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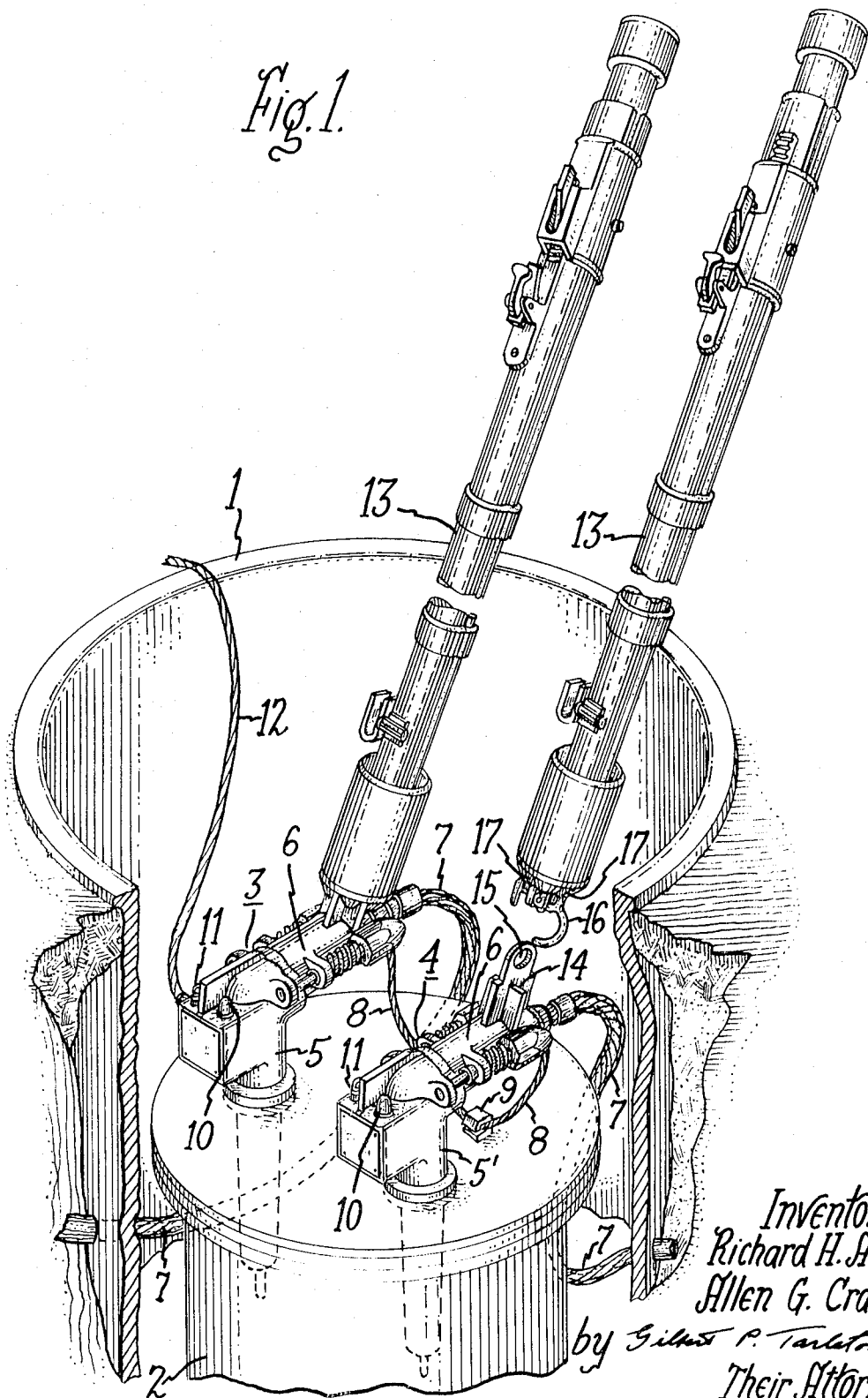
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TERMINATION

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Fig. 1.



