An entrance bushing for an electric treater subject to high voltage, temperature and pressure operating conditions. The bushing mounts in the treater by a threaded adapter on one end of an interiorly extending cylindrical Teflon member. First and second sleeves with closed ends are threaded into the member to extend coaxially from a threaded passage receiving an electrical conductor connected between an external power source and internal electrical treater components. Any fluid leaking between the adapter and member is vented exteriorly of the first sleeve and passage. The second sleeve is permanently bonded and sealed to the member by a polymer sealing element (fluorinated ethylene propylene resin) compressed between interengaged threads to exclude voids and mechanical-thermal induced seal disruption. A third sleeve encloses the second sleeve with an electrical interconnection provided by a flexible lead to isolate the sealing element from mechanical impacts.

18 Claims, 5 Drawing Figures
HIGH-VOLTAGE ENTRANCE BUSHING FOR AN ELECTRIC TREATER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electrical conductors and insulators, and more particularly, it relates to high-voltage entrance bushings for electric treaters that operate at high temperature and pressure conditions.

2. Description of the Prior Art

Electric treaters have been employed to resolve dispersions or emulsions with high-potential electric fields for over 60 years. These treaters at the present time may operate in the range of 350° F. or higher. At elevated temperatures, superatmospheric pressure must be maintained in the electric treater, for preserving the fluids therein within the liquid phase. Thus, fluid pressures of 100 psi or higher may be encountered within electric treaters.

An electric treater contains electrodes that are energized with high potential AC or DC currents to create an electric field which resolves emulsions. These emulsions may be a continuous phase of crude oil in which is dispersed solids and aqueous material. The electric treater is usually constructed with a steel vessel. An entrance bushing provides for introducing high-potential current from an external power source through the metallic vessel wall to the internal electrodes of the electric treater.

Various types of entrance bushings have interconnected the electrodes of an electric treater with an external source of high-potential current. Reference may be taken to U. S. Pat. Nos. 2,881,125, 2,924,637, 3,085,128 and 3,303,262 for entrance bushings which obtained considerable commercial acceptance and operating success. These entrance bushings employed as the basic insulating material, a plastic material that has unusual physical and chemical characteristics, and operating conditions. These plastic materials have a sufficiently high resistance to operate at elevated potentials without a dielectric breakdown creating a short-circuit through the plastic material or along its exterior surfaces. However, these plastic materials are subjected to plastic flow upon increase in temperature and pressure. Unfortunately, these increases in dimension by the resultant plastic flow are several times that experienced with the metal components employed in the entrance bushing. The entrance bushing will eventually fail, not in the insulating quality of the plastic material, but rather as a result of this plastic flow induced dimension change causing a structural failure in the insulating member or leakage of fluids through the seals between the metal and plastic material components of the entrance bushing. Many of these problems have been alleviated by employing the superior plastic material (available under the trademark Teflon) which has a non-wettability surface characteristic and high temperature and pressure service characteristics. In non-rigorous operating requirements for the electrical bushing, the insulating material may be the plastic material available under the trademark Kel-F. Thus, the construction of the entrance bushing must compensate for the plastic flow characteristics of these plastic materials to avoid the leakage of fluids which result in short circuiting the high-potential currents to the metal sidewall of the electric treater.

Various seals have been proposed for use in the entrance bushing between the metal components and plastic material. One outstanding seal is shown in U. S. Pat. No. 3,303,262 which employs a pressure molded, pliable elastomer sealing element. However, even this sealing element may fail in entrance bushings under extremely severe environments (e.g., temperatures above 350° F.) when the plastic flow is especially large in the longitudinal dimension of the entrance bushing. Severe longitudinal stresses can cause a failure of the sealing element more easily than radial stresses. A failure of the upper sealing element allows emulsion to enter the entrance bushing where it passes through the metal sidewall of the electric treater. This leaking emulsion can short circuit the conductor carrying the high potential currents directly to the metallic sidewall of the electric treater. The entrance bushing also must have a seal at its outer extremity which is connected to the electrodes within an electric treater. A failure of the lower sealing element allows emulsion to enter the entrance bushing within the treater. Fluid leaking at this location follows the electrical conductor and may enter the external power source supplying the high-potential current to the electrodes. Eventually, the power source will be damaged.

