Sept. 10, 1968 W. J. WEINFURT ETAL 3,401,370

SEPARABLE CONNECTOR FOR UNDERGROUND SYSTEM

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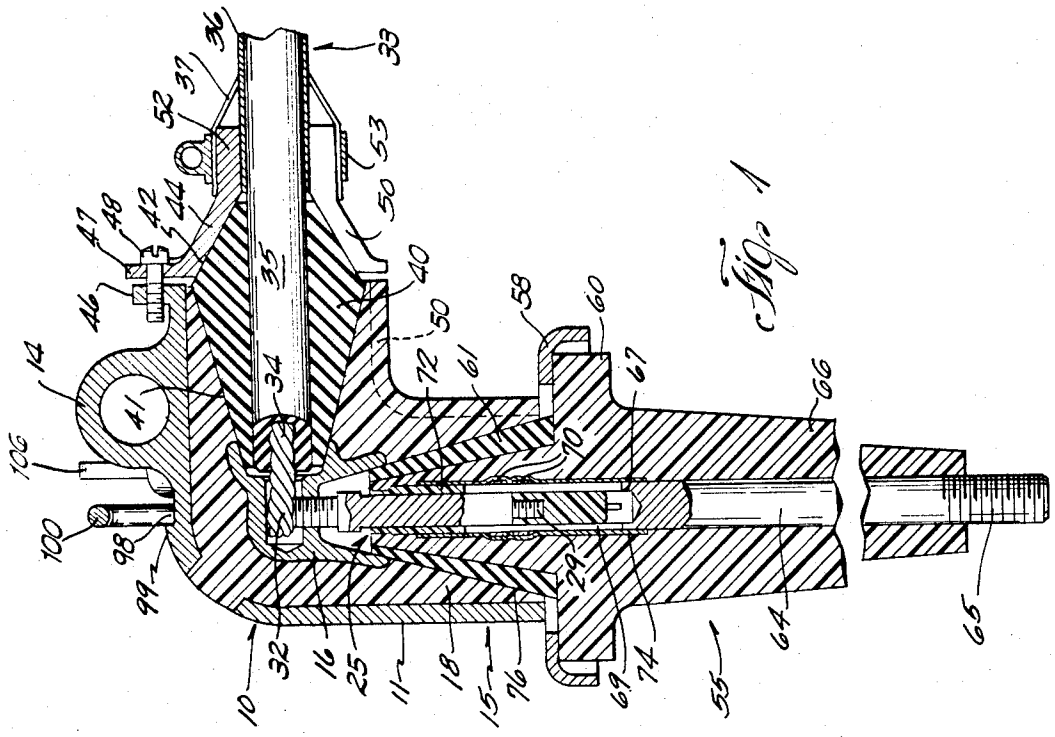


