

April 16, 1935.

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1,998,254

ELECTRIC CIRCUIT CONTROLLER

Original Filed Oct. 24, 1933 2 Sheets-Sheet 1

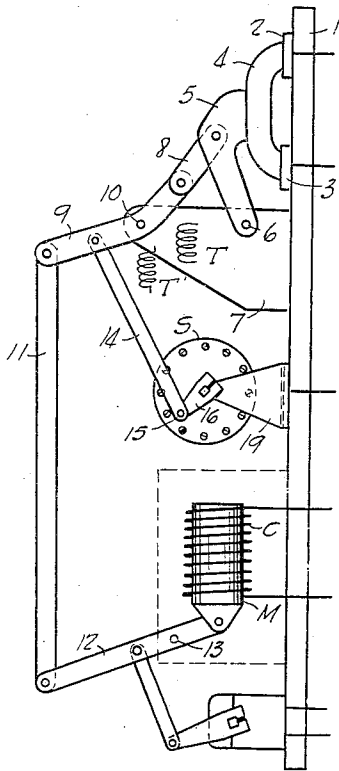


FIG. 1

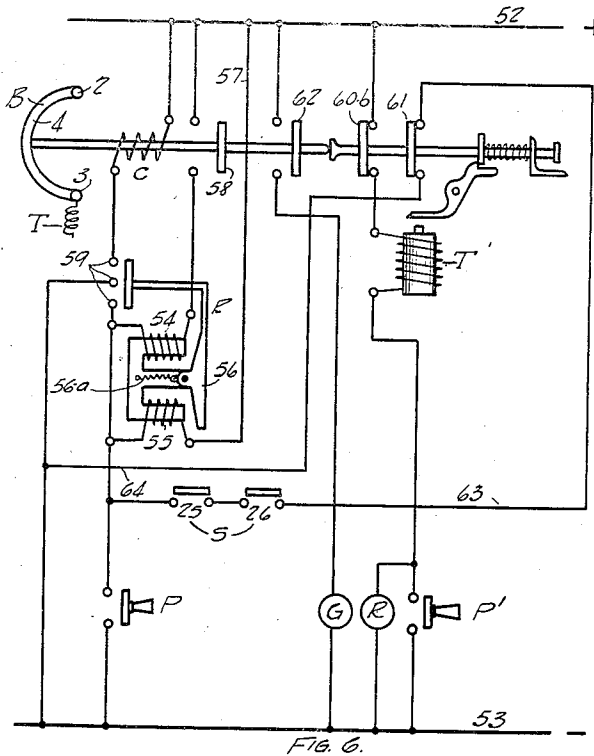


FIG. 6.