The lower sealing element is exposed to additional hazards from mechanical injury. Many entrance bushings are installed or replaced by refinery workers who are not accustomed to handling highly critical electrical components. The entrance bushings must be readily compatible with the types of threads and piping systems normally employed in refinery service. Therefore, the refinery worker will treat the entrance bushing as conventional piping and may subject it to considerable mechanical impacts and other injurious handling. For example, the entrance bushing may be dropped so as to cause an impact upon the lower metal components which directly act upon the lower sealing element. These impacts can lead to failure of the lower sealing element during service. Additionally, the careless installation of the entrance bushing may injure the upper sealing element in a like manner.

The entrance bushing of the present invention has a novel arrangement of elements such that any fluid leakage through the upper sealing element is diverted to the exterior of the entrance bushing. Additionally, the lower sealing element is arranged to be highly resistant to the longitudinal stresses causing failure of the polymerized sealing element under extreme operating conditions and mechanical injury. As a result of this construction, this novel entrance bushing is well adapted to provide superior performance over prior structures in entrance bushings.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a high-voltage entrance bushing for an electric treater which comprises an elongated tubular member formed of a high-resistance plastic material subject to plastic flow upon increase in temperature and pressure. The tubular member has a conductor receiving passage therethrough and carries a metal mounting adapter about a first end. The adapter and tubular member are spaced apart to form a first annulus between the first end of the tubular member and terminating intermediate the adapter. First sealing means are provided in the first annulus for forming a fluid tight interconnection between the adapter and the tubular member. A first metal sleeve is secured within the tubular member and extends from the first end in alignment with the passage. Fluid communication between the first annulus and an opening in the first end of the tubular member vents fluid traversing the annulus to the exterior of the passage in the tubular member. First and second diameter portions are provided at the second end of the tubular member. A second metal sleeve is threadedly secured within the first diameter portion. A polymer sealing element is held in compression in the threaded interengagement between the tubular member and the second metal sleeve. The sealing element is permanently bonded and sealed to the tubular member and the second metal sleeve and substantially fills all voids therebetween. The second metal sleeve has a closed end to which an electrical conductor in the passage is connectable remote from the threaded interconnection to the tubular member. A third sleeve is secured at one end within the second diameter portion to the tubular member and carries at the other end an external electrical connection. The third metal sleeve encloses the second sleeve in spaced apart relationship and a flexible metal conductor provides for their electrical interconnection.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an entrance bushing of the present invention applied to one type of electric treater;
FIGS. 2A and 2B are in composite an enlarged vertical section taken through the entrance bushing of FIG. 4; FIG. 3 is an enlarged fragmentary view of the polymer sealing element compressed within the threaded connection between the tubular member and a lower metal sleeve of the entrance bushing shown in FIG. 2B; and FIG. 4 is a fragmentary vertical sectional view taken through the entrance bushing of FIG. 2A but showing an alternative upper connection to an external electrical system.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring now to Fig. 1, there is shown an electric treater 11 which includes a container 12 having metal sidewalls and to which treater an emulsion is delivered through a pipe 14. The emulsion (e.g., water dispersed in crude oil) within the electric treater 11 is subjected to electrical field and gravitational action. Separated crude oil is withdrawn through the outlet 16 while separated water is withdrawn through the outlet 17. An electrical field is created between a grounded electrode 18 and an energized electrode 19 suspended upon insulators 21 within the electric treater 11. More particularly, the electrode 19 is energized by an external power supply which may be a transformer 22 having a high-voltage (relative to container 12 or ground) electrical conductor 23 extending within a protective housing 24. The protective housing 24, as shown in U.S. Pat. No. 3,303,262, can comprise metal conduits which are flange connected between the transformer 22 and a nozzle 26 carried upon the electric treater 11. An entrance bushing 27, of the present invention, is threadedly connected within a flange 28 carried atop the nozzle 26. The entrance bushing 27 connects at its lower extremity by a flexible conductor 29 to the energized electrode 19. Other means of mounting the entrance bushing 27 within an electric treater 11 may be employed, if such is desired. The entrance bushing 27 extends downwardly into the crude oil phase within the electric treater 11 so that insulting components are exposed to the thermal, pressure and mechanical stresses that may be encountered therein, especially as a result of temperature and pressure increase.

If desired, the housing 24 may contain a venting port adjacent the nozzle 26 for removing any fluids which may tend to collect therein. Alternatively, the housing 24 may be completely filled with a dielectric fluid, such as transformer oil, to maintain a dry environment, or for other reasons.

