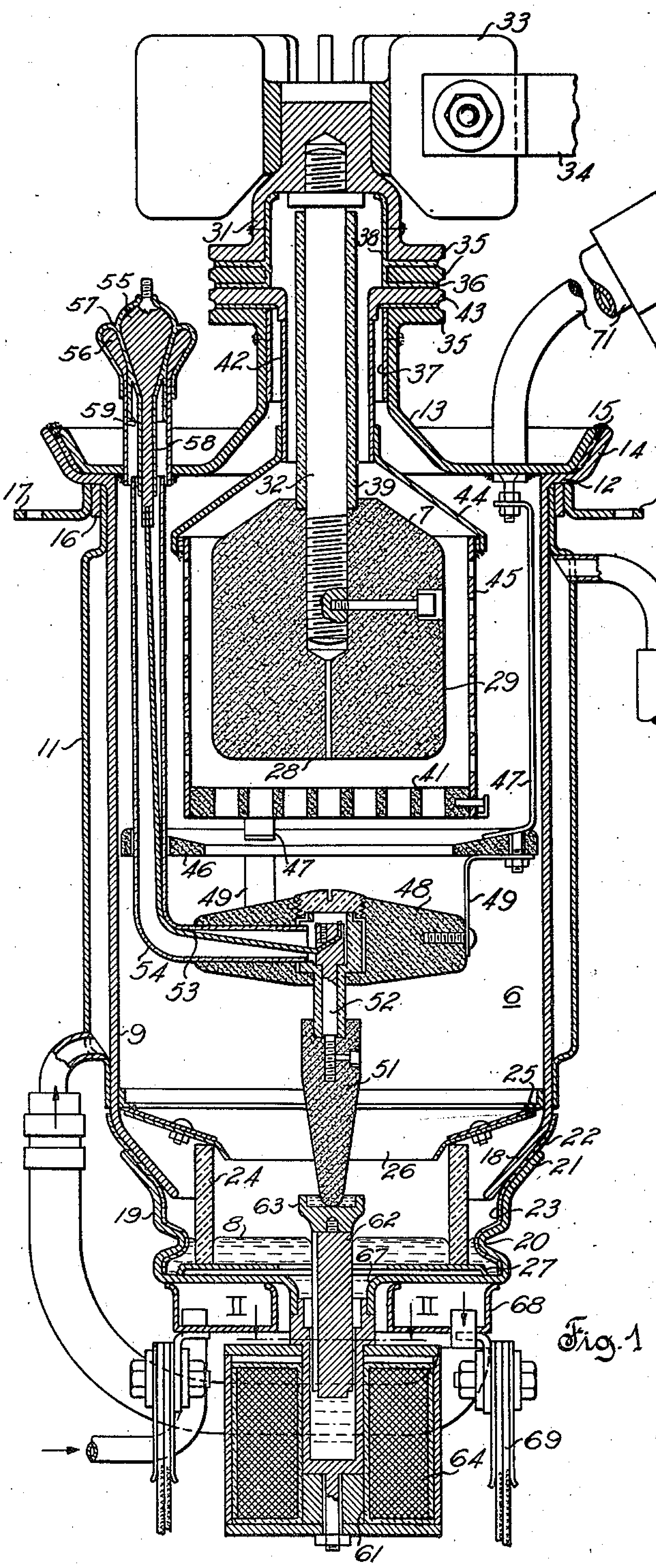
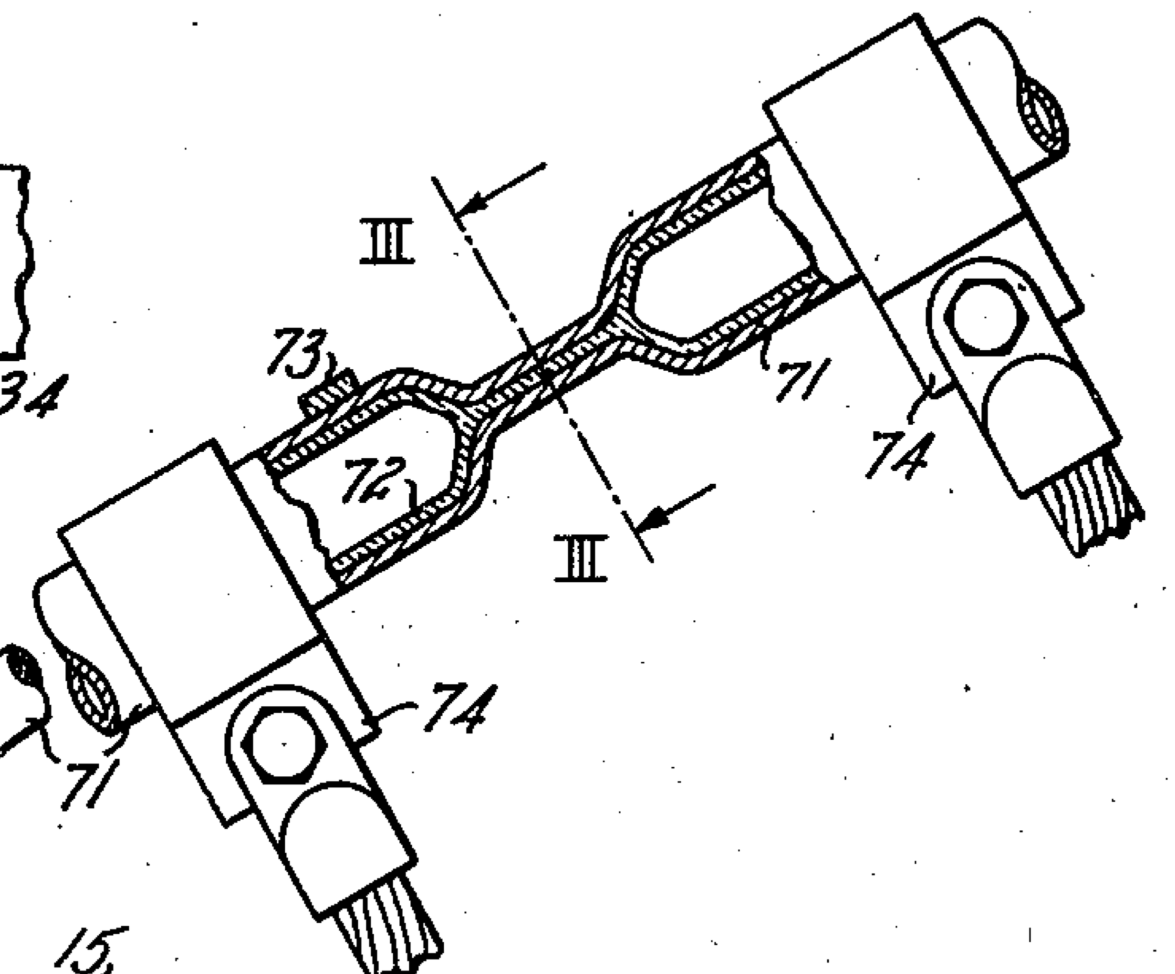
IGNITION PLUNGER FOR ELECTRIC DISCHARGE DEVICES WITH LIQUID CATHODE

