Feb. 7, 1967 D. W. TURNER 3,303,262

HIGH-VOLTAGE INSULATOR STRUCTURE WITH SEALED COMPONENTS, AND METHOD OF MAKING SAME

Filed May 26, 1964

FIG. 2.

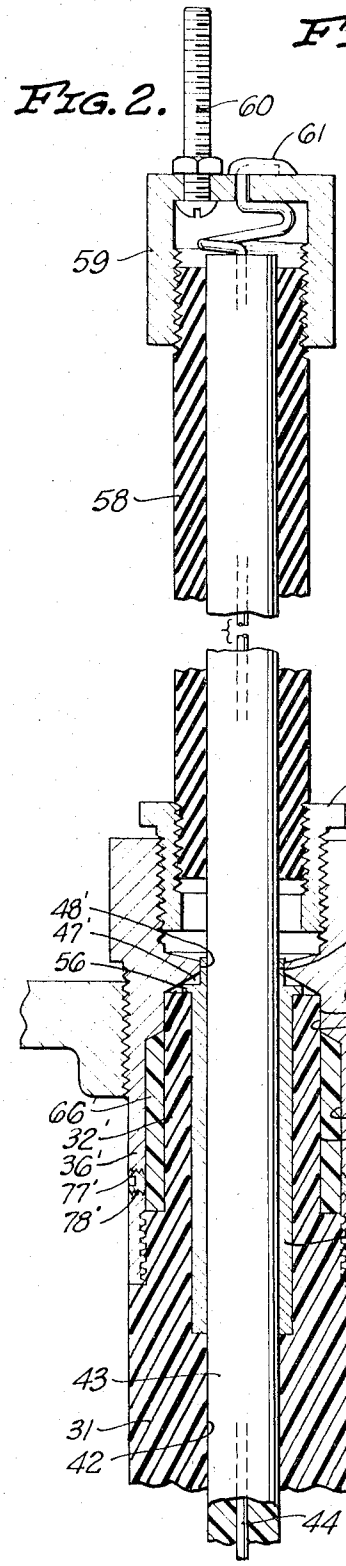


FIG. 3.

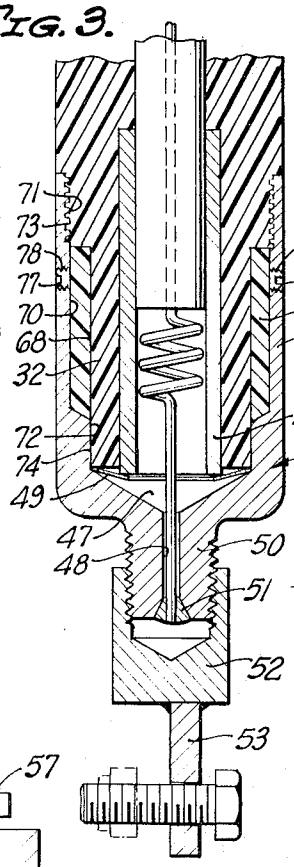


FIG. 1.

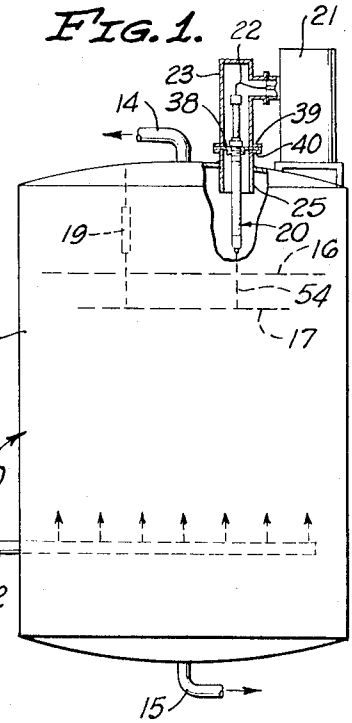
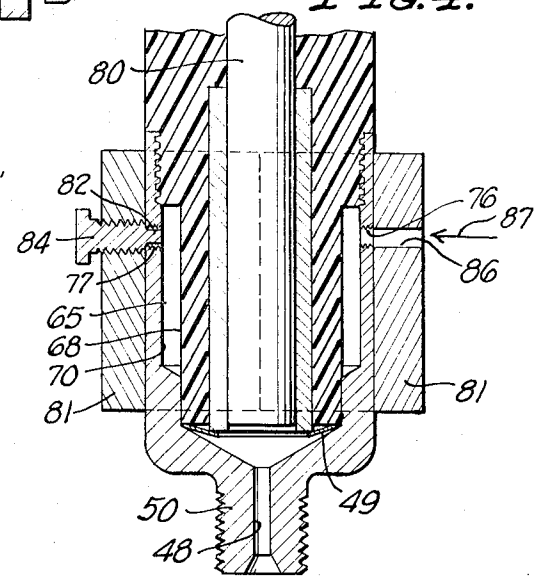


FIG. 4.