Referring now to FIGS. 2A and 2B the construction of the entrance bushing 27 is shown in greater detail. The entrance bushing 27 has an elongated tubular member 31 formed of a high-resistance plastic material and a sleeve 32 which is completely filled with a dielectric fluid upon increase in temperature and pressure. The plastic material may be of any type of a high-resistance solid. However it is preferable to use polytetrafluoroethylene (Teflon), or in lesser severe environmental conditions to employ polytetrafluoroethylene (Kev-F). However, other equivalent plastic materials may be employed, if desired. Preferably, the member 31 has a uniform cylindrical external surface 32 which is relatively free of scratches or ridges. The surface 32 is non-wettable by water or oil and does not accumulate, by electrostatic attraction or otherwise, deleterious water droplets or solids such as conductive iron sulfide deposits. A passage 33 extends longitudinally through the tubular member 31, and preferably, in coaxial alignment. The passage 33 receives an electrical conductor which interconnects the external source 22 and the electrode 19. The passage 33 extends from an upper end 34 downwardly toward the bottom 36 of the member 31.

A metal adapter 37 is secured upon the upper end 34 of the member 31. Preferably, the adapter 37 carries threads 38 which interconnect with corresponding threads carried upon the member 31. The adapter 37 is interconnected with the sidewall 12 of the electric treater 11 by bolting, flanges or the like. However, the entrance bushing 27 can have a lower threaded portion 39 on the adapter 37 for mounting within the flange 28 in a corresponding set of threads 40. The threads 39 and 41 may be conventional pipe threads so that refinery workers or the like, can readily make fluid tight connection between the entrance bushing 27 and the electric treater 11. The adapter 37 may carry an intermediate polygonally cross-sectional portion 42, as for example hexagonal, upon which wrenches may be engaged for rotating the bushing 27 into threaded mounting within the flange 28.

The adapter 37 and cylindrical member 31 have spaced-apart sidewall surfaces forming an annulus 43. The annulus 43 extends from the end 34, longitudinally within the tubular member 31 and terminates intermediate the longitudinal extent of the adapter 37. Although annulus 43 may have any desired configuration, the adapter 37 and the member 31 are readily provided with spaced-apart cylindrical sidewall surfaces 44 and 46. As a result, the annulus 43 is defined between the concentric sidewall surfaces 44 and 46, abutment shoulder 47 and the end 34 of member 31.

Sealing means are positioned within the annulus 43 for forming a fluid tight interconnection between the adapter 37 and the member 31 adjacent the end 34. Any type of sealing means may be employed. However, it is preferred to use a mechanical energized sealing system. Preferably, a plurality of ringlets 48 are positioned within the annulus 43. The ringlets 48 can be of the same high-resistance plastic material as the member 31. Preferably, the annulus 43 has a longitudinal dimension several times the relatively narrow radial dimension in the member 31. For example, the member 31 may have a diameter of approximately 2 inches, the annulus 43 may be 1 inch long, and have a width of approximately three thirty seconds of an inch. In this size of annulus, there may be seven of the ringlets 48. The ringlets 48 are compressed against the abutment shoulder 47 to provide fluid tight engagement between the adapter 37 and the member 31 by a mechanism carried at the end 34. Any mechanism may provide such compression but it is preferred to employ a mechanical follower 49 received at least in part within the annulus 43 and extending a small distance beyond the end 34 of the member 31.

A packing cap 51 is threaded over the end portion of the adapter 37. A plurality of studs 52 are threaded through the top of the packing cap 51 for pressing the packing follower 49 into the desired engagement with the ringlets 48. The packing cap 51 may contain one or more openings for venting fluid leakage from the annulus 43 to the exterior of the passage 33 in member 31. For this purpose, the cap 51 may carry a vent hole 53 in its sidewall surface. A metal sleeve 56 secured within the member 31 extends beyond the end 34 in alignment with the passage 33. Preferably, the sleeve 56 has an internal diameter equal to that of the passage 33. The sleeve 56 may be secured by threads 57 to the member 31, if desired. The sleeve 56 may carry an encircling shoulder 58 which overlays only a portion of the end 34 without sealing the opening venting fluid leakage from the annulus 43. Thus, there is no possibility that any fluid leakage from the annulus 43 can enter the passage 33 along the sleeve 56. Any fluid leakage must pass through the vent openings about the packing cap 51, and particularly vent holes 53 formed therein. The encircling shoulder 58 is engaged between the cap 51 and the end 34 to provide additional mechanical stability for the metal sleeve 56 within the member 31.

