Jan. 27, 1970 E. W. FORNEY, JR., ETAL 3,492,408

CRIMP-TYPE CONNECTOR WITH FLOWED SEAL

Filed April 11, 1967

2 Sheets-Sheet 1

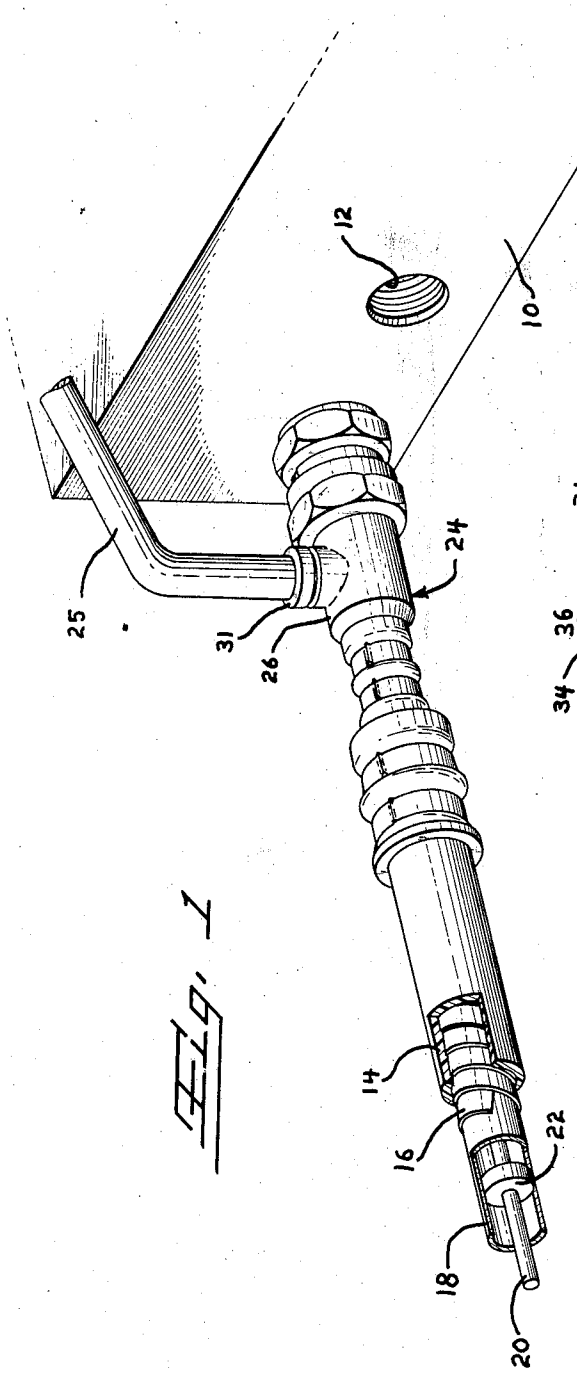

FIG. 1

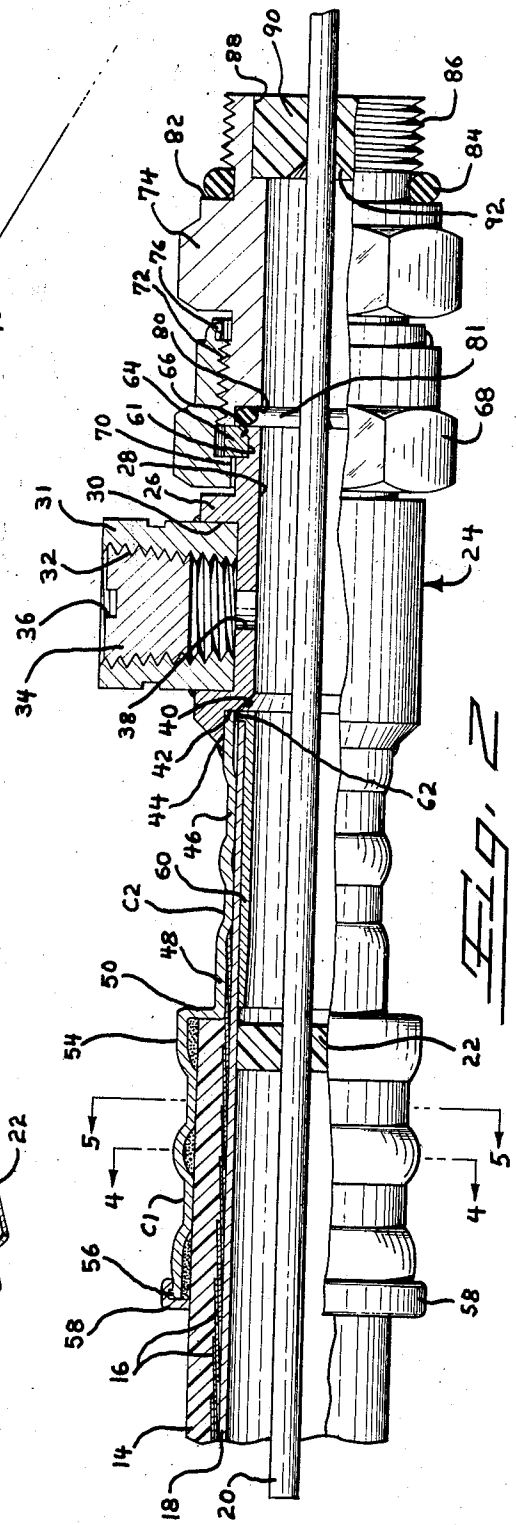

FIG. 2

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CRIMP-TYPE CONNECTOR WITH FLOWED SEAL

Filed April 11, 1967 2 Sheets-Sheet 2

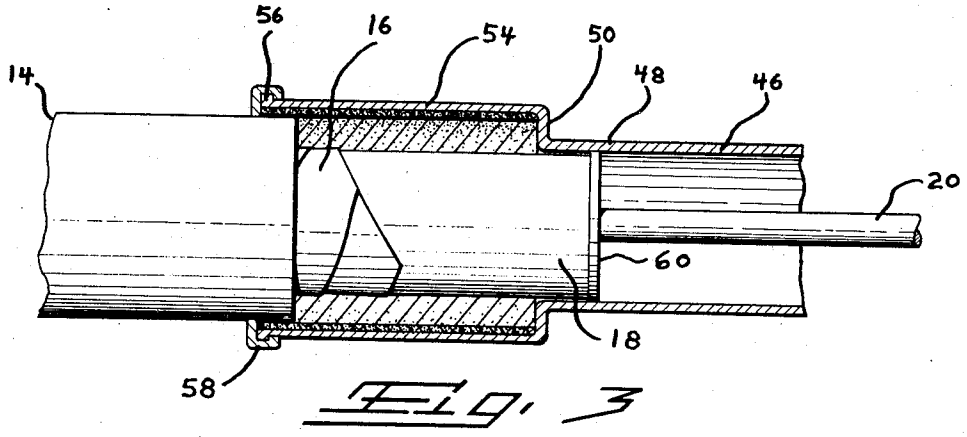


Fig. 3

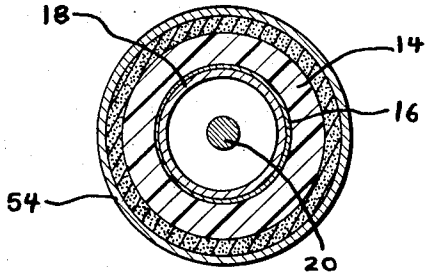
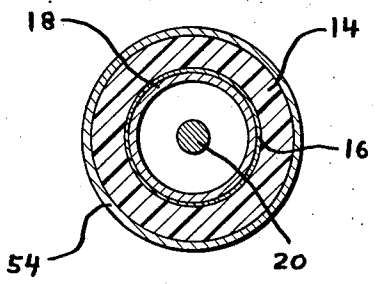


Fig. 4

Fig. 5



United States Patent Office 3,492,408 Patented Jan. 27, 1970

3,492,408

CRIMP-TYPE CONNECTOR WITH FLOWED SEAL

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Filed Apr. 11, 1967, Ser. No. 629,977
Int. Cl. H02g 15/02, 15/08; H01r 17/18
U.S. Cl. 174—75 5 Claims