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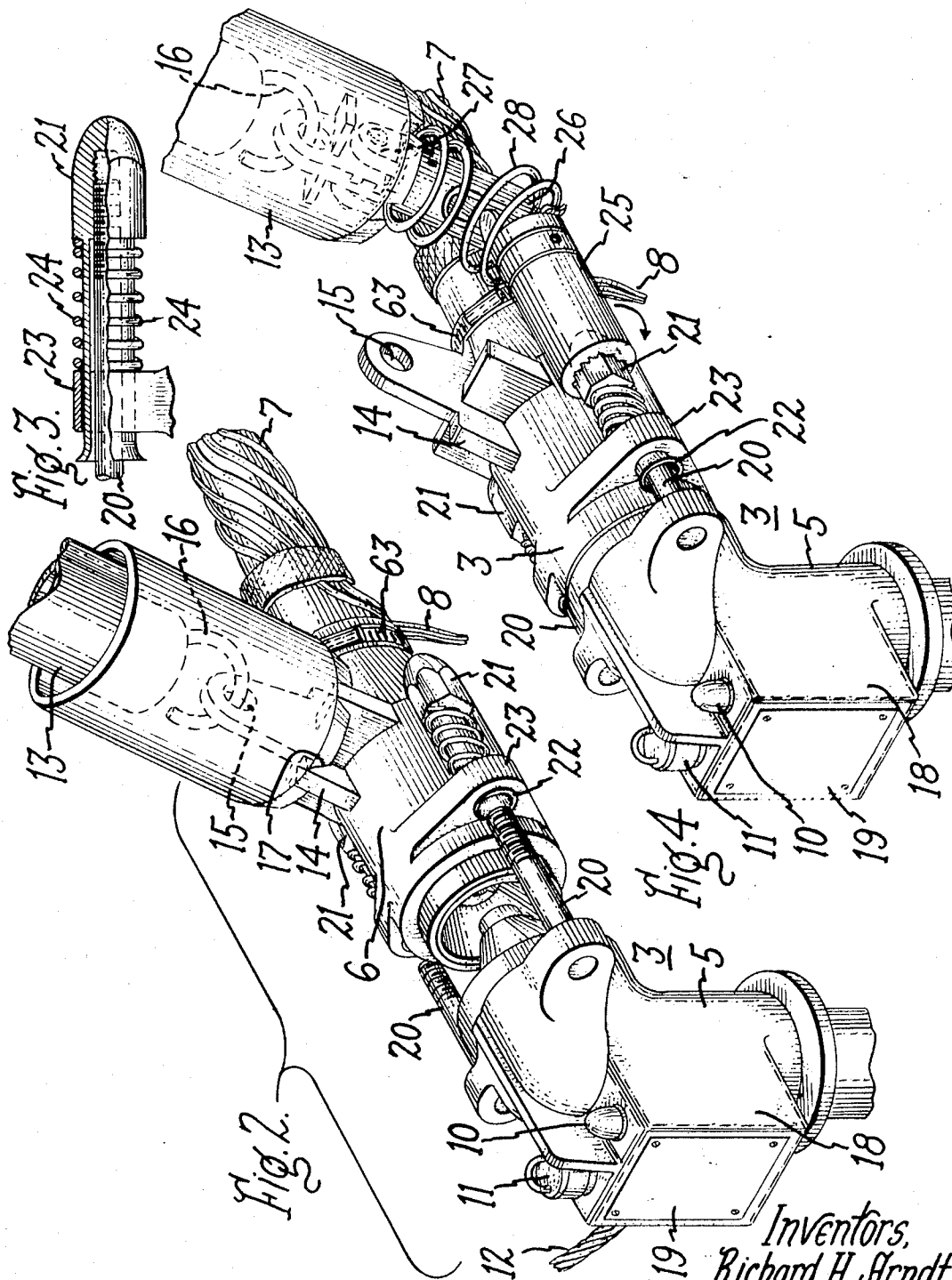
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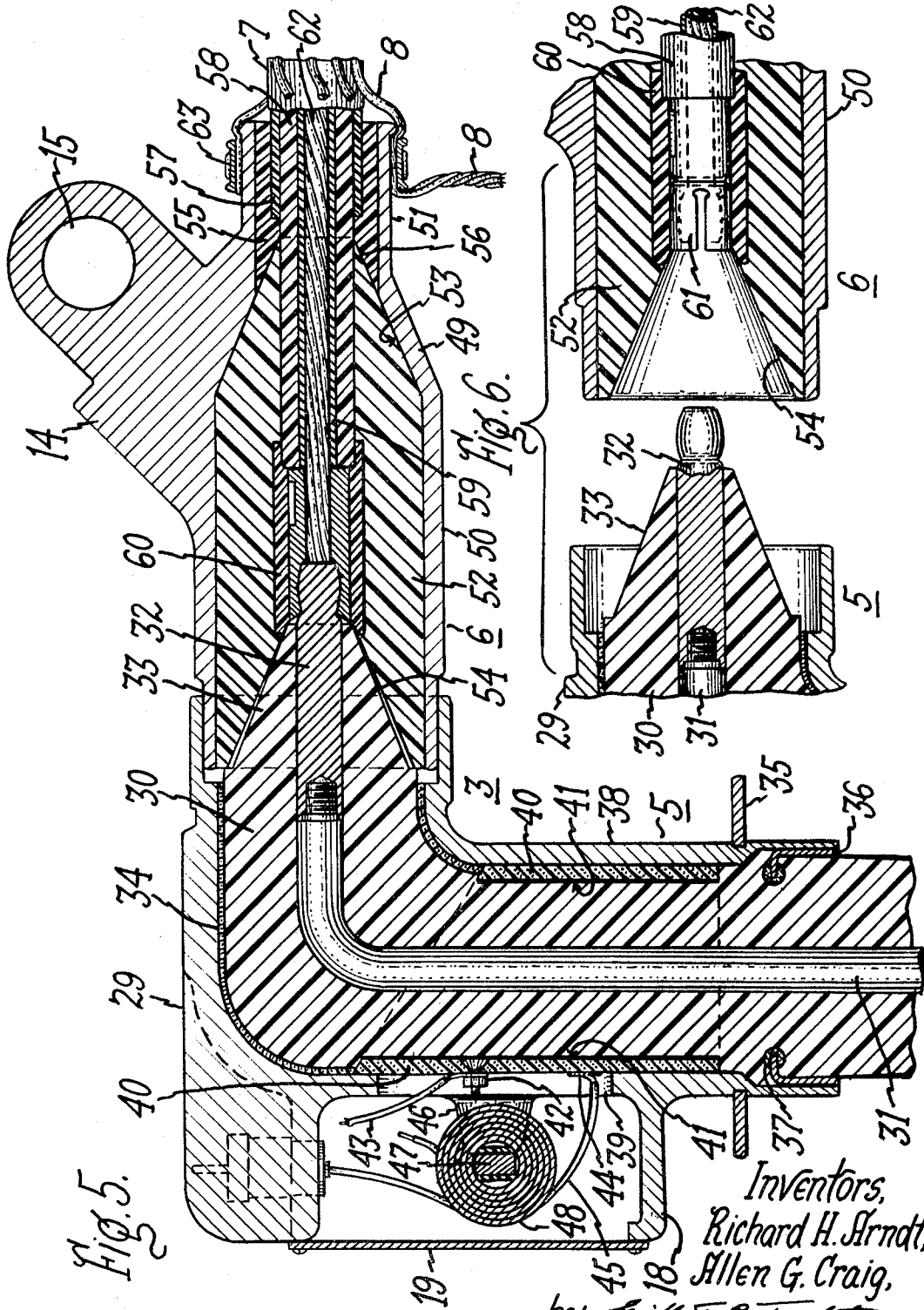