Filed Sept. 15, 1945





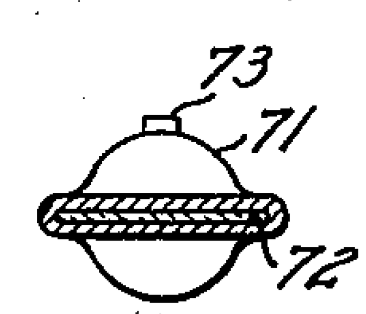


Fig. 3

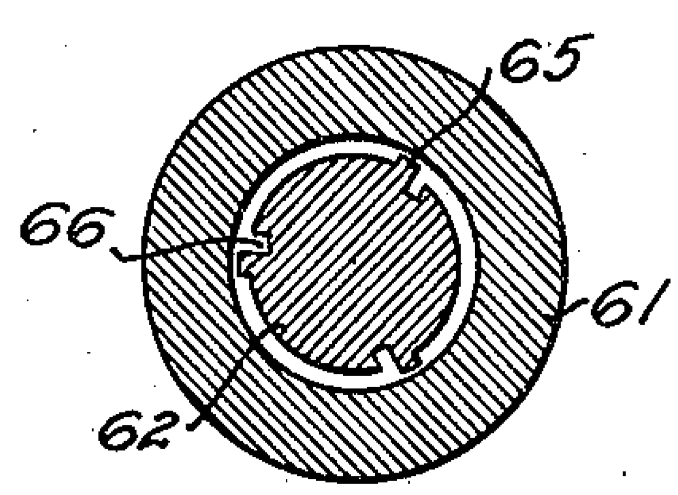


Fig. 2

Fig. 1

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Patented Nov. 11, 1947

2,430,653

UNITED STATES PATENT OFFICE

2,430,653

IGNITION PLUNGER FOR ELECTRIC DISCHARGE DEVICES WITH LIQUID CATHODE

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Application September 15, 1945, Serial No. 616,559

3 Claims. (Cl. 250—27.5)

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This invention relates in general to improvements in electric discharge devices and more particularly to improvements in such devices of the liquid cathode type in which an arc is initiated at the cathode by immersion of an electromagnetically actuated plunger into the cathode pool.

