March 21, 1950 J. D. RUSSELL ET AL 2,501,292

LIQUID CONTACTOR

Filed Nov. 28, 1945 2 Sheets-Sheet 1

Fig. 1

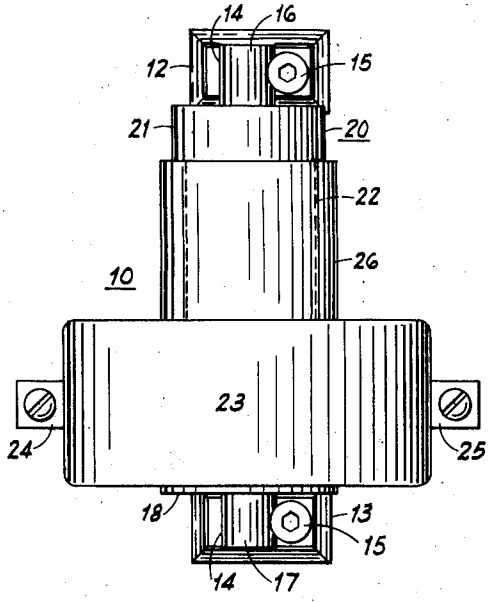


Fig. 3

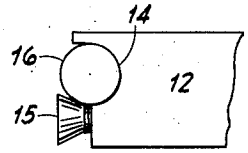
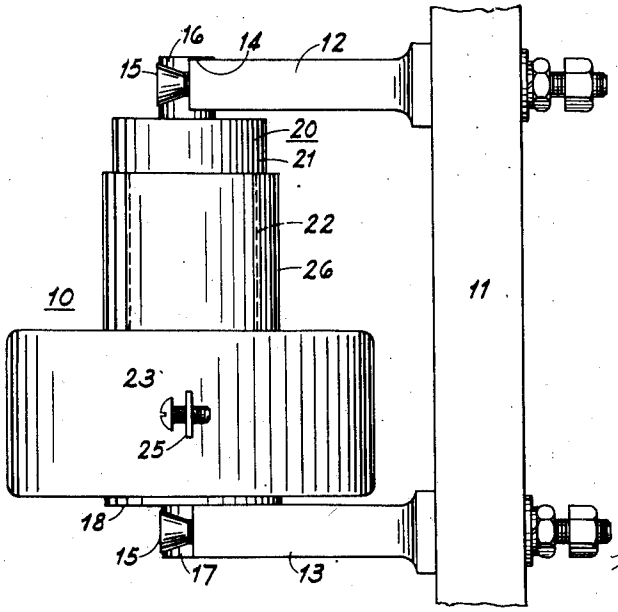


