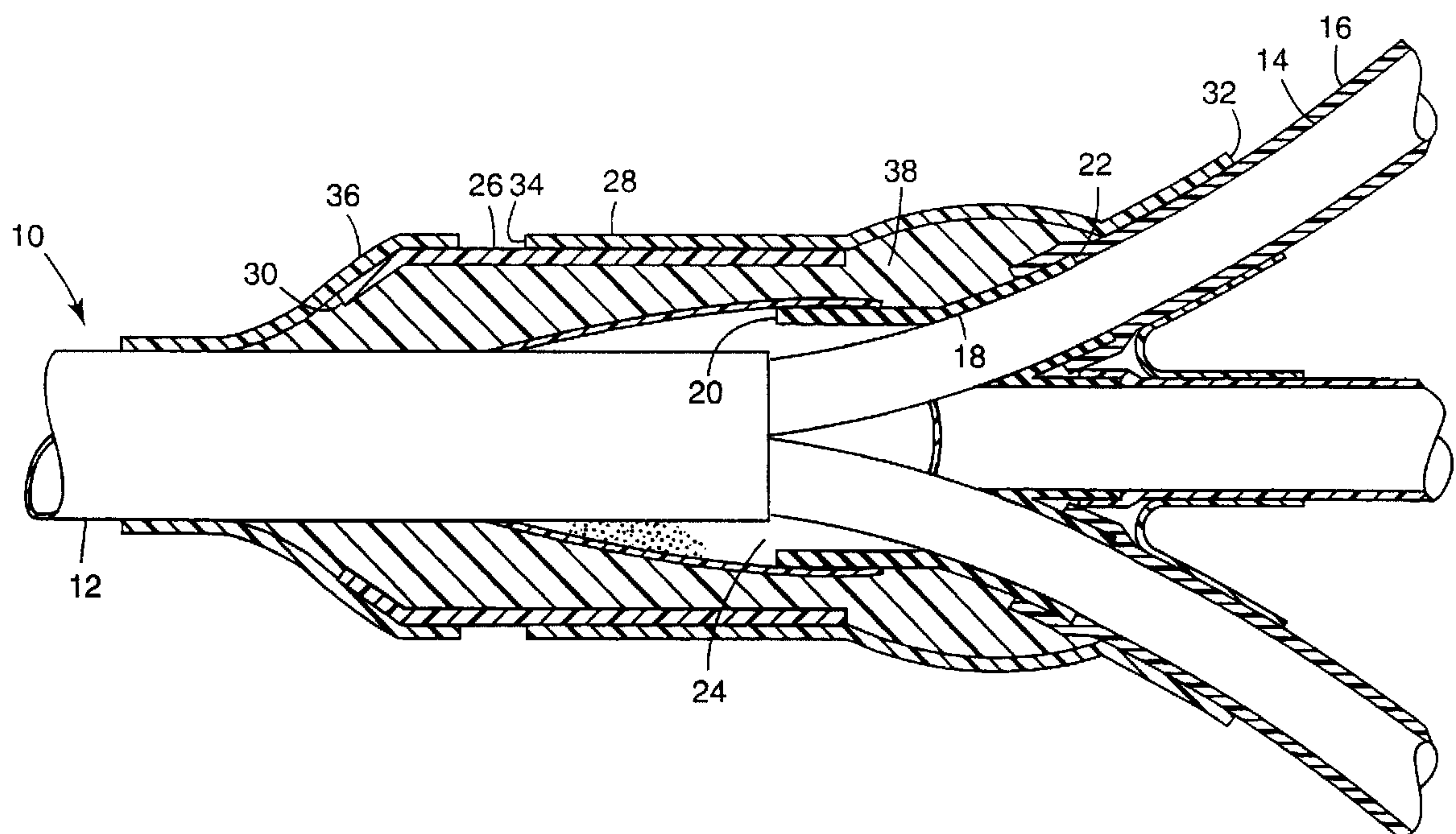




(86) Date de dépôt PCT/PCT Filing Date: 1996/01/22
(87) Date publication PCT/PCT Publication Date: 1997/07/31
(45) Date de délivrance/Issue Date: 2007/06/19
(85) Entrée phase nationale/National Entry: 1998/06/25
(86) N° demande PCT/PCT Application No.: US 1996/001004
(87) N° publication PCT/PCT Publication No.: 1997/027656