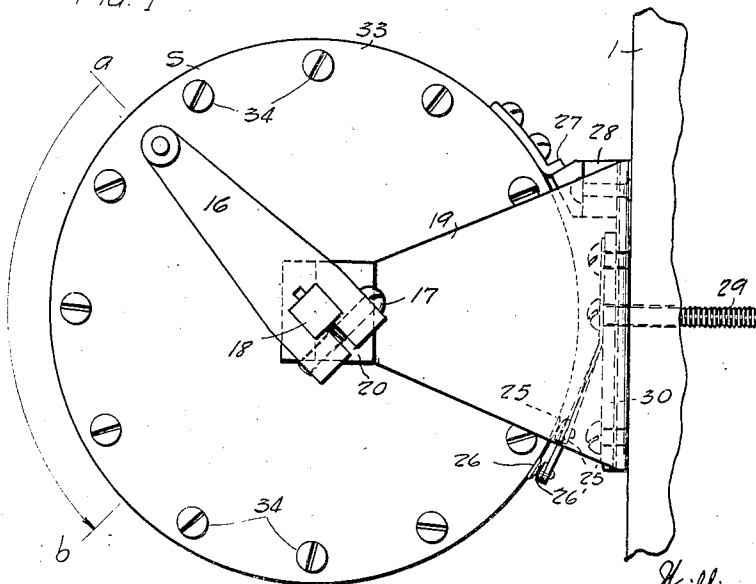


FIG. 2

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ELECTRIC CIRCUIT CONTROLLER

Original Filed Oct. 24, 1933 2 Sheets-Sheet 2

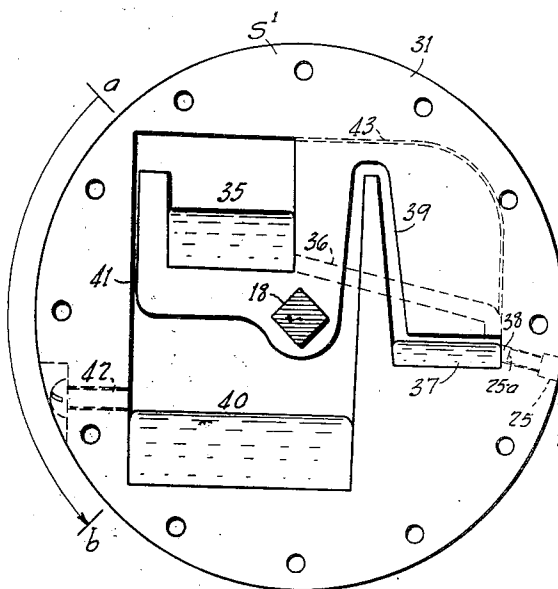


FIG. 4

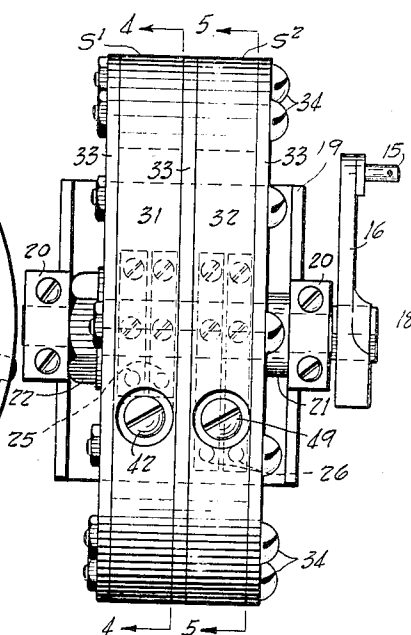


FIG. 3

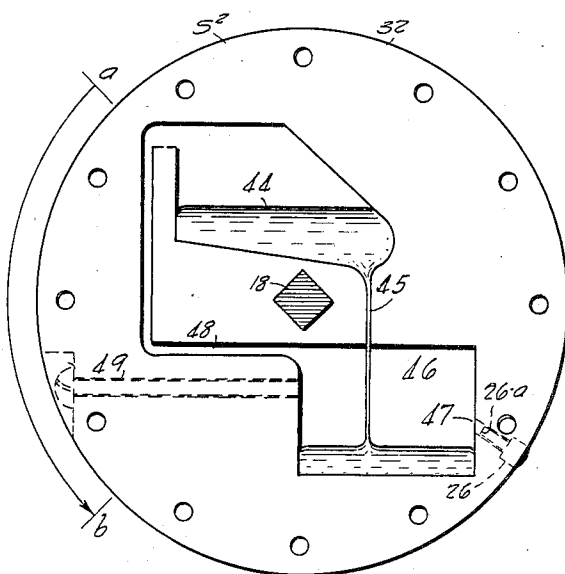


FIG. 5

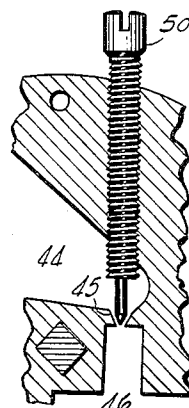


FIG. 5-a

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1,998,254

ELECTRIC CIRCUIT CONTROLLER

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Original application October 24, 1933, Serial No. 694,947, now Patent No. 1,983,817, dated December 11, 1934. Divided and this application March 26, 1934, Serial No. 717,395

13 Claims. (Cl. 200—33)

My invention relates to new and improved electric circuit controllers and, while of general application to electric control circuits and systems, it is particularly suitable for use in connection with control systems of the type disclosed and claimed in my copending application, Serial No. 694,947, filed October 24, 1933, Patent #1,983,817, Dec. 11, 1934, of which the present application is a division, and which, in turn, is a continuation in part of my application Serial No. 598,145, filed March 11, 1932.

My invention comprises a fluid circuit controller, movable between a plurality of positions to change the circuit-controlling relation of the contact structure of the controller, in which repeated movements of the controller to one of the positions effects a change in the circuit-controlling relation or condition of the contact structure only a predetermined number of times unless the circuit controller has remained in another position for a given length of time. My invention comprises further an additional fluid circuit controller having contact structure connected in circuit with that of the first circuit controller and effective to impart a time-delay in its operation.

More specifically my invention is directed to a circuit controller comprising one or more envelopes embracing a plurality of chambers and movable between predetermined positions. The chambers are in intercommunication by passages, channels or the like to form a closed fluid system in which a quantity of suitable fluid is disposed. Associated with each envelope is a contact structure the circuit relation or condition of which is changed, that is, the circuit through the contact structure may be open or closed in response to a predetermined level of fluid in one of the chambers. The disposition of the chambers of the envelope and their interconnecting passages is such that movements of the envelope between its limiting positions effect the flow of fluid between the chambers in a predetermined sequence. Preferably, the flow of fluid between the chambers is controlled, as by constricted passages, chambers, orifices or the like, to raise the fluid level in the chamber with which the contact structure is associated, in response to successive and correlated movements of the envelope, only a predetermined number of times. By successive and correlated movements of the envelope, as this expression is used hereinafter, I refer to movements separated by relatively short intervals and/or correlated in time with respect to the characteristics of the controlled circuit or those of the circuit

controller as, for example, determined by the viscosity of the fluid, the size of the restricted passages or orifices. One example of such successive and correlated movements is the successive reclosings of a circuit breaker separated by definite time intervals which may vary from a few seconds to as much as a few minutes. However, my invention is not limited to successive movements of the circuit controller separated by time intervals of any definite magnitude, but applies to such a circuit controller in which the movements are separated by any time intervals correlated with the characteristics of the controller and/or of the system of which it forms a part.