The upper portion of the sleeve 56 carries an electrical interconnection means connectable to the transformer 22. In this particular embodiment, a sleeve 59 of the plastic material is threadedly interconnected to the upper portion of the sleeve 56. Preferably, the passage 33, the sleeves 56 and 59 have the same internal diameter. The sleeve 59 extends upwardly to a threaded cap 61 which forms a closed end. An electrical conductor 62 extends through the passage 33 and by a flexible connection passes through an aperture 63 within the cap 61 to terminate in an electrical lug 64. The lug 64 is held against the cap 61 by a machine screw 66 and nut 67. The electrical conductor 62 is preferably surrounded by a sheath 68 of the plastic material forming the member 31. The lead 23 from the
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transformer 22 connects to the machine screw 66 atop the cap 61. Thus, there is an electrical interconnection provided between the entrance bushing 27 and an external power source.

Reverting briefly to FIG. 4, there is shown another embodiment of the entrance bushing 27 in which the sleeve 56 extends upwardly and provides a connection such as shown in U. S. Pat. No. 2,881,125, to the transformer 22. In this view, like parts will carry like numerals for ready correlation to the embodiment illustrated in FIGS. 2A and 2B. More particularly, the metal sleeve 56 extends upwardly from the encircling shoulder 58 into an extension 71 which projects beyond the entrance portion 70 of the member 31. The projection 71 terminates in a threaded portion 72 which receives a threaded coupling 73. The coupling 73 interconnects a metal conduit 74 to the sleeve 56. The conduit 74 extends about the insulated electrical conductor 62 which extends downwardly within the passage 33. The conduit 74 serves as a grounding sheath between the external power source, which may be a transformer 22, and the container 12.

Returning now to FIGS. 2A and 2B, the second end 36 of the member 31 is provided with first and second diameter portions 76 and 77, respectively. A second metal sleeve 78 is threadedly secured within the first diameter portion 76 and has a central opening aligned with passage 33 to receive conductor 62. More particularly, the sleeve 78 carries at its upper extremity a threaded portion 79 which is adapted to interengage with corresponding threads carried in the first diameter portion 76. These threads may be of any particular configuration. For example, member 31 may have a two inch outside diameter and the threads on sleeve 78 may be \( \frac{1}{4}-\frac{27}{32} \) straight pipe threads. Other threads may be used in accordance with the following directions for assembling the sleeve 78 within the member 31.

The threaded portion 79 of the sleeve 78 is arranged to cooperate dimensionally with the member 31 so that a very thin polymer sealing element 81 (see FIG. 3) is held in compression between the threaded portion 79 and the member 31. More particularly, the member 31 is to be heated so that the resultant radial and longitudinal expansions provide a relatively loose fit between the threaded portion 79 of the sleeve 78 (unthreaded) and the member 31 at the first diameter portion 76. A very thin tape formed of the polymer sealing element 81 is tightly secured about the threaded portion 79. The thinner the tape, the greater the fluid pressures sealing element 81 can withstand. For example, a tape one-half inch wide by 0.005 inch thick has been found to be quite satisfactory. The tape is wound spirally about at least one thickness upon the threaded portion 79 in a direction to be tightened during threaded installation of the sleeve 78. Thus, the tape embraces very tightly the threads on the portion 79. Then, the cold sleeve 78 is threaded into the first diameter portion 76 while the member 31 is heated to produce the thread clearance. When the member 31 cools to the temperature of sleeve 78, the tape is very highly compressed about the threaded portion 79 to exclude any voids.

In a specific example, the threaded portion 79 may have a relatively tight fit within the first diameter portion 76 of the member 31 when all elements are at ambient temperature. Then, the tape forming the sealing element 81 is applied to the threaded portion 79 of the sleeve 78 while cold. The member 31 is heated to an elevated temperature to provide proper thread clearances, for example 250°F. Now, the tape-covered threaded portion 79 is threaded quickly into the first diameter portion 76 to the desired extent. The member 31 is now cooled to ambient temperatures and it exerts substantial compression upon the tape about the threaded portion 79. It is desired that this compression be in the range of about 100 psi and preferably 200 psi or greater. The thermal expansion of the tape about the threaded portion 79 serves to eliminate substantially all voids from between the tubular member 31 and the sleeve 78. Next, the fluid-tight interconnecting of these elements is completed by a combined heat sealing and bonding procedure.

