May 2, 1967

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3,317,882

HIGH VOLTAGE COAXIAL CONNECTOR

Filed Oct. 5, 1964

2 Sheets-Sheet 1

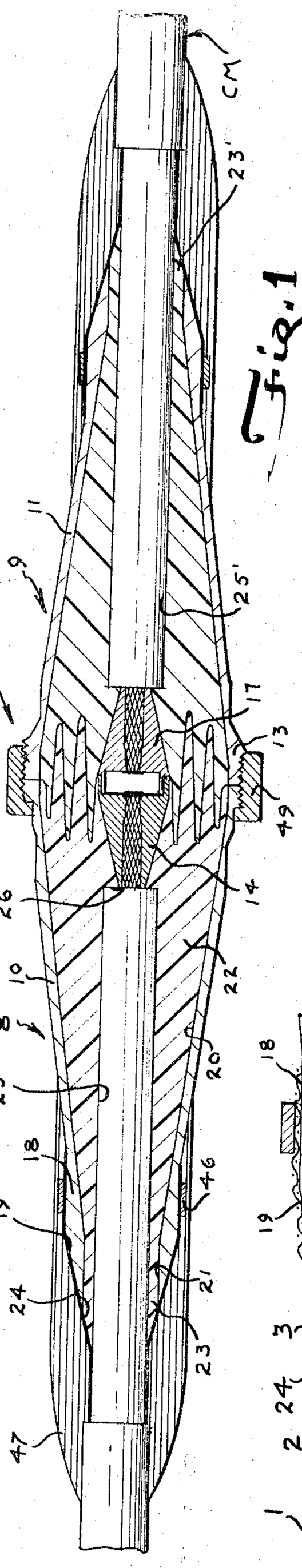

