May 13, 1969 S. GERHARD 3,444,507

ELECTRICAL CONNECTORS FOR SEMI-SOLID CONDUCTORS

Filed Oct. 23, 1967

FIG. 1

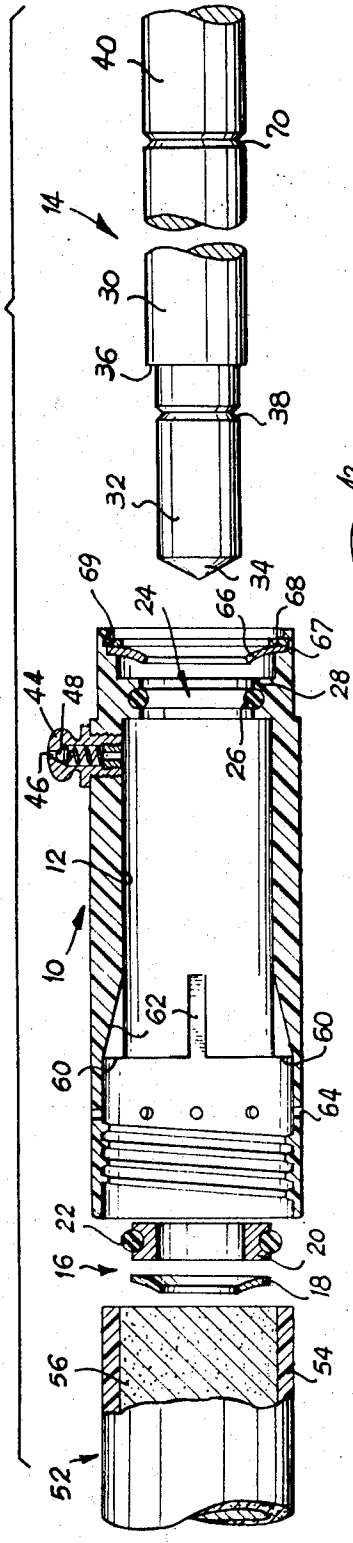


FIG. 2

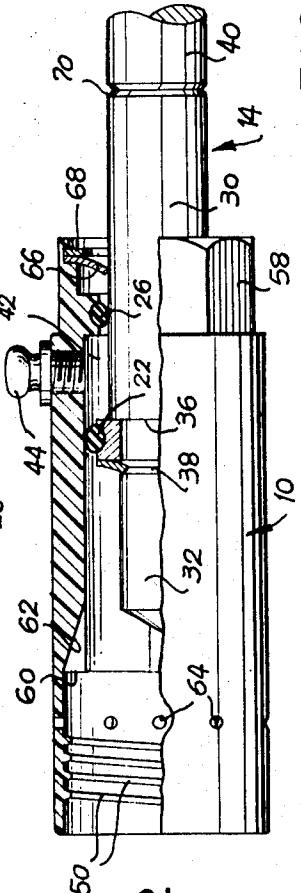
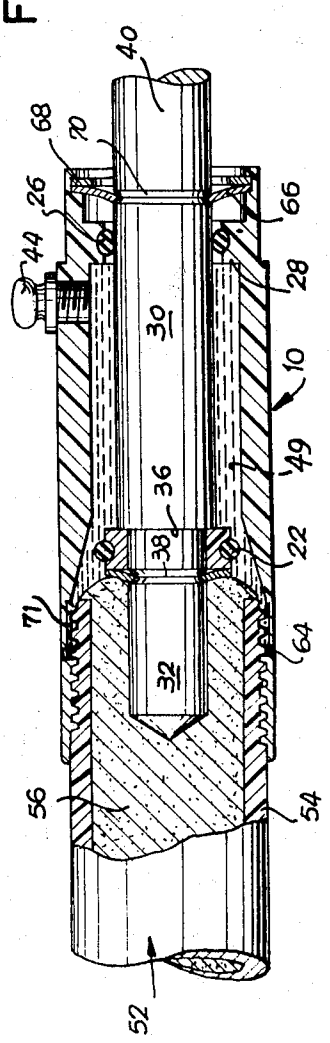


FIG. 3



INVENTOR.