This heat-sponsored procedure requires sleeve 78 in the member 31 to be heated to suitable elevated temperatures for producing the desired "fusion" of the tape. This heating step can be provided by any suitable mechanism. An R. F. heater has provided good results. The sleeve 78 must be heated quickly to a sufficient temperature, and for a sufficient time period that the tape is bonded to the member 31 and sealed to the threaded portion 79. The exact magnitude of temperatures and time in the heating step is determined by the plastic material of member 31 and the tape, and the mass of sleeve 78. Usually, these conditions are set so that the tape seals to the metal threads and bonds to the plastic material of member 31. Since only the sleeve 78 is heated by an induction or R. F. heater, heat is transferred by conduction to the tape and member 31. "Fusion" temperatures between 650°F and 750°F and time periods of 1-2 minutes are suitable where the tape (forming the sealing element 81) is a fluorinated ethylene propylene resin and the member 31 is a polytetrafluorethylene plastic material. The tape can be, for example, Teflon 100 FEP fluorocarbon resin tape, one-half inch width and five thousandths inch thick. The member 31 can be, for example, Teflon made of TFE resin. This tape softens at about 565 F. while the mentioned plastic material "gels" at about 623°F. The tape-to-sleeve 78 seal occurs at about 560°F and 580°F, and the tape-to-member 31 bond occurs at about 625°F and 650°F. Thus, the sleeve 78 must be heated to a sufficient temperature (e.g., 650°F) for a period (e.g., 1 minute) so that the necessary sealing and bonding conditions are obtained whereby the tape forms the polymer sealing element 81. The torque strength between the sleeve 78 and member 31 is a guide to proper sealing and bonding conditions. Hence, the temperature and period of R. F. heating are varied until the maximum torque strength is obtained. In order to bond the member 31, and to fuse the polymer sealing element 81, the "fusion" temperature and time period may vary in magnitude. However, it is apparent to those skilled in the art that for any arrangement of plastic materials for these components a proper set of "fusion" process conditions can be determined. Complete data on heat bonding-sealing conditions in the example can be obtained from the duPont Information Bulletin No. X-50u.

The heat bonding-sealing, under the compression effects of the member 31, results in the tape being bonded to the tubular member 31 and sealed to the threaded portion 79 which forms the sealing element 81. Inasmuch as the bonding of the tape to the member 31 produces a continuous compatible plastic material, the element 81 is essentially an integral part of the plastic material forming the member 31. Where the member 31 is formed of Teflon FEP plastic material, the yield strength at sealing element 81 may be approximately 2,000 psi at ambient temperatures. The element 81 is sealed with substantial compression to the threaded portion 79 and therefore resists any peeling by a combination of compression and adhesion forces. Since the element 81 has a thickness of only a few thousandths of an inch, fluid pressure (e.g., 250 psi) cannot disrupt the element 81. Considering these outstanding physical characteristics, there is formed a fluid-tight joint in the sealing element 81 which can resist substantially any fluid pressure likely to be placed upon the entrance bushing 27.

Referring briefly to FIG. 3, an enlarged portion of the sealing element 81 is shown residing between the threaded portion 79 and the member 31. The sealing element 81 is highly resistant to fluid leakage and mechanical damage and vastly superior to joints between spaced apart cylindrical surfaces containing a pressure-heat formed resilient seal. A seal with a rectangular cross section is more readily disrupted by mechanical impacts applied longitudinally to the seal area and these impacts sheers the compressive forces of the seal. However, the sealing element 81 is contained in compression between a threaded joint, and for this reason, it is highly resistant to disruption by either longitudinal or radially applied shearing forces. The thermal expansion of the member 31 about the sleeve 78 when the entrance bushing 27 reaches
elevated temperatures has little tendency to disrupt the sealing effects of the sealing element 81. The application of shear forces to disrupt the sealing element 81 must occur in radial and longitudinal planes. The threaded portion 79 retaining the very thin sealing element 81 is a combination of non-aligned, force absorbing undulating surfaces. Any force capable of disruption of sealing element 81 by thermal or mechanical forces would have to destroy the member 31 or the sleeve 78.

The threaded engagement of the sleeve 78 with the member 31 can be limited by a collar 82. The collar 82 resists against a forward shoulder 83 in the member 31. The lower portion of the sleeve 78 is sealed fluid-tight by a threaded cap 84. The electrical conductor 62 terminates at a cable connector 86 to form an electrical connection with the cap 84. For example, the lower extremity of the conductor 62 may be silver-soldered to the connector 86. Thus, the lower portion of the sleeve 78 is sealed to fluid entry relative to the passage 33 but yet is electrically connected to the conductor 62.

