

March 3, 1970

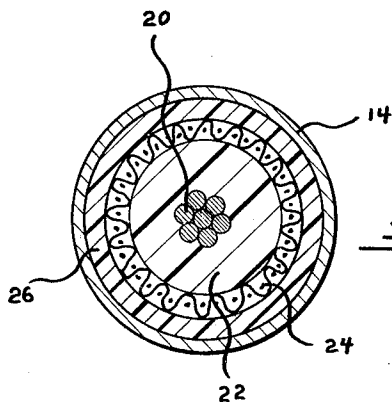
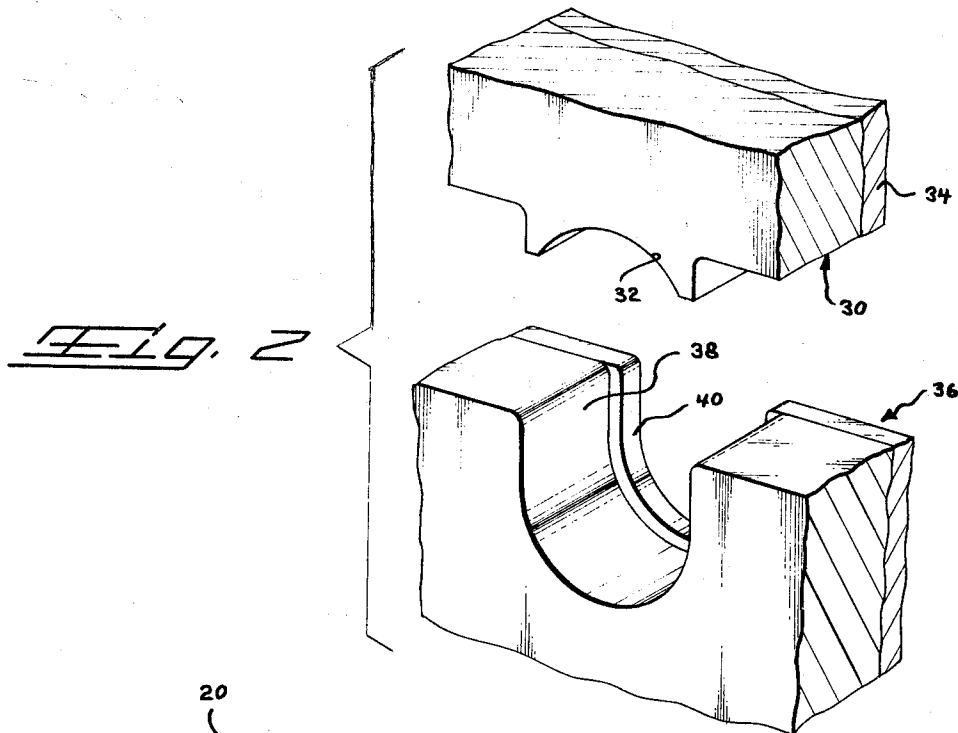
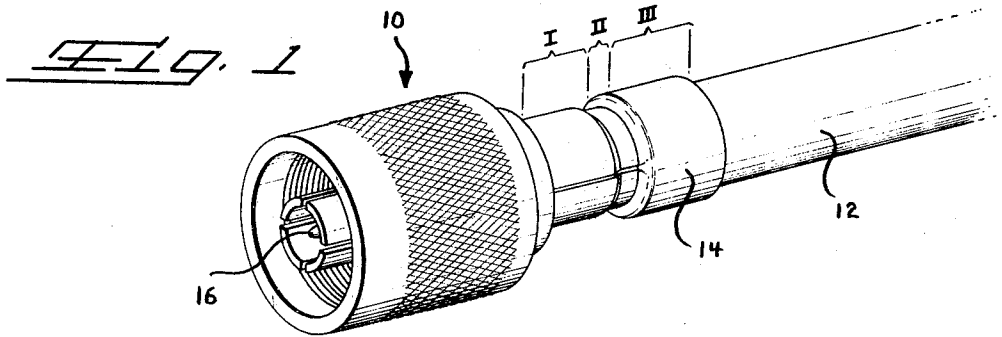
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3,499,101