(51) Cl.Int./Int.Cl. *H02G 15/04* (2006.01)
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(54) Titre : OBTURATEUR D'EXTREMITE DE CABLES A HUILE FLUIDE
(54) Title: CABLE END SEAL FOR OIL-FILLED CABLES



(57) Abrégé/Abstract:

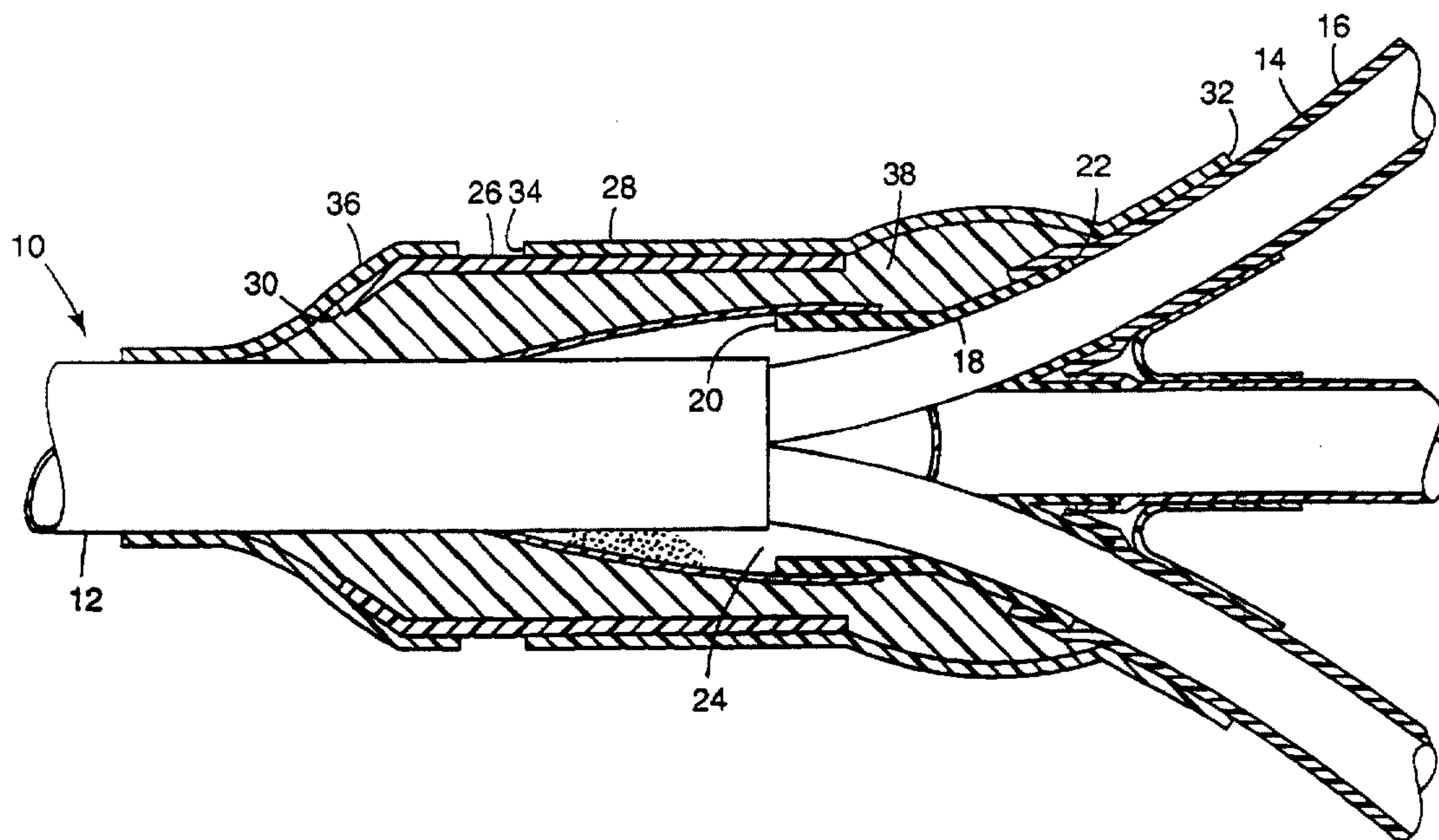
A cable end seal for a multiple-conductor oil filled cable (10) includes an inner sealing boot (18) adjacent the cable and filled with an oil restraint material (24) for the temporary restraint of cable oil and an outer boot (28) and cylindrical mold (26) filled with hardenable material (38) for the permanent containment of the cable oil. The inner boot (18) and oil restraint material (24) prevents contact between the oil and the material (38) at least until the material (38) has hardened.