Fig. 1

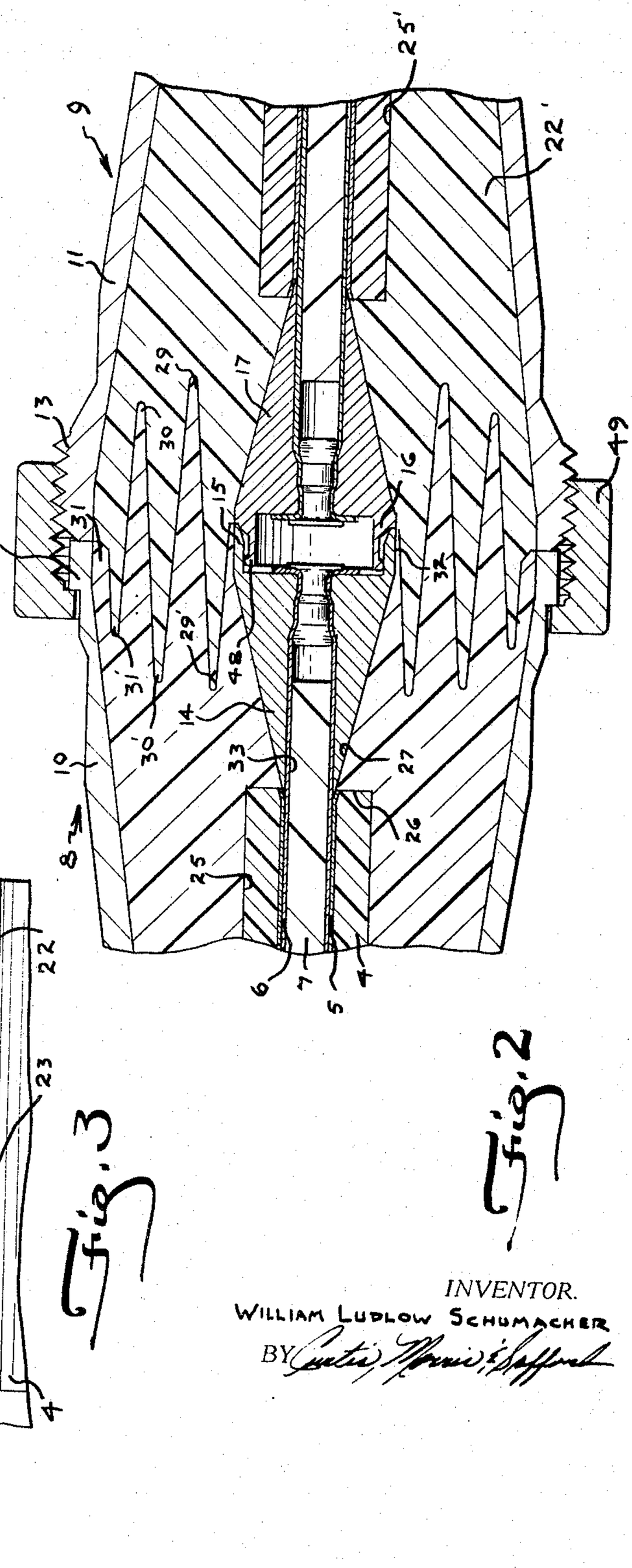

Fig. 2

Fig. 3

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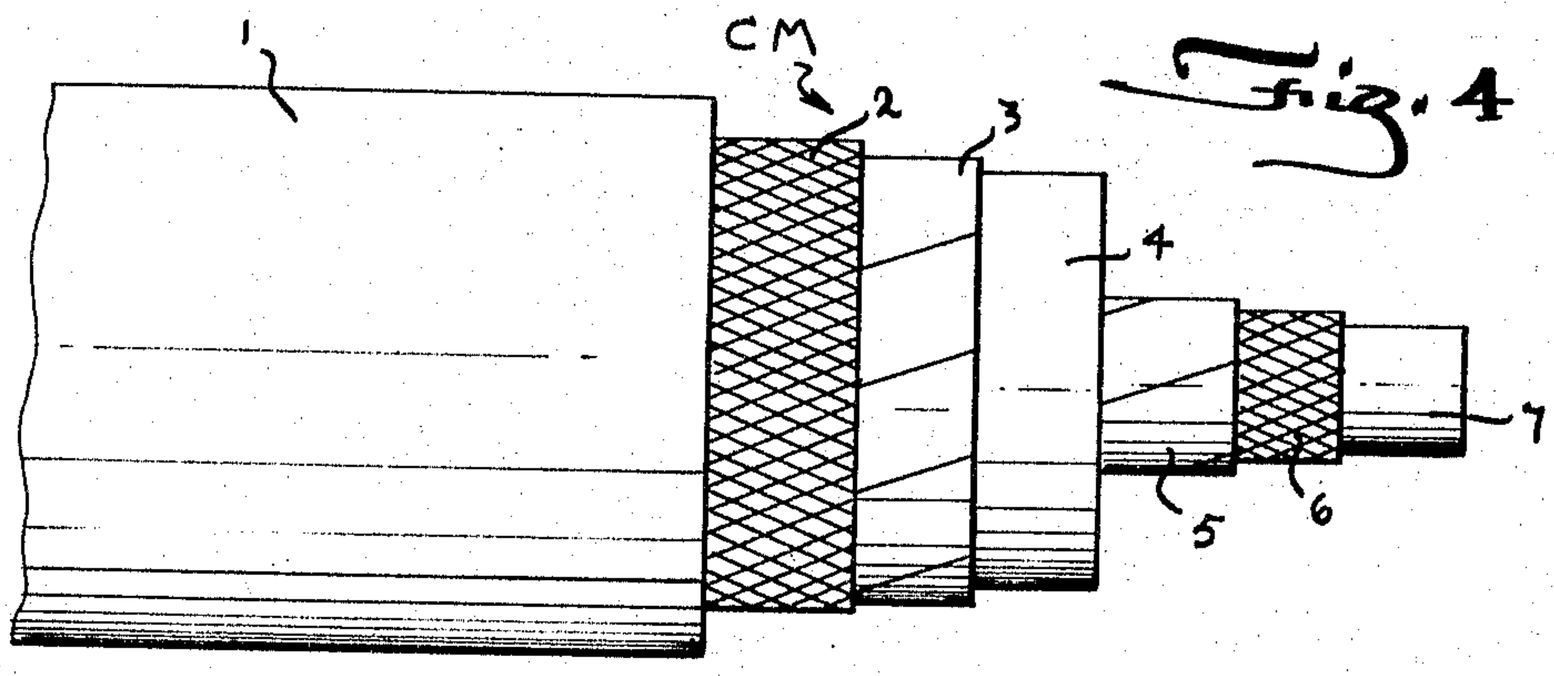