OUTER CONDUCTOR CRIMP FOR COAXIAL DEVICES

Filed Aug 23, 1968

2 Sheets-Sheet 1



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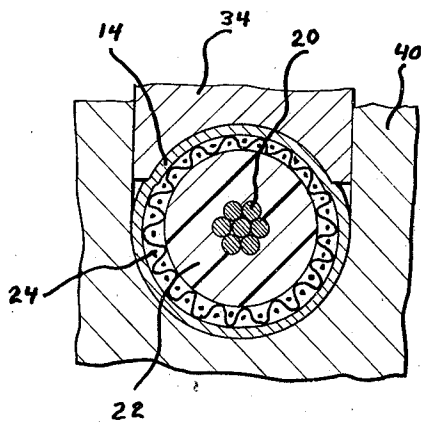
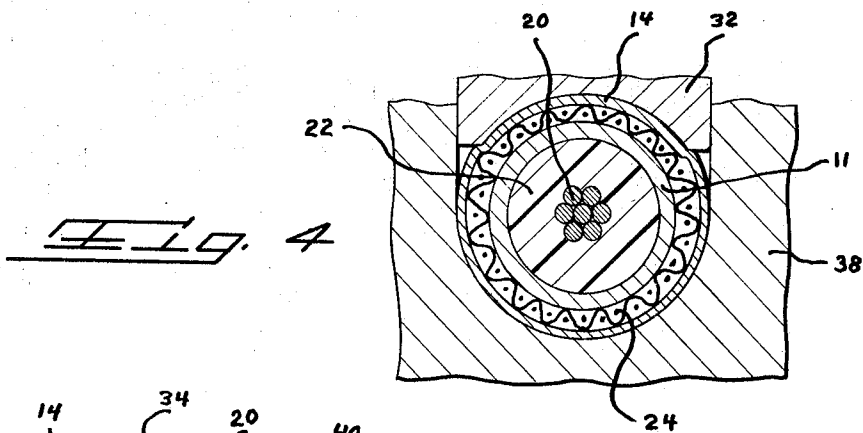
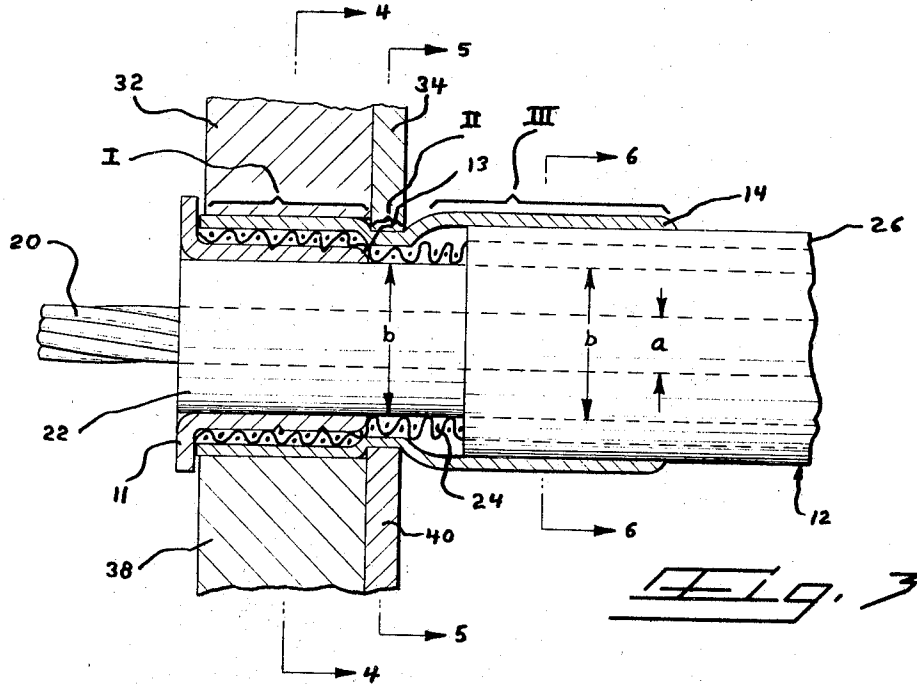
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OUTER CONDUCTOR CRIMP FOR COAXIAL DEVICES