An additional fluid-tight seal can be positioned upstream of the sealing element 81 for environment exposures at which the sealing element 81 cannot maintain its mechanical integrity for other reasons. For this purpose, the member 31 carries an inner cylindrical surface 87 adjacent the shoulder 83 which extends toward the end 36. The surface 87 and the cylindrical sidewall of the sleeve 78 form a longitudinally extending—radially narrow annulus 88 in which packing ringlets 89 are received. The ringlets 89 may be of the same material and construction as the ringlets 48. The ringlets 89 are forced against the collar 82 by a packing follower 91 held in compression by a spring 92 resting against a stop element 93. Other arrangements for moving the packing 89 against the shoulder 83 may be employed, if desired. However, the present arrangement is desirable since the spring stop 93 can carry adjusting screws 94 which permit its selected location upon the sleeve 78 to force the spring 92 into the desired compression of the ringlets 89. With the described arrangement, the ringlets 89 are compressed within the annulus 88 and seal in fluid tightness between the member 31 and sleeve 78.

The sleeve 78 is protected against mechanical impacts by an enclosing third sleeve 96 secured within the member 31 at its end 36. Preferably, the sleeve 96 is secured by a threaded portion 97 to the second diameter portion 77 but does not have to form a fluid tight interconnection. Entry of fluids into the annulus about the sleeve 78 will not create any hazard since the sealing element 81 and the ringlets 89 prevent its entry into the passage 33. The sleeve 96 terminates longitudinally beyond the cap 84 of the sleeve 78 so as to enclose entirely the sleeve 78. Thus, the sleeve 78 and the sealing element 81, and the ringlets 89 are protected should the entrance bushing 27 be dropped or otherwise mechanically abused at its end 36. Thus, the sealing element 81 needs only to accommodate the thermal and mechanical stresses during operation of the entrance bushing 27 in the electric treater 11 or the like. This is of great advantage when relatively unskilled workers install the entrance bushing 27 into an electric treater.

The sleeve 96 terminates in an electrical connector 98. The connector 98 may be a spade lug carrying a bolt to receive conductor 29 from the electrode 19 of the electric treater 11.

The connector 98 can be secured to the sleeve 96 by a cylindrical insert 99 carrying a V-groove to receive mounting screws 101. Thus, a secure mechanical and electrical connection is provided between the electrical connector 98 and the sleeve 96.

An electrical interconnection is made between the sleeves 78 and 96 which does not transmit mechanical impacts. For this purpose, a flexible conductor 102 is secured between the cap 84 and the cylindrical insert 99. The conductor 102 may be secured by silver-soldering or other suitable connection arrangement.

It is preferred that the member 31 and ringlets 48 and 89 are Teflon TFE resin (polytetrafluoroethylene plastic material). Additionally, the sealing element 81 preferably is formed from a tape Teflon FEP (fluorinated ethylene polypropylene resin) plastic material. The various other parts of the entrance bushing 27 can be formed of any suitable metals such as stainless steel.

Preferably the ringlets 48 and 89 are positioned with their joints spaced 120° from each other in adjacent members. These ringlet assemblies perform good service in the entrance bushing 27.

The entrance bushing 27 has been described with specific arrangements for the upper and lower electrical interconnections into an electric treater. However, it will be apparent that other types of electrical connections to the transformer 22 and treater 11 may be employed if such construction is desired. In addition, any voids between the electrical conductor 62 within the insulating sheath 68 and the passage 33 can be filled with silicone grease to exclude entrainment of air which may contain moisture deleterious to the electrical insulating character of the entrance bushing 27.

From the foregoing, it will be apparent that the entrance bushing of the present invention has structural arrangements well suited for and being the permanently bonded and spliced known entrance bushings. Various changes and modifications may be made to the structure of the present entrance bushing without departing from the spirit of the invention. It is intended that the present description be taken in illustration of the present invention. The appended claims define the scope of the present invention.