It is an object of the present invention to provide an improved electric discharge device of the liquid cathode type in which the operation of the ignition plunger does not disturb the operation of the other elements of the device.

Another object of the present invention is to provide an improved electric discharge device in which the buoyancy of the ignition plunger is assisted by an element of lower specific gravity normally immersed in cathode material.

Another object of the present invention is to provide an improved electric discharge device in which the ignition plunger is so dimensioned as to give a maximum response to the magnetic effect of a solenoid and also offer a minimum resistance to displacement thereof through cathode material.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing, in which:

Fig. 1 is a view in vertical cross section through one embodiment of the present invention showing a portion of the exhaust pipe on an enlarged scale;

Fig. 2 is a view in cross section taken along line II—II in Fig. 1 but drawn on an enlarged scale; and

Fig. 3 is a view in cross section taken along line III—III in Fig. 1.

Referring more particularly to the drawing by characters of reference, the device illustrated in Fig. 1 comprises a fluid tight metallic casing generally designated by 6, an anode 7, and a cathode 8 consisting of a pool of suitable vaporizable metal such as mercury. Casing 6 is made up from a plurality of sections joined together in permanently fluid tight relation. More specifically casing 6 comprises an anode-containing section 9 made from a length of welded or seamless steel tubing. Section 9 is preferably associated with suitable means for removing the heat radiated thereto from the electrodes and from the discharge taking place within the casing. For this purpose section 9 may be provided with a jacket 11 to define a passage for the flow of cooling water or may be provided with fins (not shown) when air cooling is resorted to. Jacket

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11 may also be provided with suitable means for guiding the flow of cooling water therethrough as is well known.

The steel used for section 9 may have any known composition suitable for the application thereto of any of the vitreous compositions known under the general designation of vitreous enamels. Both section 9 and jacket 11 however are preferably made of steel containing substantially 18% chrome and 8% nickel to prevent corrosion of the surfaces thereof in contact with cooling water. Section 9 is provided with a top flange portion 12 serving for the support of a cover 13 and extended by a frusto-conical edge portion 14 for centering the cover and for providing a convenient location for a vacuum tight bead of weld metal 15. Cover 13 may also be welded to edge portion 14 by a series of overlapping spot welds. Flange 12 further serves to rest the device on any suitable support (not shown) through a clamp ring 16 provided with a plurality of ears 17 welded thereon.

The lower part of casing section 9 is provided with a converging frusto-conical edge portion 18 formed integrally therewith by spinning or pressing. Casing 6 further comprises a cup-shaped cathode-containing section 19 forming a well for receiving the liquid cathode in electrically conductive connection therewith. Section 19 is preferably made of metal having the same composition as the metal of section 9 and is provided with a diverging frusto-conical edge portion 21 complementary of edge portion 18 and likewise formed by spinning or pressing. Edge portions 18, 21 are united in fluid tight insulated relation by means of a layer of vitreous material 22. Section 19 may be provided with an expandable wall portion 20 to mitigate the effects on layer 22 of mechanical efforts exerted on section 19.

Condensed cathode material is prevented from forming a conductive connection between casing sections 9, 19 by the provision of a coating of vitreous insulating material 23 applied to the inner surface of section 19 and extending from edge portion 21 to at least the surface of cathode 8. The joint between sections 9, 19 and coating 23 are protected from the heat radiated from the discharge extending between anode 7 and cathode 8 by means of a ring 24 of suitable refractory insulating material, such as quartz. The space about ring 24 is sealed against the discharge by a ring 25 welded to casing section 9 cooperating with a split funnel 26 engaging the top edge of ring 24. A steel washer 27 disposed on the bottom of the cathode well is first dished by spinning or pressing and thereafter flattened to the extent required for accurately supporting ring 24 and funnel 26 in arc impervious engagement with ring 25.