ABSTRACT OF THE DISCLOSURE

A connector for coaxial cable is disclosed having a ferrule assembly including a lining of sealing material which is soft and flowable. The ferrule assembly includes an outer ferrule containing a lining made to extend back over the outer protective sheath of a cable when inserted in the connector in conjunction with a type of crimp which causes the sealing material to flow into a reservoir or pocket extending peripherally around the cable sheath. The crimp is of a configuration which does not distort the coaxial characteristics of the cable. The outer ferrule is shaped to prevent any disturbance of the sealing material during insertion of the cable within the connector and to prevent sealing material from being deposited on conductive portions of the cable during such assembly.

The connector disclosed includes as a further feature a structure permitting the connector to be crimped onto a cable and thereafter screwed into a mating receptacle without rotating the cable. A gas port is positioned relative to the crimped and fixed portion of the connector to be maintained against rotation during threading of the connector into a receptacle.

BACKGROUND OF THE INVENTION

In U.S. Patents 3,290,640 to E. W. Forney, Jr. issued Dec. 6, 1966, and 3,283,287 to F. B. Stark et al., issued Nov. 1, 1966, coaxial connectors are disclosed having a sealing member fitted within crimp-type ferrules. In each instance the sealing member is an O-ring formed of a material which is capable of being handled. In the first mentioned patent the O-ring is positioned within a recess formed in the ferrule and has an inner diameter and thickness to be compressed against the outer sheath of the coaxial cable during assembly. In the Stark patent the ferrule is crimped over the O-ring to provide compression against the outer sheath of coaxial cable.

While both of the devices disclosed in the aforementioned patent have found utility as effective sealing structures in general use some problems have been experienced in situations wherein the cable and connector are exposed to conditions beyond that expected. These conditions include those encountered in the various extremes of cold and heat, rain and wind, by pole-strung coaxial line. These conditions accelerate aging of the materials of use and particularly of O-ring type sealing structures which tend to become hardened and to lose the flexibility required to maintain a seal throughout the range of below 0° F. to above 100° F. required of outdoor installations.

A related problem has been experienced with crimp type coaxial connectors which require rotation for mating. This problem has to do with a requirement for twisting of the connector assembly necessitated by threaded or bayonnet type fittings which tend to twist the connector body relative to the crimped joint and thus torsionally load the sealing and conductive interface between the cable and the connector to cause a resulting slippage between the cable and the connector and a deterioration of both the seal and the electrical connection therebetween.

Summary of the invention

This invention relates to a crimp-type coaxial connector having an improved sealing structure.

It is an object of the invention to provide a coaxial connector which may be crimped onto a coaxial cable to provide a permanent seal between cable and connector. It is a further object to provide a seal for coaxial cable which has characteristics tending to accommodate expansion and contraction due to temperature extremes. It is a still further object to provide a connector structure utilizing a relatively non-resilient flowable sealing medium and having a configuration to prevent disturbance of the sealing medium or deposit thereof on conductive portions of a cable or connector during installation of a cable within a connector. It is still another object to provide a coaxial cabble connector assembly having a novel sealing structure and a mounting structure to permit rotation of portions of the cable without torsionally loading the sealing structure. It is still another object of the invention to provide a coaxial connector of the seal type including a gas port affixed to a crimping structure with forward portions of the connector being rotatable relative thereto.

The foregoing objectives are achieved by the invention through a connector assembly including a crimping ferrule having a lining of a soft and relatively non-resilient sealing material in an end portion thereof which is flowed into an annular pocket or recess extending around the cable outer sheath formed by an annular crimp of the ferrule. The ferrule includes an outer portion containing the lining and an inner backup portion positioned within the outer conductor of the cable to withstand crimping forces applied thereover to terminate the cable outer conductor to the outer ferrule. The outer ferrule has an inwardly directed radial flange which serves to guide a cable during insertion within a connector to prevent disturbance of the sealing material and to prevent the sealing material from being deposited on conductive portions of the cable. The flange also prevents flow of the sealing material after crimping. The outer ferrule is permanently secured to a connector body which contains a gas port permitting the connector cable assembly to be loaded under pressure. The portion of the connector having the outer ferrule affixed thereto and the gas port affixed thereon is further permanently connected to a rotatable forward assembly which permits a right-hand threading into a receptacle without torsionally loading the cable or the ferrule structure crimped thereto.

