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Watson et al.

[11] **3,926,774**

[45] **Dec. 16, 1975**

[54] **ELECTRIC TREATER SYSTEM**

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[73] Assignee: **Petrolite Corporation**

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[51] **Int. Cl.²**.................... **C10G 33/02;** H01B 17/26

[58] **Field of Search**............ 174/11 R, 11 BH, 12 R, 174/12 BH, 15 R, 15 BH, 18, 31 R, 151, 152 R; 204/302, 304, 305, 306, 307, 308

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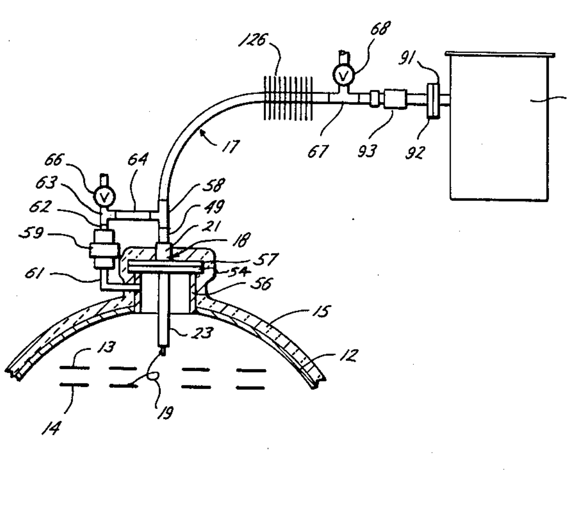
Primary Examiner—Laramie E. Askin
Attorney, Agent, or Firm—Emil J. Bednar

[57] **ABSTRACT**

Electric treater system for resolving an emulsion in a vessel with an electric field created by an energized electrode receiving current from an external power source via a feed-through insulator, an electrical conductor and a high voltage bushing within a sidewall of the vessel. A pressure conduit extends between the entrance bushing and the feed-through insulator, and it contains the electrical conductor within a dielectric liquid. A heat sink on the entrance bushing maintains its plastic insulation parts at substantially the temperature of the emulsion. System means maintain the dielectric liquid within the pressure conduit at substantially the fluid pressure of the emulsion. Also, a heat exchanger on the pressure conduit maintains the feed-through insulator at substantially the same temperature at its pressure conduit and power source terminals. As a result, the entrance bushing can operate at elevated emulsion temperatures (500°F) but at insignificant pressure differential whereas the feedthrough insulator can operate at the ambient temperatures (80°F) of the power source but at substantially the fluid pressure of the emulsion (500 psi). Neither the bushing nor feed-through insulator must withstand simultaneously high pressure (500 psi) and high temperature (500°F) conditions. The present electrical treater system operates at elevated temperatures and pressures with the relative safety of low pressure, low temperature conditions.

20 Claims, 8 Drawing Figures



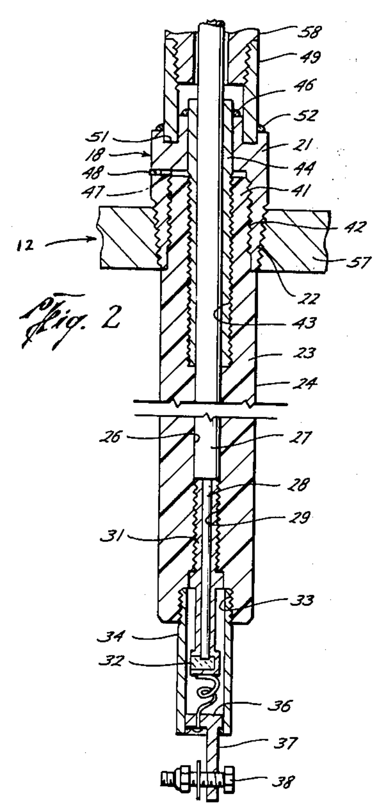


Fig. 2

Fig. 1

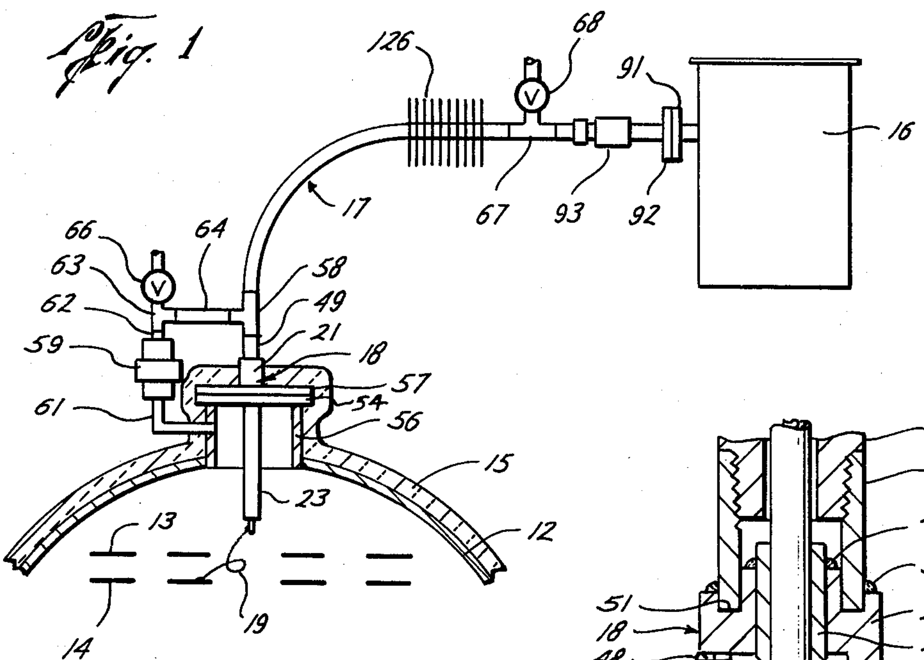
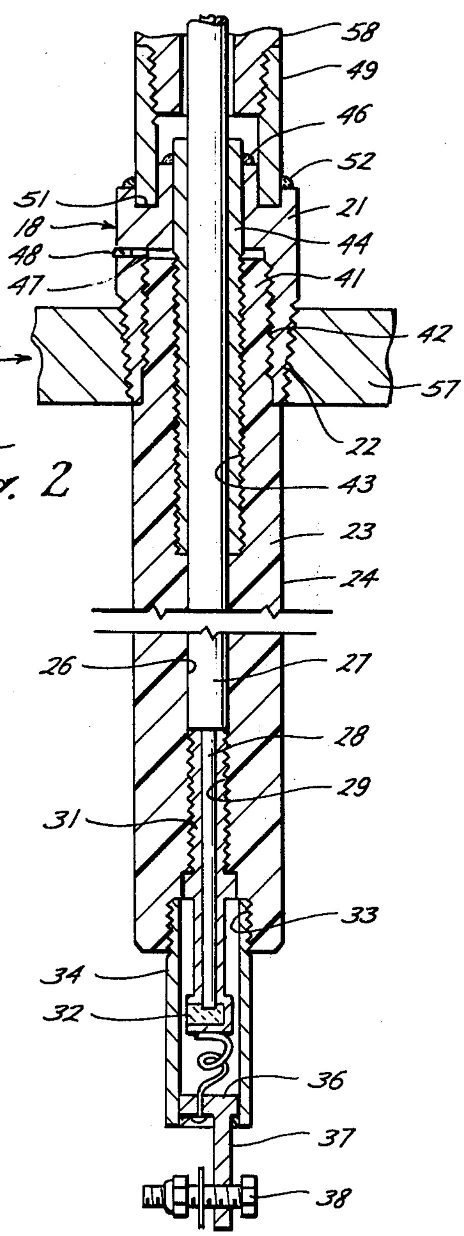