Fig. 1

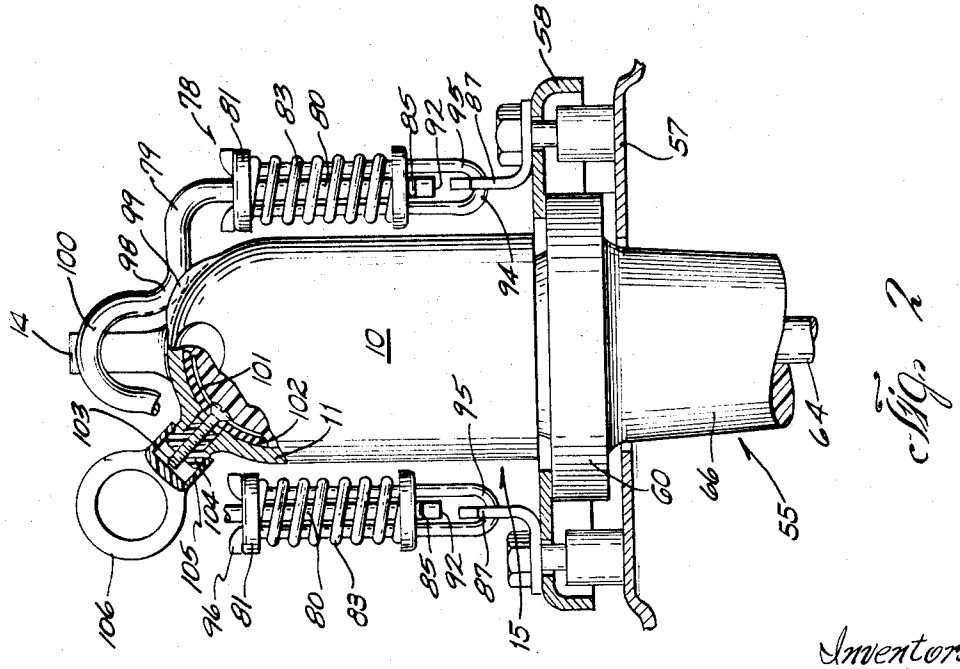


Fig. 2

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Fig. 3

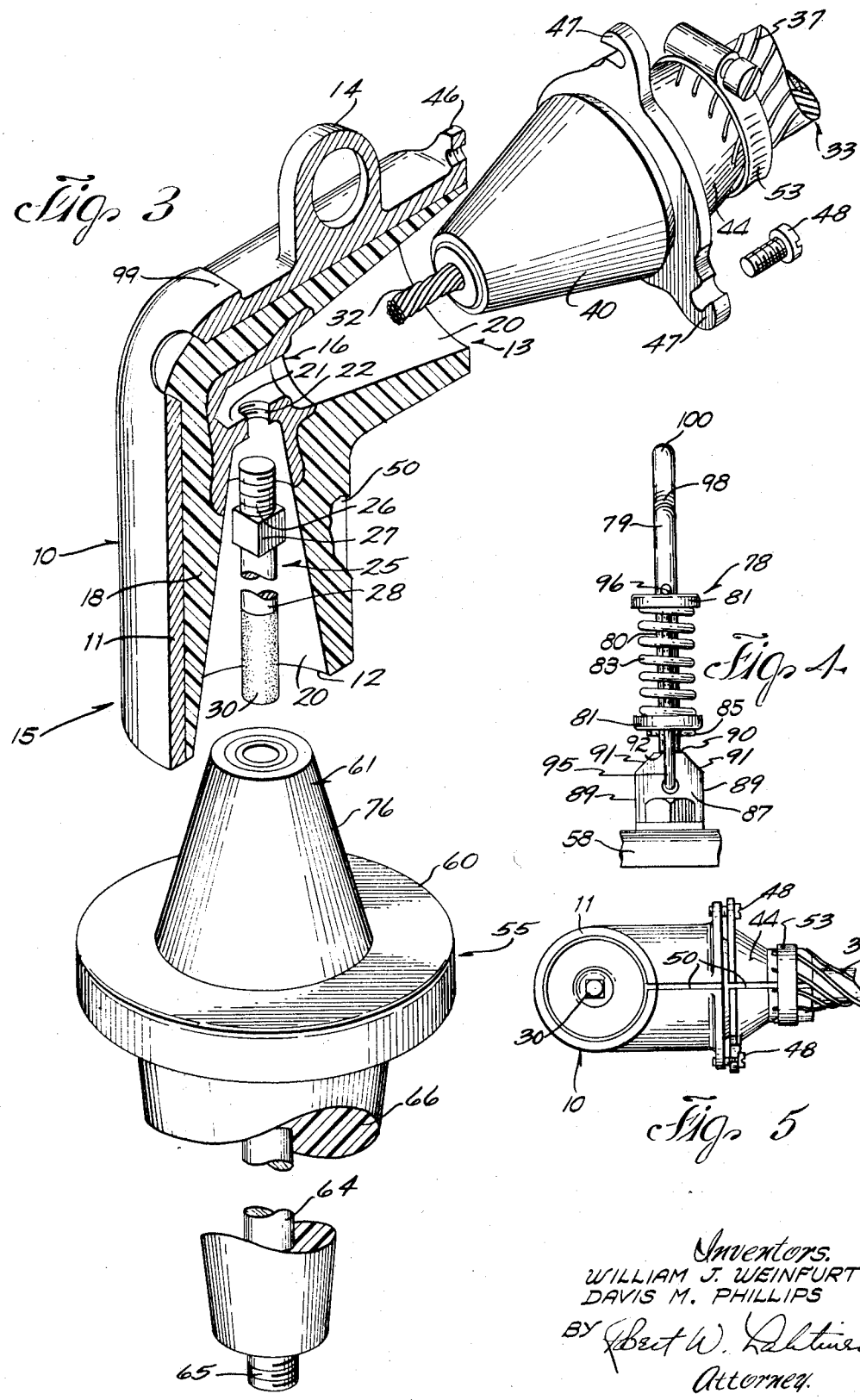


Fig. 4

Fig. 5

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SEPARABLE CONNECTOR FOR UNDERGROUND SYSTEM

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ABSTRACT OF THE DISCLOSURE

Electrical apparatus comprising a dead front electrical connector for making connection to a bushing of an underground electrical apparatus, and cable termination means for fastening a shielded cable to the connector. The apparatus includes mating frusto-conical sealing and insulating surfaces. The cable termination further includes a resilient gland surrounding the cable and having back-to-back frusto-conical surfaces, and an electrical stress relief cone for compressing the gland in contact with the mating frusto-conical cavity of the connector.

This invention relates to separable electrical connectors and, more particularly, to connectors adapted to be used for underground distribution of electric power.

In a high voltage termination, it is desirable to utilize a connector that may be readily assembled to a cable in the field without special tools and is readily separable using a common hook stick while providing fully for the electrical requirements necessary for such a device. With cables having a concentric grounded outer coating, it is vital to protect personnel and prevent conditions which give rise to deteriorating corona discharges. It is accordingly necessary that high voltage gradients which occur at the cable end be overcome and gaseous occlusions of low dielectric strength between the conductor and the outer conductive surface of the connector be avoided.

In the separable connector of the present invention, a single lineman can install the connector to the cable end using only side cut pliers, hack saw, knife and crimping tool. No potting compound is used and the connector is ready for use immediately after assembly. A resilient gland is utilized which is assembled over the insulation material surrounding the cable conductor with a slight interference fit and presents a frusto-conical surface in each axial direction. This gland is received between cooperating frusto-conical recess surfaces and clamped axially with the void portion at the connector side disposed within a conductive member at zero potential. In such manner, the gland assures that no voids occur along the parting surface and the composite structure of the gland and cable insulation functions as a stress relief cone.