In the drawings:

FIGURE 1 is a perspective showing a coaxial cable terminated by the connector assembly of the invention mated with a receptacle in an equipment housing;

FIGURE 2 is a longitudinal and sectional view of the connector and cable assembly shown in FIGURE 1;

FIGURE 3 is a longitudinal view in partial section showing a cable properly stripped and having an inner ferrule member positioned therein and partially inserted within the outer ferrule of the assembly of FIGURE 1; and

FIGURES 4 and 5 are cross-sectional views taken along lines 4—4 and 5—5 through the crimped portion of the ferrule of the connector assembly shown in FIGURE 2.

Description of the preferred embodiment

Referring now to FIGURE 1, the connector assembly of the invention is shown connected to an equipment housing **10** through a threaded receptacle like that shown as

12 in the wall of the housing. The housing 10 may be considered to contain an electrical or electronic circuit such as an amplifier or a directional coupler having coaxial input and output connections provided by coaxial cable terminated by connectors like that shown in FIGURE 1. The need for a coaxial termination is dictated by the high frequency characteristics of the signals employed by the circuit.

A typical cable for RF use is constructed in the manner indicated in FIGURE 1 to include an outer protective and insulating sheath 14, an outer armored jacket of spirally wound steel tape 16, an outer conductor formed of copper sheet material 18, and an inner conductor 20 held spaced and coaxial of the outer conductor 18 by spaced disks of dielectric material 22. In terminating high frequency cable of this type it is important to provide as little deformation to the cable as possible in order to minimize signal losses caused by discontinuities in the signal transmission path formed by the cable. In outdoor installations where the cable connector and equipment may be expected to be mounted on a pole suspended from cable strand or buried underground in conduit, it is equally important to seal the cable connector and the equipment of use against moisture. For this reason the cable shown is usually loaded under gas pressure which prevents moisture or other contaminants from entering the cable or connector through slight leaks therein.

For the foregoing reasons connector constructions of the prior art have been relatively complicated structures and have required considerable time and skill of the user in application to the cable. In one known prior art approach the connector assembly of use required a step-by-step application of sealing material during assembly followed by a taping of the overall assembly with a sealing tape. After this treatment, in order to install this particular connector, the user was required to very carefully assemble a number of different pieces into an equipment housing and then fit the connector therein by the use of several different non-standard tools, one for each of a number of different intermating parts.

The connector shown as 24 in FIGURE 1, is comprised of essentially two loose pieces which simplifies shipping, storage and handling during installation. These loose pieces include the parts shown in FIGURE 1, as connected together and an additional inner ferrule which is shown in FIGURE 2, inserted within the cable. All that is required, other than these pieces, is a relatively simple crimping tool carrying dies to apply crimps to the rear end and ferrule portion, a knife or some means to stripe the cable, a screw driver, and a standard wrench such as a crescent wrench. Installation time of the connector after stripping of the cable takes only several minutes with no required application of sealing material, tape or the like. Installation of the terminated cable carrying the assembly thereon into the equipment chassis takes only about a minute. As one of the advantageous features of the assembly 24, installation into an equipment housing is accomplished by the rotation of nuts of standard size in a standard manner; namely, by a right-handed rotation of such nuts. Removable of the terminated connector assembly from the equipment housing is also simplified and accomplished in a standard manner by a left-handed rotation of the nuts of the assembly.

The element shown as 25 in FIGURE 1, represents bypass tubing which carries gas pressure to or from the cable of use, relative to either a source of gas pressure or to another connector assembly located on the other side of the housing. The tubing 25 is connected through a gas fitting threaded into the assembly 24 through a gas port secured to the body thereof in the manner indicated in FIGURE 2. The gas port which extends out from the body of 24 is held in a fixed position relative to the forward portion of 24 which is made to be rotated for insertion of the connector into the housing without displacing or having to rotate the gas port or the hosing connected thereto.