Fig. 2



INVENTOR.
John D. Russell and James W. Woolf
BY
William D. Carothers
Their Atty

March 21, 1950 J. D. RUSSELL ET AL 2,501,292

LIQUID CONTACTOR

Filed Nov. 28, 1945 2 Sheets-Sheet 2

Fig. 4

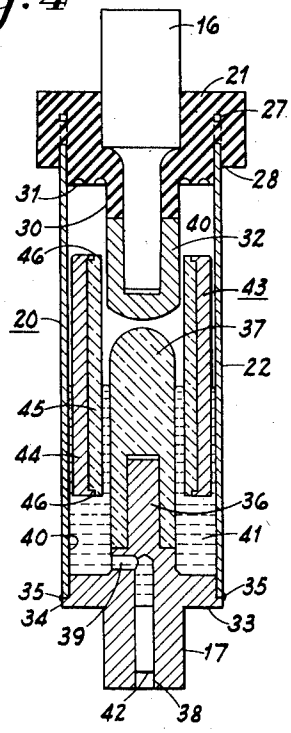


Fig. 7

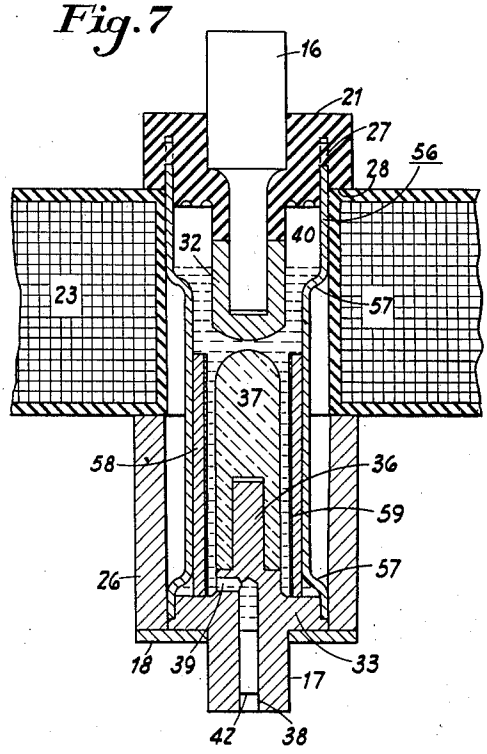


Fig. 5

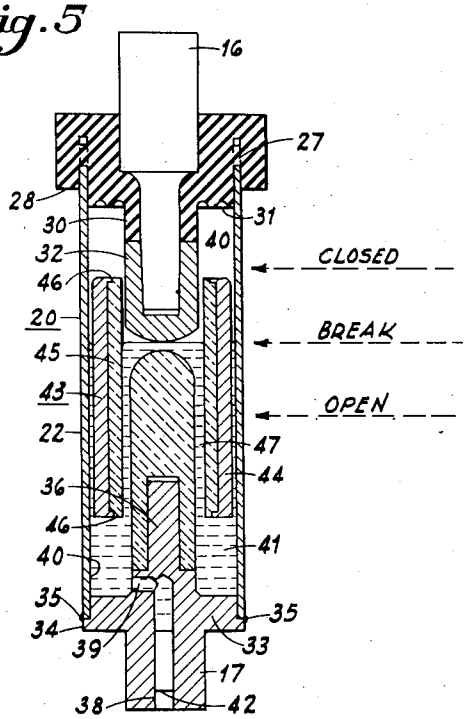
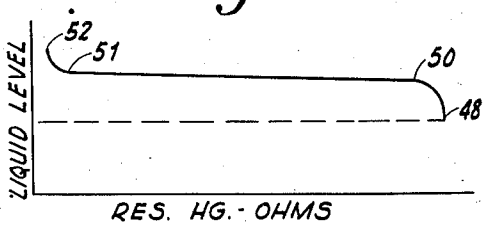


Fig. 6



INVENTOR.
John D. Russell and James W. Woolf
BY William D. Carothers
Their Atty.

Patented Mar. 21, 1950 2,501,292

UNITED STATES PATENT OFFICE

2,501,292

LIQUID CONTACTOR

John D. Russell, Victory Heights, and James W. Woolf, Franklin, Pa., assignors to Joy Manufacturing Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application November 28, 1945, Serial No. 631,390

8 Claims. (Cl. 200—112)

1

This invention relates generally to circuit makers and breakers and more particularly to liquid contact electromagnetic circuit controllers wherein the circuit is made or broken through a conducting liquid such as mercury.

The principal object of this invention is the provision of a low resistance high current capacity electromagnetic liquid contactor.

Another object is the provision of an electromagnetic liquid contactor which provides a substantially uniformly changing resistance in the circuit of the liquid during the make and break periods of operation.

Another object is the provision of an electrical liquid contactor which provides a low resistance circuit in a radially annular path through the conducting liquid between the electrodes.

Another object is the provision of an electrical liquid contactor which when open is provided with improved dielectric characteristics.

Other objects and advantages appear in the following description and claims.

Practical embodiments illustrating the principles of this invention are shown in the accompanying drawings wherein—

Fig. 1 is a view in front elevation of the electromagnetic liquid contactor when mounted as an independent unit.

Fig. 2 is a view in side elevation of the structure shown in Fig. 1.

Fig. 3 is a fragmentary plan view of the mounting post.

Fig. 4 is a view in section of a normally open circuit liquid contactor with its circuit shown fully open.

Fig. 5 is a view in section of a normally open liquid contactor with the liquid just making or breaking the circuit.

Fig. 6 is a graphic representation of the resistance of the liquid circuit at different levels when contacting the electrodes.

Fig. 7 is a view in section of a normally closed liquid contactor with its circuit fully closed.