**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H02G 15/04	A1	(11) International Publication Number: WO 97/27656 (43) International Publication Date: 31 July 1997 (31.07.97)
(21) International Application Number: PCT/US96/01004 (22) International Filing Date: 22 January 1996 (22.01.96) (71) Applicant (for all designated States except US): MINNESOTA MINING AND MANUFACTURING COMPANY [US/US]; 3M Center, P.O. Box 33427, Saint Paul, MN 55133-3427 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): SUNDHARARAJAN, Srinivasan [IN/US]; 10616 Mellow Meadows #12D, Austin, TX 78750 (US). GARCIA-RAMIREZ, Rafael [MX/US]; 10707 Lake Creek Parkway #15, Austin, TX 78750 (US). ACKLAND, Gordon, Lawrence [US/US]; 17706 North Rim Drive, Leander, TX 78641 (US). HUTCHINSON, Ted, Flynn [US/US]; 2906 Sabinal Trail, Cedar Park, TX 78613 (US). (74) Agents: ANDERSON, David, W. et al.; Minnesota Mining and Manufacturing Company, Office of Intellectual Property Counsel, P.O. Box 33427, Saint Paul, MN 55133-3427 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AZ, BY, KG, KZ, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: CABLE END SEAL FOR OIL-FILLED CABLES**(57) Abstract**

A cable end seal for a multiple-conductor oil filled cable (10) includes an inner sealing boot (18) adjacent the cable and filled with an oil restraint material (24) for the temporary restraint of cable oil and an outer boot (28) and cylindrical mold (26) filled with hardenable material (38) for the permanent containment of the cable oil. The inner boot (18) and oil restraint material (24) prevents contact between the oil and the material (38) at least until the material (38) has hardened.

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Cable End Seal For Oil-Filled Cables

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Field of the Invention

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The present invention generally relates to sealing the ends of multiple conductor electrical cables, and more particularly to a cable end seal for use when splicing or terminating a cable having an oil-impregnated layer as part of the dielectric system.

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Background of the Invention

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Electrical cables, such as those used for telephone lines, high voltage lines, cable television, etc., can develop faults or breaks in the line due to manufacturing defects, misuse or environmental factors. Faults occur both in underground and aerial cables. Rather than replacing an entire section of such a cable, it is expedient to expose a portion of cable, repair the fault, and place an enclosure about the connection. Splicing of electrical power cables is similarly useful in the connection of successive cable sections, and in the termination of such cables.

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One of the earliest constructions for these cables, particularly for underground power cables, consists of a lead jacket surrounding one or more conductors, with a layer of insulative, oil-impregnated paper placed between the lead jacket and the conductors. Although most modern underground cables now have extruded dielectric (plastic) coverings, with no fluid inside, there are still substantial amounts of the paper-insulated lead covered cables ("PILC") in use. A problem thus arises when a PILC cable needs to be repaired or terminated, due to the deleterious

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effects caused by the egress of the oil or other dielectric fluid.