As shown in FIGURE 2, the assembly 24 includes a body 26 comprised of metal having an inner bore 28 extending therethrough. The surface of a bore 28 defines the outer conductive path of the assembly, the inner conductive path being formed by a portion of the inner conductor 20 of the cable extended through the assembly, in the manner shown. The outer portion of 26 includes a bore 30 into which is fitted a metallic sleeve gas port 31 soldered, brazed or otherwise permanently secured to 26. The gas port includes an interior and tapered threading shown as 32 carrying a mating plug 34 having a slot 36 in the upper surface thereof to facilitate insertion and withdrawal of the plug from the port. In use, if it desired to connect transfer tubing, such as 25, the plug 34 is removed and a fitting, externally threaded and shaped to fit within the port is employed. A gassing aperture shown as 38 is provided in a shell 26 in alignment with the bore of the port and leading to the bore 28 of the shell.

To the left of the port bore 28 is flared outwardly by a tapered portion shown as 40, leading to a radial surface 42 and an enlarged bore 44, into which is fitted an outer ferrule 46 formed of a malleable metal. The outer ferrule is made to butt against the surface 42 and is soldered, brazed or otherwise permanently affixed to the shell 26. The outer ferrule 46 includes a first portion shown as 48, having an inner diameter slightly larger than the outer diameter of the outer conductor 18. At the end of portion 48 the ferrule is flared outwardly in a radially extending portion 50 and continued in a portion of larger diameter shown as 54. The inner diameter of portion 54 is slightly larger than the outer diameter of the protective sheath 14 of the cable of use. The end of the ferrule 46 is flared outwardly as at 56 to form a lip receiving and retaining a ring shaped cap shown as 58, snapped on the end of the ferrule. The cap 58 extends inwardly to a diameter approximately the same as the outer diameter of the protective sheath 14. The inner extension of 58 in conjunction with the portion 50 define an annular and sleeve-like recess extending along the length of portion 54.

It is contemplated that as an alternative ring 58 may be replaced by an integral and inwardly formed lip on the end of 54 to provide the same function as that of ring 58 in guiding the cable during insertion to protect the sealing compound bonded to the interior surface of the portion of 58. In the embodiment shown in FIGURE 2, having the ring 58, the sealing compound may be inserted into 46 on a suitable mandrel having a surface which holds the compound in a cylindrical form, but does not stick thereto. Teflon has been found suitable for this purpose. In the embodiment wherein the inward portion of what is shown as 58, is formed integrally, out of the material of 46, it is preferred to injection mold the sealing compound into the position shown in FIGURE 2.

In an actual embodiment the sealing compound was a commercially available unvulcanized butyl rubber, having suitable additives therein to inhibit self-vulcanizing at ambient temperatures over a period of time and to impart a stickiness, causing the material to adhere to the metal surface of the ferrule and also to the protective sheath of the cable. Polyethylene is a typical sheathing material for coaxial cable, because of low cost and inert characteristics. The use of polyethylene has, in fact, caused some of the problems in providing sealed terminations due to the difficulty of providing seals which adhere to polyethylene and due to the low cold flow resistance of polythylene and the adverse effect thereof on mechanical seals. Compressed rubber or O-ring seals heretofore mentioned have been found to be ineffective against scored or braided surfaces and also to take a set in time under adverse weather conditions. Hot seals, as presently being utilized in the field, are difficult to apply in outdoor locations and take a great deal of time and

skill. It is contemplated that other available materials resistant to being vulcanized by ambient temperatures and having a sufficient stickiness to adhere to metal and to polyethylene may be employed. It is important that the material of use be pliable and that it be readily compressed and extruded under pressure.

FIGURE 3 shows a cable suitably prepared for insertion within a connector assembly with the end portion there aligned and partially inserted within the ferrule **46**. It should be apparent from FIGURE 3 how the inner portion of the ring **58** and the portion **48** serve to align and guide the cable within the connector assembly and also protect the sealing compound from being disturbed by such insertion. The structure of the ferrule **46** in the portion **54** also precludes a deposit of a compound onto the conductive portion of the cable. Also shown in FIGURE 3 is the inner or back-up ferrule of the assembly as inserted within the cable outer conductor. This back-up ferrule is shown as **60** and includes an outer diameter substantially equal to the inner diameter of the cable outer conductor **18**. One end of the ferrule is flared outwardly as at **62** to stop the ferrule in a proper position within the cable. The other end is slightly rounded to facilitate insertion of the ferrule **60** within the cable. The ferrule **60** is made of a relatively hard and deformation resistant material such as hard brass or beryllium copper and is given a wall thickness as thin as possible to reduce the change in diameter "seen" by RF energy transmitted through the ferrule.