Referring to Figs. 1 to 3 of the drawings, 10 represents the complete electromagnetic contactor which is supported on the front of the panel 11 by means of the posts 12 and 13. The outer end of each post is provided with a semicircular socket 14. The axes of these sockets are disposed in vertical alignment. A beveled headed set screw 15 is threadably engaged in the end of each post at one side of the socket 14 for the purpose of clamping the outer ends 16 and 17 of the contactor electrodes in the sockets 14. The electrical circuit connections to this liquid contactor

2

are made with the posts 12 and 13 on the back of the panel 11. A washer 18 is placed on the lower electrode end 17 and is permitted to rest on the upper surface of the post 13.

Intermediate the outer ends 16 and 17 of the electrodes the liquid contactor tube 20 is provided with a head 21 and a tube or casing 22 which is preferably cylindrical in shape. The axial opening of the wrapped electromagnetic coil 23 is formed to fit over the casing 22 and rest on the washer 18. The terminals of the coil are brought out on opposite sides as shown at 24 and 25 which may be conveniently connected to an electrical energizing circuit. A cylindrical spacer 26 is disposed around the casing 22 between the coil 23 and the head 21 of the electrical contactor 20. If this contactor is constructed to provide a normally closed circuit the spacer 26 is placed below the coil 23 on the washer 18 to support the coil adjacent the upper end of the casing 22 as shown in Fig. 7.

The liquid contactor 20, which is shown in section in Fig. 4, consists of the head 21 of insulating material molded around the metallic electrode 16 and on the end of the metal tube or casing 22. The latter is provided with transverse holes 27 adjacent the upper end to permit the molded material to interlock therethrough. An annular shoulder 28 is formed on the under side of the head 21 for the purpose of engaging the end of a spacer such as shown at 26 in Figs. 1 and 2 or to act as a stop when the contactor is inserted into a socket which provides a magnetic air gap such as shown in application Serial No. 508,472, now Patent Number 2,472,048, May 31, 1949, filed November 1, 1943.

The head 21 is provided with an axially disposed depending boss 30 which is molded around the electrode 16 and a plurality of annular grooves 31 are formed in the under surface of the head between the boss 30 and the interior of the casing 22. The length of the boss 30 and the annular grooves 31 provide increased surface between the electrode tip 32 and the interior of the casing 22 which form the liquid engaging contact members. Thus the molded head 21 which is endowed with good insulating properties is also provided with an increased surface between the contacts to prevent the flow of a leakage current when a high potential is impressed thereacross, yet these features are obtainable by a simple and economical molding operation of the head 21.

The contact tip member 32 and the casing are preferably made of a metal that will not readily

oxidize or amalgamate with the contacting liquid when subjected to high temperature or to an arc when the circuit is made or broken. The tip 32 is preferably cylindrical and is provided with a spherically shaped end that completely encloses the electrode 16.

The other or lower end of the tube or casing 22 is closed by the electrode 17 which is provided with an intermediate enlarged section 33 having an annular shoulder 34 formed on its perimetral surface to provide a reduced portion that may be pressed into the lower end of the tube or casing 22. The casing 22 and the enlarged section 33 are sealed by means of the continuous annular weld shown at 35, thus providing a sealed envelope.

The electrode 17 extends axially upwardly into the casing 22 and is provided with a reduced stem 36 which is arranged to fit into the bore of the filler 37 which is preferably made of a suitable insulating material, such as glazed porcelain, that will not amalgamate with or absorb the conducting liquid. The electrode 17 is provided with an axial passage 38 that connects with the radial passageway 39 which opens into the chamber 40 of the casing 22 for the purpose of exhausting the air therefrom and supplying a current carrying liquid such as mercury to form the pool 41 in the casing. An inert gas may be employed in the chamber but it is preferable to supply the chamber with approximately four atmospheres of hydrogen to provide a reducing atmosphere. The passageway 38 is then closed by means of the plug 42 to seal the tube, the gas, and the liquid therein.

The annular chamber 40 which surrounds the electrode tip 32 and the filler 37 is made sufficiently large to receive the hollow cylindrical armature plunger or sleeve 43 and permit it to reciprocate within the casing with very little clearance. Thus the annular gap between the inner surface of the casing 22 and the contact tip 32 is constructed to be very small to provide the shortest path possible through the conducting liquid and very little clearance is provided between the contact tip 32 and the filler 37. These structural features thus reduce the amount of current carrying liquid required in the tube and also provide a very short and direct radial path for the current to travel through the liquid from one electrode to the other and at the same time provide maximum contact area with a minimum resistance from one terminal to the other.