Fig. 2



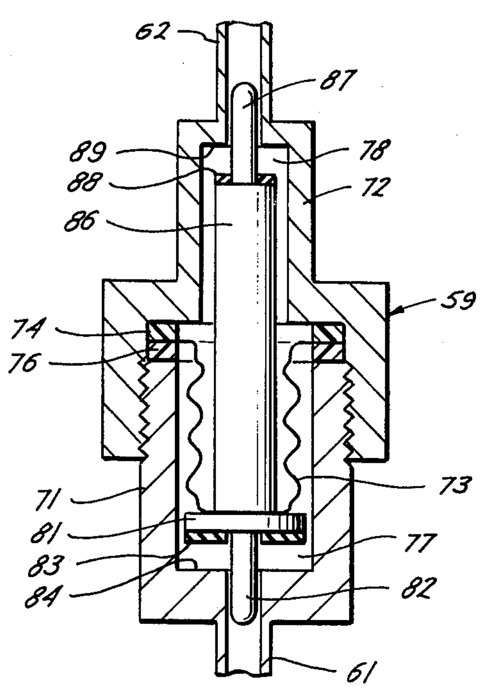


Fig. 3

Fig. 4

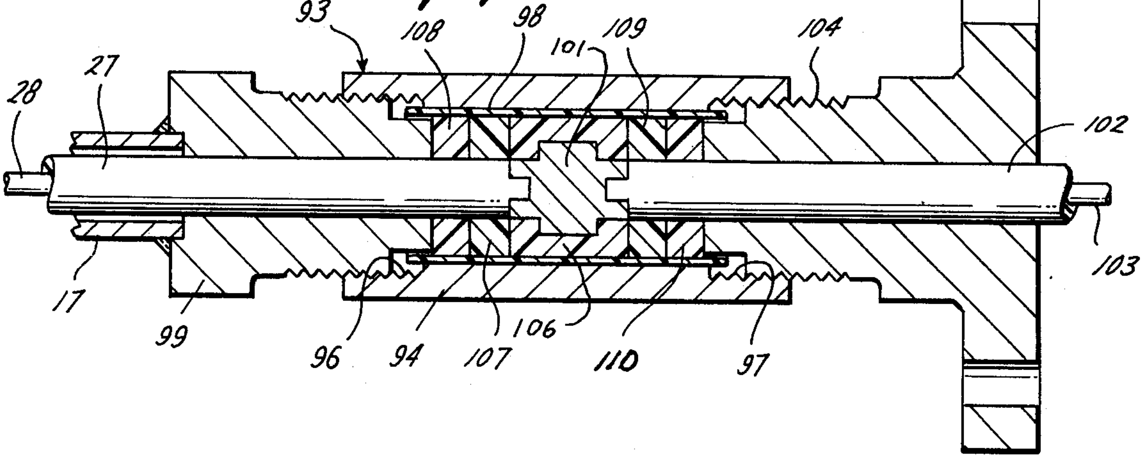


Fig. 5

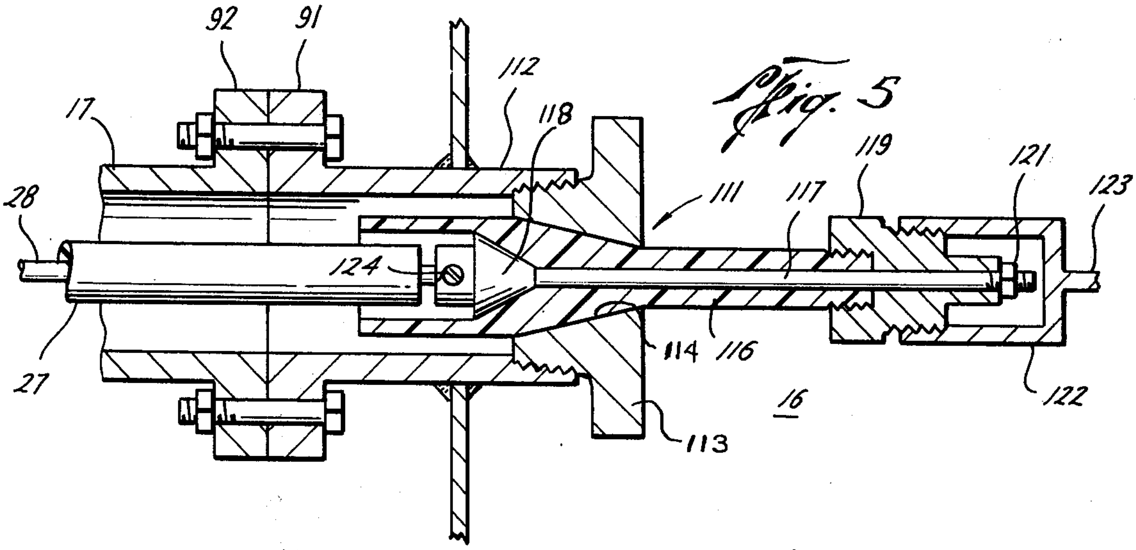
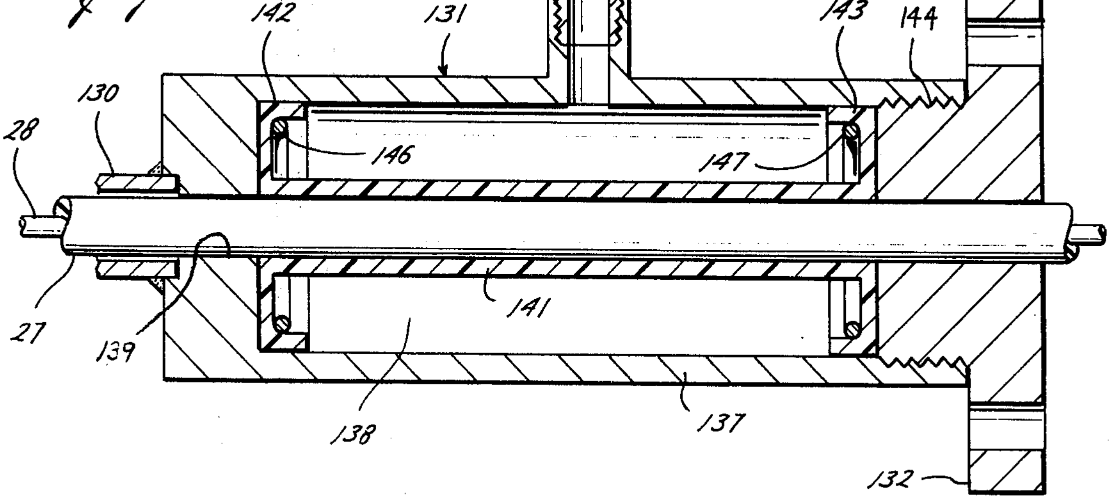


