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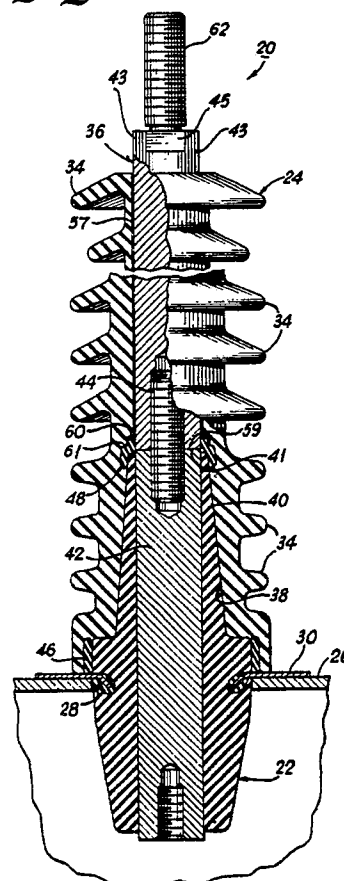
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W-8000 München 90(DE)(54) **High voltage outdoor electrical bushing assembly.**

(57) In a high voltage outdoor electrical bushing assembly (20) for use, for example, as an entrance bushing on high voltage electrical equipment, such as an interrupter or the like, a portion is formed from an indoor bushing (22) adapted to be connected to a shielded electrical cable which meets the dimensional industrial standard for indoor bushings. More specifically, the high voltage outdoor electrical bushing assembly (20) may include an indoor electrical bushing formed from a resinous material, such as an epoxy, and a complementary bushing adapter (24) including a weathershed formed from an elastomeric material, which provides the additional clearance required for outdoor applications. The bushing adapter (24) may also provide electrical stress relief at the elastomer to air interface and the elastomer to epoxy interface. Because of the standardization of the bushing (22) used for both indoor and outdoor applications, the cost of manufacturing outdoor bushings can be substantially reduced.

Fig. 1**EP 0 446 404 A1**

The present invention relates to a high voltage outdoor electrical bushing assembly.

High voltage electrical bushings are known in the art. Examples of such bushings are disclosed in U.S. Patent Nos. 1,811,887; 1,899,658; 3,071,672; 3,231,666; 3,504,106; 3,515,799; 3,551,587 and 4,563,545. Such electrical bushings are generally suitable for connection to a bare electrical cable and used as entrance bushings on various types of electrical equipment, such as interrupter switches and the like to allow connection of the equipment to an external electrical circuit. An example of such equipment is disclosed in U.S. Patent No. 3,947,650, assigned to the same assignee as the present invention.

Depending on the application, such electrical equipment may be located outdoors or indoors. In indoor applications, the bushing is generally connected to a shielded electrical cable. However, in outdoor applications, the bushing is generally connected to a bare electrical conductor. Consequently, it is necessary to provide additional clearance between the bare electrical conductor, normally at a relatively high voltage and the equipment housing, normally grounded. In such applications, weathersheds are provided to provide additional clearance between the bare electrical conductor and the equipment housing and to protect the bushing from flashover due to environmental factors such as rain, snow and the like. Examples of bushings adapted for outdoor use which include weathersheds are disclosed in U.S. Patent Nos. 1,811,887; 1,899,658; 3,071,672 and 4,563,545.

There is no known standardization between bushings connected to bare electrical cables (outdoor bushings) and bushings connected to shielded electrical cable (indoor bushings). Consequently, due to the different clearance requirements for indoor and outdoor bushings, electrical equipment manufacturers are required to produce separate bushings for indoor use and for outdoor use, which significantly increases the cost of such bushings.

U.S. Patent No. 1,899,658 discloses a method for modifying the electrical equipment to which the bushing is attached to convert a bushing designed for indoor use to one which can be utilized in an outdoor application. However, such a modification can be relatively expensive and time consuming.

The present invention as claimed solves the problem of providing a high voltage outdoor electrical bushing utilizing a standard indoor bushing without the necessity of any modification to the equipment to which the bushing is attached. It allows standardization of the bushings used for indoor and outdoor applications.