U.S. patent number 5,374,784, assigned to the assignee of the present invention, offers an approach to accomplishing a cable end seal by providing an elastomeric, pre-stretched tube adapted to be placed around the exposed end of the PILC cable, directly in contact with the oil-impregnated paper, and a heat recoverable tubular sleeve which is adapted to completely surround and confine the elastomeric tube. The heat recoverable sleeve mechanically restricts the elastomeric tube, preventing the elastomeric tube from swelling which, in turn, precludes absorption of the oil. A complete oil seal is thus achieved with only two layers in the joint, and without the need for oil-resistant mastics, sealing resins, or metal clamps. In another approach disclosed in U.S. patent number 5,408,047, which is also owned by the assignee of the present invention, the heat-recoverable sleeve is replaced by epoxy-impregnated restricting tape which accomplishes the purpose of preventing the elastomeric tube from swelling.

The above-described patent is directed specifically to single-conductor cables. It is desirable to extend and adapt the oil-stop concept to cables having multiple conductors.

25 Summary of the Invention

In accordance with an aspect of the invention, there is provided a cable end seal at an end of an intact cable having a number of conductors extending therefrom, and an oil-impregnated, electrically insulative layer surrounding each conductor, the cable end seal comprising:

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an oil stop overlying the insulative layer of each cable conductor; an elastomeric inner boot having a glove-like shape including a generally cylindrical body, a single opening at one end of said body and multiple openings
5 corresponding in number to the number of cable conductors at the other end of said body, said inner boot being applied to the cable such that the cable conductors exit one through each of said multiple openings and said multiple openings engage said oil stop of each conductor, and said single
10 opening is directed toward the intact cable; an elastomeric outer boot having a glove-like shape including a generally cylindrical body, a single opening at one end of said body and multiple openings corresponding in number to the number of cable conductors at the other end of said body, said
15 outer boot being applied to the cable such that the cable conductors exit one through each of said multiple openings and said multiple openings engage said oil stops of each conductor, and said single opening is directed toward the intact cable; a mold surrounding and radially spaced from
20 the cable and disposed to seal to said outer boot; and a hardenable material filling said outer boot and providing permanent containment of said oil when hardened.

In accordance with an aspect of the invention, there is also provided a cable end seal at an end of a cable
25 having a number of conductors and oil-impregnated, electrically insulative layers surrounding each conductor, the cable end seal comprising an oil stop overlying the insulative layer of each cable conductor, the oil stop including an elastomeric layer adjacent to the

1 insulative layer and means for restricting the
2 elastomeric layer overlying the elastomeric layer, an
3 elastomeric inner boot having a glove-like shape
4 including a generally cylindrical body, a single
5 opening at one end of the body and multiple openings
6 corresponding in number to the number of cable
7 conductors at the other end of the body, the inner boot
8 being applied to the cable such that the cable
9 conductors exit one through each of the multiple
10 openings and the multiple openings engage the oil stop
11 of each conductor, and the single opening is directed
12 toward the intact cable, preferably an oil restraining
13 material disposed within the inner boot for at least
14 temporarily preventing egress of oil from the cable,
15 preferably a mold surrounding and radially spaced from
16 the cable, an elastomeric outer boot having a glove-
17 like shape including a generally cylindrical body, a
18 single opening at one end of the body and multiple
19 openings corresponding in number to the number of cable
20 conductors at the other end of the body, the outer boot
21 being applied to the cable such that the cable
22 conductors exit one through each of the multiple
23 openings and the multiple openings engage the oil stop
24 of each conductor, and the single opening is directed
25 toward the intact cable, the outer boot overlying a
26 portion of the mold and sealing to the mold, and a
27 hardenable material filling the mold and the outer boot
28 and providing permanent containment of the oil when
29 hardened.

30 This construction offers greater simplicity
31 in design and application as compared to prior methods
32 of providing a cable end seal, affording both cost and
33 time savings. The novel cable end seal assembly adapts
34 the end of the PILC cable and makes it suitable for
35 connection to plastic (extruded dielectric) cable or
36 fitted with a termination or other electrical
37 accessory. Thus pre-molded or extruded cable
38 accessories, which are designed for use with extruded

1 dielectric cables and normally not usable with PILC
2 cables, may be used to effect these connections.