Fig. 7



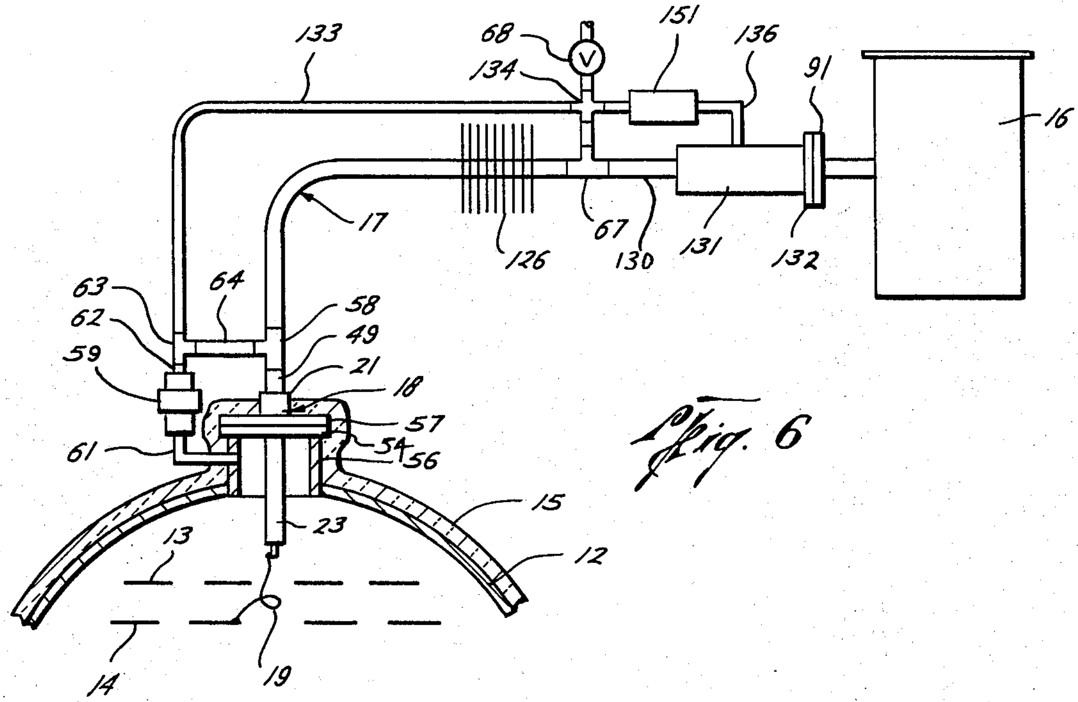

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Fig. 6

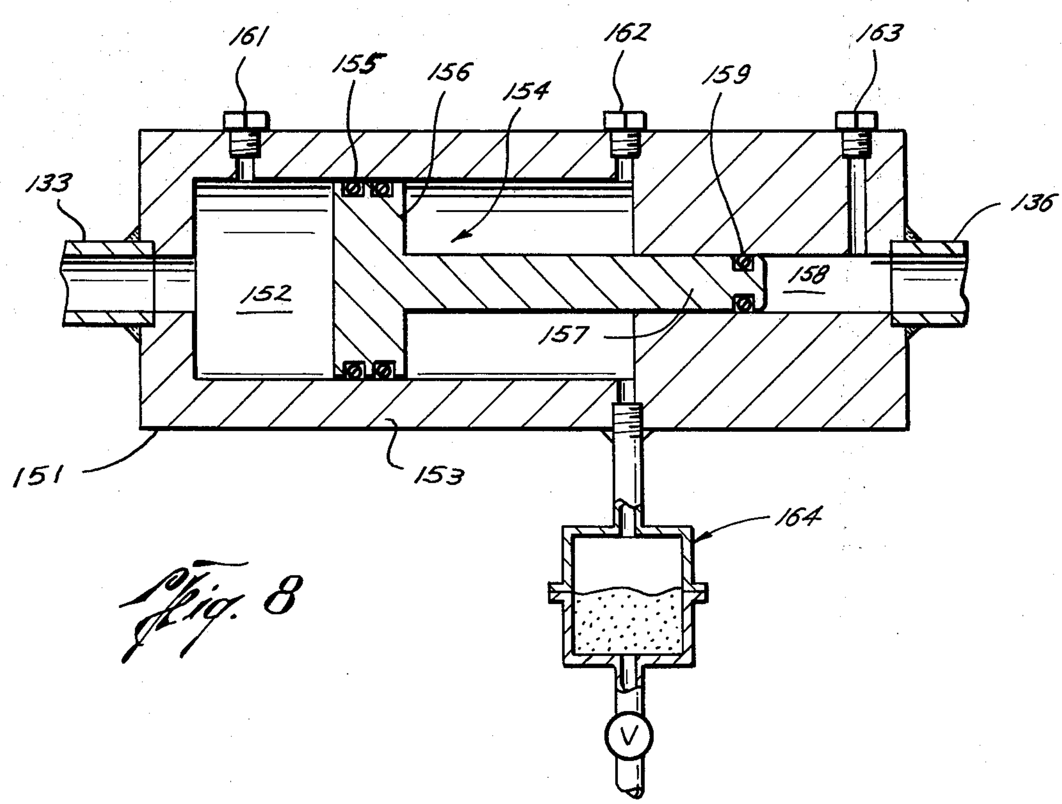
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Fig. 8

ELECTRIC TREATER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for the resolution of an emulsion consisting of immiscible external and internal liquid phases. More particularly, the invention relates to the electric treatment of oil-continuous emulsions containing dispersed aqueous phase contaminating substances.

2. Description of the Prior Art

Electric treaters have been employed for many years for resolving emulsions formed of immiscible external and internal liquid phases. Usually the external phase is oil-continuous, and the internal phase is a dispersed aqueous contaminating substance. The term "oil" includes various types of materials such as petroleum and its products, and various types of organic liquids. The internal phase is aqueous and usually will be a caustic or acid solution. One of the most common emulsions which is resolved in electric treaters is water-in-crude oil. For purposes of removing salt, the crude oil is mixed with a quantity of dispersed fresh water. A high voltage elctrical field resolves the emulsion by coalescing the internal phase into a bulk phase (carrying removed salt) which separates by gravity from the continuous external crude oil phase. The terms resolution and coalescence are used in their general meanings to denote the agglomeration of the dispersed internal phase in the continous external phase.

Conventional electric treaters have employed high voltage from external power sources of 11 to about 33 kilovolts applied to electrodes that create the electrical field. However, energizing potentials of other values have been used in certain applications. The spacing between the electrodes defining the electric field produces voltage gradients in the range of about 2.5 kilovolts to about 8.5 kilovolts per inch of spacing.

Electric treaters employed for resolving emulsions have relatively similar constructions. The treater generally employs a pressure-type metal vessel which contains an inlet for introducing the emulsion and outlets to remove the continuous phase and the coalesced internal phase. In addition, the vessel contains electrodes for creating the electrical field. One or more energized electrodes can be suspended within the vessel but are electrically isolated from its metal sidewalls. The electrical current, from an external power source, is carried to the energized electrodes through the metal sidewall of the vessel by an electrical insulating device which is termed an "entrance bushing". The entrance bushing has metal parts to integrally connect with the sidewall of the vessel; and also it has insulating components to pass the electrical current in electrical isolation through the metal sidewall of the vessel to the energized electrode. The entrance bushing must provide the necessary electrical interconnection and a liquid-tight seal at the metal sidewall of the vessel under the temperature-pressure environment in which the emulsion is resolved within the vessel.

Prior constructions of the entrance bushing have withstood moderate temperatures and pressures of the emulsion within the vessel while conducting high potential current to the energized electrode. Present state of the art techniques require that the insulating components of the entrance bushing are formed of polymer-type insulating plastic materials such as Teflon. Entrance bushings with these plastic materials provide exceptional service in commercial applications on electric treaters for resolving emulsions. For example, entrance bushings shown in U.S. Pat. Nos. 2,881,125, 3,085,128, 3,303,262, and 3,666,878 have provided outstanding operational life and safety characteristics. These bushings are exceptional in design in that they operate under exceptional environments where subjected simultaneously to temperatures as high as 400°F. and fluid pressures up to 150 psi during normal operation of the electric treater.