Fig. 4

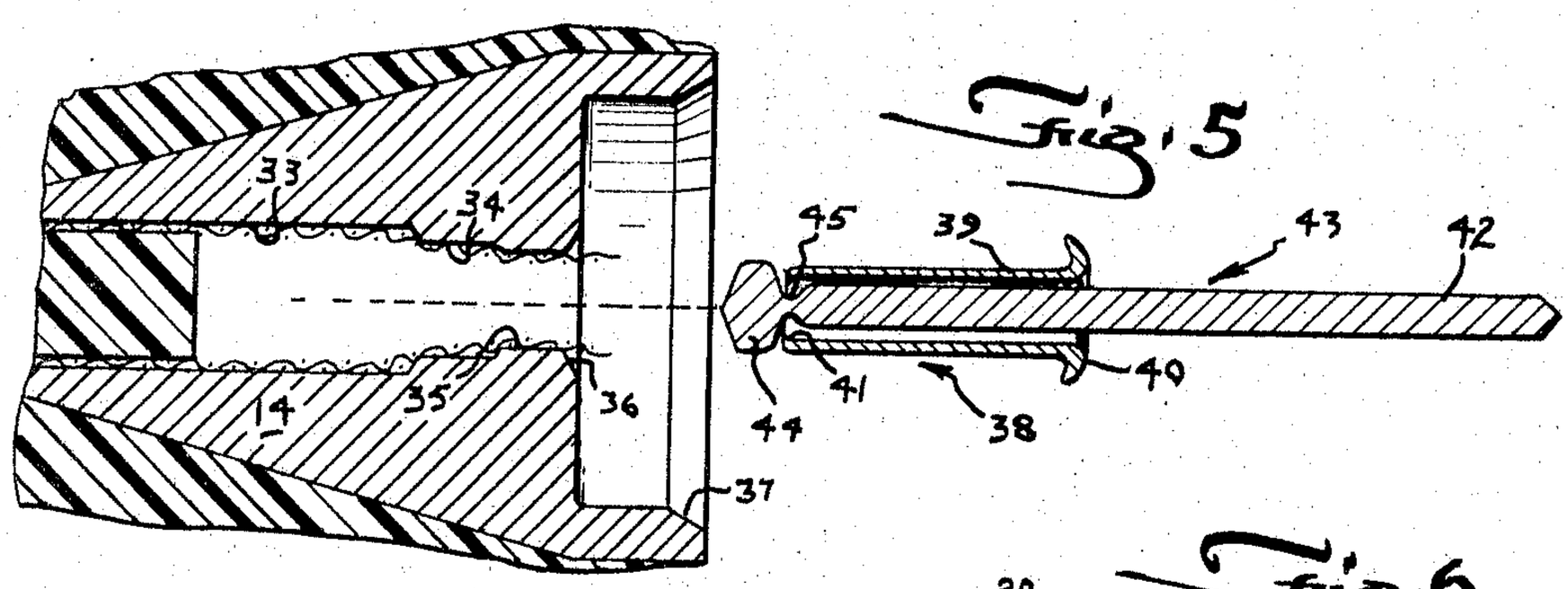

Fig. 5

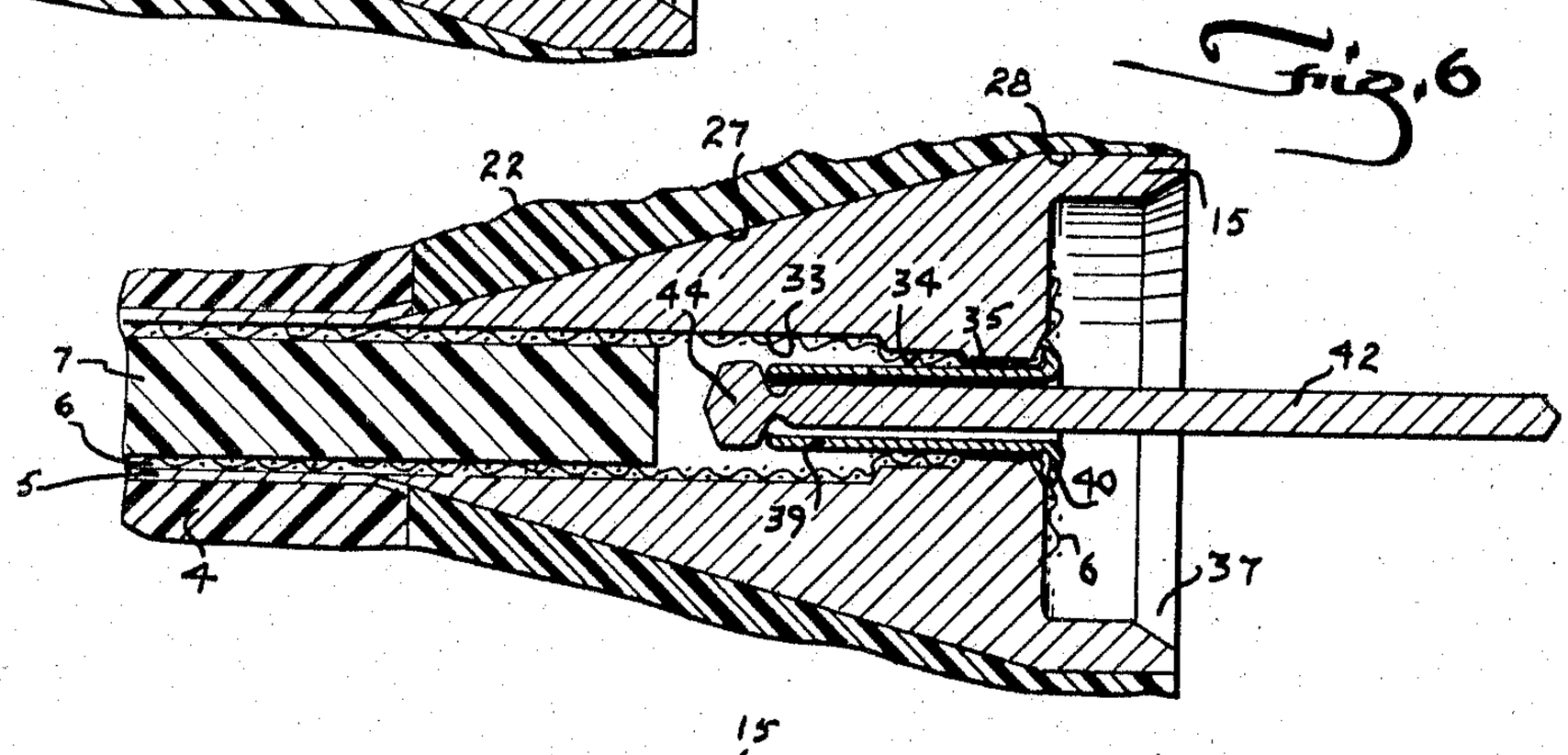

Fig. 6

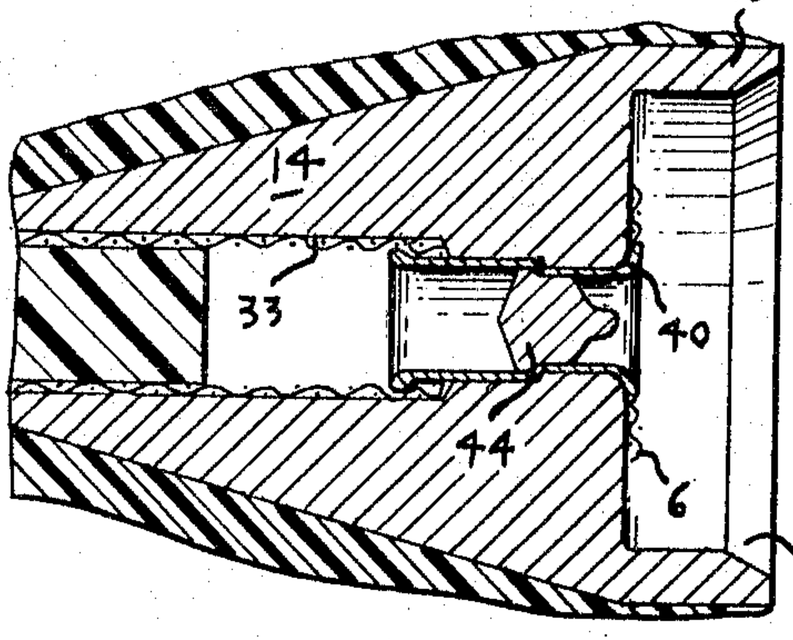

Fig. 7

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HIGH VOLTAGE COAXIAL CONNECTOR

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8 Claims. (Cl. 339—89)

This invention relates to electrical connectors and more particularly to electrical connectors for use in a high voltage environment.