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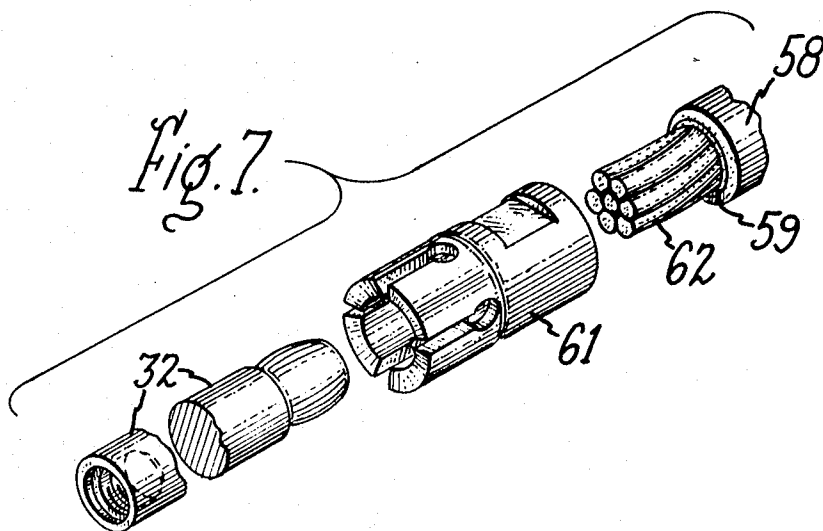
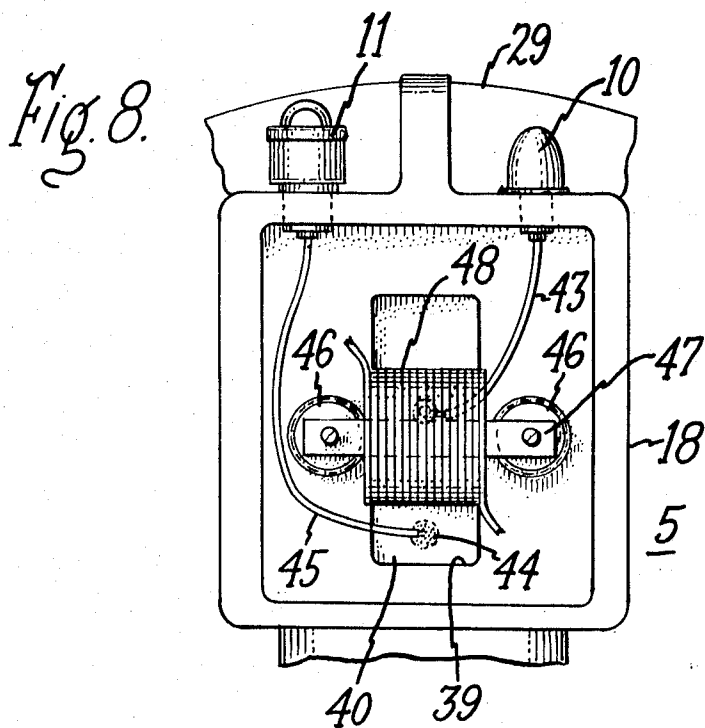
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3,466,593