Anode 7 consists of a block of suitable refractory conductive material such as graphite machined to define a plane surface 28 facing cathode 8 and a cylindrical surface 29 facing casing section 9. Surface 28 serves principally as arcing surface for the establishment of an arc discharge between the anode and the cathode. Surface 29 serves principally as heat radiating surface to transmit the heat developed at the anode to casing section 9. Anode 7 is supported on cover 13 by means of a metal cap 31 and of a rigid conductor 32 screwed into anode 7 and cap 31. A suitable radiator 33 is provided on cap 31 for controlling the temperature thereof. Radiator 33 also serves as anode terminal and is adapted for bolting a suitable conductor 34 thereto.

Cap 31 is supported on cover 13 in fluid tight insulated relation through a stack of flat or frusto-conical washers 35 surrounding conductor 32, the top washer being welded to cap 31 and the bottom washer being welded to cover 13 by means of weld metal suitable for the application of vitreous material thereto. A plurality of layers 36 of vitreous material serve to unite each washer with the adjacent washer in fluid tight insulated relation thereto.

Cathode material is prevented from forming a conductive connection between the different washers and cover 13 by means of a coating of vitreous insulating material 37 extending over the inner surfaces of the washers and the inner surface of casing 13 adjacent the stack of washers. A similar coating 38 is provided on the inner surface of cap 31 adjacent the stack of washers. The temperature distribution of washers 35 is controlled by means of a tubular member 39 disposed about conductor 32 and made of any suitable refractory heat insulating material such as sillimanite and shielding washers 35 against heat radiation from conductor 32.

A control electrode 41 of the grid type is disposed adjacent arcing surface 28 for controlling the flow of current between anode 7 and cathode 8. Grid 21 may be made of any suitable refractory conductive material such as graphite and its mesh size may be so selected that either the grid does not require energization or the grid must be connected to a source of potential to enable anode 7 to carry current. Grid 41 is supported in casing 6 by means of a tubular conductor 42 welded to an intermediate washer 43 of stack 35, a frusto-conical conductive flange 44 screwed on conductor 42, and a perforated conductive shell 45 pervious to heat radiation suitably attached between flange 44 and grid 41 for controlling the ionization of the space confined between anode surface 29 and casing section 9. Grid 41 and shell 45 may also be made in one piece machined out of a block of graphite.

The vapor density within the space surrounding anode 7 and grid 41 is controlled by means of an annular baffle 46 suspended from cover 13 through conductive straps 47 and a lenticular baffle 48 supported from baffle 46 through conductive straps 49.

Cathode 8 is to be continuously maintained in electron emissive condition by an auxiliary arc discharge established between the cathode and an ignition-excitation anode 51 suspended from baffle 48 in insulated relation thereto through an insulated stud 52. Anode 51 may be connected with a source of potential through stud 52, a metallic cable 53 enclosed in a refractory insulating tube 54 and a conductor 55 shaped as a cone preferably having an angle of divergence of between 40 and 60 degrees. The latter conductor is supported on cover 13 through a complementary funnel-shaped member 56 welded to the cover. Members 55, 56 are united in fluidtight insulated relation by means of a layer of vitreous material 57, and the tubular portion 60 of member 56 is made sufficiently thin and of sufficient length as to prevent overheating of layer 57 while member 56 is being welded to cover 13 by any suitable known method.

Conductive connection between members 55, 56 through condensed cathode material is prevented by a layer of vitreous material 58 on member 55 and a coating of vitreous material 59 on the opposite surface of member 56. The insulating members enclosing stud 52 and cable 53 are so joined as to prevent any conductive connection between anode 51 and baffle 48 through graphite dust or metal vaporized from cathode 8 or from other metallic members of the device.

Anode 51 is associated with an arc igniting system comprising a cylinder 61 having a wall of nonmagnetic metal and depending from the cathode well in vertical alignment with anode 51. A plunger 62 of magnetic material is disposed in cylinder 61 for reciprocatory movement. A cup 63 of refractory conductive material such as graphite is mounted on plunger 62 to raise material from cathode 8 into engagement with anode 51 in response to buoyant emergence of plunger 62 from the cathode. A solenoid 64 disposed about cylinder 61 may be energized for urging plunger 62 downward to cause total immersion of the plunger and of cup 63. Cup 63 is made of greater diameter than plunger 62 to add buoyancy to the plunger and thereby accelerate its emergence upon deenergization of solenoid 64 without however materially hindering the action of the solenoid on the plunger.