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10 Claims

ABSTRACT OF THE DISCLOSURE

A coaxial cable termination technique and structure is disclosed which features a malleable ferrule crimped inwardly in a region overlying the rear of the coaxial device to force the cable outer conductor against the outer surface of the rear of the connector. At the end of the rear of the coaxial device the ferrule is crimped inwardly to an even greater extent to hold the cable outer conductor down against the cable dielectric sheath and prevent any slight air gap from occurring due to the transition of the cable outer conductor from its nominal inner diameter dimension to the expanded dimension to fit over the rear of the connector device. The ferrule is not crimped at all in its rear portion, which is made to extend over the cable outer conductive sheath to provide cable support and stabilize the crimped areas.

BACKGROUND OF THE INVENTION

In terminating coaxial cable there is a mechanical requirement usually expressed in terms of pull-out force and extent of twist which can be applied to a terminated joint before failure. Workers in the art try to achieve terminations which yield pull-out and torque values approaching that of the cable itself. Hand-in-hand with the mechanical test is an electrical test, usually expressed in terms of resistance of the termination relative to the resistance of the conductive portions of the cable. Workers in the art strive to provide a resistance which is not only as low as possible, but is maintained by the termination throughout its life in the presence of expected stresses. A third factor, which is of considerable importance for coaxial devices used with signals having high frequency components such as developed by high speed pulse or RF signalling techniques, is one of maintaining a given characteristic impedance and avoiding physical discontinuities which cause signal reflection. With high frequency components, dimensional deviations on the order of several thousandths of an inch in the transmission path can cause poor electrical performance in terms of voltage standing wave ratio (VSWR). Care in manufacturing to close tolerance cannot, by itself, answer the problem, especially with connector devices which call for hand assembly, relying in large part upon manual skills and dexterity. Even with crimp type connectors utilizing precision dies driven to an exact closure to minimize reliance upon manual skills, workers have experienced a continuing problem with achieving a consistently low VSWR in various designs and even between parts of a given design. The present invention is based upon the discovery of a technique of eliminating one major source of poor performance in coaxial connectors in general and crimp type connectors in particular.

SUMMARY OF THE INVENTION

The present invention relates to a technique and structure for terminating coaxial connectors to coaxial cable in a manner providing a reduced VSWR and an improved mechanical connection.

It is an object of the present invention to provide an

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improved method of terminating coaxial cable which improves the electrical performance of devices and cables terminated therewith. It is a further object to provide a method and structure for crimping coaxial connectors to coaxial cable in a manner minimizing signal loss and signal reflections introduced by such termination. It is still another object to provide a high frequency coaxial connector and a cable crimping technique capable of use in the field without requiring developed skills or dexterity in an operator.

The present invention attains the foregoing objectives providing a malleable ferrule which is fitted over a coaxial cable outer conductor in turn fitted over the rear end of a connector device with the ferrule being crimped inwardly around its periphery through crimping dies of a circular shape. Die closure is controlled to limit the extent of deformation of the ferrule, particularly in a segment thereof overlying the cable outer conductor where it passes over the end of the connector device so as to hold the cable outer conductor inwardly in this region of diameter transition to prevent air spaces which constitute changes in the inner diameter of the outer conductor of the cable. The rear portion of the ferrule is left uncrimped and is made to have an inner diameter to receive the cable outer insulating protective sheath in a sliding fit to support such cable. Indentation of the ferrule in the forward portion serves to mechanically connect the cable to the connector and electrically connect the cable outer conductor to the connector. Ferrule deformation in the region of transition of cable diameter to fit over the rear of a connector device in conjunction with the rear support portion of the ferrule serves to stabilize the interface between the cable outer conductor and the rear portion of the connector device against relative movement destroying such interface due to the cable being pulled upon or bent or twisted. The several features together improve mechanical and particularly electrical performance of coaxial connectors in high frequency applications of use.