TERMINATION

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3 Claims

ABSTRACT OF THE DISCLOSURE

An electric power cable termination having stress cone means to relieve electrical stresses, in combination with termination handling and sealing improvements that facilitate use of the termination in underground vaults.

This invention relates to terminations for shielded electrical cables and more particularly to improvements in such terminations of the detachable connector type.

Shielding of electrical power cables is for the purpose of uniformly stressing the cable insulation and it is particularly important at the higher voltages where inequality of stress can exceed the corona starting level and where because of the cost of insulation it is particularly desirable not to use any more of it than is necessary. Such cable in cross section usually consists of a central high voltage conductor surrounded by a plurality of concentric circular cylindrical layers. The innermost layer immediately surrounding and in contact with the conductor is the so-called conductor shielding layer. Around that is the cable insulation layer. Around the insulation layer is a ground shielding layer. Around the latter is a metallic ground return conductor typically in the form of spirally wrapped strands of bare wire or a sheath of braided metal. Finally there may or may not be an outer protective covering layer typically of braided textile. The shielding layers are conductive or semiconductive and adhere closely to the insulation layer therebetween. Each provides a smooth equipotential surface and they thus respectively shield the insulation layer from stress concentration which would otherwise be produced by irregularities on the surface of the central high voltage conductor and the outer ground return conductor both of which are usually stranded or otherwise have irregular surfaces such as are caused by metal burrs or microscopic slivers extending therefrom.