Further, in accordance with my invention, the improved electric circuit controller may comprise a plurality of individual and distinct units acting conjointly, and either secured together to form a unitary structure or mounted separately but movable together. In either case any of the units may be separately removed for inspection, repair or replacement, or for the purpose of changing the operating characteristics of the control system.

More specifically, my invention relates to an electric circuit controller comprising two units, one of the units including a pair of contacts, the circuit relation or condition of which is changed for only a predetermined number of times in response to successive and correlated movements of the unit, and the other of which includes electrical contacts connected in circuit with those of the first unit and cooperating therewith to impart a time delay to the several operations of the circuit controller in response to successive and correlated movements thereof. Either of the units may be replaced by corresponding or similar units having any desired operating characteristics thereby to give any number of successive operations of the circuit controller, or different timing characteristics, or both. Circuit controllers embodying my invention are characterized by having no moving mechanical parts or complicated mechanism, and requiring a minimum of repair or replacement of parts.

My invention resides in the features of combination, construction and arrangement hereinafter described and claimed.

For an understanding of my invention, and for illustration of some of the various forms it may take, reference is had to the accompanying drawings in which:

Figure 1 is a diagrammatic, side elevational

view of my improved circuit controller in combination with an automatic circuit breaker;

Fig. 2 is a side elevational view of the circuit controller showing the same in position corresponding to open position of the circuit breaker;

Fig. 3 is a front view of the circuit controller;

Fig. 4 is a view of the circuit controller showing the arrangement of various chambers and passages, taken along the line 4—4 of Fig. 3;

Fig. 5 is a view of the circuit controller showing other chambers and passages, taken along the line 5—5 of Fig. 3;

Fig. 5a is a fragmentary view of a modification of the structure of Fig. 5;

Fig. 6 illustrates a suitable control system for a circuit breaker embodying the circuit controller of the invention.

It is often desirable or necessary to protect an electrical circuit with circuit breakers adapted to be automatically opened, as by a tripping coil, upon the occurrence of various abnormal conditions in the circuit controlled thereby. Abnormal conditions, for example, short circuits, may cause the circuit breaker to open and these conditions may disappear before a first or subsequent reclosing movement of the circuit breaker. The reclosing of a circuit breaker under such conditions may be accomplished automatically by providing auxiliary circuit controller mechanism which is actuated in accordance with movement of the circuit breaker, and which energizes the closing mechanism of the circuit breaker to reclose the same a number of times upon successive opening movements of the circuit breaker, and after a predetermined number of successive openings, to prevent further reclosing movement of the circuit breaker until the same has been manually or otherwise closed.

My improved electric circuit controller is of general application but is particularly adapted to complete the energizing circuit of the electromotive closing device of a circuit breaker after the breaker has been opened, and will function recurrently, and the number of reclosing operations, and the lag or time interval between successive opening and reclosing movements, may readily be adjusted; where abnormal circuit conditions remain, the circuit controller will close the circuit breaker a predetermined number of times, and then lock out to prevent further reclosing until the circuit breaker is closed by hand, or by auxiliary means, but if the circuit breaker remains closed for a given length of time after having been reclosed, the circuit controller automatically resets itself so that, in subsequent openings, the cycle of reclosing operations starts over again.

Referring to Fig. 1 of the drawings, there is shown a circuit breaker mounted on a supporting panel 1 of slate or other suitable insulating material, the circuit breaker having main contacts 2 and 3 between which a circuit is established, when the circuit breaker is closed, by a main bridge contact element 4. The circuit breaker is of the usual construction and, therefore, its various details are not shown; it will be understood that it includes the usual shunt or arcing contacts and also suitable latching mechanism for holding the circuit breaker in closed position. Tripping mechanism for unlatching and opening the circuit breaker, either automatically in response to an abnormal condition, or in response to manual or other control means, is diagrammatically indicated by the tripping coils T and T'.

The main bridge element 4 is carried by an arm 5 pivotally mounted at 6 to a support 7

secured to and extending from the panel 1. Link member 8 is pivotally secured at one end to the lever 5, and at the other end to a lever 9 pivotally mounted at 10 to the support 7, and representing the usual toggle mechanism of a circuit breaker. Lever 9 is connected by link 11 and lever 12, pivotally mounted at 13 to supporting structure secured to and extending from a panel 1, one end of lever 12 being pivotally connected to the solenoid plunger M operating within the closing coil C. When current is caused to flow through the closing coil or solenoid C, the solenoid plunger M is drawn into the coil, as in the position shown in Fig. 1, and this action causes counter-clockwise rotation of the lever 12, as viewed in Fig. 1, which, through the system of levers and links shown, causes the circuit breaker to latch in closed position. When the circuit breaker is opened, as by the tripping coil T, the lever 12 is rotated in a clockwise direction, as viewed in Fig. 1.