FIGURE 2 shows the cable fully inserted within the connector assembly **24**. As will be apparent, the outer protective sheath **14** is butted against the portion **50** of the outer ferrule and the outer conductor **18** is carried down to the end of the ferrule within bore **48** over the ferrule **60**. A portion of the steel tape forming the arming of the cable is permitted to extend within the portion **48**.

With the cable so inserted within the connector assembly crimps are applied to the portions **54** and **48**, as indicated in FIGURES 2, 4 and 5. The crimp labeled C1 applied to protion **54** is comprised of spaced indentations, as shown in FIGURE 2, which drive the material of the ferrule inwardly and cause an extrusion of the sealing compound to either side of the indentations. Between the two indentations a pocket or recess extending around the cable outer sheath is formed and filled with the sealing compound. This body of sealing compound is sufficiently thick to withstand substantial contraction without separation from either the metal surface of the outer ferrule or the plastic surface of the sheath of the cable. In an actual embodiment following crimping, the recess formed was approximately 0.020 to 0.025 of an inch in thickness and about 0.125 of an inch in width. The crimp C1 was made to extend around the periphery of the ferrule to provide the recess mentioned extending around the periphery of the cable. A crimp of this type is taught in U.S. Reissue Patent No. 25,847 issued Aug. 31, 1965, in the name of E. W. Forney, Jr.

The crimp C2 applied to the portion **48** of the outer ferrule over the inner ferrule **60** is as shown in FIGURE 2, and serves to terminate the outer conductor **18** to the connector body through the outer ferrule **46**. The spaced indentations forming the crimp C2 are also of the O-crimp type taught in the previously mentioned patent.

The center conductor of the cable **20** is made to extend through the body **26** of the connector and through a forward portion of the connector assembly into the housing **10**. There the center conductor is terminated to a conductive path in the circuit supplied by the cable in any suitable fashion.

The forward part of the body **26** includes a recess shown as **61** containing a locking ring shown as **64** held in the recess by a turned up flange shown as **66**. The locking ring **64** is made to extend radially outward of the outer surface of the body in the forward portion to captivate a nut member shown as **68** through an engagement with an inner flange portion **70** thereof. The nut **68** is internally threaded as at **72** to mate with an exterior threading on an inner portion of a further nut shown as **74**. A flange on the forward end of nut **68** shown as **76** is turned inwardly to hold the nuts **68** and **74** together in an axial sense but to permit relative movement between the two nuts. The rear end of **74** includes a recess shown as **80**, containing an O-ring forced in compression by a relative movement of the nuts **68** and **74**, toward each other. The nut **74** contains an outer recess portion shown as **82**, which contains an O-ring compressed against a chamfered entrance of the housing **10** when the nut **74** is threaded into the receptacle **12**. The threading on the forward end of nut **74** is shown as **86**. The interior of the forward portion of nut **74** is recesed as at **88** and contains a dielectric insert shown as **90** which serves to support the center conductor **20** extended through the connector assembly. The insert **90** includes a beveled portion **92** which facilitates insertion of the cable center conductor into the insert and through the connector assembly into the housing **10**.

As an important aspect of the invention, the overall arrangement of the connector apparatus permits the forward portions formed by the nuts **68** and **74** to be turned relative to the body **26**, the gas port and the ferrule assembly as crimped to the cable. The threading **86** on the nut **74** is in a sense so that the nut **74** may be turned in a clockwise or right-hand sense to be threaded into the threaded receptacle **12** during insertion and in an opposite sense during withdrawal. The threading on the rearward end of nut **74** and the threading **72** interiorly of nut **68** is made so that the nut **68** is rotated in a clockwise or right-handed sense to draw the two nuts together and compress the O-ring **81** and at the same time to cause an engagement of the end of the nut **74** with the ring **64** to lock the nuts to the connector body shell **26**.