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HIGH-VOLTAGE INSULATOR STRUCTURE WITH SEALED COMPONENTS, AND METHOD OF MAKING SAME

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19 Claims. (Cl. 174—18)

My invention relates to insulator structures for electrically insulating high-voltage conducting elements from other portions of electrical equipment. It will be exemplified as a high-voltage entrance bushing conducting high-voltage potentials into a container. More specifically it will be exemplified as applied to an electric treater for dispersions or emulsions because this represents what is probably the most severe service to which an entrance bushing is put. Such treaters are usually operated at temperatures above 100° F., often in the range of 300–350° F. and the required steam cleaning of such treaters at intervals makes desirable the use of insulation capable of withstanding temperatures encountered in this operation.

Along with other electrical equipment, electric treaters of this type require that the inlet bushing or other insulator structure must operate without short-circuiting or substantial surface conductivity when disposed in or opening on a zone containing oil having significant residual impurities therein, often dispersed particles of a conductive or corrosive nature. The electric field around the high-voltage conductor of an entrance bushing tends to draw such dispersed particles by electrophoretic action toward any protective coating or member around the conductor. Coatings or protective members of certain plastic materials have been found to maintain satisfactory insulation at high temperatures in the face of deposits tending to accumulate thereon with little or no surface arcing or "treeing." These are materials having surfaces that are slick and non-wettable. Examples for high temperature service are polytetrafluoroethylene ("Teflon") or polytrifluorochloroethylene ("Kel-F"). Examples for lower temperature service are polypropylene or polyethylene.

On the other hand the problem of sealing the junction of such plastic materials and the other elements of the bushing against entry of contaminants from the zone in which the bushing or insulator structure extends has never been satisfactorily solved. For example, if the conductor extends through a relatively thick tube of such plastic material and is electrically connected to a metal closure or terminal closing the inner end of the tube, no completely successful structure has been developed, prior to the present invention, for sealing the junction of the tube and its closure. Attempts to do this by appropriate threaded connection, by piston-type seals or by spring-compressed sealing rings have not fully solved the problem inasmuch as failures have occurred after extended periods of operation or in some instances shortly after the bushing has been put in service.

It is an object of the invention to provide a high-voltage entrance bushing or other insulating structure in which the component parts are so effectively sealed against entry of contaminants that extremely long service life without electric failure is achieved. In this connection it is an object to provide such an insulating structure in which component parts are permanently bonded to a molded-in-situ sealing element.

A further object is to provide an insulating structure in which a tubular or body member of insulating material is at least partially closed by a cap member with

these members designed to provide a mold space bounded by surfaces of the two members. A further object is to introduce a sealing substance into such mold space and cure or polymerize it therein while under high pressure to form the aforesaid molded-in-situ sealing element. Another object is to provide a sealing element of this type which is permanently bonded to each of such surfaces of such members. Still a further object is to mold the sealing element in such manner that some of the sealing substance closes the mouth of or enters any minute leakage spaces at one or more junctions of the tube member and the cap member.

Further objects of the invention reside in the provision of a novel method for sealing in fluid-tight relationship the elements of an insulator structure or bushing. Further objects and advantages will be evident to those skilled in the art from the following description of an exemplary embodiment of the invention.

The plastic material of the tubular or body member is preferably a thermoplastic resin. The plastic material should be a high molecular weight solid polymerized material of high resistivity but is selected primarily for its surface characteristic. The surface should be slick, having a slippery feel and should be non-wettable by water and other liquids. The material should be tough, readily machinable and chemically inert to substantially all types of chemicals. In electric treaters operating at high temperatures or that need be steamed out at intervals the material should have a softening point above about 212° F. If steam-out is not essential, or with entrance bushings not subjected to high temperatures during use, materials of lower softening temperature, such as polyethylene, can be used.