Movement of the lever 9 is transmitted, by means of a link 14, pivotally secured to an arm 16, to the circuit controller, generally designated at S, so that the circuit controller is rotated through an angle of approximately 90° to either of two positions, dependent upon whether the circuit breaker is in open or closed position.

As shown in Figs. 2 and 3, the circuit controller S is mounted on a shaft 18 carried by bearings 20, secured to a U-shaped plate 19, supported by and extending from the panel 1. In Fig. 1 the circuit controller is shown in a position corresponding to closed position of the circuit breaker, and in Figs. 2 and 3 the circuit controller is shown as having been rotated 90° from b to a and is in a position corresponding to an open position of the circuit breaker.

A stop member 27 mounted on the circuit controller cooperates with fixed stop member 28, mounted on the panel 1, to insure that when the switch is in the position of Figs. 2 and 3, the terminals or contacts 25 and 26 on the circuit controller would be in a proper position to engage complementary fixed spring contacts 25' and 26' secured to and extending from the panel 1. The fixed contacts are insulated from the support 19 in any suitable manner, as by a sheet of insulation 30, and connection to an external circuit is made through screw-threaded terminals 29.

The circuit controller preferably comprises two units S1 and S2 comprising casings or envelopes of any suitable moldable material. The casings or envelopes S1 and S2 may constitute molded bodies 31 and 32, respectively, separated from each other and sealed on either side by disks 33 of similar material. Circumferentially-spaced machine screws 34 are employed to hold the assembly together, and the assembly is held in proper relation on a square portion of the shaft 18 by an enlarged portion 21 and a nut 22 secured to the shaft.

Each of the units S1 and S2 comprises an envelope embracing reservoirs, chambers or compartments in fluid intercommunication, as by passages or channels, to form a closed system in which is contained a quantity of fluid. The disposition of the chambers is such as to cause a flow of the fluid between the chambers in a predetermined sequence by the action of gravity, upon the movement of the units between their predetermined limiting positions as, for example, the associated circuit breaker is successively opened and closed.

There is provided a pair of electrical contacts associated with each of the units, the circuit-controlling condition of which is changed in response to the level of the fluid in one of the chambers. For example, the fluid may comprise a conductive fluid such as mercury, brine solution, or other conducting medium, and the contacts may be in communication with one of the chambers, either mounted directly therein, or in recesses communicating with the chamber at a predetermined level. With this latter arrangement, the envelopes 31 and 32 are of suitable insulating material, well-known examples of which are glass, fused quartz, molded vitreous compound, or molded resinous compound, such as a synthetic phenolic condensation product. The unit S1 operates to change the circuit condition of its contacts, for example, to close the circuit therebetween, a predetermined number of times upon successive and correlated movements thereof and is, therefore, particularly suitable to cooperate with and control the circuit breaker shown in Fig. 1 and described above.

In Fig. 4 is shown the arrangement of the reservoirs, or chambers, and interconnecting passages of the unit S1 with the unit in the position corresponding to circuit-opening position of the circuit breaker of Fig. 1, which will hereinafter be referred to as the controlling position of the circuit controller, and after the first opening movement of the circuit breaker has occurred.

In this embodiment of the invention, the envelope 31 comprises a plurality of chambers or reservoirs which may conveniently be termed, respectively, a refill chamber 35, a measuring chamber 37 and a storage chamber 40 interconnected by the channels or passages 36, 39, 41 and 42. A quantity of conductive fluid, preferably mercury, is introduced into the system and is caused to flow from and into the various chambers and, under certain conditions, to rise to a predetermined level in the chamber 37 and to flow into recesses 38, completing a circuit between the electrical contact members or electrodes 25a disposed therein.

As shown in Fig. 4, and after the first opening movement of the circuit breaker has occurred, mercury from the refill chamber 35 has flowed through channel or conduit 36 into the measuring chamber 37, the level of the mercury in the latter chamber being above the recess 38 so that mercury is in contact with the inner ends 25a of the two electrodes 25 thereby to close a circuit between them. Assuming conditions to be such (dependent upon the action of the timing unit S2, described hereinafter) that the closing coil of the circuit breaker will be energized at this time by closure of the circuit between the electrodes 25a, the circuit breaker will close and the control switch will be rotated in a counter-clockwise direction, as viewed in Fig. 4, from a to b, which may be termed its resetting position. Upon this movement of the circuit controller, the chamber 37 is effectively above the chamber 40 and the mercury in the measuring chamber 37 will flow through channel 39 into storage chamber 40. When it is stated herein that one chamber is effectively above a second chamber, it is meant that the chamber or some portion thereof is above the second chamber or some portion thereof, so that the flow of fluid will be from the first chamber to the second.