Present day operation of electric treaters, of the nature employed in refineries, is placing a heavy burden upon even these entrance bushings. The temperature and pressure of the emulsion being resolved in electric treaters have steadily increased in the recent decade. Operating conditions are being approached which the plastic insulating materials of the entrance bushing cannot withstand in terms of operational life and maintenance of high safety characteristics. In one particular oil refinery, the heating, electrical field desalting and distillation process steps are arranged to conserve heat energy. For this purpose, the crude oil is heated to substantial temperatures (e.g. 375°F) upstream of the electric treater by heat exchange with the products of distillation and other petroleum thermal treating procedures. In some instances, the oil refinery could be even more efficiently operated if the crude oil before passing through the electrical treater for desalting or dehydration purposes could be heated to temperatures approaching 500°F. These severe temperatures require very high pressures of 500 psi or more to maintain the crude oil within a liquid phase condition in the electric treater. The plastic insulating material, especially Teflon, has excellent mechanical and electrical properties. However, the design of an entrance bushing to withstand these exceptionally elevated temperatures and high pressures becomes a serious task so that the present outstanding operational life and safety characteristics of entrance bushings can be maintained.

Entrance bushings constructed with proper plastic insulating material can withstand very high operating pressure in the range of several thousand psi where the temperatures are relatively low, for example, ambient temperature of 60°–80°F. Alternatively, these bushings can withstand relatively high temperatures of up to about 500°F. where the operating pressure is relatively low, for example, 15 psi differential across the plastic insulating material. In either case, the plastic insulating material can be used within an entrance bushing and safely isolate electrical potentials up to 50 kilovolts (ac-dc) for extended periods of time and in complete safety.

Designing entrance bushings incorporating plastic insulating material is very difficult when such a device must withstand simultaneously elevated operating pressures (500 psi) and temperatures (500°F). Teflon is typical of a number of high electrical resistance plastic materials which are subject to plastic flow upon increase in temperature and pressure. At elevated temperatures, these insulating materials are subject to plastic flow when subjected simultaneously to high operating pressures.

In the conventional entrance bushing, the plastic insulating material projects as a tubular member into the vessel containing the emulsion. Lower and upper fluid seals prevent the escape of emulsion from the vessel through the internal parts of the entrance bushing. For example, the upper portion of the tubular member of the plastic is carried in a metal adapter which is mounted in the sidewall of the vessel. The insulating material has a thermal expansion coefficient several times that of the metal (steel) components of the entrance bushing. Also, this insulating material in the cycling of operating temperatures, retains the structure induced at the maximum temperature. A substantial temperature gradient established along the tubular member and across metal parts which form fluid seals creates severe longitudinal stresses to produce seal failure. Emulsion leakage into the entrance bushing results with entry into the metal conduit which contains the electrical conductor connecting to the external power source. An electrical arc may then occur which can destroy the electrical conductor, the entrance bushing, or both. Although electrical treaters carry devices to disconnect the electrical current from the energized electrode upon such an arc, substantial repairs are usually necessary to place the electric treater into operation. Thus, as the emulsion within the electric treater increases simultaneously in both pressure and temperature, desigining an adequate entrance bushing which can be operated continuously in a high degree of safety becomes a difficult challenge. Thus, systems to remove the bushing from such environment may be utilized such as shown in U.S. Pat. No. 3,719,584.

Ideally, the system with the electrical treater functions such that the entrance bushing within the vessel can operate without suffering both high temperatures and high pressures. The present invention provides such a novel electrical system.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided an electrical treater system adapted for resolving emulsions in a high temperature, high pressure environment. The electric treater system includes a vessel for containing the emulsion while subjected to an electric field created by electrode means, including an energized electrode mounted in electrical isolation from the vessel. A high voltage bushing mounted within the sidewall of the vessel has an elongated tubular member projecting into the vessel and immersed within the emulsion. This tubular member, of a high electrical resistance, plastic insulating material, is subject to plastic flow upon increase in temperature and pressure. A conductor extends through the tubular member and connects at its vessel interior end to the energized electrode. The tubular member at its other end is carried in a metal adapter mounted in the sidewall of the vessel. The metal adapter includes a heat sink means for maintaining the length of the tubular member at substantially the same temperature as the emulsion. An aperture in the metal adapter passes the conductor to the exterior of the vessel. A pressure conduit extends in fluid-tight relationship from the metal adapter to an external power source having a high voltage output. A high pressure, high voltage feed-through insulator means seals the pressure conduit at the external power source. An interconnecting high voltage conductor within a dielectric liquid is carried in electrical isolation within the pressure conduit and connects between the conductor in the entrance bushing and the high voltage output of the external power source through the feed-through insulator means. A system means maintains the dielectric liquid at substantially the same pressre as the emulsion within the vessel. This system means includes a dynamic fluid barrier for preventing intermingling of the emulsion and dielectric liquid. Heat exchanger means on the pressure conduit maintain the high pressure, high voltage feed-through insulator means at substantially the same temperature at its pressure conduit and power source terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view in elevation, partially in cross-section, of an electric treating system of the present invention;

FIG. **2** is a vertical section of one embodiment of an entrance bushing carried in an electric treater;

FIG. **3** is a longitudinal section of a dynamic fluid barrier associated with the system shown in FIG. **1;**

FIG. **4** is a longitudinal section through one embodiment of a feed-through insulator employed in the system shown in FIG. **1;**

FIG. **5** is a longitudinal section through another embodiment of a feed-through insulator employed with the system shown in FIG. **1;**

FIG. **6** is a view in elevation, partially in cross section, of a second embodiment of the electric treater system of the present invention;

FIG. **7** is a longitudinal section of another embodiment of the feed-through insulator with a fluid-actuated seal for use in the system shown in FIG. **6;** and

FIG. **8** is a longitudinal section through a fluid amplifier employed with the system shown in FIG. **6** for actuating the feedthrough insulator shown in FIG. **7.**

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring now to FIG. **1** of the drawings, there is shown a system of the present invention for electrically treating an emulsion for its resolution through application of electrical field forces. The electric treating system includes a vessel **12** which contains the emulsion at suitable temperature and pressure during resolution. The vessel **12** has metal sidewalls which enclose electrodes **13** and **14** and carry insulation **15.** These electrodes may take any suitable configuration but preferably they are planar, spaced apart foraminous metal grids. In the present description, the electrode **13** is grounded to the vessel **12** and the energized electrode **14** is carried in electrical isolation relative to the metal portions of the vessel **12.** The energized electrode **14** can be suspended from the vessel **12** upon insulators (which are not shown in the present drawings). The vessel **12** can be of conventional design with inlet and outlet conduits for bringing emulsion into the vessel **12** and for removing the coalesced internal phase and the treated external phase. Reference may be taken to U.S. Pat. No. 2,855,359 for illustrations of such components to be used with the vessel **12.** These components are omitted from the present description to simplify the description of the present system.