For the plastic material of the tubular member **30** one can use a polymer containing a plurality of units of the formula



which units may be the same or different (e.g., copolymers), where A, B, X and Y are hydrogen (e.g., polyethylene); alkyl such as methyl (e.g., polypropylene); fluoro (e.g., "Teflon"); or halo (e.g., polymers containing both F and chloride such as "Kel-F"). A, B, X and Y are usually hydrogen, alkyl (preferably methyl) fluoro and chloro or combinations thereof. For high temperature uses, at least one member, selected from the group consisting of A, B, X and Y, is not a hydrogen group, e.g., materials such as "Teflon," "Kel-F," polypropylene and the like. Otherwise stated the material may be (1) a polymerized fluoroolefin, (2) a polymerized fluorohaloolefin, (3) a polymerized hydrocarbon olefin having at least three carbon atoms, or (4) copolymers thereof. "Teflon" of the FEP or TFE types is particularly suitable and will be exemplified in the following description. It should be understood however that the invention is applicable to various other insulating materials in less critical applications and that the sealing material and the bonding material to be described will then be appropriately varied to suit the materials utilized.

The sealing substance or material that is molded in situ to form the sealing element of the invention is related to the above-described plastic materials of which the tube member or body member is formed. The sealing material should be a moldable chemically-resistant elastomer impervious to solvents. When polymerized it should preferably remain pliable to compensate for differential expansion of the molding surfaces to which it is bonded when such surfaces are heated and have quite different coefficients of expansion. It should withstand

and not deteriorate in air, chemicals or corrosive liquids under temperatures encountered in use or under steam-out conditions if such steam-out is required. When using "Teflon" or "Kel-F" for the tube or outer member it is desirable that the sealing material should withstand temperatures of a least 400° F. and preferably temperatures above about 500° F. It should be capable of bonding or being bonded to such molding surfaces.

Preferred as the moldable sealing material is a polymer of a fluoroolefin, a polymer of a fluorohaloolefin, or copolymers thereof. While various synthetic rubbers can be used the sealing material is preferably a polymer having a plurality of units of the formula



which units may be the same or different, where B, X, and Y are hydrogen, alkyl (preferably methyl), fluoro, or halo (preferably chloro). Various fluorocarbon polymers are suitable, among which are the fluorohalocarbon polymers and fluoroalkylene polymers. The invention will be exemplified as using a copolymer of a fluoropropylene and a fluoroethylene, an excellent material being a copolymer of hexafluoropropylene,



and vinylidene fluoride, $CH_2=CF_2$, available under the trademark "Viton," a product of E. I. du Pont de Nemours & Co. This last-named material when polymerized is capable of withstanding temperatures of 600° F. The polymer is marketed in solid form but softens at about 300° F. sufficient to be made to flow under high pressure into the mold space. At temperatures of 300–400° F. it will polymerize in the mold space under the maintained high pressures and will form an excellent permanent bond with both the plastic material of the tubular or body member and the metal of the aforesaid cap member.

One molding surface for the sealing material is usually the plastic material of the tubular or body member while the other molding surface is usually a metal surface. The sealing substance or material may be such as to bond directly to the plastic material and the metal but if not it is desirable to employ a bonding material insuring a permanent bond. Various synthetic resins can be used as the bonding material, e.g., an epoxy resin with a suitable curing agent. Bonding materials suitable to this purpose are known in the art. For example, "Chemlok" made by Hughson Chemical Company or "Bondmaster" 17–611 used with CH–16 activator, an epoxy two-component bonding material supplied by Rubber and Asbestos Corp., Bloomfield, N.J., can be employed. Bonding techniques desirable to the invention will be later exemplified.

Referring to the drawings:

FIG. 1 diagrammatically illustrates the invention as applied to the entrance bushing or an insulator of an electric emulsion treater;

FIG. 2 is a vertical sectional view of the upper section of the bushing of FIG. 1, FIG. 3 being a vertical sectional view of a lower section of this bushing; and

FIG. 4 diagrammatically exemplifies an apparatus by which the sealing substance can be injected into a mold space of the invention.

Referring particularly to FIG. 1, the invention is exemplified as applied to an electric emulsion treater **10** including a container **11** to which a dispersion or emulsion is delivered through a pipe **12**, the constituents being separated by electrical and gravitational action so that the separated oil is withdrawn through an oil effluent pipe **14** and the separated water or conductive phase through a pipe **15**. Electrodes **16** and **17** of any suitable type are used to establish a high-voltage electrostatic field acting on the emulsion or dispersion to coalesce the dispersed conductive particles thereof into masses of sufficient size to gravitate from the oil.

The invention is concerned with energizing one of these electrodes and/or insulating it from the container **11**. As shown this is the lower or live electrode **17** which is supported by one or more insulators **19** and energized with or without such supplementary support by a high-voltage inlet bushing **20** conducting into the container the high-voltage potential of a transformer or direct-current power pack **21**. Externally of the container **11** the connecting high-voltage conductor **22** is shielded from manual contact and from the atmosphere by being enclosed in a housing **23**. As will be described, the conductor **22** is connected to the conductor element of the inlet bushing **20**.