BY SIDNEY GERHARD

Howard L. Reiter

ATTORNEY

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ELECTRICAL CONNECTORS FOR SEMI-SOLID CONDUCTORS

Sidney Gerhard, Norwalk, Conn., assignor to Burndy Corporation, a corporation of New York

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ABSTRACT OF THE DISCLOSURE

An electric terminal connector, for electrical cable of the type which has a central core of highly ductile metal enclosed within an outer insulating jacket, in which a fixed portion of the connector is secured to the cable jacket and hydraulic pressure is employed to displace a piston-like contact element relative to the fixed portion so as to urge the contact into engagement with the ductile metal core of the cable.

This invention relates to electrical connections and connectors, and has the general object of providing a simple, sturdy, and effective means for establishing reliable electrical connections to electrical cables of an unusual type.

The insulated electrical cable contemplated for use with this invention comprises a core of highly ductile conductive material such as sodium, encased within a tubular insulating jacket of strong, flexible material such as commercially available polyethelene.

Sodium conductor cables are of significant interest to the electrical power industry because the metal offers electrical characteristics favorably comparable to the more commonly used copper and aluminum conductors at substantially less cost. It is known, however, that certain other physical characteristics of sodium, and similar conductive metals, differ substantially from those of the standard cable conductors.

It has been found that the previously known connection and construction techniques for electrical cable conductors do not operate effectively with a conductor which cannot be welded, soldered, or physically clamped in any practical manner. Connections to cables of the sodium conductor type are further complicated by the necessity for protecting the conductor from exposure to air, water, and other reactive elements.

Accordingly, it is an object of this invention to provide an electrical connection which effectively seals the exposed end of a cable to which it is applied, against exposure to reactive elements.

A further object of this invention is the provision of an electrical connector which employs force-multiplying means for assuring positive engagement of a contact member with the central conductor of an electrical cable. Other objects of this invention are directed generally toward providing reliable, inexpensive, and easily applied connectors and connection techniques for establishing secure electrical and mechanical contact with electrical cables having conductors formed of reactive and/or ductile materials.

Features of this invention include the use of an outer body member which can be secured to the insulating jacket of a cable and which includes an inner cylinder portion, in combination with a piston-like contact element forming an expansible chamber within the cylinder portion of the body member, such that hydraulic pressure may be applied within the chamber to urge the contact member into engagement with the cable conductor.

These and other objects, features, and advantages of this invention will be distinctly and specifically pointed out in the accompanying claims and will be more fully

disclosed and explained in the following specification, in conjunction with the accompanying drawings, in which;

FIG. 1 is a partially-exploded, longitudinal-section view of a connector constructed in accordance with this invention, shown in axial alignment with the end of an electrical cable;

FIG. 2 is a partially-sectioned longitudinal elevation view of the connector of FIG. 1 shown in assembled position; and

FIG. 3 is a fully sectioned view of the assembled connector of FIG. 1, shown coupled to the end of an electrical cable.

Referring now more specifically to the drawings, the connector of this invention, as shown in FIG. 1, may be seen to comprise an outer body member, indicated generally by reference numeral **10** and including an inner cylinder portion **12**, and a central conductive contact member **14** which is adapted to have a piston-ring assembly **16** secured thereto by means of snap-ring **18**. The assembled relationship of the elements of the connector are shown more clearly in FIG. 2. Piston-ring assembly **16** may be seen to comprise a circular ring element **20**, formed of any suitable structural material, and an outer sealing washer **22** mounted in the outer periphery of ring **20**.

As seen in FIG. 2, body member **10** includes an end-opening **24** which opens into inner cylinder **12**. A sealing washer **26** is disposed within a reduced diameter portion **28** of body member **10** to form a sliding-seal engagement with the main body portion **30** of contact element **14**. The contact element is, in turn, provided with a forward contact portion **32** which may be pointed as at **34** to facilitate penetration into the central core conductor of a cable of the type described. A shoulder **36** is formed on the contact element between body portion **30** and contact portion **32**; and a retaining-ring groove **38** is formed in portion **32**, spaced axially from shoulder **36**. Piston-ring assembly **16** is captured to contact **14** by slipping the assembly over contact portion **32** until ring **20** abuts against shoulder **36**; locking-ring **18** is then slipped over portion **32** until it snaps into groove **38**, thereby capturing assembly **16** between itself and shoulder **36**.