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4 Brief Description of the Drawings

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6 The present invention will be described with
7 respect to the accompanying drawing wherein Figure 1 is
8 a cross-sectional view of a three-conductor PILC cable
9 having a cable end seal applied according to the
10 present invention.

11

12 Description of the Preferred Embodiment

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14 Figure 1 illustrates an exemplary multi-
15 conductor cable 10 which contains a dielectric fluid
16 therein. Such a cable 10 is typically constructed of
17 an outer lead jacket 12, surrounding a group of
18 conductors each covered by an insulative layer formed
19 of oil-impregnated paper and a semiconducting layer 14
20 formed of carbon-loaded paper. The present invention
21 is primarily designed for making a transition from such
22 an oil-filled cable 10. It should also be understood,
23 however, that the invention will work with cables
24 having other fluids therein, including those filled
25 with a dielectric jelly. Some PILC cables also have a
26 plastic sheath which surrounds the lead jacket 12.

27 The PILC cable 10 is prepared for splicing by
28 first cutting off a large section of the lead jacket
29 12, thereby exposing semiconducting layers 14. Sharp
30 corners at the edge of the lead jacket 12 should be
31 peened. A section of the semiconducting layers 14 are
32 similarly removed, exposing insulative layers (not
33 shown). Finally, a section of the insulative layers
34 are removed, exposing the central conductors (not
35 shown). Details of this preparation have not been
36 illustrated for the sake of clarity but are illustrated
37 and described in detail in the above-mentioned U.S.
38 patent number 5,374,784.

1 According to that patent, each phase of the
2 cable 10 is completed by applying an oil stop layer 16
3 which includes an elastomeric tube and a restricting
4 layer overlying the elastomeric tube. The elastomeric
5 tube is typically fabricated by extrusion and, in its
6 relaxed state, is generally cylindrical. It may be
7 formed of any oil-absorbing elastomeric material. The
8 preferred material for the elastomeric tube is
9 ethylene-propylene non-conjugated diene terpolymer
10 (EPDM), which is electrically insulative.

11 The restricting layer may be a heat
12 recoverable sleeve formed from a wide variety of
13 materials, particularly polymeric resins such as
14 polytetrafluoroethylene, polychloroprene,
15 fluoroelastomers or cross-linked polyolefins. The
16 preferred material is polyvinylidene fluoride, which
17 meets the primary requisites of being heat recoverable
18 and electrically insulative, and having a crystalline
19 melting point higher than that generated in emergency
20 overload conditions of the cable 10. Such material is
21 sold by Minnesota Mining and Manufacturing under the
22 brand name Kynar. Other heat recoverable materials may
23 be used if their melting point is greater than 125° C,
24 and preferably about 175° C. The term "heat
25 recoverable" refers to any thermoelastic material,
26 which, upon the application of heat, either returns to
27 its original (smaller) shape, or shrinks without having
28 been previously deformed. As an alternative to the
29 heat recoverable sleeve a restricting tape may be
30 applied in overlapping fashion to the outer surface of
31 the elastomeric tube. A suitable tape is an epoxy
32 impregnated tape sold by the Minnesota Mining &
33 Manufacturing Company under the product designation
34 White Restricting Tape.

35 To seal the area where the three conductors
36 branch from the cable body, a two-step approach is
37 utilized. Generally speaking, the area where the
38 individual conductors separate from the cable body is

1 sealed with a slow-reacting fluid material injected
2 into a mold surrounding the area. The material may be
3 anything which hardens, such as polymer concrete,
4 urethane or gels, but preferably is epoxy resin.
5 However, contact with oil will prevent resin from
6 reacting, and oil will migrate through other materials
7 until the material hardens. In order to allow the
8 resin or other material to harden, an inner rubber seal
9 is provided which is preferably filled with an oil-
10 restraining mastic which at least temporarily prevents
11 any oil or other liquid dielectric from contacting the
12 resin or other sealing material and possibly seeping
13 through before hardening of the material. Attempts in
14 the past to simply encapsulate the area in resin have
15 failed because oil from the main portion of the cable
16 prevented the resin from curing. The oil seeped
17 through the resin causing small tunnels which allowed
18 continued leakage.