The energized electrode **14** receives high potential current from an external power source **16.** The power source **16** can be a DC power pack which produces elevated DC potentials, e.g. 33 kv dc. Alternatively the power source **16** can be a transformer energized from available AC supply sources with an output of convenient magnitude, e.g. 13 kv ac. The high potential current from the power source **16** is carried through a metal pressure conduit **17** to an entrance bushing **18** which then passes the current, in electrical isolation relative to the vessel **12,** through a flexible lead **19** to the energized electrode **14.** The electrode **14** energized to elevated potentials creates an electric field within the vessel **12** for resolving the emulsion.

The entrance bushing **18**, as seen in greater detail in FIG. **2**, has a metal adapter **21** integrally secured within the sidewall of vessel **12**. For this purpose, the adapter **21** may have a lower extremity **22** received within complementary threads in an opening through the sidewall of the vessel **12**. An elongated tubular member **23** projects from the metal adapter **21** into the interior of the vessel **12**. The tubular member **23** is formed of a high electrical resistance, plastic insulating material, preferably a polymeric solid not readily wetted by the emulsion or accumulating deposits of arc inducing materials. It is preferable to use polytetrafluoroethylene ("Teflon"), or in lesser severe environmental conditions to employ polytrifluorochloroethylene ("Kel-F"). However, other equivalent plastic insulating materials may be employed, if desired.

Preferably, the tubular member **23** has a uniform cylindrical exterior surface **24** which is relatively free of scratches or ridges that promote the accumulations of arc inducing materials. The tubular member **23** has a longitudinal passage **26** extending between its top and bottom extremities. The passage **26** accommodates a high voltage cable **27** with an electrical conductor **28** encased within a plastic sheath. This plastic sheath is of a plastic material similar to the tubular member **23**. However, the cable **27** may be formed of other materials capable of resisting dielectric puncture at the high voltages which are applied to the electrode **14** of the vessel **12**. The lower extremity of the tubular member **23** is provided with a first threaded portion **29** in which is received a metal sleeve **31**. The metal sleeve **31** has a complementary passageway for the conductor **28** which is secured electrically to the sleeve **31** by silver solder **32**. The solder **32** also provides a fluid-tight seal at the bottom of the sleeve **31**.

The sleeve **31** is mounted within the threaded portion **29** in a fluid-tight connection to withstand moderate pressure differentials. A relatively durable seal to even elevated pressure differentials is provided by first wrapping the sleeve **31** with a very thin Teflon tape. The sleeve **31** is cooled and the tubular member is heated, and then, these parts are threaded together. Lastly, dielectric heating fuses the tape between the threaded portion **29** and the sleeve **31** to form an excellent high pressure fluid seal. Reference to U.S. Pat. No. 3,666,878 provides a complete description of such seal manufacture. The lower portion of the tubular member **23** is completely immersed in emulsion and is maintained throughout its extent adjacent the sleeve **31** at a substantially uniform temperature (no significant thermal gradient). Thus, no thermal stress created by differential longitudinal expansion exists along the threaded interconnection between the sleeve **31** and the tubular member **23**.

The lead **19** could be secured directly to the end of the sleeve **31**. However, it is preferred to protect the sleeve **31** with an enclosing sleeve **34** mounted in a second threaded portion **33** provided in the tubular member **23**. The sleeve **34** and threaded portion **33** interconnection need not provide a fluid seal. The lower end of the sleeve **34** is closed by a cylindrical insert **36** secured in place, as by welding. The insert **36** has a projecting lug **37** carrying a bolt and washer assembly **38** for connection to the lead **19**.

In the conventional bushing, the end of the tubular member **23** at the vessel **12** is cooled by the external conduits connected thereto. As a result, the upper end of the tubular member **23** is under a longitudinal thermal gradient which can disrupt fluid pressure seals. In the present system, the adapter **21** is arranged with a heat sink so that the entire upper portion of the tubular member **23** is maintained at substantially the same temperature as the emulsion contained in the vessel **12**. For this purpose, the upper portion **41** of the tubulr member **23** carries external threads which inter-fit with internal threads **42** carried within the interior of threaded portion **22** of the metal adapter **21**. An enlarged cylindrical threaded portion **43** about the passageway **26** receives a metal sleeve **44** which extends beyond the adapter **21** into the upper portion of the tubular member **23**. The sleeve **44** is integrally connected to the metal adapter **21** by suitable means which provide for an efficient transfer of heat, and preferably, a fluid-tight metal-to-metal connection. For example, these components can be secured integrally into metal-to-metal contact by an induction weld **46**. With this arrangement, the sidewall of the insulated vessel **12** is at substantially the same temperature as the emulsion in the vessel **12**. Heat energy can flow through the heat sink provided by metal-to-metal integral connection of the adapter **21** and sleeve **44** about the upper end of the tubular member **23**. As a result, the tubular member **23** is without significant longitudinally directed temperature gradients. The insulation **15** preferably is carried about the entrance bushing **18** up to and covering the metal adapter **21**.

The sleeve **44** is mounted within the tubular member **23** to provide a pressure seal. If desired, the sleeve **44** is secured to the tubular member **23** in the same manner as the sleeve **31** in a fluid-tight interconnection through the use of a plastic tape which is fused to form the desired pressure seal. The induction weld **46** may generate a sufficient temperature at the top end of the tubular member **23** to generate a small amount of gas. This gas is vented to the exterior of the metal adapter **21** by a vent port **47**. The vent port **47** is closed upon completion of the fabrication by a small welded plug **48**.

The pressure conduit **17** is connected in fluid-tightness to the metal adapter **21**. For this purpose, a coupling **49** received within a groove **51** in the metal adapter **21** is secured integrally to the metal adapter **21** by an induction weld **52**. Although the coupling **49** removes heat energy from the metal adapter **21**, the heat sink therein conducts replacement heat energy from the sidewall of the vessel **12**. As a result, the tubular member **23** is maintained at substantially the same temperature during operation of the vessel as the emulsion contained therein irrespective of losses through the coupling **49**.

Other arrangements of the metal adapter **21** in the entrance bushing **18** may be employed to provide a heat conductive element integrally interposed between the tubular member **23** and the pressure conduit **17**. Preferably, the opening in the metal adapter **21** accommodating the cable **27** is the sole aperture through the heat conductive element. This arrangement insures that the tubular member **23** will be maintained at substantially the same temperature throughout its length, and at the temperature of the emulsion within the vessel **12**.

Returning now to FIG. **1**, other features of the present electric treater system will be described. The entrance bushing **18** usually resides within a nozzle **56** carried upon the vessel 12. In particular, the nozzle 56 carries a flange 54. The metal adapter 21 threadly mounts into a complementary flange cover 57 secured to the flange 54. However, the entrance bushing 18 may be placed directly in a coupling within the sidewall of the vessel 12. The coupling 49 connects the entrance bushing 18 to the pressure conduit 17. In this embodiment, the pressure conduit 17 contains a tee 58 which permits fluid access to the dielectric liquid surrounding the cable 27 within the pressure conduit 17.

A system is provided for maintaining the dielectric liquid within the high pressure conduit 17 at substantially the same pressure as the emulsion within the vessel 12. In this system, a dynamic fluid barrier 59 is in fluid communication with the emulsion in the vessel 12 and the dielectric liquid within the pressure conduit 17. For this purpose, the barrier 59 has an inlet conduit 61 connected to the nozzle 56 for sensing the emulsion's pressure within the vessel 12. An outlet conduit 62 from the barrier 59 connects by a tee 63 and conduit 64 to the pressure conduit 17 for applying fluid pressure to the dielectric liquid. Preferably, the tee 63 connects to a valve 66 to permit filling of the barrier 59 and pressure conduit 17 with dielectric liquid. The pressure conduit 17 may also contain a tee 67 adjacent the power source 16. The tee 67 may carry a valve 68 for venting gases from the pressure conduit 17 to insure a completely liquid-filled system.