The inner end of the inlet bushing **20** can be partially or completely shielded from direct contact with the treated oil in the upper end of the container **11** by a depending skirt **25** which may contain an inert gas. Regardless of whether the inner end of the bushing **20** is surrounded by the treated oil or such gas it is found that the minute residual contaminants in the treated oil tend to reach the inlet bushing and cause trouble if they enter therein. The present invention provides the first way of successfully sealing the elements of the inlet bushing **20** against such contaminants.

Referring particularly to FIGS. 2 and 3 the inlet bushing **20** is shown as including a relatively thick tubular member **30** made of one of the aforesaid high-resistance plastic materials and sometimes referred to herein as the body member. If of tubular shape, as illustrated, the member **30** is relatively thick. It includes a body portion **31** with end portions therebeyond, illustrated as necks **32** and **32'**. Cap members **35** and **35'** have sleeve portions or side walls **36** and **36'** which embrace the end portions of the tubular member **30**. The cap members **35** and **35'** are permanently sealed to the end portions of the tubular member **30** as will be described. The lower cap member **35** acts primarily as a terminal member while the upper cap member **35'** can be used as a means for mounting the inlet bushing. As shown, the upper cap member **35'** is externally threaded to be received in a threaded opening **37** of a plate **38** clamped between flanges **39** and **40** of component parts of the housing **23**. Other differences between the cap members **35** and **35'** will appear from the following discussion.

The tubular member **30** provides a conductor-receiving passage **42** therethrough adapted to receive a length of high-voltage cable **43** having a central conductor **44**. The opposite ends of the conductor-receiving passage **42** are preferably counterbored to receive metal pressure-back-up sleeves **46** and **46'** each extending inwardly to a position beyond the end of the corresponding side walls **36** and **36'**. The sleeves **46** and **46'** form a continuation of the conductor-receiving passage **42**. They are respectively electrically connected to the cap members **35** and **35'** as described in the following paragraphs.

The lower cap member **35** provides a conical cavity **47** bounded by a conical wall leading to a central passage **48**. A metal washer **49** engages the bottom of the metal sleeve **46** and seats on the conical wall to connect the sleeve electrically to the cap member **35**. Near the bottom of the high-voltage cable **43** the central conductor **44** is coiled with its end extending through the central passage **48** and soldered to a threaded neck portion **50** as indicated by the numeral **51**. A terminal member **52** can be threaded onto the neck portion **50** and provides a terminal **53** which can receive any suitable connector **54** (FIG. 1) attached to the electrode **17** in energizing and if desired supporting relation.

The upper cap member **35'** likewise provides a conical cavity **47'** bounded by a conical wall leading to a central passage **48'**. The upper end of the metal sleeve **46'** has a neck portion **55** fitting into the central passage **48'**,

establishing the desired electrical connection between the metal sleeve 46' and the cap member 35'. Between the neck portion 55 and the main body of the metal sleeve 46' this sleeve may provide a flange 56 overlying the uppermost end of the tubular member 30.

The construction of the inlet bushing above the top cap member 35' is optional. All that is required is that the central conductor 44 of the high-voltage cable 43 should be suitably connected to the high-voltage terminal of the transformer or power pack 21. As shown, an adaptor 57 threads into the top of the upper cap member 35' and carries a smaller tube 58 of any suitable insulating material capped by a terminal member 59 carrying a connector screw 60 to which the conductor 22 (FIG. 1) may be connected. The upper end of the central conductor 44 of the high-voltage cable 43 extends through an opening in the terminal member 59 and is soldered at 61 to the top thereof.

The feature of primary importance to the invention is the manner in which either or both of the cap members are sealed and bonded to the tubular member 30 to prevent the possibility of ingress of contaminants at the junctions of these members. This is particularly important at the inner end of the bushing but a positive seal is preferably provided at both ends thereof. The sealing arrangement at the lower or inner end of the inlet bushing will be specifically described, elements in the upper end being similar and being indicated by primed numerals.

Referring particularly to FIGS. 3 and 4 the invention provides an annular mold space 65 (FIG. 4) between the end portion of the tubular member 30 and the cap member 35. A sealing element 66 (FIG. 3) formed of one of the aforesaid molding materials, is molded in situ in this space in a manner to be described. The tubular member 30 and the cap member 35 are in contacting or embracing relationship at positions at opposite ends of the mold space 65. At one of these positions these members should be locked together. At the other of these positions means is preferably provided for permitting relating movement between the two members to compensate for differences in expansion upon increase in temperature due to the differences in thermal coefficient of expansion between the dissimilar materials of which these members are made.