What is claimed is:

1. A high-voltage entrance bushing for an electric treater comprising:
   a. an elongated tubular member formed of a high-resistance plastic material subject to plastic flow upon increase in temperature and pressure, and said tubular member having a condenser receiving passage therethrough;
   b. a metal mounting adapter secured about a first end of said tubular member, said adapter and tubular member having spaced-apart sidewall surfaces forming a seal-containing first annulus between said first end of said tubular member and terminating intermediate the longitudinal extent of said adapter;
   c. first sealing means positioned in said first annulus for forming a fluid-tight interconnection between said adapter and said tubular member;
   d. a first sleeve secured within said tubular member and extending from said first end in alignment with said passage;
   e. said first annulus in fluid-communication with an opening in said first end of said tubular member, and said opening spaced from said first metal sleeve by an imperforate part of said tubular member whereby any fluid traversing said annulus is vented to the exterior of said passage in said tubular member;
   f. said tubular member at the second end thereof and said passage having first and second diameter portions;
   g. a second metal sleeve threadedly secured within said first diameter portion, a polymer sealing element held in compression in the threaded interengagement between said tubular member and said second metal sleeve, and said sealing element being permanently bonded and spliced to said tubular member and said second metal sleeve and substantially filling all voids therebetween, and said second metal sleeve having a closed end to which an electrical conductor in said passage is connectable remote from the threaded interconnection to said tubular member;
   h. a third metal sleeve secured at one end within said second diameter portion and carrying at the other end an external electrical connector, said third sleeve enclosing said second sleeve in spaced-apart relationship; and
   i. a flexible conductor carried within said third metal sleeve for electrical interconnection between said second and third metal sleeves.

2. The entrance bushing of claim 1 wherein said tubular member is a polytetrafluoroethylene plastic material and said polymer sealing element is fluorinated ethylene propylene resin.
The entrance bushing of claim 1 wherein said passage is threadedly secured within said passage and carries an encircling shoulder adjacent to said first end of said tubular member and said encircling shoulder overlaying a portion of said tubular member about said passage.

The entrance bushing of claim 1 wherein said first sleeve is threadedly secured within said passage and carries an encircling shoulder adjacent to said first end of said tubular member and said encircling shoulder overlaying a portion of said tubular member about said passage.

The entrance bushing of claim 1 wherein said first metal sleeve at its end remote from the interconnection with said tubular member is provided with electrical interconnection means connectable with an external electrical system.

A high-voltage entrance bushing for an electric treater comprising:

- An elongated tubular member formed of a high-resistance plastic material subject to plastic flow upon increase in temperature and pressure, said tubular member having a conductor receiving passage therethrough, and said tubular member having threaded end portions;
- A metal mounting adapter threadedly secured about said tubular member at one end thereof, said tubular member having a reduced diameter portion adjacent said one end and said portion terminating in an abutment shoulder intermediate an internal cylindrical surface on said adapter, thereby forming a longitudinally extending, radially narrow annulus;
- First packing members positioned in said annulus;
- Means carried at said one end of said tubular member on which is secured said adapter for compressing said first packing members against said adapter to provide fluid-tight engagement in said annulus of said first packing members with said adapter and tubular member;
- A first metal sleeve threadedly secured within said passage to said tubular member at said one end carrying said adapter;
- Said annulus between said adapter and said tubular member at its open end removed from said abutment shoulder being spaced from said sleeve by an imperforate end part of said tubular member whereby any fluid traversing said annulus is vented to the exterior of said first metal sleeve within said passage in said tubular member;
- Said tubular member at the second end of said passage having first and second diameter threaded portions;
- A second metal sleeve threadedly secured within said first diameter threaded portion, a polymer sealing element held in compression in the threaded interengagement between said tubular member and said second metal sleeve, and said sealing element being permanently bonded and sealed to said tubular member and said second metal sleeve and substantially filling all voids therebetween, and said second metal sleeve having a closed end to which an electrical conductor in said passage is connectable remote from the threaded interconnection to said tubular body;
- Said tubular member having an enlarged diameter portion intermediate said first and second threaded portions and said enlarged diameter portion forming an interior cylindrical surface terminating in an abutment shoulder intermediate an external cylindrical surface on said second metal sleeve thereby forming a longitudinal extending narrow second annulus;
- Second packing members positioned in said second annulus;
- Means carried at said second end of said tubular member on which is secured said second metal sleeve for compressing said second packing members against said shoulder to provide fluid-tight engagement in said second annulus with said second metal sleeve and said tubular body;
- A third metal sleeve threadedly secured at one end within said second threaded portion and carrying at the other end an electrical connector, said third sleeve extending from said tubular member to enclose said second sleeve; and
- A flexible conductor carried within said third metal sleeve for electrical interconnection between said second and third metal sleeves.

The entrance bushing of claim 6 wherein said adapter carries an external threaded portion on which is secured a packing cap adapted to receive said first metal sleeve and to vent fluids from said first annulus in said tubular member and said packing cap is associated with said means for compressing said first packing members within said first annulus.