Briefly, the present invention relates to a relatively high voltage outdoor electrical bushing used,

for example, as an entrance bushing on high voltage electrical equipment, such as an interrupter or the like, a portion of which is formed to meet the dimensional industrial standard for indoor bushings. A high voltage outdoor electrical bushing in accordance with the present invention may e.g. include an indoor electrical bushing formed from a resinous material, such as an epoxy, and a complementary prophylactic weathershed or bushing adapter formed from an elastomeric material, which provides the additional clearance required for outdoor applications. Such bushing adapter also provides electrical stress relief at the elastomer to air interface and the elastomer to epoxy interface. Because of the possibility of standardization of the bushing which is used for both indoor and outdoor applications, the cost of manufacturing can be substantially reduced.

In the following preferred embodiments of the present invention are described in detail taking reference to the accompanying drawings. In these

FIG. 1 is an elevational view, partially in section, of a high voltage outdoor electrical bushing assembly in accordance with the present invention, shown attached to a housing of an interrupter switch or the like;

FIG. 2 is an elevational view of an alternate embodiment of a portion of a termination stud on a high voltage outdoor bushing assembly in accordance with the present invention;

FIG. 3 is similar to FIG. 2 and illustrates another alternate embodiment of a portion of a termination stud on the high voltage outdoor bushing assembly in accordance with the present invention;

FIG. 4 is an elevational view, partially in section of an alternate embodiment of a bushing forming a part of the high voltage outdoor bushing assembly in accordance with the present invention;

FIG. 5 is a partial sectional view of a high voltage bushing assembly without stress relief which illustrates the electrical field lines in percent of line to ground voltage adjacent an embedded flange in the bushing;

FIG. 6 is similar to FIG. 5 and illustrates the electrical field lines with the addition of stress relief in accordance with the present invention;

FIG. 7 is a view of a conductor rod illustrating a method of making a bushing adapter in accordance with present invention;

FIG. 8 is similar to FIG. 7 and illustrates and subsequent step in the method of making a conductor rod in accordance with the present invention; and

FIG. 9 is a sectional view of a bushing adapter in accordance with the present invention.

The shown high voltage outdoor bushing as-

sembly in accordance with the present invention is generally identified by the reference numeral 20. The assembly includes a bushing 22 and a bushing adapter 24. The high voltage bushing assembly 20 is adapted to be used, for example, as an entrance bushing on various types of electrical equipment, such as an interrupter switch as disclosed in U.S. Patent No. 3,947,650, assigned to the same assignee as the present invention and hereby incorporated by reference. When used as an entrance bushing, the high voltage bushing assembly 20 is rigidly mounted to a tank or housing 26 of the electrical equipment. More specifically, the bushing assembly 20 is disposed in an aperture 28, for example, on the top of the housing 26, such that a portion of the bushing 22 extends inwardly into the housing 26 and a portion extends outwardly from the top of the housing 26.

The bushing assembly 20 is then rigidly attached to the housing 26. Various means are known in the art for attaching the bushing assembly 20 to a housing 26. For example, as shown in FIG. 1, the bushing 22 is provided with an annular metallic flange 30 which extends radially outwardly from the bushing 22. The flange 30 is embedded in the bushing 22 and welded to the housing 26. However, it should be apparent to those of ordinary skill in the art that the principles of the present invention are equally applicable to a bushing 32, such as illustrated in FIG. 4, which does not include an embedded flange but, rather, an integrally formed flange 31, for example, from epoxy. Such bushings 32 include a clamp 33, fasteners 35 and one or more gaskets 37 forming a clamping assembly 39 to allow bushing 32 to be clamped and gasketed to the housing 26 to form a seal therebetween.