In the drawings:

FIGURE 1 is a perspective view of a coaxial connector terminated to a coaxial cable;

FIGURE 2 is an enlarged perspective and partially sectioned view showing crimping dies used to terminate the connector of FIGURE 1;

FIGURE 3 is an enlarged and partially sectioned view of the rear portion of the connector shown in FIGURE 1 being terminated to the cable by the dies shown in FIGURE 2;

FIGURE 4 is a sectional view taken along lines 4—4 of FIGURE 3;

FIGURE 5 is a sectional view taken along lines 5—5 of FIGURE 3; and

FIGURE 6 is a sectional view taken along lines 6—6 of FIGURE 3.

Referring now to FIGURE 1, a coaxial connector half 10 is shown terminated to a coaxial cable 12. In use half 10 is mated with a complementary half which might be in the form of a receptacle attached to some equipment or to a mating connector half attached to cable. In general, half 10 defines a structure for mechanically and electrically connecting the inner and outer conductive portions of cable 12 to inner and outer conductive portions of a coaxial transmission path. The rear of the connector half 10 is terminated to the outer conductor of cable 12 by a ferrule 14. The ferrule has an original configuration in the form of a cylinder and a crimped configuration as shown in FIGURE 1 with different length segments I, II and III identified for ease of explanation. The center contact member 16 of half 10 is terminated to the cable inner conductor and there is a dielectric and insulating structure (not shown) provided between 16 and the outer conductive portions of half 10.

Referring now to FIGURE 3, the cable 12 may be seen to be comprised of a center conductor 20 surrounded by a dielectric sheath 22, an outer conductor 24 in the form of metallic braid covered over by an outer insulating and protective sheath 26. A given coaxial cable has a characteristic impedance Z_0 which is determined by the outer diameter of the inner conductor 20, the inner diameter of the outer conductor 24 and the effective dielectric constant of the dielectric sheath 22. Characteristic impedances is expressed as:

$$Z_0 = \frac{138.05}{\sqrt{\epsilon}} \log \frac{b}{a}$$

where:

b is the inner diameter of the outer conductor 26, a is the outer diameter of the inner conductor 20 and ϵ is the dielectric constant sheath 22.

In accordance with signal transmission theory, a change in characteristic impedance of a transmission line will result in a mismatch causing signal degradation. Such change can be caused by a variation in any of the parameters ϵ , b or a , along the transmission line. Signal degradation and reflections which are undesirable can be separately caused by physical discontinuities in the conductive surfaces forming the inner and outer conductive paths of a coaxial device, cable or connector. These two factors, mismatch and/or physical discontinuity becomes more significant as the rate of change of electro-magnetic field constituting a given signal increase. Such increase may be caused by an increased pulse rate where the rise and fall times of pulses becomes very brief, or by an increase in RF signalling frequency. Put another way, very small discontinuities and very small variations in connector parameters become relatively large as the wavelength of transmitted signal becomes very small.

We have discovered that an improved coaxial termination can be made by carefully deforming the crimping ferrule 14 inwardly in the region denoted II where the cable outer conductor fits over the rear of the connector device so as to make the cable outer conductor 24 conform to the dimension b in this region of transition. The improvement in performance runs to both a lower VSWR for a given connector design and to a more constant VSWR as between various parts of a given design. The improvement also manifests itself in providing a more stable electrical and mechanical interface between a cable and a connector device.