The connector is connected to a cooperating bushing and secured by a detachable bail that applies an axial retaining force with connection or disconnection from the bushing being accomplished by use of a hook stick. The connector has a metal housing for safety and to provide a continuous visible ground. Further, the connector is adaptable for use with a wide variety of cable sizes by interchanging only the gland and occasionally the compression cone.

It is an object of this invention to provide a separable connector for high voltage distribution use that can be assembled in the field with common tools.

It is a further object of the invention to provide a connector that can be connected and disconnected by a lineman exclusively with the use of a hook stick.

It is also an object of this invention to provide a connector adaptable to use with a wide range of cable sizes with a minimum interchange of parts.

It is also an object of this invention to provide a connector for a high voltage distribution system that has load break capacity.

It is also an object of this invention to provide a bail securing means for a connector that can be retained in a plurality of relaxed positions and incorporates biasing means that cannot be overstressed.

These and other objects and advantages of this invention will become apparent from the following description when taken in connection with the accompanying drawings, wherein:

FIGURE 1 is a vertical section view of the connector of this invention in association with the cable end and cooperating equipment bushing with the bushing retaining bail partly broken away;

FIGURE 2 is an elevation view of the connector and bushing of FIGURE 1 partly broken away and partly in section as seen from the right side of FIGURE 1;

FIGURE 3 is an exploded view partially broken away and partially in section of the connector, cable end and bushing of FIGURE 1;

FIGURE 4 is an elevation view of the bail assembly; and,

FIGURE 5 is a bottom view of the connector and pressure cone assembly shown in FIGURE 1.