Assuming further that the abnormal conditions have not been removed from the circuit controlled by the circuit breaker, and that the

circuit breaker is tripped out a second time, due to such abnormal conditions, this will again cause rotation of the circuit controller in a clockwise direction to the position shown in Fig. 4, and a second flow of mercury from refill chamber 35 will pass through channel 36 and fill the measuring chamber 37 to again close the circuit between terminals 25. The circuit breaker will again close, the circuit controller will again be rotated counter-clockwise from a to b, and the second mass of mercury in chamber 37 will flow through channel 39 to storage chamber 40. If abnormal conditions still obtain, the circuit breaker will again be opened, the circuit controller again rotated to the position shown in Fig. 4, and the remaining mercury in refill chamber 35 will flow into the measuring chamber 37, and thereby cause a third reclosing of the circuit breaker.

If the circuit breaker is again opened by the abnormal conditions, the circuit controller is again rotated to the position shown, in which mercury from the reservoir 35 could run into the measuring chamber 37, but as there is no mercury remaining in chamber 35, no circuit will be closed between the terminals 25 and the energizing circuit of the closing coil of the circuit breaker will remain open, the circuit controller thus locking out the circuit breaker. The ratio of the volume of mercury contained in the refill chamber 35 to that in the measuring chamber 37 effecting closure of the contacts 25 determines the number of successive and correlated reclosures permitted before locking out the circuit breaker, and this ratio may be such as to give any desired number of reclosing movements.

When normal conditions again obtain, and the circuit breaker is closed either manually or by auxiliary means, the circuit controller will again be rotated from a to b, that is, to its resetting position, in which position the chamber 40 is effectively above the refill chamber 35 and the mercury, which is now all in the storage chamber 40, will return through the slow leak passage 41 into refill chamber 35 until the levels of the mercury in the two chambers are the same, and thus the circuit controller is automatically reset after a given time interval, for example, from 2 to 30 minutes, dependent upon the area of the slow leak passage 41.

From the above, it will be apparent that, in case the circuit breaker is opened a number of successive and correlated times in response to maintained abnormal circuit conditions, it will be reclosed a corresponding number of times and locked out, as described above. However, if the circuit breaker is opened in response to separate and distinct abnormal circuit conditions, separated by appreciable intervals of time, the control switch will be automatically reset between successive openings. The circuit controller is thus effective to lock out the circuit breaker only after a predetermined number of successive and correlated circuit openings; that is, circuit openings occasioned by the same or related electrical disturbances and separated by intervals of time dependent upon the constants of the control system and the characteristics of the circuit controller.

A screw-threaded plug member 42 is provided for initially inserting the mercury into the unit S1. A small passageway 43 connects the measuring chamber 37 with refill chamber 35 to provide for an interchange of air, and thus prevent the formation of an air trap in the measuring cham-

ber 37 due to the flow of the mercury. The area of the passageway, however, is sufficiently small to prevent mercury from flowing therethrough so that no mercury flows from chamber 37 through this passage.

Fig. 5 shows the arrangement of the reservoirs or chambers, and interconnecting passages in the body 32. The chamber 44 is in communication, by means of a restricted channel or passage 45, with a measuring chamber 46, and the mercury or other contact-controlling fluid flows from the chamber 44 into the measuring chamber 46 when the circuit controller is in its controlling position, as shown in Fig. 5, corresponding to open position of the circuit breaker. Two electrodes or contact members 26a are enclosed in a recess 47 opening into a side wall of the measuring chamber and, after a given time interval as determined by the area of the restricted passage 45, the mercury level in the measuring chamber will rise and flow into the recess 47 to contact with and close a circuit between the electrodes 26a.

The contacts 25 of the unit S1 and the contacts 26 of the unit S2 are interconnected in the same sense; that is, if the contacts 25 are adapted to be closed in response to the fluid level in the chamber 37, the contacts 26 are adapted to be closed by a predetermined fluid level in the chamber 46. As illustrated, the contacts 25 and 26 are connected in series so that corresponding changes in their circuit condition must be effected to complete the closing of the circuit in which they are connected. It will be readily apparent that, if the contacts are of the circuit-opening type, they must be connected in parallel so that the controlled circuit will be broken only upon the coincident opening of both pairs of contacts.

The energizing circuit of the closing coil of the circuit breaker is controlled jointly by the condition of contacts 25 of unit S1 and contacts 26 of unit S2, as by a series connection of the contacts, so that the circuit breaker will not be closed until after a given time interval, determined by the time required for a sufficient volume of mercury to flow from chamber 44 into measuring chamber 46 to close the circuit between the electrodes 26a. After the first reclosure movement of the circuit breaker, the unit S2, in common with unit S1, will be rotated in a counter-clockwise direction, as viewed in Fig. 5, from a to b, in which position the mercury in the measuring chamber will at once return freely by way of passage 48 to the chamber 44 so that, regardless of the number of successive opening movements of the circuit breaker or their time relation, sufficient mercury will be present in the chamber 44 to fill the measuring chamber 46 to a point above the recess 47. When the unit S2 is rotated to the position shown in Fig. 5, some of the mercury in passage 48 will return to the chamber 46, but this amount is relatively small, and its effect may generally be disregarded in computing the timing of the unit. A screw-threaded member 49 is provided for initial insertion of the mercury.