19 According to the preferred sealing method, an
20 inner boot 18 of rubber is provided which is formed in
21 the shape of a glove with a large opening 20 at one end
22 facing the intact cable 10 and a number of smaller
23 openings 22 at the other end allowing the individual
24 conductors to separate and exit the inner boot 18. Of
25 course, the number of small openings 22 corresponds to
26 the number of conductors and the small openings 22 are
27 sized in diameter to effectively seal to the outer
28 surface 14 of the conductors. In this configuration
29 shown in Figure 1, the inner boot 18 is installed
30 before the oil stops 16 are applied to the
31 semiconductive layer 14 of the conductors, so that the
32 oil stops 16 will overlap the outer surface of the
33 inner boot 18 for a short distance. As an alternative,
34 the small openings 22 may be sized to overlap the outer
35 surfaces of the oil stop 16 after the same have been
36 applied to the conductors.

37 The large opening 20 of the inner boot 18 is
38 larger in diameter than the diameter of the cable 10 to

1 allow material 24 within the inner boot 18 to extend
2 from the boot 18 and along the outer surface of the
3 cable 10 for a short distance. The temporary oil
4 restraint material 24 within the inner boot 18 may be
5 any mastic which will at least temporarily resist and
6 retain oil such as that sold by the Minnesota Mining &
7 Manufacturing Company in tape form under the
8 designation 2228 rubber mastic, or may be a rubber tape
9 such as that sold by Minnesota Mining & Manufacturing
10 Company under the designation 23. In either case, a
11 portion of the inner boot 18, the oil restraint
12 material 24 and a portion of the cable 10 are
13 preferably wrapped in restricting tape such as the
14 epoxy-impregnated tape described above and sold by
15 Minnesota Mining & Manufacturing Company under the
16 designations White Restricting Tape or glass cloth tape
17 also sold by Minnesota Mining & Manufacturing Company.

18 Once this preparation of the inner boot 18 is
19 completed, the second and more permanent layer of
20 protection is applied. A hard mold 26, preferably of
21 plastic, in the shape of a cylinder is preferably
22 installed over the area of the inner boot 18, and an
23 outer boot 28 is applied to overlap the mold 26. The
24 mold may be of any material which is compatible with
25 the materials injected therein as described below. The
26 mold 26 may include a taper 30 at its end angled toward
27 the intact cable 10. The mold 26 may also include
28 projections or longitudinal ribs (not shown) extending
29 radially inward from the inner surface of the mold 26
30 to maintain the mold 26 concentric with respect to the
31 cable 10. The outer boot 28 is similar in shape to the
32 inner boot 18 although, of course, larger in diameter
33 and length. The small, exiting openings 32 of the
34 outer boot 28 are sized to seal to the outer surface of
35 the oil stop 16 of each conductor and the large opening
36 34 of the outer boot 28 is sized to seal to the outer
37 surface of the mold 26. The open, tapered end 30 of
38 the mold 26 is overwrapped with sealing tape 36 or a

1 cold-shrink tubing product, both available from the
2 Minnesota Mining & Manufacturing Company. The sealing
3 product used extends to the cable 10 surface.

4 The cavity within the outer boot 28 and the
5 mold 26 is filled with a hardenable sealing material 38
6 through a hole or cut in the boot 28 or a fill hole in
7 the mold 26. If the material 38 is injected this way,
8 the mold 26 or boot 28 can be provided with small holes
9 to allow trapped air to escape. If the mold happens to
10 be oriented vertically with the outer boot downward,
11 the assembly can be filled through the open tapered end
12 30 of the mold 26 and the sealing tape 36 or cold-
13 shrink tubing applied afterward. Once the mold 26 and
14 boot 28 assembly is filled with the hardenable material
15 38, attachment of cable accessories to the bared ends
16 of the conductors may proceed.