The neck 32 of the lower end portion of the tubular member 30 may be of reduced size and is shown as providing an outwardly-facing mold surface 68 forming the inner wall of the mold space 65. The side wall 36 is formed by a counterbored portion of the cap member 35 and provides an inwardly-facing mold surface 70 forming the outer wall of the mold space 65. Respectively beyond the ends of the mold space the side wall 36 provides first and second inwardly-facing seal surfaces 71 and 72 respectively embracing first and second seal surfaces 73 and 74 of the tubular member 30. One of the engaged pairs of sealing surfaces is preferably threaded and the other arranged to permit relative motion therebetween upon change in temperature. As shown, the end portion of the tubular member 30 is externally threaded to receive the internally-threaded inner end of the side wall 36, forming a minute potential leakage space between the seal surfaces 71 and 73. The lower end of the neck 32 of the tubular member forms a sliding fit with the lower interior of the cap member 35, forming another minute potential leakage space between the seal surfaces 72 and 74. The inner ends of these leakage spaces open on the mold space 65.

Initial access to the mold space 65 is provided by at least one ingress passage 76 for injecting the sealing material which is to form the sealing element 66. A second opening 77, preferably diagonally opposite, is provided for a purpose to be described. Both openings are preferably internally threaded and are closed by short screw elements, preferably set screws 78, after the molding is complete and during use of the inlet bushing.

It is important to the invention that the sealing material be molded in situ in the mold space 65 under high pressure and under polymerizing temperatures to form the sealing element 66. The sealing material must be injected into the mold space under extremely high pressure, sufficient to exhaust air from the mold space through the minute leakage spaces and/or through the passage 77 to fill the mold space with the sealing material. Under the high pressures used the air in any residual pocket will be so severely compressed as to occupy only a negligibly-small volume of the mold space. It is also essential to the invention that the resulting molded sealing element 66 shall be permanently bonded to the mold surfaces 68 and 70 of the tubular member 30 and the cap member 35. If a suitable elastomer is thus injected into the mold space 65 under high pressure and cured therein while such pressure is maintained the resulting sealing element 66 will be permanently bonded to the surfaces of the mold space.

The resulting sealing element 66 will extend completely to the inner ends of the minute leakage spaces. Indeed a minute portion of the sealing element will extend a short distance into the inner ends of such leakage spaces between the threaded surfaces 71, 73, and between the longitudinal surfaces 72, 74. For any contaminant to reach the mold space 65 requires that it pass inwardly of one of these leakage spaces so that the first contact between such contaminants and the sealing material will be in such leakage spaces, usually at a position not far removed from the end of the mold space. If for example the ambient fluid around the inlet bushing contains certain components, such as a small percentage of aromatic hydrocarbons, that might react with the material of the sealing element 66, any leakage would bring this reactive component into contact with the material of the sealing element deep within the leakage space between the threaded surfaces 71, 73. Once the minute reactive component reacts with the most extended surface of the sealing element in the leakage space the fluid trapped therein becomes nonreactive with the material of the sealing element. Even if some of the ambient fluid should pass completely through the minute leakage space into the end of the mold space its progress is further and positively blocked by the sealing element 66 that is bonded to the walls of the mold space 65. It is thus prevented from traversing the mold space and entering the interior of the tubular member 30.

To obtain a permanent bond the surfaces of the mold space are carefully prepared. Importantly, it is desirable that these surfaces be initially roughened by mechanical and/or chemical means. Rough machining and use of emery cloth can be used to roughen initially the surfaces that are to bound the mold space. The internal surfaces of the metal cap can be roughened by sand blasting. Various chemical etching components are known that will effect roughening, many of them sodium-base materials such as "Tetra-etch," a trademarked product of Fluorocarbon Company. Sodium compounds such as sodium naphthalene when applied to a "Teflon" surface produce a carbonaceous surface having both roughness and susceptibility of adhesion. A wide variety of the aforesaid bonding materials will bond the sealing material to such a surface. One or more coats of such a bonding material are then applied to the roughened surfaces of both members. When thus prepared the member 35 can be screwed onto the tubular member 30 and the sealing material injected and molded in situ.