In high voltage applications, the conductor means carrying the high voltage has to be terminated at specific locations. These terminations have to be selected with care in order to preclude the occurrence of corona, since, if corona does occur, the efficiency of the high voltage application is diminished, and deterioration of the insulating medium at the terminations occurs.

It is, therefore, an object of the present invention to provide an improved electrical connector suitable for use with high voltages.

Another object of the present invention is to provide an electrical connector wherein the amount of air therein is reduced to a minimum.

An additional object of the present invention is to provide a high voltage electrical connector in which corona discharges do not occur.

A still further object of the present invention is to provide a high voltage electrical connector wherein termination of the center conductor is riveted in place.

Other objects and attainments of the present invention will become apparent to those skilled in the art upon a reading of the following detailed description when taken in conjunction with the drawings in which there is shown and described an illustrative embodiment of the invention; it is to be understood, however, that this embodiment is not intended to be exhaustive nor limiting of the invention but is given for purposes of illustration and principles thereof and the manner of applying it in practical use so that they may modify it in various forms, each as may be best suited to the conditions of a particular use.

In the drawings:

FIGURE 1 is a cross-sectional view of the high voltage electrical connector connected to a coaxial cable means;

FIGURE 2 is a partial sectional view of FIGURE 1 but on an enlarged scale;

FIGURE 3 is a partial sectional view but on an enlarged scale of FIGURE 1;

FIGURE 4 illustrates a type of coaxial cable onto which the present invention is to be connected; and

FIGURES 5–7 illustrate the steps by which the center conductor means of the cable means is connected to a center connector element.

Turning now to the drawings and more particularly FIGURES 1–4, there is illustrated a high voltage connector C for connection onto a coaxial cable means CM. This coaxial cable means is a high voltage cable and is manufactured by the Boston Insulated Wire and Cable Company, Boston, Massachusetts, and comprises an outer insulation **1** surrounding a conductive braid **2** which, in turn, surrounds a semi-conductive tape **3**. A dielectric medium **4** is disposed between tape **3** and another semi-conductive tape **5** which, in turn, surrounds another conductive braid **6**. A core **7** of insulation material is disposed within braid **6** and provides support therefor. Coaxial cable means CM is stripped in the manner set forth in FIGURE 1 so that the high voltage connector can be properly connected thereto.

High voltage connector C comprises two identical members **8** and **9** except that hollow metallic shell **10** includes a flange **12** at its large end while the large end of hollow metallic shell **11** includes thread **13**. Another

minor difference is that center connector element **14** in member **8** in which the center conductor is to be secured, has a female section **15** in which a male section **16** of similar center connector element **17** disposed in member **9** is to be disposed. Since members **8** and **9** are identical in construction; with the exception of the differences pointed out hereinabove, only one member will be described in detail.

Shell **10** is frusto-conical in configuration and has a flat section **18** near the small end thereof which extends parallel to the longitudinal axis. Flat section **18** merges into a tapered section **19** which terminates at the small end of shell **10**. The inner surface of shell **10** is frusto-conical to a point almost opposite the junction between sections **18** and **19** whereupon it merges into a flat surface **21** coaxial with the axis of shell **10**.

Insulating material **22**, which is preferably made of silicone rubber, or the like, is disposed in shell **10**, and, as can be perceived, the outer surface of insulating material **22** has a configuration consonant with that of inner surfaces **20** and **21** of shell **10**. A segment **23** of insulating material **22** extends outwardly beyond the small end of shell **10** and has a tapered surface **24** in alignment with the tapered surface of section **19** so that these tapered surfaces define a frusto-conical configuration. A bore **25** of the same diameter extends centrally through insulating material **22** and terminates at an abutting surface **26**. Bore **25** is in communication with a frusto-conical opening **27** disposed in the large diameter end of insulating material **22**. Entrance **28** of frusto-conical opening **27** is circular until it merges with frusto-conical opening **27**, as seen in FIGURES 5–7. The surface of insulating material **22** between entrance **28** and the edge of the large diameter section of shell **10** is serrated defining spaced circular sections **29**, **30** and **31**. Sections **29** and **30** extend outwardly beyond the edge of shell **10** while section **31** is in alignment therewith. Part **32** of insulating material **22** also extends outwardly from the edge of shell **10**. It is to be noted that section **29** extends outwardly further than that of section **30**, and, of course, section **30** extends outwardly further than section **31** from the edge of shell **10**.

