the ferrule 87 into hexagonal form to hold the metallic braid 88 of the cable in firm mechanical and electrical union with the sleeve 89 of the core sub-assembly. Also, as shown in the drawings, both the plug and jack assemblies may be provided with resilient boots 91 and 92 of relatively yieldable synthetic rubber to enclose the joint between the connector parts and the cable to which they are attached.

From the foregoing description it should be apparent that the principles of the present invention succeed in reconciling the heretofore conflicting requirements of mechanical strength, electric continuity, and simplicity of assembly; and result in a connector having advantages in all of these important respects. It is to be noted that the internal design of the connector parts is such that there is positive electrical union between the connector contacts and the cable conductors at all times. Also, the contacts of the connectors are positively held against lateral displacement in the bores of the dielectric inserts, and at the same time are confined in a manner to avoid axial "float" or shifting. This is important in overcoming the tendency of prior types of connectors to change their radio frequency electrical characteristics in response to changes in temperature or mechanical stresses, and it is particularly desirable in installations subjected to extreme temperature differentials which might otherwise shift the contacts because of relative expansion and contraction of the parts and cable involved. Notwithstanding the above, the mechanical union between the flexible cable and the connector assembly is extremely strong, and so well protected against stresses, strains, and impacts that there is little likelihood that the cables will be torn from the connector fittings even under the most extreme conditions.

In addition to the mechanical and electrical objects achieved by the present construction, an extremely valuable improvement in assembly procedures is accomplished. The fact that the plug may be pre-assembled with the parts of each of two sub-assemblies locked together at the factory serves a double purpose in that it not only provides for quick and easy assembly of the connectors in field installations, but also avoids the possibility by incomplete or improper assembly of parts which is ever-present in connectors so designed that several small washers, contacts and inserts must be individually assembled at the time of attachment to the cable.

With all of the advantages noted above, it is also to be observed that the present invention provides a coaxial connector which is well suited to modern high production methods of commercial manufacture, whereby the units will not be overly expensive, and can be manufactured at a cost not greatly exceeding the cost of prior types heretofore regarded as standard.

Having thus described the invention, what I claim as new and desire to protect by United States Letters Patent is:

1. In a connector for coaxial radio frequency transmission lines of the type having an inner conductor surrounded by a dielectric layer and a tubular outer conductor consisting of a layer of metallic braid enclosed in a protective sheath, the combination of two separate subassemblies comprising a body assembly and a core assembly coacting to form said connector; said body assembly comprising a conductive metallic casing having a central cavity; a dielectric insert carried in said central cavity and including a central mounting bore, with fastening means outside of said casing for interengagement with the casing of a mating connector: said core assembly consisting of a conductive metallic shell having a central cavity with a thin-walled metallic sleeve projecting rearwardly from the shell and adapted to be slipped between the dielectric layer of the transmission line and the metallic braid comprising the outer conductor thereof; with clamping means comprising a tubular ferrule surrounding the end portion of the metallic braid of the line and adapted to be crimped against the aforementioned thin-walled sleeve to establish firm mechanical connection and intimate electrical union between the outer conductor of the line and the shell; with a portion of the ferrule extending over the protective sheath of the line; the shell including a dielectric insert with a central bore supporting a central contact for the connector; said contact having a tubular shank fixedly mounted in the said central bore of the dielectric insert of the core assembly, with an outside shoulder on the contact engaging the dielectric, and a terminal portion of the contact extending forwardly therefrom; with the core assembly inserted into the body assembly whereby the central contact-supporting bore of the dielectric insert of the body directly receives the central contact of the core to support its forward end.

2. In a connector for coaxial radio frequency transmission lines of the type having an inner conductor surrounded by a dielectric layer and a tubular outer conductor consisting of a layer of metallic braid, the combination of two separate subassemblies comprising a body assembly and a core assembly coacting to form said connector; said body assembly comprising a conductive metallic casing having a central cavity; a dielectric insert carried in said central cavity and including a central mounting bore; and core assembly consisting of a conductive metallic shell having a central cavity with a thin-walled metallic sleeve projecting rearwardly from the shell and adapted to be slipped between the dielectric layer of the transmission line and the metallic braid comprising the outer conductor thereof; with clamping means comprising a tubular ferrule surrounding the end portion of the metallic braid of the line and adapted to be crimped laterally inwardly against the braid in a plurality of areas along the length of the aforementioned thin-walled sleeve to establish firm mechanical connection and intimate electrical union between the outer conductor of the line and the shell; the shell including a dielectric insert with a central bore supporting a central contact for the connector; said contact having a tubular shank fixedly mounted in the said central bore of the dielectric insert of the core assembly, with an outside shoulder on the contact engaging the dielectric, and a terminal portion of the contact extending forwardly therefrom; with the core assembly inserted into the body assembly whereby the central contact-supporting bore of the dielectric insert of the body directly receives the central contact of the core to support its forward end.

3. A connector according to claim 2 wherein the outside shoulder on the central contact for the connector is

positioned between a rearwardly facing surface of the dielectric insert of the body assembly and a forwardly facing surface of the dielectric insert of the core assembly whereby said shoulder is clamped between the body and the core to preclude longitudinal shifting of said central contact with respect thereto.

4. A connector according to claim 2 wherein the dielectric insert of the core assembly includes a reduced diameter pilot portion projecting forwardly therefrom and extending into a counterbore adjacent the rearward end of the dielectric insert of the body assembly, with the shoulder of the central contact for the connector restrained between the forward end of said pilot portion and the bottom of said counterbore in the dielectric insert of the body assembly.

5. A connector according to claim 2 wherein the walls

of the central cavity of the body portion and the walls of the central cavity of the core portion comprise aligned concentric surfaces of diameters substantially proportional to the exterior diameters of corresponding incremental lengths of the central contact therewithin, to provide substantially constant impedance throughout the connector.

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