The injection and curing of the sealing material to form the sealing element 66 can be accomplished in various ways. FIG. 4 illustrates rather diagrammatically one way in which this can be accomplished. Referring thereto a close-fitting steel rod 80 is temporarily inserted in the conductor-receiving passage 42 to prevent collapse during the high-pressure molding operation. The end portion of the bushing is then placed in a split mold 81 hav-

ing a cavity size substantially the same as the outer surface of the cap member 35. One section of the mold 81 desirably provides an index or closure pin 82 shown as at the small inner end of a screw 84 providing a shoulder sealing the outer end of the passage 77. The other half of the mold 81 provides suitable means for forcing the sealing material into the mold space 65 while at high temperature and under high pressure. As shown, this means includes a passage 86 through which the sealing material can be forced under high temperature and pressure by any suitable means.

In this respect the aforesaid "Viton" or similar sealing material can be heated to a temperature of about 350° F. and forced by suitable equipment under pressures of 10,000 p.s.i. or more through passage 86 of the mold as indicated by the arrow 87. This is done while the mold has been preheated to a temperature of about 350° F. The halves of the mold 81 must of course be suitably clamped together during these operations. The sealing material is injected until a portion thereof exudes from the opposite passage 77. The injected material is maintained in the mold space at a pressure of 8,000–12,000 p.s.i. and at high temperature until the sealing material polymerizes or cures. The desirable high temperature can be developed in an oven or in suitable molding equipment. As soon as curing has continued to the point where the polymerized material will not flow from the mold space the bushing may be removed from the mold and post-cured at atmospheric pressure.

With "Viton" or similar materials it is desirable to maintain a pressure of about 10,000 p.s.i. for at least 30 minutes at about 350° F. before releasing the pressure. Post-curing at 250° F. for several hours can be used to complete the cure. The two passages 76 and 77 of the cap member 35 are then cleaned and plugged by the set screws 78. These seal the mold space and the sealing element 66 against entry of contaminated fluids during use.

It will be evident to those skilled in the art that various means can be employed for heating and injecting the sealing material into the mold space 65. If the sealing material is initially in solid state it must be heated sufficient to be flowable under high pressure and a high pressure should be maintained during its curing in the mold space 65. The resulting molded-in-situ sealing element 66 will effectively seal the bushing as concerns contaminants, solvents, etc. normally found in petroleum products being subjected to treatment in an electric treater 10.

It will be understood that if a similar sealing element 66' is to be molded in the corresponding mold space at the opposite end of the bushing, this molding can be accomplished in similar fashion, either simultaneously with the molding of the sealing element 66 or at a subsequent time. The high-voltage cable 43 may then be installed, preferably using silicone gerase or other material to fill all voids in or at the ends of the passage 42 of the bushing. The terminal member 59 can then be inserted and the conductor 44 soldered thereto whereupon the bushing is ready for use.

The mold space 65 in the above-described bushing is desirably of an axial length much longer than its radial width. At the same time such width should be substantial, preferably of at least a significant fraction of an inch, e.g., ⅛" or more. The width of this space should be such that the resulting sealing element 66 will be of sufficient thickness to allow for relative movement of the materials of the tubular and cap members without subjecting the material of the sealing element to damaging forces. The width of the mold space should also be sufficient to prevent too great a wiping or scouring action as the sealing material flows along the surfaces of the mold space during injection.

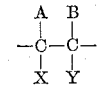
Structures and techniques similar to those mentioned above can be used to manufacture the insulators 19 of the treater 10 but the invention has greatest significance in the production and use of inlet bushings where effective seals are vital.

Various changes and modifications can be made without departing from the spirit of the invention as defined in the appended claims. In these claims the term "solidified" when used with reference to the sealing element 66 or 66' or with reference to a specific material or materials of which it is made is to be construed as such an element or material molded and polymerized in situ in the mold space under high pressure.

I claim:

1. In combination with a container having an internal oil zone containing oil contaminated with significant amounts of dispersed particles of an electrically-conductive nature, a high-voltage insulator structure made up of components sealed together against entry therebetween of such contaminated oil, said insulator structure including in combination:

a body member formed of plastic material selected from the group consisting of polymers and copolymers containing a plurality of units of the formula



where A, B, X and Y are selected from the group consisting of hydrogen, alkyl, fluoro and halo, said body member comprising one of said components and having a body portion and a neck at one end thereof;

means at the other end of said body member supporting same in said container with said neck and at least a portion of said body member within said zone and exposed to said contaminated oil therein;

a metal cap member having a side wall surrounding and closely embracing said body portion at a position inwardly of said neck, said side wall being fixedly attached to said body portion at said position against axial movement of said cap member relative to said neck, said metal cap member comprising another of said components and being exposed to said contaminated oil in said zone, there being an annular mold space of substantial width between said side wall and said neck positioned toward said other end of said body member from said position, said mold space being sealed by the close embracement of said side wall and said neck, said mold space being bounded inwardly by an outwardly-facing mold surface of said neck and bounded outwardly by an inwardly-facing mold surface of said side wall; and

a pliable elastomer sealing element filling said mold space polymerized and molded in situ therein and bonded permanently to said mold surfaces of said neck and said side wall.