In order to make connections to the central conductor at the ends of the cable, it is necessary to strip back all of the surrounding layers so as to bare a length of the central conductor. It is also necessary further to strip back the outer conductive ground potential layers so as not to arc over the edge of the insulation layer. Even so, the discontinuity in the shielding layers at their ends tends to cause undesirable local stress concentration and one of the functions of a termination is to control and ameliorate such concentration.

Another function of a termination is to serve as a detachable connector or disconnecting switch, i.e., a maker and breaker of deenergized circuits as distinguished from an arcing duty circuit breaker which is capable of interrupting load currents and even overload or fault currents. A termination, therefore, usually comprises two separate mating parts one of which has a plug connector or equivalent and the other of which has a mating jack connector or equivalent. Typically one part can be an apparatus or equipment bushing or equivalent and the other can be a stress controlling end cap for the cable which connects to the apparatus or equipment.

Such terminations are particularly useful in underground residential distribution systems having so-called

open primary loop circuits. Such a circuit comprises a plurality of spaced underground distribution transformers, each usually located in a separate vault, whose respective primary windings are fed electrically in parallel from a loop consisting of serially connected buried cables running between adjacent transformers, i.e., each vault has an incoming and an outgoing cable connected to its transformer primary winding line terminal. Thus, there is a need for at least two terminations per transformer. The loop is feed from both ends through separate over-current protective means such as a fuse and it is called an open loop because one of the connections to a transformer, usually near the electrical middle of the loop, is left open. In this manner, approximately half the transformers are fed through one fuse and the remainder through the other fuse. With such an arrangement, a fault which develops in any particular cable section between adjacent transformers will blow only one of the two fuses so that service is interrupted to only half of the open loop and a service crew can immediately determine from customer complaints and verify by inspecting the fuses in which half of the open loop the faulted cable section is. The faulted section can then be identified by conventional cut and try methods, or preferably by means of fault current detectors in the vaults and preferably in the terminations. Once identified, the faulted cable section can be isolated by disconnecting its terminations. Then service can be restored to all the transformers by replacing the blown fuse, the open part of the loop then being the isolated faulted cable section.

It is essential that the entire below ground level primary circuit be completely covered with insulation which must also be waterproof as transformer vaults are subject to flooding. It is therefore essential that the vaults and preferably the terminations be provided with means for indicating whether or not the conductors which are sheathed in insulation are or are not at a voltage substantially different from zero or ground potential. Such voltage indication is particularly useful when the parts of a termination are to be separated or joined as it is, of course, only safe to do this when the circuit is deenergized.

Because of the cramped space in distribution transformer vaults and the hazards involved, it is desirable to be able in a reliable and positive manner to make and break termination connections from grade level by means of an insulated tool such as a standard lineman's hot stick tool.

In accordance with the invention, there is provided a new and improved termination having all of the above features.

An object of the invention is to provide a new and improved cable termination.

Another object of the invention is to provide a new and improved composite stress cone for controlling electrical stress in the insulation of a cable termination.

A further object of the invention is to provide means, in addition to the means which holds the main parts of termination together, which looks the high voltage current carrying parts together so that the cable cannot readily be pulled out of the termination.

An additional object of the invention is to provide a new and improved termination structure adapted for firm attachment to the end of a standard shotgun type of stick tool so that it can be manipulated in a positive and reliable manner.

A still further objective of the invention is to provide a new and improved cable termination adapted to contain main circuit monitoring subcircuits for indicating the presence or absence of voltage therein and for detecting and storing for subsequent readout whether or not a fault current has passed through the termination.

An added object of the invention is to provide a high voltage cable termination which is substantially corona-proof and has low radio noise level.

The invention will be better understood from the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the drawings,

FIGURE 1 is a broken away perspective view of a vault for an underground distribution system containing a transformer equipped with two terminations embodying the invention and showing their operative relation to a hot stick tool,

FIGURE 2 is an enlargement of the left-hand termination shown in FIGURE 1 with its parts separated or disconnected,

FIGURE 3 is an enlarged detail view partly broken away and partly in section showing the captive nut and flared guide tube construction,

FIGURE 4 is similar to FIGURE 2 showing the use of a hot stick tool with an adapter socket wrench for turning the fastening nuts on the termination,

FIGURE 5 is an enlarged longitudinal midsectional view of the termination shown in FIGURES 2 and 4.