Instead of controlling the timing of the unit S2 by means of the area of the passage 45, a needle valve 50, or equivalent, may be employed for adjusting the rate of flow of mercury through the passage, as shown in Fig. 5a.

A control system for a circuit breaker including my improved circuit controller, and to which it is particularly adapted, is shown in Fig. 6. The circuit breaker B has its closing coil C energized through contacts 59 by movement of an armature 56 of a relay R, the armature being biased by

spring means 56a to the intermediate position shown, and controlling the circuit between contacts 59. Control of the circuit breaker is obtained by two circuits, either manually by a switch or push-button P causing closure of the contacts 59 of the relay R, or by contacts 25, 26 controlling relay R. The relay has an operating coil 54 and a holding coil 55. The closing push-button P is connected to both the operating and holding coils of the relay. The holding coil is connected directly, by means of conductor 57, to the positive control bus 52, while the operating coil 54 is connected through a pallet switch 58 to the positive control bus. Pallet switch 58 is mechanically operated in accordance with movement of the circuit breaker, and is adapted to open when the circuit breaker is closed, and to close when the circuit breaker is opened.

The operating coil 54 of the relay is stronger than the holding coil 55 and, therefore, when both coils are energized simultaneously, coil 54 predominates and contacts 59 are closed, thus energizing the closing solenoid C. The circuit thus completed short-circuits the control push-button P so that it may be momentarily closed and then released without affecting the operation of the circuit breaker. At the end of the closing operation of the circuit breaker, the pallet switch 58 in the relay operating coil circuit is opened, thus deenergizing the operating coil 54 and permitting the armature 56, which is normally biased to an intermediate position, to break the relay contacts 59. If, during this process, the control button P has been closed, the holding coil 55 is energized and draws the armature 56 to its pole face, preventing reclosing of the relay contacts 59 through possible reenergization of the operating coil 54. This action prevents reclosure of the circuit breaker in the event the circuit breaker should reopen by reason of an abnormal condition during the attempted closure by switch P.

The circuit controller S, represented by contacts 25, 26, is connected in parallel with the switch P, and the contacts 25, 26 are connected in series with each other and also in circuit, by means of conductor 63, with an auxiliary or pallet switch 61 operated by the circuit breaker, which switch is closed when the circuit breaker is closed and which opens only when the circuit breaker is tripped manually. This switch will, therefore, remain closed when the circuit breaker has been opened due to an abnormal condition and, in this case, it permits the circuit controller to determine the proper intervals for reclosing the circuit breaker.

The trip coil T', for opening the circuit breaker, is connected in circuit with a push-button or switch P' and an auxiliary or pallet switch 60b operated by the circuit breaker, which switch is closed when the circuit breaker is closed, and which opens only when the circuit breaker is tripped manually, as in the case of switch 61 hereinbefore referred to. This arrangement also permits the tripping circuit to function, irrespective of the condition of the other control circuits, and makes possible the energization of the trip coil T' from the switch P' after the circuit breaker has opened due to overload or other abnormal condition, or when it has been locked open by the circuit controller S. The operation of the trip coil at this time, through the tripping mechanism, causes the pallet switches 60b and 61 to open, thus disconnecting the trip coil and control contacts 25, 26 from the circuit. When the circuit breaker is automatically opened, due to abnormal

conditions, it is under the supervision or control of the circuit controller S; when the circuit breaker is tripped by hand, or by the switch P', the controller S is disconnected from the circuit; thus, the circuit breaker remains open until it is closed either by hand or by the closing switch P, after which the controller S again controls.

A signal lamp R is connected in parallel with the push-button P', and burns whenever the auxiliary switch 60b is closed. A second signal lamp G is connected through an auxiliary or pallet switch 62, which switch is open when the circuit breaker is closed, and the lamps R and G, therefore, indicate the condition of the circuit breaker; when the circuit breaker is closed, lamp R burns; when the circuit breaker has been opened or tripped manually, the lamp G will burn; and when the circuit breaker is open, having been tripped by abnormal or overload condition, both lamps G and R will burn.

The switching device or unit shown in Jensen Patent No. 1,909,540 is suited for use as switches 60b, 61 and 62 by providing extra contacts for each shaft, or by using two such units.