2. In combination with a container having an internal oil zone containing oil contaminated with significant amounts of dispersed particles of an electrically-conductive nature, a high-voltage insulator structure made up of components sealed together against entry therebetween of such contaminated oil, said insulator structure including in combination:

a body member comprising one of said components formed of high-resistance plastic material having a body portion terminating in an end portion, said end portion having an outwardly-facing mold surface, said body portion having a threaded portion near said end portion;

a metal cap member comprising another of said components having a sleeve portion around said end portion, said sleeve portion having at one end threads engaging said threaded portion of said body portion, said sleeve portion having near such threads an inwardly-facing mold surface opposite and spaced a substantial distance outwardly of said outwardly-facing mold surface forming a high pressure mold

space therebetween extending axially of said body member, said threaded portion and said threads on said sleeve portion of said cap member providing embracing walls closing the end of said mold space and providing therebetween a potential leakage space for said contaminated oil, said potential leakage space opening on said mold space; and

a molded solidified sealing element made of a pliable elastomer filling said mold space and extending a minute distance into said potential leakage space between said threads and said threaded portion, the peripheral surfaces of said sealing element being bonded permanently to said mold surfaces and conforming to all surface irregularities thereof.

3. In combination with a container having an internal oil zone containing oil contaminated with significant amounts of dispersed particles of an electrically-conductive nature tending to be attracted to a high-voltage electric conductor in such zone by a high-voltage field thereabout, a high-voltage inlet bushing adapted to receive such a high-voltage conductor and capable of maintaining same insulated from said container under widely different conditions of temperature and pressure to which said bushing is subjected, said inlet bushing including in combination:

a body member formed of high-resistance plastic material having a body portion terminating in an end portion, said end portion having an outwardly-facing mold surface;

means attaching said body member to said container with said end portion and a large portion of said body member within said zone and exposed to said contaminated oil therein;

a metal cap member having a sleeve portion around said end portion, said sleeve portion having an inwardly-facing mold surface opposite and spaced a substantial distance outwardly of said outwardly-facing mold surface forming a mold space therebetween extending axially of said body member, said members providing pairs of embracing walls respectively at the ends of said mold space closing the latter against outflow therefrom of sealing material when the latter is forced into said mold space under high pressure; and

a solidified pliable sealing element formed of said sealing material filling said mold space with its peripheral surfaces permanenty bonded to said mold surfaces and conforming to all surface irregularities thereof.

4. A high-voltage inlet bushing combination as defined in claim 3 in which said body member is made of a material selected from the group consisting of polymers and copolymers containing a plurality of units of the formula



where A, B, X and Y are selected from the group consisting of hydrogen, alkyl, fluoro and halo.

5. A high-voltage inlet bushing combination as defined in claim 4 in which said sealing element is a polymer prepared from olefins selected from the group consisting of (1) fluoroolefins, (2) fluorohaloolefins, and (3) copolymers thereof.

6. A high-voltage inlet bushing combination as defined in claim 3 in which said body member is made of a polymer prepared from olefins selected from the group consisting of (1) fluoroolefins, (2) fluorohaloolefins, (3) hydrocarbon olefins having at least three carbon atoms, and (4) copolymers thereof.

7. A high-voltage inlet bushing combination as defined in claim 3 in which said body member is made of a material selected from the class of polytetrafluoroethylene and copolymers thereof, polytrifluorochloroethylene and copolymers thereof, and polypropylene and copolymers thereof, said material being capable of withstanding high temperatures, and in which said sealing element is a chemically-resistant fluoro-type elastomer.

8. A high-voltage inlet bushing combination as defined in claim 7 in which said sealing element is a solidified fluoroalkylene polymer.

9. A high-voltage inlet bushing combination as defined in claim 7 in which said sealing element is a fluorohalocarbon polymer.

10. A high-voltage inlet bushing combination as defined in claim 7 in which said sealing element is a solidified copolymer of a fluoropropylene and a fluoroethylene.

11. A high-voltage inlet bushing combination as defined in claim 7 in which said sealing element is a solidified copolymer of hexafluoropropylene and vinylidene fluoride.