The barrier 59 can have a variety of elements as long as these elements prevent the intermingling of the emulsion and dielectric liquids while transmitting the emulsion's pressure in the vessel 12 to the dielectric liquid within the pressure conduit 17. Preferably, the barrier 59 includes an impermeable fluid barrier displaceable by pressure differential for isolating the emulsion and the dielectric liquid while transmitting fluid pressure from the emulsion to the dielectric liquid. With this system, the dielectric liquid within the pressure conduit 17 is maintained at substantially the emulsion's pressure within the vessel 12. The impermeable fluid barrier may be provided by various elements such as free pistons, immiscible liquid barriers or by flexible bellows.

In the preferred embodiment shown in FIG. 3, the barrier 59 has a flexible bellows 73. The barrier 59 has a two piece tubular body formed of an inner-part 71 received within an outer part 72 with the free end of the bellows 73 held in fluid-tightness by seals 74 and 76 confined between the body parts. The bellows 73 forms an inlet chamber 77 and an outlet chamber 78 within the outer body parts. The inlet chamber 77 is in fluid communication to the vessel 12 through the conduit 61. The outlet chamber 78 is in fluid communication with the pressure conduit 17 through the conduit 62. A dielectric liquid, such as transformer oil or silicone grease, is introduced via the valve 66 to fill the outlet chamber 78 and the pressure conduit 17 containing the cable 27. Any gas is vented through the valve 68 until a liquid-fill condition within the pressure conduit 17 is obtained. At this time the valves 66 and 68 are closed.

During operation of the vessel 12, the emulsion (in a dehydrated form) passes upwardly of the electrodes to fill the conduit 61 and inlet chamber 77. The bellows 73 is then displaced by differential pressure until the dielectric liquid within the pressure conduit 17 is at the same pressure as the emulsion within the vessel 12. The passageway 26 in the tubular member 23 carrying cable 27 also will be filled with dielectric liquid at the same pressure as the emulsion within the vessel 12. As a result, the fused seals between the sleeves 31 and 44, and the tubular member 23 are not subjected to any significant pressure differential. Additionally, these fused seals between metal and plastic material are maintained at the same temperature throughout the tubular member 23. Therefore, no fused seal suffers stressed conditions caused by differential longitudinal thermal expansion. As a significant result, the bushing 18 contains a plastic material which does not have to withstand any pressure forces across liquid-tight seals. The plastic material of tubular member 23 merely has to provide the necessary insulator for bringing high potential current through the conductor 28 to the electrode 14 in an insulated relationship to the sidewall of the vessel 12 at the emulsion's temperature.

In the event of unforeseen accidents, explosions, fires, etc., the pressure conduit 17 might have excessively high fluid pressures developed in the dielectric liquid. Alternatively, the emulsion's pressure within the vessel 12 might increase above the designed limits of the barrier 59. In either event, the barrier 59 can be arranged to prevent rupturing of the bellows 73 by application of excessive pressure differentials above certain magnitudes. For this purpose, the barrier 59 is provided with a check-valve arrangement. A valve member 81 is carried by the bellows 73 within the inlet chamber 77 and has a projecting pin 82 which passes into the conduit 61 for maintaining alignment during valve operation. The valve member 81 is provided with an annular seal 83 which cooperates with the end-face 84 of the inner-body part 71. Upon a pre-set pressure differential occurring by pressure rise within the pressure conduit 17, the bellows 73 moves to bring the annular seal 83 into sealing engagement with the face 84. As a result, conduit 61 is sealed to fluid flow. In a similar manner, the bellows 73 carries a valve member 86 which projects into the outlet chamber 78 with an aligning pin 87 extending into the conduit 62. An annular seal 88 carried upon the valve member 86 coacts with the end face 89 of the outer body part 72 to close conduit 62. As a result, the bellows 73 is protected from excessive pressures of the emulsion. With this check valve arrangement, excessive fluid pressures across the bellows 73 cannot disrupt the fluid barrier between the emulsion and the dielectric liquid.

Referring again to FIG. 1, the pressure conduit 17 connects in a fluid-tight relationship to the external power source at its high voltage output. For this purpose, the high voltage output of the power source 16 is available at a flange 91 which is secured to a complementary flange 92 on the pressure conduit 17. It is not desirable to construct the power source 16 with a container sufficiently strong to withstand the pressure of the emulsion in the vessel 12. Preferably, a high voltage feed-through insulator 93 is interposed in the pressure conduit 17 to protect the power source 16 from the pressure of the emulsion within the vessel 12. The feed-through insulator 93 can be carried by the flange 91 on the power source 16.

The feed-through insulator 93 has two basic requirements. First, it must carry in an insulated relationship the high potential current from the power source 16 to the cable 27 within the pressure conduit 17. Second, the feed-through insulator must provide a fluid-tight seal between the pressure conduit 17 and the power source 16. For these requirements, suitable high voltage insulating materials are employed, and the fluid seal is provided mechanical or fluid-actuated sealing members.

The feed-through insulator 93 is shown in FIG. 4 with mechanically actuated seals. The feed-through insulator 93 has a cylinderical body 94 with internal threaded ends 96 and 97. An insulating sleeve 98 within the body 96 receives the various sealing and insulating parts of the feed-through insulator 93. More particularly, the cable 27 passes through a compression nut 99 which engages the threaded end 96 for longitudinal movement relative to the body 94. The cable 27 terminates at an upset or flanged ferrule 101. The conductor 28 of the cable 27 is received within a complementary opening in the ferrule 101 and silver soldered thereto to provide proper electric contact. The cable 102 is received within flange 92 and carries a conductor 103 to the high voltage output of the power source 16. The conductor 103 is received within a complementary opening in the ferrule 101 and silver soldered thereto for proper electric contact. The flange 92 carries a threaded portion 104 which engages the threaded end 97 of the cylindrical body 94. Annular insulator 106 surrounds the ferrule 101. Insulating and packing members 107 and 108 cooperate with the packing nut 99, and insulating members 109 and 110 cooperate with the flange 92. The sleeve 94 threads between complementary right and left hand threads of nut 99 and threaded portion 104 to place the packing members and ferrule 101 into compression thereby providing the fluidtight seal at the end of the pressure conduit 17 adjacent the power source 16. The mentioned packing and insulating members may be of any suitable materials. However, a plastic material similar to the tubular member 23 is preferred for purposes of the present electric treater system. The sleeve 98 can be formed of the same plastic matrial, if desired.

Referring to FIG. 5, an alternate form of mechanically actuated seals in feed-through insulator 111 is shown. The pressure conduit 17 connects through flange connections 91 and 92 to the external power source 16. The flange 91 contains a tubular member 112 which extends into the interior of the power source 16. A metal adapter 113 having a tapered opening 114 formed centrally thereof threads into the end of the member 112. The opening 114 coaxially carries an insulator 116 which may be formed of the same plastic insulating material as the tubular member 23. However, other materials such as ceramics or various inorganic insulative materials may be employed. The insulator 116 has a central opening to receive conductor rod 117 which extends to the interior of the power source 16. One end of the rod 117 carrys an enlarged wedge 118 which interfits within a complementary opening in the insulator 116. The rod 117 at its other end traverses a metal adapter 119 threaded onto the insulator 116. The metal adapter 119 provides a keyed (non-rotating) retention of the rod 117 in the insulator 116. A compression nut 121 threads onto the end of rod 117 for tensioning the wedge 118 in fluid-tightness within the insulator 116. A metal cap 122 encloses the nut 121 and has a terminal 123 connected to the high voltge output of the external power source 16. The cable 27 terminates at the feed-through insulator 111 and the conductor 28 is secured to the wedge 118 in a complementary opening by set screw 124. In this manner high potential current can be passed through the feed-through insulator 111 and the conductor 28 to the energized electrode 14. The insulator 111 also seals the end of conduit 17 against the emulsion's pressure in vessel 12.