Referring to the drawings, the connector assembly **15** has a body member **10** with an exterior rigid magnetic metal shell or housing **11** with angularly disposed openings **12**, **13** and an upwardly projecting loop portion **14** provided to permit manipulation of the connector in use by a hook stick. Centrally located within the connector body is an inner conductive member **16**. The inner conductive member is radially spaced from the housing and retained in position by epoxy material that is cast about the inner member by introduction through the housing opening so as to form a generally tubular insulating member **18** between housing **11** and inner conductive member **16**. Extending inwardly from each of the principal openings **12**, **13** in the housing is a frusto-conical recess **20** with the frusto-conical surface extending from adjacent the opening in the housing through the tubular insulating member **18** to provide a continuous conical surface which terminates within the inner conductive member **16**. The recesses **20** are separated by a wall **21** presented by the inner conductive member **16** through which extends a threaded aperture **22** which is co-axial with the recess **20** extending from the opening **12**. The connector body carries a silver coated copper stem **25** that has a threaded portion **26** which is received in the inner conductive member threaded aperture **22**, has an adjoining portion **27** of square cross section which provides wrench flats for assemblying the stem to the connector body assembly with a cylindrical contractor portion **28** extending therefrom and an end **29** of reduced diameter which has a threaded surface. At the distal end of the stem is a follower **30** of insulating material which has a threaded axial recess in which the terminal end of the stem is received to secure the follower to the stem **25**. The follower is formed of an insulating material which in the presence of an arc responds by emitting an arc snuffing gas. As seen in FIGURE 1 the stem projects through the inner conductive member aperture **22** to engage the end **32** of a cable **33** terminated at the connector to cause the cable to bear against a wall portion of the inner conductive member **16** and thereby secure a positive high pressure contact and good electrical conduction between the conductor end portion, the inner conductive member and the conductive portion of the stem. As seen in FIGURES 1 and 3 the cable **33** which terminates at the connector includes an inner conductor **34** of copper or aluminum which is surrounded by an insulating sheath **35** such as high molecular weight polyethylene with an