Insulating material **22'** of member **9** includes sections **29'** and **30'** similar to circular sections **29** and **30** of insulating material **22** in member **8** but that section **31'** extends outwardly from the edge of shell **11** further than corresponding section **31**. Thus, the distance measured along circular sections **29** through **31** of insulating material **22** and circular sections **29'** through **31'** of insulating material **22'** defines a path which is over 10 inches in length.

Center connector element **14** defines a frustoconical configuration from female section **15** to the end thereof. A bore **33** of constant diameter extends centrally through center connector element **14** and is in communication with stepped-down sections **34** and **35**, which, in turn, are in communication with the interior of female section **15**. Entrances **36** and **37** of respective sections **35** and **15** are preferably beveled (see FIGURES 5–7).

Shells **10** and **11**, insulating material **22** and **22'** and center connector elements **14** and **17** are assembled to form unitary structures. This is accomplished by securing center connector elements **14** and **17** and shells **10** and **11** to respective mold parts having a configuration corresponding to that of circular sections **29–31** and **29'–31'** by means of mandrels which form bores **25** and **25'**. Another mold part is secured to shells **10** and **11** at their smaller end via the mandrels, and these mold parts form segments **23** and **23'**. The inner surface of shells **10** and **11** and the outer surface of elements **14** and **17** are preferably coated with a suitable bonding material while the mandrels are coated with a suitable release agent. Insulating material

22 and 22' is then introduced within shells 10 and 11 through one of the mold parts to form the desired configuration of the insulating material in accordance with that disclosed. After the insulating material has filled the void within shells 10 and 11, the insulating material is placed under vacuum in order to remove all air pockets and render it free of air as well as to remove all air from the interfaces between the shells and the insulating material and the center connector elements and the insulating material. When the insulating material has set, the mold parts and mandrels are removed from shells 10 and 11 which are now unitary structures.

Of course, it is possible to mold insulating material 22 and 22' in its desired form and then insert this material within respective shells 10 and 11 with elements 14 and 17 being inserted in their proper places in the presence of bonding material on the shells and the elements to form the shell unitary structures.

In assembly, coaxial cable means CM is properly stripped in the manner illustrated in FIGURES 1 and 2. If dielectric material 4 is of the wrapped variety, it is preferable to wrap the stripped end thereof with a nylon monofilament or the like in order to preclude any air gaps occurring therein. Grease is also applied to the forward portion of dielectric 4 to eliminate any air gap made possible by mismatch of dielectric 4 and abutting surface 26 of insulating material 22. The assembly of shell 10, insulating material 22 and center connector element 14 is pushed onto the coaxial cable means such that elements 4 through 7 pass into bore 25 of insulating material 22 and the tapered surfaces of sections 23 and 19 of insulating material 22, and shell 10 fits underneath semi-conductive tape 3 and braid 2, as shown in FIGURE 3, with tape 3 terminating about halfway along the tapered surface of section 19. The stripped end of dielectric 4 engages surface 26 and braid 6 and core 7 extend into bore 33 with the end of braid 6 extending beyond entrance 36 while the end of core 7 terminates about midway of bore 33, as illustrated in FIGURES 2 and 5 through 7. As stated hereinbefore, the grease applied to the stripped end of dielectric 4 is disposed between surface 26 and the stripped end of dielectric 4 in order to compensate for any mismatch therebetween, to exclude any air therefrom, and to form a seal therebetween. This grease is preferably of the monoflow type identified as Nebula EP–2, which is manufactured by the Standard Oil Company of New Jersey.

As shown in FIGURE 6, the inner sharp edge of center connector element 14 extends within semi-conductive tape 5 and dielectric 4 so that semi-conductive tape 5 is in engagement with the outer surface of center conductor element 14.

A Pop rivet assembly 38 of the type manufactured by United Shoe Machinery Corporation, Shelton, Connecticut, comprises a tubular member 39 having at one end an outwardly-directed flange 40 and an inwardly-directed flange 41 at the other end. Shank 42 of a pin 43 is disposed within tubular member 39 and extends outwardly from flange 40. Pin 43 includes a head 44 disposed adjacent flange 41, and area 45 between shank 42 and head 44 is of less diameter than that of shank 42.