An important aspect of the invention relates to the fact that a standardized bushing 22 or 32 which conforms to the industrial dimensional standard for indoor bushings (i.e., bushings normally attached to a shielded cable), can be used in an outdoor (i.e., connected to an unshielded cable) application with the addition of a prophylactic weathershed in the form of the bushing adapter 24 illustrated in FIG. 9. More specifically, the bushing 22 or 32 is designed to conform to the dimensional standards for bushings connected to shielded electrical cables promulgated in ANSI/IEEE Std. 386-1985, entitled IEEE STANDARD FOR SEPARABLE INSULATED CONNECTOR SYSTEMS FOR POWER DISTRIBUTION SYSTEMS ABOVE 600 VOLTS, which is hereby incorporated by reference. This standard applies to bushings with various ratings above 600 volts. For example, FIG. 10 relates to 27 kilovolt (kv), 600 ampere (A) bushings while FIG. 11 relates to a 38 kv, 600 A bushing. FIG. 3 relates to a 15-38 kv, 200A bushing. It will be appreciated by those of

ordinary skill in the art that the principles of the present invention are applicable to all such dimensionally standard bushings adapted to be connected to shielded electrical cables.

The bushings 22 and 32 are exemplary and formed from epoxy, normally used in indoor applications for connection to shielded cables. An example of bushing 22 is available from Joslyn Power Products Corporation of Alsip, Illinois under Part No. 030B900, for example, for a 27 kilovolt application. By utilizing a standardized bushing normally used for connection to a shielded cable 22 or 32 in the assembly of the high voltage electrical bushing assembly 20 for outdoor use normally connected to unshielded cables, the cost of manufacturing such an outdoor bushing can be significantly reduced.

In outdoor applications, where the bushing is normally attached to a bare electrical conductor (not shown), the bushing adapter 24 is required to provide clearance between the bare electrical conductor, generally at a relatively high voltage and the equipment housing 26, normally grounded, to prevent flashover. The axial length of the bushing adapter 24 is dependent upon the magnitude of the electrical voltage at the bare electrical conductor. This length is adjusted by the number of skirt portions 34 used to form a weathershed. Such clearance requirements are clearly within the ordinary skill in the art.

The bushing adapter 24 is formed as a housing with an elastomeric material concentrically disposed about the bushing 22. An annular well 38 is formed at one end having a contour complementary to the outer contour of an upper portion 40 of the bushing 22. The bushing adapter 24 includes a centrally disposed electrical conductor or bushing rod 36, disposed between roughly the top 41 of the well 38 and extending outwardly from the top skirt portion 34 of the bushing adapter 24. When the bushing adapter 24 is assembled to the bushing 22, the bushing rod 36 in the bushing adapter 24 is adapted to be mated with a bushing rod 42 in the bushing 22 to form a continuous electrical connection therebetween.

Various means are known for mating of the bushing rods 36 and 42. For example, the top end of the bushing rod 42 may be provided with a threaded hole, axially aligned with a threaded hole provided in the bottom portion of the bushing rod 36. A threaded stud 44 may then be received in the threaded holes in the bushing rods 36 and 42 to make a secure connection therebetween. A portion 43 of the bushing rod 36 extending outwardly from the bushing adapter 24 may be provided with a pair of flats 45 to facilitate assembly.

In order to reduce the electrical stress at the elastomer to air interface and the electrical stress

at the elastomer to epoxy interface (e.g., bushing 22 interface), means are provided to reduce the electrical stress in these areas. More specifically, one or more inserts 46 and 48 may be provided. The insert 46 is a stress relief insert and is formed from an elastomeric semiconductor material and is formed as a ring disposed at the base of the bushing adapter 24 and acts as an interface between the bushing 22 and the bushing adapter 24. The second insert 48 is a shielding insert, also formed as a ring, may be provided at the interface between the top of the bushing 22 and the top 41 of the well 38, formed in the bushing adapter 24. The stress relief insert 46 reduces the electrical stress at the elastomer to air interface and the elastomer to epoxy interface. This is illustrated in FIGS. 5 and 6. FIG. 5 illustrates a portion of a bushing assembly 20 wherein equal potential lines 50 are shown as a percentage of line to ground voltage due to the electrical potential difference between the bushing rods 36 and 42 (generally at a relatively high voltage) and the annular flange 30 (normally at ground potential). As shown in FIG. 5, the equal potential lines 50 are relatively closer together causing a relatively high electrical stress at the base of the bushing 22. Such electrical stress can break down the air adjacent the bushing 22 and cause the bushing assembly 20 to flashover. With the addition of the stress relief insert 46 and 48 as shown in FIG. 6, the equal potential lines 50 are spread out relative to the bushing rod 42 which results in reduced electrical stress at the epoxy to elastomer interface and the elastomer to air interface.