The plunger 43 consists of a hollow open ended tube 44 of magnetic material having a porous ceramic liner 45 the surface of which is also preferably sealed by glazing to provide buoyancy for the tube 44, causing the plunger 43 to float in the pool as shown in Fig. 4. Small flanges or lugs 46 are provided on the ends of the tube 44 which may be peened over a portion of the ends of the ceramic liner 45 to hold the latter in place.

When the coil 23 is deenergized the plunger 43 floats on the pool 41 of current carrying liquid and no current can flow between the casing 22 and the contact tip 32. When the coil 23 is energized the plunger 43 is attracted by the magnetic field and is pulled downwardly into the liquid pool causing it to be displaced and rise in the annular chamber 40 until it first contacts the spherical bottom of the contact tip 32 as shown in Fig. 5, at which time the circuit is closed and current travels in either direction between the posts 12 and 13.

When the liquid first touches the end of the contact tip 32 as shown in Fig. 5 the current must travel through the long thin column 47 of liquid between the filler 37 and the liner 45 to the bottom of the pool 41 where it may pass to the casing 22 and thence to the electrode 17 and also directly to the latter. This column 47 of the current carrying liquid thus provides a relatively high resistance to the flow of current therethrough as indicated on the curve at 48 of the graph shown in Fig. 6. As the plunger descends further into the liquid pool 41 the liquid level rises above the plunger 43 and directly connects the contact tip 32 with the casing 22 which reduces the resistance to the flow of current as indicated by the beginning of the long sloping portion 50 of the resistance curve. Further downward movement of the plunger 43 increases the contact area and materially reduces the resistance to the flow of current therethrough until the point 51 is reached, after which time a material increase in the liquid level or surface contact has little effect in changing the resistance of the contacting circuit as indicated by the upward trend 52 of the curve and the plunger 43 is drawn to the bottom of the tube and into engagement with the electrode 17. In this position the top of the plunger is below the lowest point of the contact tip 32 thus providing maximum contact which is uninhibited by the plunger and the liquid level is at the height shown in Fig. 7.

When the coil 23 is deenergized the plunger 43 rises and floats on the liquid and the resistance of the circuit increases as shown in Fig. 6 until the liquid ceases to contact the bottom of the contact tip 32. It should be noted that when the liquid makes or breaks contact with the bottom of the tip 32, as shown in Fig. 5 the ceramic liner 45 shields the inner wall of the casing 22 from any arc that may occur between the liquid and the contact tip. This is an important structural feature of this invention. When the tube has been completed and is ready to receive the current carrying liquid it is preferable to exhaust it before the liquid is inserted and then add approximately four atmospheres of inert gas or hydrogen depending upon the nature of the current carrying liquid. The tube is then sealed by means of the plug 42.

In Fig. 7 the tube or casing 56 is necked intermediate of its ends as shown at 57 and the plunger 58 of magnetic material does not have a ceramic liner but its surface is glazed as indicated at 59 with a very thin ceramic coat by subjecting it to the vapors of fusing minerals of high fluxing quality so that it is ineffective as a mechanical contactor and the coating provides a proper shield. However this plunger has a close sliding fit with the necked wall of the tube 56 but some clearance is provided between the tube and the contact tip 32. Owing to the fact that the ceramic liner is omitted from the plunger 58 and the latter is heavier than the plunger 44 it is not sufficiently buoyant to float in the pool 41 of the current conducting liquid and it drops to the bottom of the tube, displacing the liquid or mercury, causing the circuit between the contact tip 32 and the tube 56 to be normally closed. The coil 23 is supported by the spacer 26 adjacent the top of the tube and when energized draws the plunger 58 upwardly. The level of the liquid thus drops and interrupts the circuit as long as the plunger 58 is held in its upper position. The resistance characteristic of the circuit in making and breaking the current passing

therethrough is the same as that described with reference to Fig. 6.