FIGURE 2 shows a die structure for use with the invention, including an upper die half 30 and a lower die half 36. The die halves are shown in an open position shown in FIGURE 2. In FIGURE 3 the die halves are shown in closure crimping ferrule 14 onto cable 26 and the rear connector 10. The upper die half 30 includes a die element 32 having a downwardly projecting portion with a rounded inner surface and a die element 34 of a similar configuration, but made to project beyond the surface of element 32 in the manner shown in FIGURE 3. The lower die half 36 includes a receptacle die element 38 having an inner rounded surface which leads into parallel sidewalls and there adjacent a similar die surface defined in an element 40 positioned slightly above the surface of 38. In closure the die halves 30 and 36 are driven together so that the projecting portions of 30 enter into the relieved portions of 36 to define essentially a circular configuration of die surfaces as shown in FIGURES 4 and 5. The dies 30 and 36 are driven in closure in a straight line through a straight action applicator mechanism. A number of bench-mounted applicators and hand tools are available to provide straight action die closure. As can be seen from FIGURE 3, elements 32 and 38 effect a crimp of portion I of the ferrule and elements 34 and 40 effect a crimp of portion II; portion III being clear of the dies and undeformed.

The element numbered 11 in FIGURE 3 represents

the rear end or back-up sleeve portion of connector 10. The portion 11 preferably has an inner diameter approximately equal to the outer diameter of the cable dielectric sheath 22 so as to receive such sheath inserted therein in a sliding fit and is preferably of a thickness and material to support the forces developed in crimping ferrule 14 inwardly thereabout. Portion 11 has an outboard end 13 which is preferably rounded, as shown in FIGURE 3 for reasons to be described.

In practice, cable 26 is first stripped to expose a portion of the center conductor 20 and a portion of the cable outer conductor 24. The ferrule 14 which has an initial inner diameter approximating the outer diameter of the cable protective sheath 26, is slipped back over the cable outer sheath with the cable outer conductor then being flared and the cable being fitted over the rear end of portion 11; the cable dielectric and center conductor being inserted therethrough in the manner shown in FIGURE 3. Ferrule 14 is then brought forwardly to the position shown in FIGURE 3 with the die halves 30 and 36 then being driven inwardly to deform the ferrule in the manner shown. As can be seen from FIGURE 4, the ferrule is deformed in the region overlying 11 into a circle driving the cable outer conductor 24 into surface engagement with the periphery of 11. As can be seen from FIGURE 4, the ferrule 14 is left with a pair of small protruberances due to the configuration of the die halves. These protruberances deviate from a circle only slightly and are held to a minimum consistent with providing dies which can be repeatedly used without breakage or excessive wear; i.e., without sharpened ends which would define a more perfect circle but would be worn or broken more easily.

As can be seen from FIGURES 3 and 5, ferrule 14 is deformed to an even greater extent in the region near the rounded end 13 of element 11 by the die surfaces of die elements 34 and 40. The width of the die elements 34 and 40 and the position relative to 13 is preferably controlled so that the deformed material of 14 follows the configuration of 13. This deformation results in the material of the ferrule holding the outer conductor 24 down snugly against the end 13 and against the outer surface of sheath 22. Die movement is controlled so that the deformation in region II adjacent end of 13 is sufficient to close all air space between the inner surface of outer conductor 24 and the outer surface of the sheath 22 so as to maintain the spacing between the cable inner and outer conductors constant. In other words, the crimp in region II is made to maintain the inner diameter of the outer conductor equal to b . As can be discerned from FIGURE 3, the indentation of 14 in region II has a length sufficient to clamp 24 in a band extending back from 13. This length is also made sufficient to avoid die surfaces which tend to cut the relatively thin material of ferrule 14 and also to provide body and strength to the die elements to avoid die breakage. By holding the outer conductor tightly, but without deformation relative to b , in the region II consistent, improved performance can be assured.