12. A high-voltage inlet bushing adapted to receive a high-voltage conductor, said inlet bushing including:

a relatively thick tubular member formed of high-resistance plastic material, said tubular member having a conductor-receiving passage therethrough, said tubular member having a body portion and an end portion, said end portion having an outwardly-facing mold surface with first and second outwardly-facing seal surfaces respectively beyond the opposite ends of said mold surface;

a metal cap member having a side wall surrounding said end portion, said side wall having an inwardly-facing mold surface opposite said outwardly-facing mold surface of said tubular member spaced therefrom and forming a mold space therebetween, said side wall having first and second inwardly-facing seal surfaces respectively beyond the opposite ends of its inwardly-facing mold surface respectively embracing said outwardly-facing seal surfaces and forming therebetween minute leakage spaces with their inner ends opening on said mold space, said first seal surfaces being threaded and embracing in threaded engagement, said second seal surfaces being substantially parallel to the axis of said tubular member and embracing in sliding engagement; and

a polymerized sealing element in said mold space filling same to said inner ends of said minute leakage spaces and bonded permanently to said mold surfaces.

13. A high-voltage inlet bushing adapted to receive a high-voltage conductor, said inlet bushing including:

a relatively thick tubular member formed of high-resistance plastic material subject to plastic flow upon increase in temperature and pressure, said tubular member having a conductor-receiving passage therethrough, said tubular member having a body portion and an end portion, said end portion having an outwardly-facing mold surface with first and second outwardly-facing seal surfaces respectively beyond the opposite ends of said mold surface;

a metal cap member having a side wall surrounding said end portion, said side wall having an inwardly-facing mold surface opposite said outwardly-facing mold surface of said tubular member and spaced therefrom and forming a mold space therebetween, said side wall having first and second inwardly-facing seal surfaces respectively beyond the opposite ends of its inwardly-facing mold surface respectively embracing said outwardly-facing seal surfaces and forming therebetween minute leakage spaces with their inner ends opening on said mold space;

a metal pressure-back-up sleeve in said conductor-receiving passage engaging said high-resistance plastic material of said tubular member and extending inwardly from the end of such member to a position beyond said first seal surfaces; and

a polymerized sealing element in said mold space filling

same to said inner ends of said minute leakage spaces and bonded permanently to said mold surfaces.

14. An inlet bushing as defined in claim 13 including electrically-conductive means within said cap member electrically connecting said metal sleeve and said cap member.

15. An inlet bushing as defined in claim 14 in which said electrically-conductive means includes a spring washer seated in said cap member and engaging the outer end of said metal sleeve.

16. An inlet bushing combination as defined in claim 3 in which the walls of one pair of embracing walls at one end of said mold space are fixedly attached together, and in which the walls of the other pair of embracing walls at the other end of said mold space are substantially parallel to the axis of said body member and embrace in sliding engagement.

17. An inlet bushing combination as defined in claim 3 in which said body portion has another end portion at its opposite end from said first-named end portion and also exposed to said contaminated oil in said zone, said other end portion providing another outwardly-facing mold surface, and including a second cap member having a sleeve portion around said other end portion and having another inwardly-facing mold surface opposite and spaced a substantial distance outwardly of said other outwardly-facing mold surface forming another mold space therebetween extending axially of said body member, said walls of said members providing other pairs of embracing walls respectively at the ends of said other mold space closing same against outflow therefrom of sealing material when forced into such mold space under high pressure, and another solidified sealing element formed of such sealing material filling said other mold space with its peripheral surfaces permanently bonded to said other mold surfaces and conforming to all surface irregularities thereof.

18. A method of making a high-voltage entrance bushing, which method includes the steps of:

forming a tubular member of high-resistance plastic material with an end portion having two wall zones at opposite ends of an outwardly-facing surface;

forming a cap member with a side wall having two wall zones sized respectively to surround and embrace said wall zones of said end portion of said plastic-material member and with an inwardly-facing surface facing but spaced outwardly a substantial distance from said outwardly-facing surface to form a mold space therebetween closed at its ends by the embracement of said wall zones;

disposing a rod in said tubular member closely fitting the interior thereof to reinforce said tubular member against collapse when a high pressure is present in said mold space;

injecting into said mold space under high temperature and pressure a polymer capable of bonding permanently to said surfaces;

polymerizing said polymer in said mold space under high pressure and temperature to form a sealing member bonded permanently to said surfaces; and

withdrawing said rod from said tubular member.

19. A method as defined in claim 18 in which said polymer is a solid, and in which the step of injecting includes the steps of heating said polymer to a temperature at which it softens sufficiently to be forced under high pressure into said mold space, and then injecting the softened polymer into said mold space under such high pressure to fill said mold space to said embracing wall zones, said polymer being maintained at said high pressure and temperature during polymerization in said mold space.

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