In use, the particular position desired for the gas port is selected relative to the normal lay of cable and relative to any adjacent cable or connector assembly to provide proper clearance. The connector body is then terminated to the cable by inserting the cable as previously described and effecting a crimp thereto. When this is done the gas port will be permanently oriented relative to the cable and to any adjacent assembly in a fixed position. At this time nut **68** is displaced to the relative left to **74** by a slight distance so that there is clearance between the portions **70** and ring **64**. The surface between these portions serves as a clutch to lock the two nuts together and to the body **26**. With the nut **68** displaced to the left and the assembly positioned at the entry of **12**, rotation clockwise of the nut **74** will cause it to be threaded within **12**, nut **68** following by reason of the engagement of **76** with **74**. During this time both nuts are free for rotation relative to the body **26**. After nut **74** is fully seated within **12** to compress the O-ring **84**, the nut **68** may then be rotated clockwise to first free it from engagement with nut **74** by displacing portion **76** to the right, as shown in FIGURE 2 and to bring the portion **70** into engagement with **64**, locking **64** and, in turn, locking **26** against the end of **74** compressing the O-ring **81**. At this time both nuts are locked together and to the body **26**. To remove the assembly from the housing the nut **68** is rotated counterclockwise until **70** is out of engagement with **64** and **76** is in engagement with the portion of **74** axially displaced therefrom, as shown in FIGURE 2. Then the nut **74** is rotated counterclockwise to back the threads thereof out of the threads in **12**.

Both nuts **68** and **74** have the same hex shape so as to permit rotation by the same size wrench or by the same setting of an adjustable wrench. The required rotation of both of the nuts is the same for both insertion and withdrawal, relatively fool-proof.

What is claimed is:

1. In a connection of coaxial cable of the type including

an inner conductor surrounded by an outer conductor and an outer protective and insulating sheath, a connector body having a bore receiving the cable inner conductor extended therethrough and means to support said inner conductor coaxially of said body, a malleable metallic ferrule joined to said body and a separate rigid metallic ferrule, the said rigid ferrule being fitted within the cable outer conductor with the outer conductor fitted within the malleable ferrule, a first portion of said malleable ferrule being crimped inwardly against said rigid ferrule to terminate said outer conductor to said body, a second portion of said malleable ferrule being crimped inwardly against the cable sheath, said second portion including a lining of sealing compound flowed by said crimping into a bonding and sealing engagement with said ferrule and the cable sheath around the periphery of said cable and means on the end of said ferrule to guide said cable therewithin without disturbing said lining or depositing sealing compound on the conductive portions of said cable, said means operating following crimping to preclude flow of said compound out of said ferrule.

2. The connection of claim 1 wherein said connector body includes means on the forward end thereof adapted to be rotated into a connecting engagement with mating connector means without rotation of said body and said ferrules.

3. The connection of claim 2 wherein said means on the forward end of the connector body includes further means to lock said connector body and ferrules against rotation following the said connecting engagement with said mating connector means.

4. The connection of claim 3 wherein each of said means includes a structure to permit a right handed rotation for engagement and locking of said connector.

5. In a termination of a coaxial cable having an inner conductor surrounded by an outer conductor and a protective sheath, a connector body including a forward body portion having an inner bore and means to receive and support the cable inner conductor coaxially within said body portion, said body portion having means on the end secured to the body portion and rotatable relative thereto to mate said connector with other connector means, a ferrule assembly mounted on said body including a separate circular inner ferrule of rigid construction positioned within the cable outer conductor and an outer ferrule joined to said body and including a first portion crimped inwardly against the cable outer conductor and the inner ferrule to join the body to the cable outer conductor and a second portion crimped inwardly against the cable sheath by a circular crimp extending around the sheath to form a circular recess surrounding said sheath, a pliable and adhesive sealing compound carried within said second portion and flowed by said crimp to fill said recess and provide a sealing bond between said second portion and said sheath.

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DARRELL L. CLAY, Primary Examiner

U.S. Cl. X.R.

29—628; 174—88; 339—177, 223, 276