The entrance bushing of claim 7 wherein said means for compressing said first packing members includes an annular packing follower received in said first annulus and screw adjusting in said packing cap for urging said packing follower into engagement with said first packing members.

The entrance bushing of claim 7 wherein said packing cap compresses an encircling shoulder on said first metal sleeve, said shoulder overlaying an end part of said tubular member but not said first annulus, and said packing cap carrying at least one opening to vent fluids from said first annulus through said packing cap and exteriorly in said first metal sleeve within said passage in said tubular member.

The entrance bushing of claim 6 wherein the end of said first metal sleeve remote from the threaded interconnection with said tubular member is provided with electrical interconnection means connectable with an external electrical system.

The entrance bushing of claim 6 wherein said second sleeve carries a teflon-coated annular packing follower received in said second annulus and resilient means for urging said annular packing follower into engagement with said second packing members for compression with said abutment shoulder at the inner extremity of said second annulus.

The entrance bushing of claim 11 wherein said resilient means is a helical spring compressed between said second packing members and a spring stop element secured to the exterior of said second metal sleeve.

The entrance bushing of claim 12 wherein said spring stop element is adjustable to a selected longitudinal position on said second metal sleeve.

The entrance bushing of claim 6 wherein said abutment shoulder in said second annulus is provided by an external metal ring integrally carried by said second metal sleeve and resting in engagement in said second annulus adjacent said first diameter threaded portion.

The entrance bushing of claim 6 wherein said tubular member is a polyfluoroethylene plastic material and said polymerized sealing element is a fluorinated ethylene propylene resin.

A high-voltage entrance bushing for an electric treater comprising:

- An elongated tubular member with a uniform cylindrical external sidewall surface and formed of a high-resistance plastic material subject to plastic flow upon increase in temperature and pressure, and said tubular member having spaced-apart external surfaces forming a seal-containing first annulus between said first end of said tubular member and terminating intermediate the longitudinal extent of said adapter;
- Means carried at said second end of said tubular member on which is secured said second metal sleeve for compressing said second packing members against said shoulder to provide fluid-tight engagement in said second annulus with said second metal sleeve and said tubular body; and
- A third metal sleeve threadedly secured at one end within said second threaded portion and carrying at the other end an electrical connector, said third sleeve extending from said tubular member to enclose said second sleeve; and
d. a first metal sleeve secured within said tubular member and extending from said first end in coaxial alignment with said passage, said first metal sleeve at its end remote from interconnection with said tubular member provided with electrical interconnection means connectable to an electrical system external of the electrical treater;
e. said first annulus in fluid communication with an opening in said first end of said tubular member, and said opening spaced from said first metal sleeve by an imperforate part of said tubular member whereby any fluid traversing said first annulus is vented to the exterior of said first metal sleeve within said passage in said tubular member;
f. said tubular member at the second end thereof and said passage having first and second diameter portions;
g. a second metal sleeve threadedly secured within said first diameter portion, a polymer sealing element held in compression in the threaded interengagement between said tubular member and said second metal sleeve, and said sealing element being permanently bonded and sealed to said tubular member and said second metal sleeve and substantially filling all voids therebetween, and said second sleeve having a closed end to which an electrical conductor in said passage is connectable remote from the threaded interconnection to said tubular member;
h. said sealing element is a fluorinated ethylene propylene resin when said tubular member is a polytetrafluoroethylene plastic material;
i. a third metal sleeve secured at one end within said second diameter portion and carrying an external electrical connector adapted for electrical interconnection to electrical components within the electrical treater, and said third metal sleeve enclosing said second metal sleeve in spaced apart relationship whereby said polymer sealing element is protected from mechanical injury; and
j. a flexible conductor carried within said third metal sleeve for electrical interconnection between said second and third metal sleeves.
17. The entrance bushing of claim 16 wherein said first metal sleeve carries an electrical interconnection means connectable to an electrical system external of an electrical treater by a threaded conduit connector having an external grounded sheath connected to said first metal sleeve and a dielectric solid covering surrounding an electrical conductor connected to said second metal sleeve.
18. The entrance bushing of claim 16 wherein said first metal sleeve carries an electrical interconnection means connectable to an electrical system external of an electrical treater by an air-insulated electrical conductor connected to said second metal sleeve and rigid piping forming an external grounded sheath connected to said first metal sleeve.