Pop rivet assembly 38 is inserted within braid 6, stepped sections 34 and 35 and into bore 33 of center connector element 14, as illustrated in FIGURE 6. With the Pop rivet assembly in position within center connector element 14, a conventional Pop rivet actuating tool (not shown) is placed into engagement with the part of shank 42 extending outwardly from flange 40. Upon actuation of the Pop rivet actuating tool, end 43 moves relative to center connector element 14 causing head 44 to move completely within tubular member 39 and coming to a wedged position of rest therein within stepped section 35, as illustrated in FIGURE 7.

The action of head 44 moving within tubular member 39 causes flange 40 to be seated within beveled entrance 36, moves the part of tubular member 39 disposed in bore

33 outwardly against braid 6 disposed in bore 33 thereby spreading braid 6 against bore 33 and the interface between bore 33 and stepped section 34, and, at the same time, shortening the length of tubular member 39. The continued movement of head 44 within stepped section 34 moves the tubular member, in this section, outwardly against braid 6 causing the braid to be wedged against stepped section 34 effecting excellent electrical and mechanical contact. At the interface between stepped sections 34 and 35, head 44 then comes to rest with parts disposed in stepped sections 34 and 35, and, in doing so, moves the part of tubular section 39 therein outwardly against braid 6 causing the braid to be wedged against stepped section 35. After head 44 has moved to its position of rest at stepped sections 34 and 35, as illustrated in FIGURE 7, shank 42 is removed from head 44 by additional tensile force which causes shank 42 to break at area 45 so that shank 42 does not remain a part of the Pop rivet assembly after the Pop rivet has been secured in position. The wedging action of tubular member 39 against braid 6 becomes progressively increased from bore 33 to stepped section 35 whereat it reaches its maximum wedging action. The wedging action of flange 40 against braid 6 at entrance 36 is also excellent. Thus, as can be discerned, there has been disclosed a unique connection of the center braid 6 onto center connector element 14 by a rivet means to provide an excellent electrical and mechanical connection external of the critical high voltage field where sharp projections or air of any amount cannot be tolerated.

Now that braid 6 has been effectively connected to center connector element 14, braid 2 and tape 3 are affixed in intimate contact with the tapered surfaces of sections 19 and 23. A suitable insulating material 47, such as, insulating tape is wrapped tightly over braid 2 and semi-conductive tape 3 so as to exclude any air pockets. Clamp 46 of any desirable form is used to affix braid 2 to flat section 18 of metallic shell 10, thus, providing a positive electrical connection as well as providing mechanical strength. Additional wrapping of insulating tape 47 is used to cover the clamp and braid ends. If desired, a conductive paint or grease may be spread on the surface of cable dielectric medium 4 and surface 24 to aid the exclusion of air during this final assembly operation. Also, if desirable, insulating material 47 may be accomplished in any desirable fashion such as, slipping a premolded boot having a contoured inner surface so as to provide air exclusion from between the surfaces of 4 and 24 and tape 3. The same procedure, as outlined hereinbefore, is followed in connecting the coaxial cable means to the elements of member 9.

After the coaxial cable means has been connected to the elements of members 8 and 9 of the connector member, members 8 and 9 are ready to be brought into engagement to interconnect shell 10 with shell 11 and center connector element 14 with center connector element 17. After members 8 and 9 have been brought into engagement, circular sections 29 through 31 of insulating material 22 mesh with circular sections 29' through 31' of insulating material 22' and male section 16 of center connector element 17 is disposed within female section 15 of center connector element 14. Beveled entrance 37 of female section 15 and semi-circular segmented spring lip 48 on male section 16 facilitate the insertion of male section 16 within female section 15. The diameter of semi-circular spring lip 48 is slightly larger than that of the interior surface of female section 15 so that an excellent mechanical and electrical connection is obtained between center connector element 14 and center connector element 17.

In order to draw the edges of members 8 and 9 into a tightly abutting relationship, as illustrated in FIGURES 1 and 2, a threaded coupling member 49 engages flange 12 of shell 10 and threaded section 13 of shell 11, and, upon tightening coupling member 49 onto threaded sec-

tion 13, members 8 and 9 are brought into tight engagement. At this position of engagement, circular sections 29 through 31 are tightly meshed with circular sections 29′ through 31′, which excludes all air therefrom and male section 16 is properly seated within female section 15. Thus, the path from engaged shells 10 and 11 to engaged center connector elements 14 and 17 is along tightly meshed circular sections 29 through 31 and 29′ through 31′, and is over 10 inches in length, as mentioned hereinbefore. As can be perceived, the points of change in the direction of the path are not in alignment so that these points which are parallel with the voltage stress between center connector elements 14 and 17 and outer shells 10 and 11 will not have any cumulative effect. The points of circular sections 29 and 29′ have been arranged to be the farthest from the center line of the connector in order to place them at a point of lower voltage stress in the field because the highest voltage stress occurs at the surface of inner tape 5 and center connector elements 14 and 17.