FIGURE 6 is a similar detail view with the parts separated,

FIGURE 7 is a detail view of the plug and jack connector, and

FIGURE 8 is an end view, with the cover removed, of the housing for circuitry of the termination.

Referring now to the drawings and more particularly to FIGURE 1, this shows a partially broken away vault 1 set into the ground and enclosing a distribution transformer 2 equipped with separate primary circuit terminations 3 and 4. The termination 3 consists of a bushing part 5 extending through the cover of the transformer and a cable end cap part 6 for a high voltage shielded cable 7 whose outer bare wire ground conductor 8 is attached conductively to the cap 6 and then extends downwardly to a ground connection 9 on the cover of the transformer. The bushing part 5 of the termination 4 is generally the same as the bushing part 5 except that it need not have all of the circuitry of the former. The end cap 6 for the termination 4 is the same as for the termination 3. The cable 7 may comprise part of an open loop circuit for an underground residential distribution system.

Each termination is shown equipped with a voltage indicator lamp 10 which is preferably a neon glow lamp or equivalent and which, as will be described more fully hereinafter, is capacitively coupled to the central high voltage conductor of the termination so as to indicate whether or not that conductor is energized. Each termination is also provided with a test terminal covered by a cap 11 for testing the integrity of the circuit of the voltage indicator lamp so as to insure that when the lamp is not lighted the cause is lack of voltage in the cable conductor and not a failure of the lamp circuit. Extending from the bushing part 5 is a lead 12 which may lead to a socket in a grate (not shown) for covering the vault 1. This is so that a service crew of the power company can interrogate the termination 3 from grate level to determine whether or not a fault current has passed through it and thus identify whether or not a fault has occurred in the section of cable 7 to which it is connected.

The parts 5 and 6 of the terminations may be separated and/or brought together from outside the vault by means of a so-called standard shotgun type hot stick tool illustrated at 13. As shown more clearly in connection with termination 4, the end caps 6 have a cruciform shaped boss or lug 14 extending rearwardly and upwardly at an angle of about 45° and having an eyelet 15 for receiving a hook 16 of the tool 13. The end of the tool has slots 17 for engaging the ends of the cruciform shaped lug 14 when the hook 16 engages the eyelet and is drawn into

the tool 13 by the operation of a sliding handle on the upper end of the tool. Thus the tool and the cap 6 may be securely locked together in this manner as shown in connection with termination 3 so that an operator standing on the ground and grasping the outer end of the tool 3 can position the cap 6 over the end of the bushing part 5 without any lost motion or looseness in the connection between the parts.

Referring now to FIGURE 2, this shows in phantom how the hook 16 when it is pivoted and drawn into the tool after linking the eyelet 15 draws the end of the tool 13 snugly against the lug 14 with its crossed arms engaging the slots 17 in the end of the tool. FIGURE 2 shows the parts 5 and 6 separated. This figure also shows more clearly the housing 18 for the monitoring circuitry of the termination which is closed by a cover 19. The bushing part 5 has a pair of studs or bolts 20 which cooperate with captive nuts 21 on the cap portion 6 for drawing the two main termination parts snugly together.

As shown more clearly in FIGURE 3, the captive nuts 21 are attached to sleeve having flared ends 22. The sleeves slide in openings in a boss 23 on the cable end cap 6. A spring 24 serves to hold the nut 21 in its retracted position. Thus when the cap 6 is pushed against the bushing part 5, the flared ends 22 of the sleeve act as guides for the ends of the studs 20 so that the cap 6 may be readily and accurately positioned and pushed home by the tool 13.

After this is done, the tool 13 is released and as shown in FIGURE 4 it is fitted with a socket wrench 25 having a universal joint 26 and an adapter fitting 27 for locking engagement with the hook 16 of the tool 13. A spring 28 may be provided for normally positioning the socket wrench 25 in its extended position.