The shielding insert 48 is for shielding trapped air pockets between the conductor 43 to epoxy interface and the epoxy to elastomer interface (i.e., near the interface between the surfaces 59 and 41). If any air is trapped because of an imperfect fit of the components, any electrical voltage stress is eliminated because the edge of the high voltage surface in effect has been moved to the outer surface of the shielding insert 48.

In manufacturing the bushing adapter 24, initially the conductor rod 36 is prepared.

The conductor rod 36 may be fabricated with various high electrical conductivity metallic members, such as AA 6262-T9 aluminum or ASTM B301 copper, alloy 145, HO2 tempered. If aluminum is used for the conductor rod 36, it may be electro-tin-plated with approximately 0.8 thousandths of an inch (mils). If the conductor rod 36 is formed from a copper alloy material, it may either be used as is or electro-tin-plated with approximately 0.2 mils.

After the electro-tin-plating process, the conductor rod 36 should be cleaned. For example, the conductor rod 36 may be degreased in an ultrasonic degreaser to remove machine oil and other

contaminants. After the conductor rod 36 is degreased, it may be wiped down with a solvent, such as, methyl ethyl ketone, with a clean, lint-free towel with an upward motion towards the top of the conductor rod 36. After the conductor rod 36 is cleaned, it is placed in an appropriate fixture (not shown) for further processing.

Once the conductor rod 36 is in the fixture, the conductor rod 36 is prepared for one or more coats of adhesives. More specifically, the conductor rod 36 is masked with masking tape. FIG. 7 illustrates portions 50 and 52 of the conductor rod 36 which should be masked. Masking tape is applied to a portion 50 since this portion 50 will extend outwardly from the bushing adapter 24. This portion 50 may extend approximately one inch in axial length. Approximately one-half inch of the conductor rod 36 is masked intermediate the end of the conductor rod 36 in the area identified with the reference numeral 52. The unmasked portion 54 between the portions 50 and 52 may be approximately one inch. The portion 54 is unmasked to allow electrical contact between the bushing rod 36 and a semiconducting heat-shrinkable tube 57, discussed below. After the conductor rod 36 is masked, an even coat of adhesive is applied. Various types of adhesives may be used, such as Pliobond adhesive as manufactured by the W. J. Ruscoe Company of Akron, Ohio. The adhesive is then cured, for example, for one hour at 149° C. After curing, the adhesive may be allowed to cool to ambient temperature.

Next, a piece of ethylene propylene rubber (EPR) heat-shrinkable tubing 57 is cut to the length 58 identified in FIG. 7. The inner diameter surface of the heat-shrinkable tubing may be cleaned with a solvent, such as Isopropanol. The adhesive that is already cured on the conductor rod 36 should also be cleaned with a solvent, such as Isopropanol or Heptane.

Another adhesive, such as Chemlock 238, as manufactured by the Elastomer Product Division of Lord Corporation of Erie, Pennsylvania, may be applied over the first adhesive on the conductor rod 36. After the second adhesive has partially dried, the masking tape is removed from the conductor rod 36.

The next step is to place the shielding insert 48 onto an end 59 of the conductor rod 36 as shown in FIG. 8. The shielding insert 48 is formed with an annular shoulder 60 forming a stepped surface 61 and may be compression molded with a semiconductive compound, for example, ethylene propylene diene monomer (EPDM). After the shielding insert 48 is in place, the precut and precleaned semiconducting heat-shrinkable tubing 57 is slipped over the conductor rod 36 such that one end rests on the stepped surface 61 of the

shielding insert 48 as shown in FIG. 8. The heat-shrinkable tubing 57 is then shrunk down with a proper torch near the stepped surface 61 to provide a good fit between the heat-shrinkable tubing and the shielding insert. The entire assembly is then cured, for example, for one hour at approximately 149° C. After the assembly is cooled to ambient temperature, it should be allowed to stand for about twelve hours or more. Subsequently, the assembly may be degreased in an ultrasonic degreaser and stored in a closed container until further processing.