Plunger 62 has a diameter which is slightly smaller than the inside diameter of cylinder 61 to prevent sticking of the plunger to the cylinder by capillary action. The periphery of plunger 62 is provided with a plurality of ribs 65 for guiding the plunger in the cylinder and is further provided with a plurality of grooves 66 for the flow of cathode material displaced by movement of the plunger.

Cylinder 61 is joined to the bottom portion of the casing section 19 by a flange 67 formed on the cathode well by pressing or spinning and defining a diverging nozzle. Momentary short circuiting of anode 51 and cathode 8 by surging of the cathode material in response to immersion of plunger 62 and cup 63 into the cathode is thereby prevented. The cathode well is cooled by means of a water jacket 68 serving as cathode terminal for the attachment thereto of a suitable cathode conductor 69. Jacket 68 may also be replaced by fins when the device is air cooled.

Casing 6 is provided with a metallic pipe 71 welded to cover 13 for connecting the casing with suitable evacuating means (not shown). Pipe 71 comprises a section provided with an inner lining 72 of vitreous material of appropriate thickness. It has been found that when pipe 71 consists of ordinary steel tubing having an inside diameter of one-half inch particularly desirable results are obtained with a lining having a thickness between ten and fifteen thousandths of an inch. A spot 73 of vitreous material may be provided on the outer surface of pipe 71 to give an indication of the degree of fluidity of lining 72 when pipe 71 is heated by application thereto of electric current through a pair of clamped terminals 74.

The vitreous material referred to herein may be any suitable known material of the class generally designated as vitreous enamels and may comprise any number of coats that may be required to obtain the desired thickness, including a so-called ground coat when the nature of the supporting metal requires it. Before the elements of the device are assembled all the portions thereof requiring coating with vitreous material for sealing or insulating purposes are separately coated with the necessary number of coats of material and are subjected to the corresponding number of firings at the required temperatures. Washers 35 and the members welded thereto are then assembled and suitably supported while being additionally fired to cause the coatings of adjacent washers to coalesce and form a single layer uniting the washers in fluid tight insulated relation. Casing sections 9, 19 and seal members 55, 56 are likewise united in fluid tight insulated relation. In each instance the component parts are provided with a coating of vitreous material preferably between fifteen and twenty-five thousandths of an inch in thickness and when adjacent parts are united by fusion of their vitreous coatings the vitreous material confined between the parts is partly squeezed out to leave an intervening layer of total thickness between twenty and thirty-five thousandths of an inch, depending on the thickness of the original coating on the parts.

The different elements of the device with the exception of cathode 8 are then assembled as shown on the drawing and cover 13 is welded to casing section 9. The device is connected to suitable evacuating means through pipe 71 and is subjected to a suitable heating and evacuating process to cause removal of the gases occluded within the walls of the casing and within the members contained within the casing. The cathode material is thereafter distilled into the casing through pipe 71 and the device may be permanently sealed. For this purpose current is passed through pipe 71 by means of clamps 74 to heat the lined portion of the pipe. Heating is continued until the vitreous lining has reached its fusion temperature, which may be ascertained by observing spot 73, while the evacuating means are maintained in operation.

It will be noted that during such heating lining 72 substantially reduces the emission of occluded gases from the wall of pipe 71 toward the inside thereof while the absence of any vitreous lining on the outside surface of pipe 71 permits the free emission of such occluded gases into the atmosphere. The thickness of the vitreous coating should preferably be above the lower limit, of ten thousandths of an inch, hereinabove specified to avoid the coating being disintegrated by the passage of gas bubbles therethrough, and the thickness should preferably be below the upper limit, of fifteen thousandths of an inch, to permit obtaining a mechanically resistant seal.

During heating of pipe 71 the gas pressure within the pipe is momentarily increased by the emission of occluded gases, and is thereafter returned to a value within the permissible range by the action of the evacuating means. As soon as the gas pressure is again normal a short length of pipe 71 is flattened by any suitable means, for example by pinching in a hydraulic vise, until the pipe thickness is reduced to preferably slightly less than twice the original wall thickness. In the course of this operation, the opposite portions of the vitreous material lining the flattened pipe section are first caused to coalesce, and the pipe is further flattened to reduce the thickness of the coalesced portion of vitreous material to a substantial extent, and preferably appreciably less than one-half of its original thickness. Satisfactory results have been obtained by reducing the thickness of vitreous material to two thousandths of an inch or slightly less. It is preferable to bring the thickness of vitreous material within the latter limit because the resistance of the joint to mechanical efforts and to thermal stresses is adversely affected by the presence of a large volume of vitreous material within the flattened pipe section. When pipe 71 has cooled to the extent that the vitreous lining has returned to the solid condition, the flattened pipe section is thereby permanently sealed and the pipe portion extending beyond the flattened section may be sawed off to reduce the space taken by the device.