As shown most clearly in FIGURE 3, the nuts 21 have tapered ends so that an operator can readily fit the socket wrench over the end of the nuts and then by pushing on the stick and turning it, the socket wrench 25 can be slid over the nuts 21 whereby rotation of the tool 13 will draw the nuts up snugly, the springs 24 serving to insure a snug fit of the bushing parts under all temperature conditions of operation.

Referring now to FIGURE 5, the bushing part 5 comprises an outer metal housing 29 enclosing solid electrical insulation 30 of any suitable type for a central conductor 31 terminating in a plug type connection 32 which may be threadedly attached thereto and which extends through a cone shaped terminal portion 33 of the insulation 30. Preferably the outer surface of the insulation 33 is coated with a closely adherent conductive plastic layer 34 for reducing the radio noise level of the termination. The bushing part 5 is provided with a mounting flange 35 which is attached to a sleeve 36 locked to the insulation 30 by inwardly extending portions of rounded shape 37, the rounded shape being for controlling electrical stress in the insulation 30. The conductive housing 29 has a section 38 which is generally cylindrical, a portion of which is cut away to provide a window 39. Enclosed in this section around the insulation 30 is an insulating cylinder 40 whose inner surface is coated with a conductive layer 41 and which is provided with a terminal 42 extending between the conductive surface 41 and the outer surface of the insulating cylinder. This is connected by a wire 43 to the voltage indicator lamp 12. The conductive surface 41 is in effect a capacitor plate between the grounded housing 29 and the high voltage conductor 31, all of which parts constitute a capacitance voltage divider for applying a sufficiently reduced voltage to the indicator lamp 10.

The outer surface of the insulating cylinder 40 has a portion which is conductively coated to form a capacitive surface which is connected by means of a wire 45 with a test terminal covered by the cap 11. By impressing voltage to ground on the surface 44 through the wire 45, the conductive surface 41 is capacitively energized so that if the lamp circuit and the dielectric qualities of

the cylinder 40 are intact, the lamp will light thus demonstrating that the indicator circuit is not defective.

These circuitry parts are also shown in FIGURE 8 and as shown in both FIGURES 5 and 8 the metal housing 29 of the part 5 inside the circuitry housing 18 has a pair of integral extensions 46 which act as flux collecting pole pieces which are bridged by a bar 47 carrying a coil 48. This construction amounts to an inexpensive current transformer in that magnetic flux produced by current in the central conductor 31 will have a part of it diverted through or linking the coil 48. This may be used for energizing a fault current detector, the details of which form no part of the present invention.

Returning to FIGURE 5, the end cap 6 has a conductive or metal outer housing consisting essentially of an intermediate conical section 49 between generally cylindrical end sections 50 and 51. Inside the end cap is a filler 52 of elastomeric insulating material such as polyurethane or silicone rubber. This filler 52 has a tapered or conical surface closely fitting the conical inner surface 53 of the conical section 49 and having an inwardly extending conical end surface 54 for mating with the conical end surface 33 of the bushing part 5. It will be noted that the cone angles of the surfaces 33 and 54 are not quite the same, the angle of 33 being slightly less than the angle 44 so that when these parts are pressed together their contact is first at their inner ends near their apices. However, as the nuts 21 are drawn up and the end cap 6 is forced on to the bushing part 5, the yielding of the elastomeric material 52 will cause progressive engagement or contact thus forcing out any air in the interface and reducing the possibility of corona formation.

Integral with the elastomeric insulation member 52 is an elastomeric conductive member 55 having a conical shaped end 56 mating with the conical right-hand end of the elastomeric insulation 52 which extends inwardly beyond the conical shaped surface 53 of the metallic housing. In other words, the cone shaped conductive metal housing 53 and the cone shaped conductive elastomeric surface 56 together comprise a stress cone for controlling the electrical stress in the end cap 6. The conductive elastomeric end section 55 has a slightly enlarged bore to receive the ground sheath or shield 57 surrounding the main insulation layer 58 of the cable 7.

The conductor shielding layer 59 and the insulation layer 58 of the cable terminate at a conductive elastomeric cylinder 60 also forming an integral part of the filler 52 and in which is located a jack connector 61, these parts being shown in greater detail in FIGURES 6 and 7. The jack connector 61 may be crimped or otherwise attached to the central conductor 62 of the cable and it is shown longitudinally slotted and recessed to receive the rounded end of the plug connector 32.