Next, the assembly is placed in a mold cavity along with the stress relief insert 46. The stress relief insert 46 may also be compression molded with a semiconductive EPDM compound. The weathershed is then molded in a ram injection press with an elastomeric material to form the completed bushing adapter 24, as illustrated in FIG. 9.

The bushing adapter 24 is then assembled to the bushing 22 or 32. In order to facilitate assembly, a lubricant or grease may be applied to the mating surfaces. The conductor rod 36 in the bushing adapter 24 is then attached to the bushing rod 42 as discussed above. When assembled, the bushing adapter 24 will be in relatively tight contact with the bushing 22. The bottom surface 63 of the bushing adapter 24 will also be relatively tightly seated against the top of the flange 30.

Various types of terminals 62, 64 and 66 may be attached to the free end 43 of the bushing rod 36 as shown in FIGS. 1, 2 and 3. For example, FIG. 1 illustrates a threaded terminal 62 while FIG. 2 illustrates a straight rod 64 and FIG. 3 illustrates a flattened pad 66 with connection holes. In order to attach the terminals 62, 64 and 66 to the bushing rod 36, the free end 43 of the bushing rod 36 may be provided with a threaded hole (not shown) for receiving a threaded portion (not shown) formed on one end of the terminal 62, 64 or 66. All such terminals are intended to be within the scope of the present invention.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. Thus, it is understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically designated above.

Claims

1. A high voltage outdoor electrical bushing assembly (20) comprising:
 - an indoor bushing (22; 32) having a centrally disposed electrical conductor (42) defining a terminal end; and
 - a bushing adapter (24) for adapting said

bushing (22) for outdoor use.

2. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, wherein said bushing adapter (24) includes a weathershed (34).
3. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, wherein said indoor bushing (22; 32) is formed to meet an industrial dimensional standard for such bushings.
4. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, wherein said indoor bushing (22; 32) is formed from a resinous material.
5. A high voltage outdoor electrical bushing assembly (20) as recited in claim 2, wherein said weathershed (34) is formed from an elastomeric material.
6. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, further including means (48) for reducing the electrical stress at an interface defined between the indoor bushing (22; 32) and the bushing adapter (24).
7. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, further including means (46) for reducing the electrical stress at an interface defined between said bushing adapter (24) and air.
8. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, further including, in said bushing adapter (24), a terminal (36) formed from an electrically conductive material, electrically coupled to the terminal end of said electrical conductor (42) in said indoor bushing (22; 32) and having a free end (43) for connection to an external electrical circuit.
9. A high voltage outdoor electrical bushing assembly (20) as recited in claim 8, wherein said free end (43) of said terminal (36) is provided with a rod (64).
10. A high voltage outdoor electrical bushing assembly (20) as recited in claim 8, wherein said free end (43) of said terminal (36) is provided with a threaded portion (62).
11. A high voltage outdoor electrical bushing assembly (20) as recited in claim 8, wherein said

free end (43) of said terminal (36) is provided with a flattened pad (66).

12. A high voltage outdoor electrical bushing assembly (20) as recited in claim 1, further including means (30; 31, 39) for attaching said bushing assembly to an equipment housing (26). 5
13. A high voltage outdoor electrical bushing assembly (20) as recited in claim 12, wherein said attaching means includes a metallic flange (30), partially embedded within said indoor bushing (22). 10
14. A high voltage outdoor electrical bushing assembly (20) as recited in claim 9, wherein said attaching means (31, 39) includes a clamping assembly (39). 15