It will be understood that various other control systems may be employed in lieu of that illustrated. Also, the circuit controller units S1 and S2 may comprise individual units and may, for convenience, be located in different positions, it only being necessary that the units be rotated in unison to either of two positions corresponding to the movement of the circuit breaker. It is, furthermore, not necessary that the units S1 or S2 be actuated by link mechanism, as shown in Fig. 1; either of the units may be rotated by various other position-controlling means known in the art, for example, electromagnetic mechanism, as a solenoid, controlled by a pallet switch actuated by movement of the circuit breaker, so that the solenoid is energized or deenergized in accordance with the position of the circuit breaker to cause or permit rotation of the units S1 or S2 to either of two positions corresponding to the position of the circuit breaker. In such an arrangement, the units S1 or S2 may be biased to one position, as by a spring or weight, and therefore, the solenoid is required to act in one direction only to rotate the units to their other position upon movement of the circuit breaker to a given position.

If the time interval between the opening and reclosing movements of the circuit breaker is unimportant, it is also possible to use the unit S1 alone, without employing unit S2. Either of the units may be replaced by corresponding units having different operating characteristics to thereby give a different number of successive reclosing movements, or different timing characteristics, or both, to the circuit breaker and control circuit.

The portions of the chambers and passages and particularly the contact enclosing chambers of the units S1 and S2 unoccupied by the conductive liquid or mercury may be filled with a non-conducting fluid, chemically inert with respect to the switch elements, and adapted to minimize or prevent chemical change in the conductive liquid or mercury, or in the electrode material, by arcing occurring at the contacts or electrodes. An inert gas, as nitrogen, argon, etc., may be used; or a liquid, of lower density than that of the conductive liquid, such as carbon tetrachloride, may be employed for this purpose.

The contact arrangement of either of the units of the circuit controller provides for a quick-make

mercury contact, and also insures that an amount of mercury sufficient to carry a substantial current, flows into contact with the electrodes 25 or 26 at the time of making contact. The electrodes of each unit are positioned within recesses 38 and 47, respectively, and the recesses have a small cross-section as compared with that of the measuring chambers 37 or 46, so that when the convex meniscus of the mercury breaks as its level rises above the openings of the recesses, a relatively large amount of mercury will flow into the recesses and cover the electrodes, and there will be ample depth of mercury to carry a substantial current. The recesses are preferably, although not necessarily, inclined downwardly, as shown, to further facilitate quick-make action at the time of making contact. The electrodes of each unit may be positioned in the same recess, or individual recesses for each electrode may be provided. Also, one of each set of electrodes may extend through the wall of the measuring chamber so that it is in contact with the mercury before the other electrode which is positioned within a recess.

What I claim is:

1. An electric circuit controller comprising a contact structure, means including an envelope containing a quantity of fluid effective, upon successive movements of said envelope to a given position, successively to change the circuit controlling condition of said contact structure, and fluid flow control means effective to limit the number of successive changes of the circuit controlling condition of said contact structure in response to successive and correlated movements of said envelope.

2. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of fluid contained within said system, and a pair of electrical contacts the circuit controlling condition of which is changed in response to a predetermined level of fluid in one of said chambers, said chambers being so related that successive and correlated movements of said envelope in the same sense between said predetermined positions are effective successively to deliver sufficient quantities of fluid to said one chamber to effect said predetermined level therein for a predetermined number of times only.

3. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of conductive fluid contained within said system, a pair of contacts in communication with one of said chambers and disposed to be bridged by said conductive fluid when it rises to a predetermined level therein, said chambers being so related that successive and correlated movements of said envelope in the same sense between said predetermined positions are effective successively to deliver sufficient quantities of fluid to said contact chamber to bridge said contacts for a predetermined number of times only.

4. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of fluid contained within said system, a pair of electrical contacts the circuit condition of which is changed in re-

sponse to a predetermined level of fluid in one of said chambers, said last-named chamber being disposed to empty into another of said chambers in a first of said positions of said envelope, said chambers being so related that successive and correlated movements of said envelope from said first position to another of said positions are effective to refill said one chamber to said predetermined level for a predetermined number of movements only.

5. An electric circuit controller comprising an envelope movable between predetermined positions and embracing three or more chambers in fluid intercommunication to form a closed system, a quantity of fluid contained in said system, a pair of electrical contacts the circuit condition of which is changed in response to a predetermined level of liquid in one of said chambers, said chambers being so disposed that successive movements of said envelope between said predetermined positions effect the flow of said fluid between said chambers in a predetermined sequence, thereby intermittently filling said one chamber to said predetermined level, and a restriction interposed between two of said chambers effective to limit the number of refillings of said one chamber in response to successive and correlated movements of said envelope.

6. An electric circuit controller comprising an envelope movable between predetermined positions and embracing three or more chambers in fluid intercommunication to form a closed system, a quantity of fluid contained in said system, a pair of electrical contacts the circuit condition of which is changed in response to a predetermined level of liquid in a first one of said chambers, a second chamber disposed to discharge fluid by gravity into said first chamber in one of said positions of said envelope and having a fluid capacity a multiple of said first chamber, said first chamber being disposed to discharge fluid by gravity into a third of said chambers in the other position of said envelope and said third chamber being disposed to discharge by gravity into said second chamber in said other position of said envelope, and a restricted passage limiting said last-named discharge.