The electrical connection between male section 16 and female section 15 of the center connector elements is made interiorly of the electrical field so that the space therebetween which contains air does not effect this connection. Semi-conductive tapes 3 and 5, disposed on each side of dielectric medium 4, obviate the occurrence of any air between braids 2 and 6, since they are in intimate contact with this dielectric medium. Dielectric medium 4 fits snugly within insulating material 22 so that no air is present within the connector. If the surface of dielectric medium 4 is not smooth, a grease is used to fill any possible voids.

As can be discerned, there has been disclosed a novel coaxial cable connector for connection on coaxial cable means carrying high voltage and including a unique connection for the center conductor means.

It will, therefore, be appreciated that the aforementioned and other desirable objects have been achieved; however, it should be emphasized that the particular embodiment of the invention, which is shown and described herein, is intended as merely illustrative and not as restrictive of the invention.

What is claimed is:

1. A high voltage coaxial connector for connection onto coaxial cable means comprising hollow metallic means including a first and a second shell member, each shell member having a section for securing outer conductor means of said coaxial cable means thereon, insulation means disposed in said shell members, each insulation means having a bore for receiving center conductor means therethrough, center connector means in said insulation means, said center connector means having an opening provided with areas of less and decreasing diameter than said bore adjacent one end of said center connector means, said opening receiving a center conductor means, connecting means disposable within said areas of said opening with said center conductor means being disposed between said areas and said connecting means, movable means comprising a frangible member disposable within said connecting means and being forcefully movable along said connecting means thereby forceably driving said connecting means into engagement with said center conductor means and said areas with said frangible member being broken from said movable means after said movable means has driven said connecting means into engagement with said center conductor means and said areas, means to secure said shell members together to interconnect said center connector means and to interconnect said outer conductor means, and insulation means for disposition over said shell members from said outer conductor means securing section onto said coaxial cable means.

2. A high voltage coaxial connector according to claim 1 wherein said center connector means of one shell member includes a female section and said center connector means of the other shell member includes a male section for engagement within said female section so that electrical contact therebetween is made interiorly of the electrical field.

3. A high voltage coaxial connector according to claim 1 wherein each shell member and corresponding insulation means and center connector means constitutes a unitary structure.

4. A high voltage coaxial connector according to claim 1 wherein said insulation means include matable concentric circular sections defining a path between said outer and center conductor means exceeding a diameter of said coaxial connector.

5. A high voltage coaxial connector according to claim 4 wherein said concentric circular sections decrease in length from the innermost circular section to the outermost circular section.

6. In a coaxial connector for connection of coaxial cable means having an outer insulation covering, and outer and inner conductor means and dielectric means between said outer and inner conductor means, hollow metallic means having ends for disposition under said outer conductor means of coaxial cable means to be joined, securing means for securing said outer conductor means proximate the ends of said hollow metallic means, said hollow metallic means comprising two shell means each of which includes insulation means snugly disposed therewithin, said insulation means having a bore therethrough for receiving said dielectric means and inner conductor means, a center connector means in said insulation means, said center connector means having an opening in communication with said bore, said opening provided with connection areas of less diameter than said opening, means for affixing said inner conductor means to said center connector means including connection means disposable within said connection areas and movable means forcefully movable along said connection means to forcefully drive said connection means into engagement against said connection areas with said inner conductor means disposed between said connection areas and said connection means, and means to secure said shell means together to interconnect said outer conductor means, to interconnect said inner conductor means and to intimately bring said insulation means into tight engagement along a path between said inner and outer conductor means which exceeds the diameter of said coaxial connector.

7. In a coaxial connector according to claim 6 wherein the end surface of each insulation means containing said center connector means includes concentric circular sections which mesh when said shell means are secured together to define said path.

8. In a coaxial connector according to claim 7 wherein the circular section adjacent said center connector means is longer than the other circular sections.

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