Ferrule 14 in the region III is left substantially undeformed. FIGURE 6 shows this portion of the connection in section. This portion of the termination serves to provide a mechanical support of the cable so as to minimize stresses developed by the cable being bent. The indentation of 14 in region II in conjunction with the extension in III operates to resist forces transmitted due to mechanical loads on the cable including bending, twisting moments and pull-out to thus better maintain the conductive interface defined in region I.

In accordance with an actual embodiment of the invention for a series N connector used with RG214/U cable (double braid), ferrule 14 had a nominal undeformed outer diameter of 0.472 of an inch and a thickness of 0.015 of an inch. The ferrule was formed of annealed copper silver plated and was approximately 0.800 of an inch in length. The ferrule deformation in region

I was approximately 0.317 of an inch in length with the deformation in the region II being approximately 0.062 of an inch in length. The foregoing is by way of example only as the invention is contemplated as useful with numerous other types of coaxial connectors, terminals, adapters and with coaxial cable of different constitutions including cable with other thin braid outer conductors such as thin metal tubing or foil.

Having now disclosed the invention in terms intended to enable a preferred practice thereof, the invention is defined through the appended claims.

What is claimed is:

1. In a method of terminating coaxial cable to a coaxial device of a type having a rear outer conductive shell portion of the steps including providing a malleable ferrule of a size to fit over the cable outer conductor as positioned over said shell portion, deforming said ferrule in a first region inwardly to terminate the cable outer conductor to said shell portion and deforming said ferrule inwardly in a second region just adjacent the end of said shell portion to press the cable outer conductor into a configuration with the inner diameter thereof substantially held by the ferrule in the second region to the nominal inner diameter of the cable outer conductor.

2. The method of claim 1 wherein said ferrule is made to have a length appreciably longer than said shell portion and a portion thereof is left undeformed to extend in a surrounding relationship over a portion of the cable to produce mechanical support to said cable and stabilize the termination.

3. The method of claim 1 wherein the end of the shell portion is rounded and the deformation in said second region is made to substantially conform to said rounded end.

4. The method of claim 1 wherein the deformation of said ferrule is made substantially circular in both said first and second regions.

5. The method of claim 1 wherein said ferrule is circular and is made appreciably longer than the said shell portion so as to extend back over a portion of said cable and the said deformation is controlled to provide a substantially circular cross-section throughout the length of the ferrule.

6. The method of claim 1 wherein said deformation in both said regions is achieved simultaneously.

7. In a method of terminating a coaxial connector of a type having a rear conductive shell portion to a coaxial cable of a type having an outer conductor of a given inner

diameter less than that of said shell portion including the steps of positioning the cable outer conductor over said shell portion providing a malleable ferrule of a diameter to fit over the cable outer conductor as positioned over said shell portion and of a length greater than said shell portion, deforming said ferrule to terminate said cable outer conductor to said shell portion and deforming said ferrule in a region adjacent the end of said shell portion in a manner controlled to eliminate the air gap between the inner surface of said cable outer conductor and the inner surface of said shell portion of the end thereof.

8. The method of claim 7 wherein said deformation of said ferrule in the region adjacent the end of said shell portion is limited to preclude deformation of said cable outer conductor to a diameter less than said given inner diameter.

9. In a connection of coaxial cable to a coaxial connector a connector including a metallic shell portion of an inner diameter approximating the inner diameter of a cable outer conductor and an outer diameter sufficient to provide a wall thickness for said shell portion to support crimping forces, a coaxial cable with a portion of the outer conductor positioned over the shell portion, a malleable ferrule of a length greater than said shell portion, said ferrule being crimped inwardly in a first region down against said portion of the cable outer conductor terminating said outer conductor to said shell portion, said ferrule being further crimped inwardly in a second region just adjacent the end of said shell portion to permanently hold said cable outer conductor inwardly to maintain the inner diameter thereof in said region equal to the inner diameter of the shell portion.

10. The connector of claim 9 wherein said ferrule includes a further portion extended back over the cable outboard of said second region to provide cable support and stabilize said termination.

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29—630; 339—177