outer layer or jacket **36** of conductive material and a series of tined copper concentric neutral wires **37** which progress helically about the outer periphery of the cable conductive jacket. The cable is terminated at the connector by laying back the concentric neutral wires **37** and thereafter removing a terminal portion of the outer conductive coating **36** and insulation sheath **35** to expose the end portion **32** of the conductor **34** as shown in FIGURES 1 and 3. Thereafter, a length of the conductive jacket **36** is removed from the cable insulating material for an axial length approximately equivalent to the axial length of the gland **40** which will subsequently be placed about the periphery of the insulating sheath from which the conductive jacket has been removed. While removing the conductive coating, care must be taken not to score the surface of the underlying insulating sheath portion. The compression cone is then received concentrically about the cable end. The gland **40** of substantially noncompressible resilient insulating material has frusto-conical surfaces **41, 42** facing in each axial direction and an axial bore which fits over the cable insulating sheath portion from which the conductive coating **36** has been removed. The bore through the gland is of such a dimension with respect to the diameter the exposed portion of the insulating sheath **35** that a slight interference fit is effected as it is axially pressed into place about the sheath end. A compression cone **44** is provided and may be made of rigid conducting and magnetic material. The compression cone **44** which had been previously slipped over the cable end is moved axially along the cable to place the frusto-conical recess therein in contact with the cooperating frusto-conical surface **42** of the gland **40**. The cable end is then inserted into the recess so that the conductor end portion **32** is received within the innermost end of the recess extending from opening **13** which is intersected by the connector stem end **26** when the latter is subsequently inserted through the aperture **22**. A series of three ears **46** project from the connector housing **11** equi-angularly spaced about the opening **13** to the frusto-conical recess with threaded apertures therethrough. A corresponding series of correspondingly equi-angularly disposed hook portions **47** are provided about the periphery of the compression cone **44** which are received under the heads of screws **48** received in the threaded openings of the housing ears **46** whereby the cable end can be inserted into the housing and turned to retain the hooked portions **47** behind the heads of screws **48** whereupon an axial force can be applied by tightening the screws **48**. As will be seen in FIGURE 5 both the housing **11** and the compression cone **44** have a slit or saw cut **50** extending axially thereof to interrupt the conductive path about the periphery of these members. The saw cut in the compression cone **44** is aligned with that of the housing **11** in the assembled condition. The cylindrical bore portion of the compression cone **44** fits snugly over the axial end of the outer conductive coating **36** of the cable. The concentric neutral wires **37** are thereafter drawn forward and laid over the compression cone collar **52** and secured thereto by a circular clamp **53**. The loose ends of the neutral wires may then be gathered together and twisted into a pigtail for connection to a ground terminal. A cooperating bushing **55** is mounted through an aperture in an electrical apparatus housing **57** and secured to the housing by a hold-down plate **58** which bears against the bushing flange **60**. The bushing is formed of cast epoxy insulating material which is formed about a central axial terminal assembly. The bushing assembly has a collar **61** member of resilient substantially noncompressible insulating material that presents an exterior frusto-conical surface that conforms to and is adapted to be received in the frusto-conical recess **20** in the connector which extends from opening **12**. The bushing central terminal assembly includes a cylindrical conductor **64** having a threaded lower **65** portion that projects from the bushing epoxy body **66** surrounding the terminal assembly to provide a connecting portion within the apparatus. At the opposite end of the cylindrical conductive member is an axial bore **67** of a diameter adapted to slidably receive the stem portion **28** and follower **30** of the connector member. This tubular end of the terminal member has saw cuts **69** extending longitudinally thereof and disposed at right angles to one another with a pair of axially adjoining tempered steel rings **70** surrounding the terminal end portions to provide a constricting force to assure a positive pressure electrical contact with the stem conductor portion **28** when the latter is received in the bushing. At the upper end of the bushing extending from adjacent the entry to the passageway for receiving the connector member stem is a sleeve **72** of insulating material which emits an arc extinguishing gas when subjected to high temperatures as in the presence of an arc. Surrounding the upper terminal portion and the lower portion of the insulating sleeve is a tubular member **74** of shrinkable plastic that is shrunk about the sleeve **72** and terminal end and to which an exterior coating of conductive material is applied to afford shielding about any of the included voids. This tubular member **74** also serves to retain the sleeve **72** and terminal conductor **64** as an assembly during the casting process and to prevent the epoxy material from flowing into the passageway or the saw cuts **69** in the terminal member **74** during the casting operation. In the assembled position with the connector **15** secured to the bushing **55**, the frusto-conical surface **76** of the collar **61** of resilient insulating material presented by the bushing **55** is received in intimate contacting relation with the frusto-conical recess **20** extending from opening **12** in the connector with its axial end terminating within the recessed portion of the inner conductive member **16** whereby the void at the frusto-conical axial end of the bushing **55** is wholly radially enclosed within the inner conductive member **16**. The connector **15** is maintained in close compressive contact with the bushing end by a bail assembly **78** which is secured to the apparatus housing and engages the connector to exert a compressive force. The bail member includes a generally U-shaped rod **79** having the legs **80** thereof extending through apertures in the spring retainers **81** and generally axially through the compression spring members **83** held between the spring retainers **81** and the terminal end of the legs are cotter pins **85** which project through apertures in the legs **80** to retain the legs against withdrawal with respect to the spring retainers **81**. At either side of the bushing are a pair of bail support brackets **87** which, as seen in FIGURE 4, have vertical edge surfaces **89**, a top surface **90** and connecting surfaces **91** therebetween disposed at about a 45° angle to the top and vertical surfaces. When the bail member is elongated as when it is extended by a hook stick or retains the connector **15** to the bushing **55**, the springs **83** cause or urge the legs of the generally U-shaped rod **79** downwardly. When not retaining a connector to the bushing or being extended by a hook stick, the springs **83** urge the end surfaces **92** of the U-shaped rod **79** into contact with the bracket member edge surfaces **89, 90** or **91** so that the end surfaces **92** of the legs engage edge surfaces of the brackets, as cooperating detents, to retain the bail member assembly **98** in a vertical, inclined, or horizontal attitude depending upon which of the edge surfaces **89, 90** or **91** is engaged. Through an aperture in each of the brackets is disposed the bight portion **94** of the U-shaped wire **95**. The legs of each U-shaped wire extend through the compression springs **83** and the spring retainers **81** and terminate above the upper spring retainer with the ends **96** turned out so that the compression spring **83** is held captive between the retainers **81** which in turn are limited in their travel by the upper turned ends **96** of the U-shaped wires held by the brackets **87** and the cotter pin **85** at the end of the leg of the U-shaped rod members **79**. The bight portion of the bail assembly rod member **79** has two inwardly curved portions **98** which in the assembled condition with the connector **15** engage the outer surface of the housing **11**