Contact element **14** includes extending tail portion **40** which is disposed externally of the body portion **10**. In use, tail portion **40** may be given any suitable configuration for establishing electrical connections between contact element **14** and external electrical conductors. Piston-ring assembly **16** is formed separately of contact **14** to permit the connector to be assembled by slipping forward end portion **32** of the contact element through sealing washer **26** when the transverse dimension of tail portion **40** is greater than the diameter of sealing washer **26**. It is considered obvious, however, that alternate means may be employed to provide the contact element **14** with a tail portion **40** and with a piston-ring assembly **16**, without departing from the concepts and scope of this invention.

When the elements of the connector have been assembled together as described above, sealing washer **26** and piston-ring assembly **16** form, between them, an expansible chamber **42** bounded by the inner wall of cylinder **12** and the main body portion **30** of contact **14**. An inlet fitting **44**, which includes central inlet passage **46**, is mounted in the wall of body member **10** to provide access to expansible chamber **42** from the exterior of the connector. Hydraulic fitting **44** is preferably of the one-way valve type, characterized by a ball valve **48**, which is adapted to permit passage of hydraulic fluid material in one direction only (into chamber **42**) through inlet passage **46**. By means of inlet passage **46**, therefore, it is possible to introduce flowable fluid material into expansible chamber **42**. Introduction of the fluid, under pres-

sure, will displace contact element **14** relative to body member **10** from the position shown in FIG. 2 to the relative position shown in FIG. 3. The fluids contemplated for use in this application include greases, "liquid rubbers," and hardenable materials, such as epoxies and the like, in addition to the more conventional hydraulic pressure fluids. The use and advantages of this feature will be made apparent below.

The end of body member **10** which is remote from sealing washer **26** is provided with an internally formed helical screw thread **50**. This threaded portion is adapted to receive the outer diameter of an electrical cable such as **52**, in threaded relationship. As shown most clearly in FIG. 1, cable **52** includes an outer jacket **54** of insulating material which surrounds a central core **56** of highly ductile, conductive metal. Screw threads **50** are self-tapping in nature, and are designed to engage and cut a mating helical-thread into the outer surface of cable jacket **54**. To facilitate threaded engagement of the body member with the cable, the outer surface of the body member is provided with a series of flat surfaces, such as **58**, in the manner of the well-known wrench-flats on a standard nut and bolt. An ordinary mechanic's wrench may thus be used to facilitate application of body member **10** to the end of a conductor **52** with sufficient force to securely fasten the two together. The interior of body member **10** may be provided with a cable-strap shoulder **60** at one end of cylinder **12** as a means for assuring that a sufficient length of the cable jacket **54** will enter the connector as the body member **10** is threaded onto the cable jacket.

The connector of this invention, which has been described thus far, is secured to an electrical cable to form a terminal connection as follows: with contact element **14** in the "retracted" position relative to body member **10**, as shown in FIG. 2, the threaded portion **50** of the body member is engaged to the insulating jacket **54** of a cable **52**, by hand or by means of a wrench applied to wrench-flats **58**. After the body member has been securely fastened to the cable jacket, a source of hydraulic material is coupled to inlet fitting **44** and hydraulic material **49** is pumped into expansible chamber **44** until contact element **14** has been displaced from the position shown in FIG. **2** to the position shown in FIG. 3. The contact and body member are relatively dimensioned so that in its forward-most position, forward contact portion **32** of contact element **14** is embedded within the highly ductile central conductive core **56** of cable **52**. Embedding of the contact portion has been found to be necessary to break through the high resistance film which forms at the cut end of a cable due to reaction of the sodium with airborne water vapor. The pressure applied to hydraulic material **49** in filling expansible chamber **42** assures penetration of the care by the conductive element.