To place the device in operation, anode 51 and cathode 8 are connected to a source of direct current through solenoid 64, thereby energizing the solenoid which causes immersion of plunger 62. The solenoid circuit is thereby interrupted between anode 51 and cup 63 and an arc discharge is established therebetween. Attachment of the arc at plunger 62, which would cause vaporization of metal from the plunger, cannot take place as only cup 63 emerges from cathode 8 at the time of establishment of an arc between anode 51 and the cathode material contained in cup 63. Upon immersion of cup 63 the cathode spot of the arc is transferred to the surface of cathode 8. If a source of alternating current is connected with a load device through anode 7 and cathode 8, and grid 41 is at the proper potential, anode 7 carries current during its periods of positive energization with respect to the cathode potential. During the idle periods of anode 7, grid 41 and shell 45 deionize the space surrounding anode 7 to prevent accidental reversal of the flow of current between anode 7 and cathode 8.

If grid 41 operates without energization the potential thereof during the anode idle periods is determined to a large extent by the action of washers 35 dividing the potential between anode 7 and casing 6 by capacitive action, whereby the grid is caused to assume a definite potential varying with the anode potential. If the grid is connected to a source of alternating current through a resistor of relatively high value as is common practice, the capacitive coupling of grid 41 with anode 7 and casing 6 through washers 35 prevents the control operation of the grid from being disturbed by transient potentials appearing in adjacent elements of the device.

During operation of the device vaporized cathode material condenses on the walls of casing 6 including the coatings of vitreous material provided adjacent the different insulating seals thereof. The coatings however are all made sufficiently wide to insure that condensed cathode material cannot bridge the adjacent conductive members to provide a conductive connection therebetween.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims. Features disclosed but not claimed herein are claimed in copending application of Othmar K. Marti, Serial No. 616,557, filed September 15, 1945, and in copending application of Othmar K. Marti and Ervin B. Steinberg, Serial No. 616,558, filed September 15, 1945.

It is claimed and desired to secure by Letters Patent:

1. An electric discharge device comprising a fluid tight casing defining a cathode well, a liquid cathode in said well, an anode disposed within said casing above said cathode, a cylinder having a wall of nonmagnetic material depending from said well in vertical alignment with said anode, a plunger of magnetic material disposed in said cylinder for reciprocatory movement, a cup of refractory conductive material mounted on said plunger to raise material from said cathode into engagement with said anode in response to buoyant emergence of said plunger from said liquid cathode, a solenoid disposed about said cylinder for urging said plunger downward to cause total immersion of said plunger and said cup, and means forming a diverging nozzle joining said cylinder with said well in fluid tight relation to reduce surging of said liquid cathode in response to immersion of said plunger and said cup.

2. An electric discharge device comprising a fluid tight casing defining a cathode well, a liquid cathode in said well, an anode disposed within said casing above said cathode, a cylinder of predetermined inside diameter having a wall of nonmagnetic material depending from said well in vertical alignment with said anode, a plunger of magnetic material of diameter smaller than said predetermined diameter disposed in said cylinder for reciprocatory movement, a plurality of ribs on the periphery of said plunger for guiding said plunger in said cylinder, a plurality of grooves in the periphery of said plunger for the flow of cath-

ode material displaced by movement of said plunger, a cup of refractory conductive material mounted on said plunger to raise material from said cathode into engagement with said anode in response to buoyant emergence of said plunger from said liquid cathode, and a solenoid disposed about said cylinder for urging said plunger downward to cause total immersion of said plunger and said cup.

3. An electric discharge device comprising a fluid tight casing defining a cathode well, a liquid cathode in said well, an anode disposed within said casing above said cathode, a closed cylinder having a wall of nonmagnetic material depending from said well in vertical alignment with said anode, a solenoid disposed about said cylinder, a plunger of magnetic material disposed in said cylinder within said solenoid for downward movement into retracted position in response to energization of said solenoid, and a graphite cup so mounted on said plunger for causing said cup as to become totally immersed in said cathode material in response to movement of said plunger into said retracted position, said cup being of greater diameter than said plunger to exert a substantial buoyant effort on said plunger and assist the buoyant emergence of said plunger in response to deenergization of said solenoid to raise material from said cathode into engagement with said anode.

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