and are retained by being positioned behind the bosses **99** cast in the housing outer surface. The upwardly extending loop **100** of the bight portion of the bail assembly rod **79** is provided for hook stick operation. Also included as part of the connector is a test-tap which is formed by installing a metal plate **101** within the housing insulated from the housing wall by a sheet of rubber material **102** and secured by a screw **103** that extends through an aperture in the housing and is secured in place by an insulating collar or nut **104** that is threadably received about the threaded screw end. The metal plate provides a limited capacitive coupling with inner conductive member and the exposed end of screw **103** affords a terminal which may be checked with appropriate instruments to determine whether the terminated cable is energized. Normally surrounding the exposed end of the screw is a cap **105** with an inner ridge that is received in the peripheral groove of the insulating nut with the cap having at its outer end a ring **106** to provide for ready manipulation.

Although but one embodiment has been shown and described it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. Dead front termination means comprising in combination a metallic electrical apparatus outer casing adapted to be connected to ground; an insulating bushing extending through an opening in said casing, including a projecting frusto-conical first connecting portion; a connector member having a hollow conductive outer housing, an inner conductive member disposed within said outer housing in radially spaced relation thereto, and a tubular insulating member disposed between said outer housing and said inner member; a second connecting portion presented by said connector member including a frusto-conical recess in said tubular insulating member extending from an opening in said outer housing and terminating within said inner conductive member for releasably receiving said first connecting portion with the frusto-conical projection of said first connecting portion terminating within said inner conductive member; and releasable retaining means for securing said connector member to said bushing by applying an axial compressive force therebetween.

2. The termination means of claim **1** wherein said releasable retaining means comprises a bail member of conductive material having the legs thereof connecting to said casing and a bight portion engageable with said connector member outer housing with a pair of compression springs respectively surrounding portions of the legs of said bail as a constituent part thereof whereby said leg portions are elongated by compression of said pair of springs.

3. The termination means of claim **1** wherein said frusto-conical first connecting portion is formed by a wall of resilient, substantially incompressible insulating material.

4. The termination means of claim **1** wherein said outer housing has an axial slit through one side thereof to interrupt the conductive path about the periphery of said housing.

5. Dead front voltage termination means comprising in combination a metallic electrical apparatus outer casing adapted to be connected to ground; an insulating bushing extending through an opening in said casing; said bushing presenting a first connector portion including projecting frusto-conical portion; a connector having a hollow conductive outer member; an inner conductive member disposed within said outer member in radially spaced relation thereto; a tubular insulating member disposed between said inner and outer members and having a second connector portion at one end complementary to and releasably engageable with said first connector portion; said second connector portion including a frusto-conical recess in said tubular insulating member extending from adjacent said one end and terminating within said inner conductive member and conductive means for releasably affixing said outer member to said casing with said first connector frusto-conical portion in axially compressive engagement with said second connector portion frusto-conical recess surface.

6. The termination means of claim **7** wherein said first connector frusto-conical portion comprises a resilient substantially noncompressible insulating material forming said frusto-conical surface.

7. The termination means of claim **6** wherein said conductive means for releasably affixing said outer member to said casing comprises a bail assembly including a pair of compression springs, a generally U-shaped first member having the legs thereof extending longitudinally through said compression springs with means adjoining the ends thereof abutting one end of the surrounding spring, a pair of apertured flange means at opposite sides of said bushing and fixably supported with respect to said apparatus casing, second and third U-shaped members each having the bight portion received in the apertures of one of said flange means and the legs of each thereof passing through one of said compression springs and terminating with means respectively abutting said compression springs at the end opposite said one end.

8. The termination of claim **7** wherein said apertured flange means each present a plurality of edge surfaces angularly disposed to one another and generally co-planar with the like surface of the other of said flanges, end surfaces on the legs of said first U-shaped member whereby said compression springs urge said first U-shaped member end surfaces toward contact with a co-planar pair of flange edge surfaces to retain said main assembly in a position substantially upright with respect to said co-planar flange surfaces.