17 In time the material 38 will harden and
18 permanently restrict the inner boot 18 from expanding
19 to maintain the oil within against pressure generated
20 by elevated temperatures due to energizing the cable.

21 Thus there has been described a cable end
22 seal which is easily and effectively applied to oil
23 filled cable to allow the connection of such cables to
24 other types of cables or cable accessories. The cable
25 end seal operates in the manner of the oil stop
26 described in U.S. patent number 5,374,784 in that a
27 rubber layer (inner boot 18) is provided to seal the
28 cable and prevent oil from escaping and a second
29 material (hardenable material 38) is provided to
30 restrict the rubber layer and prevent the rubber layer
31 from degrading due to the absorption of oil and
32 consequential swelling.

33 Although the invention has been described with
34 respect to a particular embodiment including preferred
35 parts and materials, it will be apparent to those
36 skilled in the art that many modifications may be made
37 without departing from the spirit of the invention.
38 For example, the mold and/or the boots need not be
39 circular in cross-section, and the mold may or may not

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1 be provided with such features as stand-off projections
2 or ribs, air escape holes or resin fill holes. In
3 fact, the mold may be eliminated if the outer boot is
4 extended to cover the lead coating of the cable and is
5 sized to seal to the cable. Likewise, the inner boot
6 may be extended to seal to the cable and the White
7 Restricting Tape or glass cloth tape eliminated. In
8 addition, the oil-restraint material 24 within the
9 inner boot 18 could be eliminated if care is taken to
10 adequately seal the inner boot to the conductors and
11 the cable, as by the use of White Restricting Tape.
12 The materials described for the mold, boots and oil
13 restraint and containment substances may be changed so
14 long as the described function is accomplished.

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CLAIMS:

1. A cable end seal at an end of an intact cable having a number of conductors extending therefrom, and an oil-impregnated, electrically insulative layer surrounding
5 each conductor, the cable end seal comprising:

an oil stop overlying the insulative layer of each cable conductor;

an elastomeric inner boot having a glove-like shape including a generally cylindrical body, a single
10 opening at one end of said body and multiple openings corresponding in number to the number of cable conductors at the other end of said body, said inner boot being applied to the cable such that the cable conductors exit one through each of said multiple openings and said multiple openings
15 engage said oil stop of each conductor, and said single opening is directed toward the intact cable;

an elastomeric outer boot having a glove-like shape including a generally cylindrical body, a single opening at one end of said body and multiple openings
20 corresponding in number to the number of cable conductors at the other end of said body, said outer boot being applied to the cable such that the cable conductors exit one through each of said multiple openings and said multiple openings engage said oil stops of each conductor, and said single
25 opening is directed toward the intact cable;

a mold surrounding and radially spaced from the cable and disposed to seal to said outer boot; and

a hardenable material filling said outer boot and providing permanent containment of said oil when hardened.

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2. A cable end seal according to claim 1 wherein said oil stop overlaps said inner boot.

3. A cable end seal according to claim 1 wherein said inner boot overlaps said oil stop.

5 4. A cable end seal according to claim 1 wherein said mold includes a tapered end extending toward the intact cable.

5. A cable end seal according to claim 1 wherein said mold includes projections extending radially inwardly to
10 position said mold with respect to the cable.

6. A cable end seal according to claim 1 wherein said mold includes longitudinal ribs extending radially inwardly to position said mold with respect to the cable.

7. A cable end seal according to claim 1 wherein said
15 mold includes air escape holes.

8. A cable end seal according to claim 1 further including overlapping tape extending from said mold to the cable to retain said hardenable material within said mold and said outer boot.

20 9. A cable end seal according to claim 1 wherein said hardenable material is epoxy sealing resin.

10. A cable end seal according to claim 1 further including an oil restraint material disposed within said inner boot for at least temporarily preventing egress of oil
25 from the cable.

11. A cable end seal according to claim 10 wherein said oil restraint material is a rubber mastic.

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12. A cable end seal according to claim 10 further including overlapped layers of tape extending from said inner boot single opening to the intact cable to contain said oil restraint material and seal said inner boot to the
5 cable.

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