However in both the normally open and the normally closed electrical liquid contactors the current flows radially through the liquid between the poles of concentric cylindrical surfaces for the full length that the liquid lies in contact therewith and the plunger is wholly withdrawn from this direct path of current flow. Thus a liquid such as mercury, which has a resistance fifty-five times that of silver and fifty times that of copper, offers very little resistance to the circuit as the path of current flow, when the plunger is down, is very short and since this path is radially annular the current carrying capacity is a maximum for a given diameter of electrodes and a make and break liquid contactor of high current carrying capacity is provided. This structural feature represents a very important object of this invention.

To prevent accidental closing of the electrical liquid contactors, when the plunger is up and the liquid is in the open circuit position, sufficient space is provided between the level of the liquid and the bottom of the contact tip **32** to prevent splashing of the liquid when the contactor is jolted or vibrated. The parts of this liquid contactor and the volume of liquid are so proportioned that upon operation of the plunger the level of the liquid will rise or fall more rapidly than the movement of the plunger. This is an important object of this invention as it provides a fast operating contactor.

We claim:

1. In a high current carrying liquid contactor, the combination of a sealed tubular electrode envelope, a current carrying liquid contained in the envelope, a coaxial electrode mounted above the liquid in spaced concentric relation within the envelope and insulated therefrom, and a noncurrent conducting immersible means operable when submerged to displace a portion of the liquid thereabove and between the electrodes to electrically connect them by a direct and uninhibited circuit in annular radial planes through the liquid for its full engagement along the coextending surfaces of the electrodes.

2. The structure of claim 1 characterized in that the length of the portion of said coaxial electrode in contact with the liquid is greater than the distance between the electrodes to increase the current carrying capacity of this radial circuit.

3. The structure of claim 1 characterized in that said noncurrent conducting immersible means is an open ended tubular plunger that displaces a portion of the liquid to first electrically connect the electrodes in a longer electrical circuit through the current carrying liquid within the tubular plunger before the latter becomes completely immersed.

4. The structure of claim 1 characterized in that said noncurrent conducting immersible means is an open ended tubular plunger that displaces a portion of the liquid to first electrically connect the electrodes in a longer electrical circuit through the current carrying liquid within the tubular plunger before the latter becomes completely immersed, and the coaxial electrode having a surface of a spherical sector to initially make or break with the liquid.

5. The structure of claim 1 characterized in that said immersible means is an open ended tubular plunger that displaces a portion of the liquid to first electrically connect the electrodes in a longer electrical circuit through the current carrying liquid within the tubular plunger before the latter becomes completely immersed, and a filler member mounted in the envelope and projecting within the tubular member to limit the volume of liquid in said longer electrical circuit through the liquid.

6. A liquid contactor consisting of a cylindrical electrode tube closed at the bottom thereof, a head of insulating material enclosing the top of the tube, an electrode carried by said head and centered axially within the tube, a pool of current carrying liquid in said tube, a cylindrical filler member of insulating material substantially the same diameter as said electrode and supported in the tube in coaxial alignment with said electrode, and an immersible open ended tubular plunger member surrounding the filler member and arranged to reciprocate in the tube over the central electrode and the filler member to first displace a portion of the liquid to electrically connect the electrodes by a liquid path between said filler and plunger members and when the plunger is completely immersed to displace a portion of the liquid thereabove and between the electrodes to electrically connect them by a direct and uninhibited circuit in annular radial planes through the liquid for its full engagement along the coextending surfaces of the electrodes.

7. The structure of claim 5 characterized in that sufficient clearance is made between the electrodes to admit the tubular plunger and to provide a low resistance electrical current path when the plunger is fully immersed, and a small clearance is made between the tubular plunger and the filler member to provide a high resistance electrical current path when the plunger is partially immersed with its top above the surface of the liquid.

8. The structure of claim 5 characterized in that the surface of the head within the tube is provided with an increased effective length between the electrode and the tube.

JOHN D. RUSSELL.
JAMES W. WOOLF.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
638,186	Robertson, Jr.	Nov. 28, 1899
968,208	Town	Aug. 23, 1910
1,228,058	Schmidt	May 29, 1917
1,915,462	Zuckschwerdt	June 27, 1933
2,266,469	Larson	Dec. 16, 1941
2,288,090	Hedin	June 30, 1942
2,393,904	Hedin	Jan. 29, 1946
2,402,739	Doughty, Jr.	June 25, 1946

FOREIGN PATENTS

Number	Country	Date
443,289	Germany	Apr. 26, 1927