9. In combination with the end portion of an insulated cable having a central conductor and a concentric conductive means, a dead front termination means comprising a connector having an outer surface of conductive material with first and second openings therein, an inner conductive member disposed within said connector and radially spaced from said outer surface, and a substantially rigid insulating member disposed between said inner member and said outer surface; a frusto-conical recess in said connector extending from said first opening, said frusto-conical recess extending into said insulating member and terminating inwardly within said inner conductive member; said cable end portion having a conductor end portion in electrical contact with said inner conductive member, and a first cable portion adjoining said conductor end portion with the concentric conductive means removed; a gland of resilient insulating material surrounding said first cable portion in intimate contact with the periphery of the cable insulation and presenting frusto-conical peripheral surfaces in each axial direction; a compression cone of rigid conductive material surrounding said cable and having a frusto-conical axial recess; and securing means releasably attaching said compression cone to said connector with said gland compressed axially therebetween.

10. The combination of claim **9** wherein said connector outer surface comprises a hollow conductive outer housing and said insulating member comprises insulating material cast between said housing and said inner conductive member.

11. The combination of claim **10** wherein said connector hollow conductive outer member and said compression cone are formed of rigid magnetic material and each has a continuous longitudinal slit extending the length thereof.

12. The combination of claim **10** wherein said connector outer housing first and second openings are angularly disposed to one another and said connector further includes a recess extending from said second opening and

terminating within said inner conductive member, said inner member presenting a wall portion between the recesses extending from said first and second openings with a threaded aperture therethrough; said combination further comprising a stem member with a threaded end entering into said recess extending from said second opening and received in said threaded aperture with said stem threaded end portion projecting into said recess extending from said second opening and engaging said conductor end portion to clamp said conductor end portion between said stem and a wall surface of said inner member.

13. A termination device for an end portion of a cable; said cable having a central conductor extending therefrom, outer concentric conductive means, and intermediate insulation; and for being connected to an electrical connection apparatus having a central conductor, a conductive outer surface adapted to be grounded, intermediate insulating means and a frusto-conical recess having its base toward the outer surface of said apparatus and extending inwardly to an apex at said conductive member, said termination device comprising:

gland means made of resilient insulating material surrounding said cable in intimate contact with the periphery of said insulation and presenting base-toward-base frusto-conical peripheral surfaces in each direction, one of said frusto-conical peripheral surfaces being adapted to be pressed into engagement with said frusto-conical recess;

a compression cone of rigid conductive material surrounding the other frusto-conical peripheral surface in close contact therewith and for surrounding said cable; and

securing means for releasably attaching said compression cone to said connector with said gland compressed axially therebetween.

14. The invention as defined in claim **13** together with means for electrically connecting said compression cone to said outer concentric conductive means of said cable.

15. The invention as defined in claim **14** in which said securing means is electrically conductive and serves to electrically connect said compression cone to said conductive outer surface of said electrical connection apparatus.

16. The invention as defined in claim **15** in which said compression cone is formed of rigid magnetic material and has a continuous longitudinal slit in one side thereof and extending the length thereof.

17. In combination with the end portion of an insulated cable having a central conductor and a concentric conductive means, a dead front termination means comprising:

connection means having an outer surface of conductive material with an opening therein, an inner conductive member disposed within said connection means and radially spaced from said outer surface, and an insulating member disposed between said inner member and said outer surface;

a frusto-conical recess in said connection means extending from said opening, said frusto-conical recess extending into said insulating member and terminating inwardly of said insulating member at said inner conductive member;

said cable end portion having a conductor end portion in electrical contact with said inner conductive member, and a first cable portion adjoining said conductor end portion with the concentric conductive means removed;

a gland of resilient material surrounding said first cable portion in intimate contact with the periphery of the cable insulation and presenting frusto-conical peripheral surfaces in each axial direction;

a compression cone of rigid conductive material surrounding said cable and having a frusto-conical axial recess; and

securing means releasably attaching said compression cone to said connector with said gland compressed axially therebetween.

18. The combination of claim **17** wherein said outer surface comprises a hollow conductive outer housing and said insulating member comprises insulating material cast between said housing and said inner conductive member.

19. The combination of claim **18** wherein said compression cone is formed of rigid magnetic material and has a continuous longitudinal slit in one side thereof and extending the length thereof.

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U.S. DEPARTMENT OF COMMERCE

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CERTIFICATE OF CORRECTION

Patent No. 3,401,370 September 10, 1968

William J. Weinfurt et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 8, the claim reference numeral "7" should read -- 5 --.

Signed and sealed this 3rd day of February 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR
Commissioner of Patents