Mechanically energized fluid seals in the feed-through insulators make it desirable that the temperature at the pressure conduit 17 and the power source 16 ends of such insulators be maintained at substantially the same temperature, which temperature is usually the ambient temperature of the environment surrounding the electric treater system. For this purpose a heat exchanger is associated with the pressure conduit 17, and preferably, it is positioned adjacent the feed-through insulator. The heat exchanger is arranged to maintain the feed-through insulator at substantially the same temperature at its pressure conduit and power source terminals. For example, the pressure conduit 17 may be constructed with an integral heat exchanger. However, externally mounted heat exchangers can be employed on the conduit 17, such as the finned tubing 126 shown in FIG. 1. Finned tubing is satisfactory for the most purposes since the amount of heat energy transferred relative to the pressure conduit 17 and power source terminals of the insulators is relatively of small magnitude. circulating ambient temperature air is sufficient to transfer the required heat energy for most applications of the present invention. In some high temperature environments, it might be desired to provide the heat exchanger with a liquid cooling.

The feed-through insulator can be provided with fluid actuated seals. More particularly, the fluid actuated seals operate from the pressurized dielectric liquid within the conduit 17. Referring to FIG. 6, an embodiment of the present electric treater system employing fluid actuated seals in the feed-through insulator 131 is shown. In FIG. 6, like elements and like parts will be given numeral designations corresponding to FIG. 1. Feed-through insulator 131 is secured to the conduit 17 through the tee 67 and conduit 130. A flange 132 connects the insulator 131 to the flange 91 carried by the power source 16. The feed-through insulator 131 receives actuating pressure from a conduit 133, which connects to the tee 63, a four-way tee 134 and a conduit 136. The valve 68 can be connected to the tee 134 for introducing dielectric liquid and venting of gasses from the pressure conduit 17. The tee 134 also connects to the tee 67 in the pressure conduit 17 for purposes of filling, and venting of fluids from, the pressure conduit 17. With this arrangement, the barrier 59 not only equalizes the pressure between the dielectric liquid within the conduit 17 and the emulsion within the vessel 12 but also applies the dielectric liquid through the conduit 133 and 136 to actuate the fluid seals in feedthrough insulator 131.

Referring to FIG. 7, a detailed description of the feed-through insulator 131 will be given. The feed-through insulator 131 has a body 137 which carries the flange 132. The body 137 has formed therein a cylindrical chamber 138 in communication with the conduit 136 for receiving pressurized dielectric liquid. An axial opening 139 within the body 137 receives the cable 27 which extends through the feed-through insulator 131 to the high voltage output within the external power source 16. A fluid actuated seal 141 resides within the chamber 138 and longitudinally embraces the cable 27. The seal 141 may be of a resilient, but high electrical resistance, plastic material such as TFE polymer. In addition, the seal 141 has lip end portion 142 and 143 embracing the ends of the chamber 138. The flange 132 is interconnected by threads 144 to the body 137 to permit access to the chamber **138** for installing the seal **141.** The end portions **142** and **143** are held against the interior sidewalls of the chamber **138** by annular springs **146** and **147** to provide sufficient pre-compression engagement that a fluid actuated seal is obtained upon introduction of the dielectric liquid into the chamber **138.**

The pressurized dielectric liquid within the chamber **138** causes the seal **141** to embrace the cable **27** in fluid-tightness. Also the end portions **142** and **143** are distended into fluid-tight engagement with the body **137** and the flange **132.** The cable **27,** the seal **141** and dielectric liquid provide the electrical isolation of the conductor **28** from the metal portions associated with the pressure conduit **17** and insulator **131.**

In many cases, a fluid seal in the insulator **131** is desired at a greater pressure than the dielectric liquid within the pressure conduit **17.** For this purpose, in reference to FIg. **6,** a fluid amplifier **151** is inserted between the conduits **133** and **136.** The fluid amplifier **151** may be of any construction to produce in the conduit **136** a predetermined corresponding increase in pressure over the dielectric liquid that is contained in the conduit **17.**

In FIG. **8,** one embodiment of the fluid amplifier **151** is shown. The fluid amplifier **151** has a body **153** enclosing a cylindrical operating chamber **152** with an inlet connected to the conduit **133** and an outlet connected to the conduit **136.** A piston assembly **154** is mounted for reciprocation within the body **153,** and carries a first piston **156** within the chamber **152** and a second piston **157** within an outlet chamber **158.** The piston **156** is larger in diameter than the piston **157** by the desired pressure increase magnitude in the dielectric liquid in the outlet chamber **158** relative to the chamber **152.** The piston **156** is sealed to the sidewalls of the chamber **152** by O-rings **155.** In a like manner, the piston **157** is sealed to the sidewalls of the chamber **158** by O-ring **159.** The chamber **152** has vent plugs **161** and **162** so that both sides of the piston **156** in chamber may be vented and completely filled with dielectric liquid. The chamber **152** behind the piston **156** also connects with a reservoir **164** to allow dielectric liquid to flow into and out of chamber **152** from behind piston **156.** The reservoir **164** may be of a pneumatic balance accumulator design. The outlet chamber **158** also has a vent plug **163** to insure that dielectric liquid completely fills the chamber **158** and the conduit **136** in communication with the feed-through insulator **131.**

The embodiments of the electric treater system heretofore described provide a system wherein neither the entrance bushing **18** nor the feed-through insulators **93** etc. are required to withstand elevated pressures and high temperatures simultaneously. In the entrance bushing **18** on the vessel **12,** the fluid-tight seals between the tubular member **23** and the metal adapter **21** are exposed to only insignficant pressure differentials. The tubular member **23** is maintained at substantially the same temperature throughout its length, and that temperature is substantially that of the emulsion contained within the vessel **12.** The feed-through insulator **93** etc. adjacent the external power source **16** withstands the full pressure of the emulsion within the vessel **12.** However, the insulator is maintained at the same (ambient) temperature at its pressure conduit **17** and high voltage output ends.

For example, the entrance bushing **18** can operate under conditions which impose a temperature of 500°F. while suffering practically no pressure differential between the emulsion within the vessel **12** and the dielectric liquid within the conduit **17.** The feed-through insulator associated with the pressure conduit **17** may contain a fluid pressure of 500 pounds while being maintained at ambient temperatures of about 80°F. This separation of the temperature and pressure operating conditions at the entrance bushing and feed-through insulator permits a system which can operate at elevated tempertures and high pressures with the same safety as if the system were operated with a single entrance bushing or insulator containing essentially zero fluid pressure at ambient temperatures. Thus, the outstanding safety and operating records of earlier entrance bushings employed in electric field treaters are maintained for operating conditions of temperature and pressure greatly in the excess of those heretofore encountered in oil refineries and other installations by using the present electric treater system.

From the foregoing, it will be apparent that there has been provided a system for electrical resolution of emulsions which is well adapted to satisfy the purposes of the present invention. Various changes may be made to the system without departing from the spirit of this invention. The foregoing description is to be taken as illustrative of the present invention.