The elastomeric conductive sleeve 60 serves as a shield for the jack connector so as not to produce excessive stress in the elastomeric insulation 52.

A feature of the invention is that by means of the cone shaped surfaces 33 and 54, when the nuts 21 are drawn up, sufficient pressure is generated in the elastomeric insulation 52 to press the tines of the jack 61 snugly against the connector 32 so as to lock those electrically connected parts mechanically together so as not only to provide a good electrical connection, but also to aid in retaining the cable end in the cable end cap 6.

A function of the cylindrical end section 51 of the cap 6 is to provide a surface to which the bare outer metal wire wrapping 8 of the cable may be clamped as by a clamp 63 shown in FIGURE 5.

The diameter of the cylindrical end section 51 of the cap 6 is large enough to receive the largest size cable for which the termination is adapted to be used. The end cap can be adapted to receive a wide range of cable sizes by means of preformed elastomeric composite fillers 52-55-60 each having a stepped bore of the proper diam-

eter steps to receive the ground shield 57, the insulation layer 58 and the jack connector 61 snugly. Of course, all of the composite fillers will have the same outside diameter for snugly fitting into the end cap 6.

In connection with the capacitive voltage divider for supplying the voltage indicator lamp, it is of course not essential that the intermediate conductive surface or capacitor plate 41 be a coating on an insulating cylinder, and it can be formed in any other suitable manner such, for example, as by a cylinder of wire mesh embedded in the insulation 30.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a cable termination, a bushing part and a cable end cap, said bushing part and end cap having central coaxial mating plug and socket electrical connector elements, an integral attachment lug on said cap extending upwardly and rearwardly therefrom at an angle of approximately 45° to the axis of said elements, said lug having a central long eye piece surrounded by shorter perpendicularly disposed ribs, said eye piece being adapted to receive the hook of a shotgun type hotstick tool and to be drawn into said tool by retraction of said hook, said ribs being adapted to engage slots in the hook end of said tool when said eye is drawn into the hook end of said tool whereby an operator can firmly but detachably lock said cap to the hook end of said tool for connecting and disconnecting said connector elements with full visibility of said termination when said termination is substantially below grade level in a vault and the operator is standing at grade level by said vault.

2. A cable termination end cap comprising a metal housing having two integral adjacent sections one of which is a cylindrical end section and the other of which is an outwardly flared conical section, said sections being for receiving an end of a shielded cable, the cylindrical end section having an inside diameter substantially greater than the outside diameter of such cable, and a composite molded elastomer sleeve filling the scape in said housing around said cable end, said sleeve having a main portion of insulating material and an end portion of conducting material, the main portion of insulating material having an outer conical surface fitting the conical inner surface of the conical section of the housing but extending inwardly therefrom, the end portion of conducting material having a cylindrical outer surface fitting the inner surface of the cylindrical section of the housing and having an inner conical end surface forming a conical interface with the extended outer conical end surface of the main insulating portion whereby when the outer shield of such cable is electrically in contact with said conducting end portion said conical interface and the conical section of the housing together constitute a stress relief cone.

3. A cable termination end cap comprising, in combination, a metallic housing of circular cross section having cylindrical end sections of different diameter joined by an integral intermediate conical section, and a composite molded elastomer filler for said housing having a stepped axial bore which is conical at the end in the larger diameter cylindrical section of the housing, cylindrical at the end in the smaller diameter cylindrical section of the housing and cylindrical but of smaller diameter therebetween, said filler being of nonconducting elastomeric material except for conducting portions of elastomeric material at opposite ends, one conducting end portion being a liner of the intermediate cylindrical section of said bore adjacent the apex of the conical end section, the other conductive end portion forming the larger diameter cylindrical end section of said bore and having a conical interface with the nonconducting main

body portion of the elastomeric filler which interface is an extension of the conical inner surface of the intermediate section of the metallic housing whereby said conical inner metal surface and conical elastomeric interface collectively constitute a conductive stress relief cone.

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