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Fig. 1

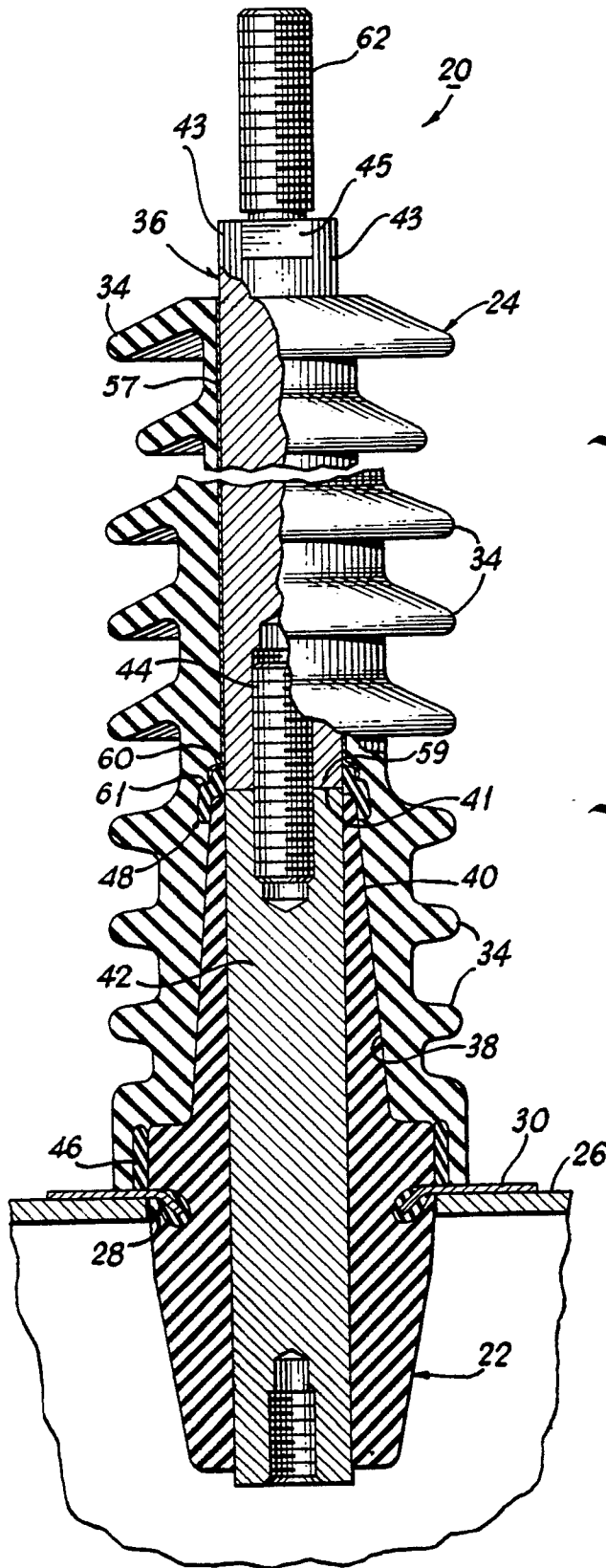


Fig. 2

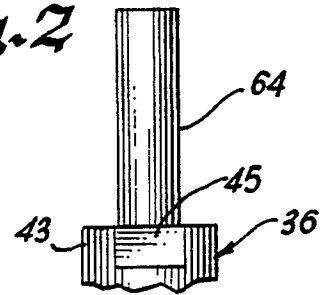


Fig. 3

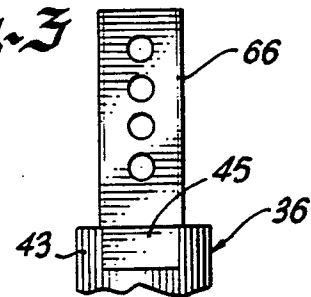
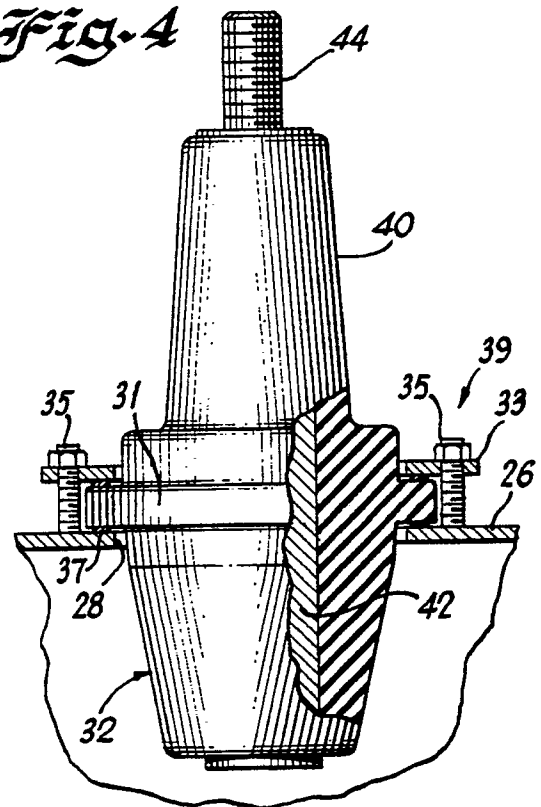
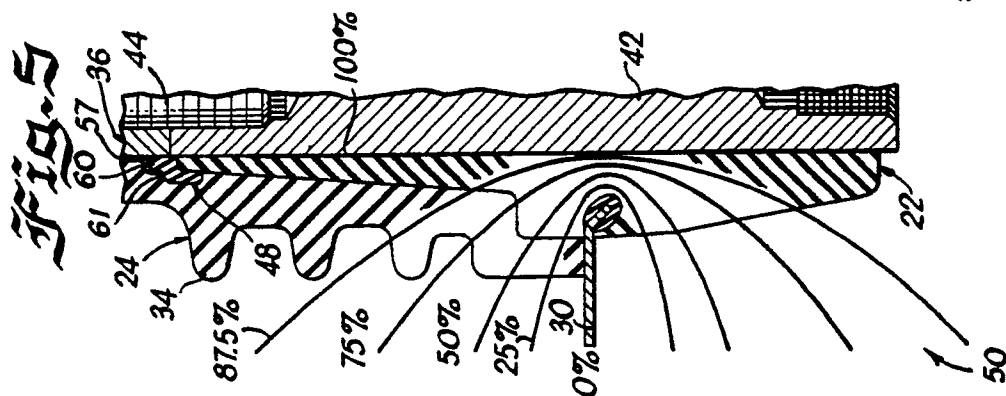
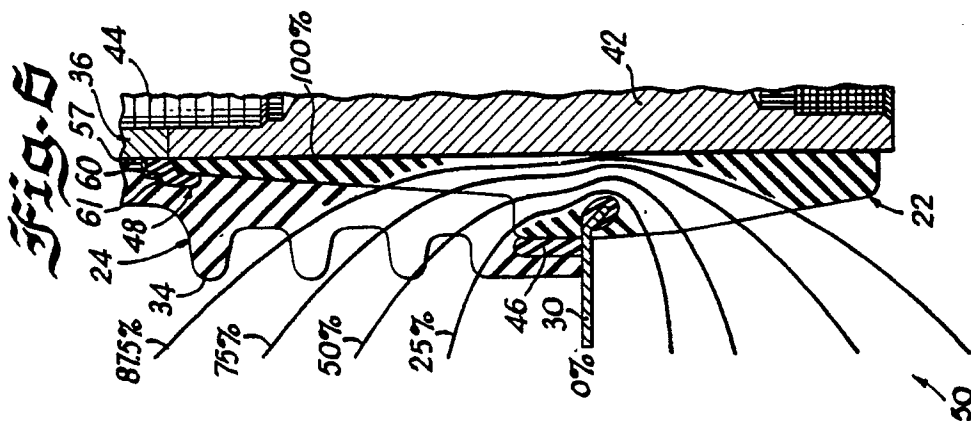
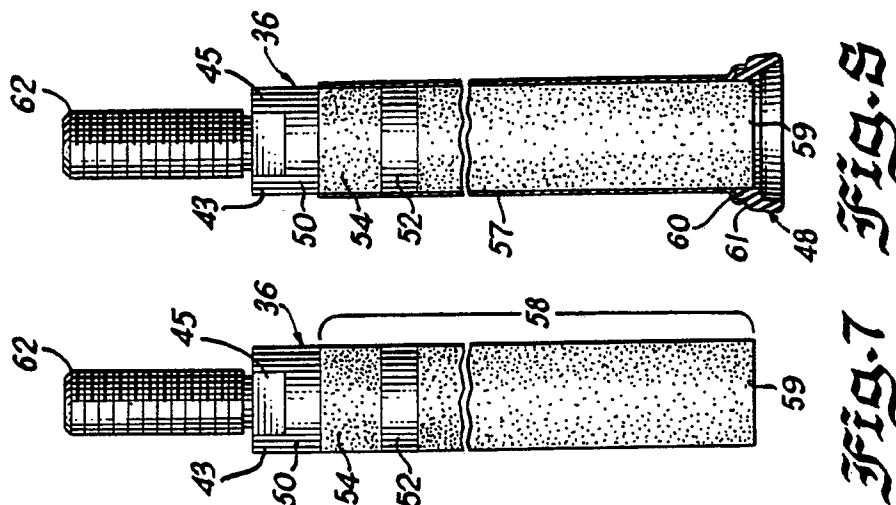
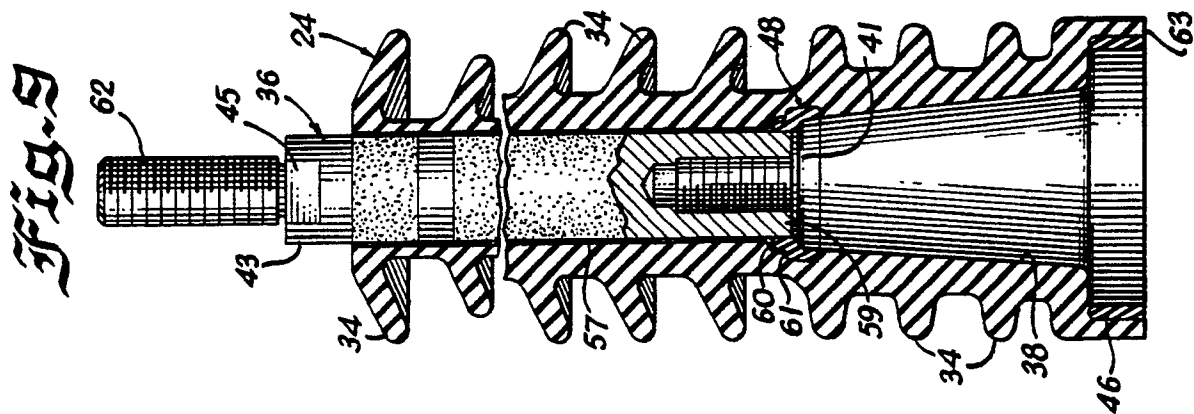


Fig. 4







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EUROPEAN SEARCH REPORT

Application Number

EP 90 10 9975

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 283 897 (KABEL- UND LACKDRAHTFABRIKEN) * column 2, line 51 - column 5, line 54; figures 1-3 * - - -	1,2,6-8, 10	H 01 B 17/26
Y,A	GB-A-2 212 005 (PIRELLI) * page 3, line 2 - page 4, line 35; figures 1-3 * - - -	1,2,5	
Y,A	GB-A-9 435 78 (WESTINGHOUSE) * page 7, lines 61 - 63; claims 1-7; figure 18 * - - -	1,2,4,5	
Y,A	EP-A-0 036 243 (AMERACE) * figures 1-9 * - - -	1,6,7	
Y,A	US-A-3 861 777 (CLARK) * figures 1, 4 * - - - - -	1,8,10,12, 14	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5) H 01 B H 01 F
Place of search The Hague		Date of completion of search 12 June 91	Examiner DEMOLDER J.
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