As the contact element penetrates the core, a portion of the core material will be displaced unavoidably beyond the end of the cable jacket **54**, as shown in FIG. 3. Air displaced by the core material and by the moving contact element is vented through outlet ports **64**. By-pass passages **62**, which are provided within the body **10** between cylinder **12** and annular chamber **71**, are a feature of this invention which permit the use of hydraulic material **49** to prevent escape of the displaced core material. Use of the hydraulic material in this manner also prevents further contact of the core material with air, water vapor and water which may be present outside the body **10**.

As shown in FIG. 3, the by-pass passage operate, when contact element **14** is in its forward-most position, to permit escape of hydraulic material **49** from chamber **42** past piston-ring assembly **16** and into contact with the exposed core material. As the flowable hydraulic material is pumped into chamber **42**, by-pass passages **62** and annular chamber **71** become filled, thereby completely surrounding the core material and a portion of the cable jacket **54**. A plurality of outlet ports **64** are provided through the wall of body member **10** to permit limit escape of material **49** after the material has completely filled annular chamber **71**.

The several outlet ports **64** permit the venting of air from within the connector assembly regardless of the attitude or position of the connector. Additionally, they provide a convenient external visual indication that the connector has been sealed, by material **49**, against escape of core material **56** and against entry of air, water and water vapor into body **10**.

A further feature of this invention is the provision of additional means for locking contact element **14** in the "advanced" position shown in FIG. 3. This locking means includes resilient detent locking-ring **66**, which is secured to body member **10** by means of a retention washer **68** positioned within an annular groove **69** in body member opening **24**. Locking-ring **66**, which is canted inwardly in the direction of advancement of contact element **14**, interengages with locking groove **70** in the contact element, to prevent rearward movement of the contact after it has reached the forward-most position shown. The use of this detent means may replace or supplement the retention achieved by the use of a hardenable or "settable" hydraulic fluid.

This invention has now been described, but it is desired to be understood that it is not confined to the particular forms or usages herein set forth for the purpose of illustration, and that the invention may be carried out in other ways without departing from the spirit or scope of the invention; therefore, equivalent instrumentalities may be employed by means of which objects of this invention are attained and new results accomplished, as it is obvious that the particular embodiments herein shown and described are only some of the many that can be employed to obtain these objects and accomplish these results.

I claim:

1. An electrical connector, adapted to be electrically coupled to the end of an electrical cable which has a homogeneous central core of highly ductile metal enclosed within a substantially tubular insulating jacket, said connector comprising:

an outer body member having a substantially central cylinder portion therein;

a central conductive contact member having a piston portion telescopically disposed within said central cylinder portion, defining an expansible chamber within said body member;

means on said body member for securing said body member to the insulating jacket of an electrical cable in coaxial relationship;

means on said body member for introducing flowable hydraulic material into the said expansible chamber, under pressure, to displace said piston portion relative to said cylinder portion;

a contacting portion on said contact member, extending from said piston portion, for engaging the conductor of an electrical cable secured to said body member upon displacement of said piston portion relative to said body member;

external connection means on said contact member disposed externally of said expansible chamber for establishing electrical connections therewith.

2. The electrical connector of claim **1** wherein said means to secure said outer body member to the insulating jacket of an electrical cable comprises an internally threaded cylindrical portion capable of engaging the outer surface of the insulating jacket in threaded relationship.

3. The electrical connector of claim **1** wherein the piston portion on said contact member comprises a piston ring, detachably coupled to said contact member, which forms a radially extending annular projection on the contact member.

4. The electrical connector of claim **1** further including

a by-pass portion within said cylinder portion, located so as to permit flowable material from said expansible chamber to escape past said piston portion of said contact member when the expansible chamber has been expanded to a predetermined position of the piston.

5. An electrical connector in accordance with claim 4 further including an outlet port extending through the wall of said body member from said by-pass portion to the exterior of said body member, permitting escape of the flowable material to evidence passage of said material through said by-pass portion.

6. The electrical connector of claim 1 further including cooperating detent means on said contact member and on said body member, adapted to interengage and lock when said contact member has been displaced to a given position relative to said body member.

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RICHARD E. MOORE, *Primary Examiner.*

U.S. Cl. X.R.

174—77; 339—116, 223