7. An electric circuit controller comprising an envelope movable between predetermined positions and embracing three or more chambers in fluid intercommunication to form a closed system, a quantity of fluid contained in said system, a pair of electrical contacts the circuit condition of which is changed in response to a predetermined level of liquid in one of said chambers, said chambers being so disposed that successive movements of said envelope between said predetermined positions effect the flow of said fluid between said chambers in a predetermined sequence, thereby intermittently filling said one chamber to said predetermined level, and means governing the flow of fluid between certain of said chambers effective, upon operation of said envelope between said positions at a frequency greater than a predetermined magnitude, to limit the number of refillings of said one chamber.

8. An electric circuit controller comprising an envelope movable between predetermined positions and including a fluid system comprising a storage chamber, a refill chamber, and a measuring chamber, said chambers being in fluid intercommunication to form a closed system, a quantity of fluid contained in said system, a pair of electrical contacts the circuit condition of which is changed in response to a predetermined level

of liquid in one of said chambers, said chambers being so disposed that successive movements of said envelope between said predetermined positions effect the flow of fluid between said chambers in the sequence refill chamber, measuring chamber, storage chamber, refill chamber, or the like, thereby intermittently filling said measuring chamber to said predetermined level, and a restriction interposed between said storage chamber and said refill chamber effective to limit the number of refillings of said measuring chamber from said refill chamber in response to successive and correlated movements of said envelope.

9. An electric circuit controller comprising an envelope movable between two limiting positions and including a fluid system comprising a storage chamber, a refill chamber, a measuring chamber, and fluid conducting passages interconnecting said chambers, a quantity of electrically conductive fluid contained in said systems, and a pair of electrical contacts disposed in said measuring chamber to be bridged by said conductive fluid when it rises to a predetermined level therein, said chambers and passages being so disposed that successive movements of said envelope between said limiting positions effect the flow of fluid between said chambers in the above-named sequence, thereby intermittently filling said measuring chamber to said predetermined level, and the passageway between said storage chamber and said refill chamber including a restriction effective to limit the number of refillings of said measuring chamber in a predetermined interval.

10. An electric circuit controller comprising a pivotally mounted envelope movable between controlling and resetting positions and including a fluid system comprising a storage chamber, a measuring chamber, and a refill chamber disposed effectively above said measuring chamber in the normal position of said envelope, a quantity of electrically conductive fluid contained in said system, a passage connected to conduct fluid from said refill chamber to said measuring chamber in the controlling position of said envelope, said measuring chamber being disposed effectively above said storage chamber, and said storage chamber effectively above said refill chamber in the resetting position of said envelope, a passage connected freely to conduct fluid from said measuring chamber to said storage chamber in said latter position of said envelope, a restricted passage connected to conduct fluid from said storage chamber to said refill chamber in said latter position of said envelope, and a pair of contacts in communication with said measuring chamber.

11. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of fluid contained within said system, a pair of electrical contacts, the circuit condition of which is changed in response to a predetermined level of fluid in one of said chambers, said chambers being so related that successive and correlated movements of said envelope in the same direction between said predetermined positions are effective successively to deliver sufficient quantities of said fluid to said one chamber to effect said predetermined level therein for a predetermined number of times only, and a second pair of contacts operatively connected to said envelope and having their circuit condition changed in the

same sense as said first-named contacts but with a time-delay upon movement of said envelope in said direction to deliver a quantity of fluid to said one chamber, said pairs of contacts being so interconnected that their coincident change in circuit condition is required to effect the desired change in circuit condition of the circuit controller.

12. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of fluid contained within said system, a pair of electrical contacts closed in response to a predetermined level of fluid in one of said chambers, said chambers being so related that successive and correlated movements of said envelope in the same direction between said predetermined positions are effective successively to deliver sufficient quantities of said fluid to said one chamber to effect said predetermined level therein for a predetermined number of times only, and a second pair of electrical contacts operatively connected to said envelope and closed after a time-delay upon the movement of said envelope in a direction to close said first-named contacts, said pairs of contacts being connected in series, whereby their coincident closure is required to effect the closure of the circuit controller.

13. An electric circuit controller comprising an envelope embracing a plurality of chambers and movable between predetermined positions, said chambers being in fluid intercommunication to form a closed system, a quantity of conductive fluid contained within said system, a pair of contacts in communication with one of said chambers and disposed to be bridged by said conductive fluid when it rises to a predetermined level therein, said chambers being so related that successive and correlated movements of said envelope in the same direction between said predetermined positions are effective successively to deliver sufficient quantities of fluid to said contact chamber to bridge said contacts a predetermined number of times only, and a second envelope operatively connected to said first-named envelope and movable therewith and comprising a pair of chambers, a restricted passage for conducting fluid between said chambers in one position of said envelopes, a substantially unrestricted passage for conducting fluid in an opposite direction between said envelopes when in their other position, and a second pair of electrical contacts in communication with said chamber into which said restricted passage leads and connected in series with said first-named contacts.

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