What is claimed is:

1. A system for electrically treating an oil - continuous emulsion containing dispersed phase contaminating substances comprising:

a. a vessel for containing said emulsion while subjected to resolution forces;

b. electrode means for creating an electric field for promoting emulsion resolution within said vessel;

c. said electrode means including an energizable electrode mounted in electrical isolation from said vessel;

d. a high voltage entrance bushing mounted within a sidewall of said vessel, said entrance bushing having projecting within said vessel an elongated tubular member with an external sidewall surface for immersion within said emulsion, said tubular member being formed of a high electrical resistance plastic material subject to plastic flow upon increase in temperature and pressure, a conductor extending through said tubular member and connected at its vessel interior end to said energizable electrode, said tubular member at its other end being carried in a metal adapter mounted in the sidewall of said vessel for supporting said tubular member in operative position within said vessel, heat sink means associated with said metal adapter for maintaining said tubular member and vessel at substantially the same temperature during operation of said vessel in resolving the emulsion, said metal adapter having an aperture through which said conductor extends to the exterior of said vessel;

e. an external power source with a high-voltage output;

f. a pressure conduit extending in fluid-tight relationship from said metal adapter to said external power source;

g. a high-pressure, high-voltage feedthrough insulator means sealing said pressure conduit at said external power source;

h. an interconnecting high-voltage conductor within a dielectric liquid carried in electrical isolation in said pressure conduit and connecting said conductor in said entrance bushing with said high voltage output of said external power source via said feedthrough insulator means;

i. system means for maintaining the dielectric liquid within said high pressure conduit at substantially the same pressure as the emulsion within said vessel, and said system including a dynamic fluid barrier for preventing intermingling of the emulsion and dielectric liquid; and

j. heat exchanger means associated with the pressure conduit for maintaining said high-pressure, high-voltage feedthrough insulator means at substantially the same temperature at its pressure conduit and power source terminals.

2. The system of claim **1** wherein said heat sink means associated with said metal adapter form a metal-continuous enclosure coextensive with said sidewall and integrally interpose a heat conductive element between said tubular member and the exterior of said sidewall with the aperture containing said condutor being the sole opening in said heat conductive element.

3. The system of claim **2** wherein said pressure conduit is metal and is secured to said metal adapter in integral metal-to-metal interconnection immediately adjacent said heat conductive element.

4. The system of claim **3** wherein said pressure conduit immediately adjacent said heat conductive element is secured to said metal adapter by an induction weld.

5. The system of claim **1** wherein said heat exchanger means are carried on said pressure conduit adjacent said feedthrough insulator means and employ air surrounding the external power source as a heat exchange fluid.

6. The system of claim **5** wherein said heat exchanger means are air cooled finned tubing integrally carried by said pressure conduit.

7. The system of claim **1** wherein said system means includes valving means for introducing dielectric liquid into said pressure conduit and venting fluid therefrom for insuring that said high voltage conductor is carried within a gas-free dielectric liquid.

8. The system f claim **1** wherein said dynamic fluid barrier includes a pressure differential displaceable impermeable fluid barrier for isolating the emulsion in said vessel from the dielectric liquid in said pressure conduit.

9. the system of claim **8** wherein said dynamic fluid barrier is comprised of a container having inlet and outlet chambers separated by a fluid impermeable wall displaceable by differential pressure.

10. The system of claim **9** wherein said fluid impermeable wall is a flexible bellows.

11. The systm of claim **10** wherein inlet and outlet valves are carried by said flexible bellows and a preset displacement of said flexible bellows responsive to pressure differentials above certain magnitudes produces closure of one of said inlet and outlet valves to seal said inlet and outlet chambers, respectively, to the emulsion and dielectric liquid.

12. The system of claim **8** wherein block valving means are activated by preset displacements of said impermeable fluid barrier whereby pressure differentials above certain magnitudes produce closure of said block valving means to seal the emulsion and dielectric liquid pressure communication at said dynamic fluid barrier.

13. The system of claim **1** wherein fluid amplifier means cooperate with said dynamic fluid barrier whereby a preset pressure differential is maintained between the emulsion and dielectric liquid.

14. The system of claim **13** wherein said feedthrough insulator means includes a fluid actuated resilient seal for sealing said pressure conduit at said external power source.

15. The system of claim **14** wherein said fluid actuated resilient seal communicates with said fluid amplifier means and is operated by dielectric liquid at a pressure differential relative to the emulsion within said vessel.

16. The system of claim **15** wherein said fluid amplifier means is adapted to apply dielectric liquid to said fluid actuated resilient seal at a pressure greater than the pressure of the emulsion in said vessel.

17. The system of claim **14** wherein said fluid actuated resilient seal is provided by a longitudinally extending resilient tubular member enclosing said high-voltage conductor and sealed thereagainst by application of pressurized dielectric liquid.

18. The system of claim **1** wherein said feedthrough insulator means is provided by a metal housing carried by said pressure conduit and having a flanged ferrule interposed within said high-voltage conductor and said flanged ferrule and adjacent high-voltage conductor are sealed to and insulated from said metal housing by mechanically actuated resilient seals formed of a high electrical resistance plastic material.

19. The system of claim **1** wherein said feedthrough insulator means is provided by a metal body carried on said external power source and mounting in fluid-tight relationship an insulator member formed of a high electrical resistance solid capable of withstanding high-voltage and high pressure environments, at ambient temperatures, and said insulator member carrying in fluid-tightness a metal conductor forming an electrical circuit between said high-voltage conductor and said high-voltage output of said external power source.

20. A system for electrically treating an oil-continuous emulsion containing dispersed phase contaminating substances comprising:

a. a vessel for containing said emulsion while subjected to resolution forces;

b. electrode means for creating an electric field for promoting emulsion resolution within said vessel;

c. said electrode means including an energizable electrode mounted in electrical isolation from said vessel;

d. a high-voltage entrance bushing mounted within a sidewall of said vessel, and said entrance bushing having projecting within said vessel an elongated tubular member with a uniform cylindrical external sidewall surface, said tubular member being formed of a high electrical resistance plastic material subject to plastic flow upon increase in temperature and pressure, a conductor extending through said tubular member and connected at its vessel interior end to said enrgizable electrode, said tubular member at its other end being carried in a metal adapted mounted in the sidewall of said vessel, a tubular metal sleeve extending from said tubular member beyond said metal adapter and coaxially enclosing said conductor, said metal adapter and metal sleeve secured into intimate metal-to-metal relationship whereby the metal adapter and metal sleeve form a heat sink means whereby said tubular member and said vessel are maintained at substantially the same temperature during operation of said vessel in resolving an emulsion;

e. an external power source with a high-voltage output;

f. a pressure conduit extending in fluid-tight relationship from said metal adapter to said external power source;

g. a high-pressure, high voltage at ambient temperature feed-through insulator means sealing said pressure conduit at said external power source;

h. an interconnecting high-voltage conductor carried in electrical isolation in said pressure conduit within a dielectric liquid and connecting said conductor in said entrance bushing with said high voltage output of said external power source;

i. system means for maintaining the dielectric liquid within said high pressure conduit at sustantially the same pressure as the emulsion within said vessel, and said system means including a dynamic fluid barrier for preventing intermingling of the emulsion and dielectric liquid while transferring pressure differentials therebetween; and

j. heat exchanger means associated with said pressure conduit for maintaining said high-pressure, high voltage feedthrough insulator means at substantially the same temperature at its pressure conduit and power source terminals.

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