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CIRCUIT INTERRUPTER

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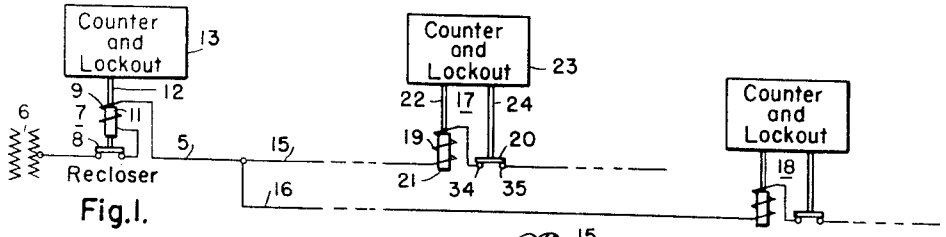

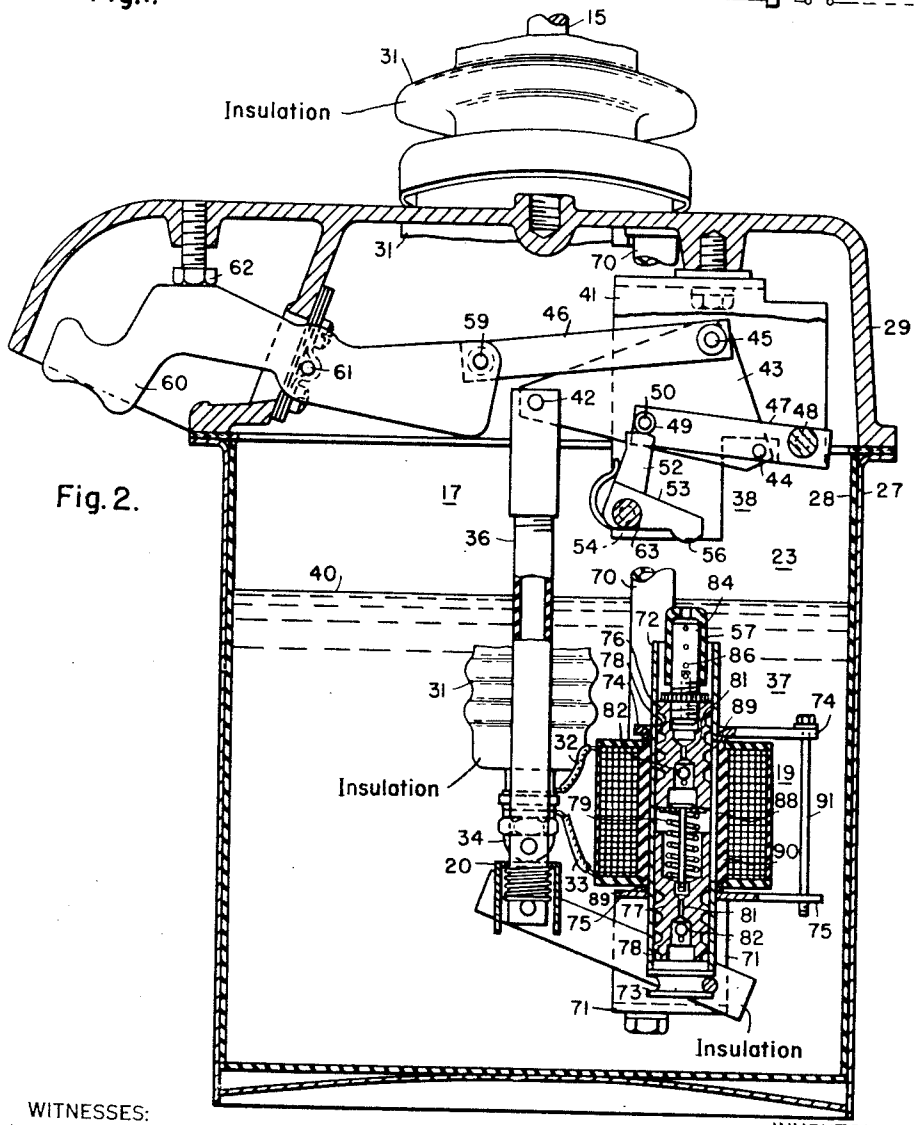

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CIRCUIT INTERRUPTER

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9 Claims. (Cl. 200—108)

Our invention relates generally to circuit interrupters, and it has reference in particular to circuit interrupters of the line sectionalizing type, such as may be used in conjunction with automatic reclosing circuit breakers on feeders in distribution systems.

This application is a continuation of our application, Serial No. 106,886, which was filed on July 26, 1949, which is now abandoned, and has been divided out of our copending application, Serial No. 196,508 (also a continuation of application Serial No. 106,886) filed on November 18, 1950, now Patent No. 2,757,321 dated July 31, 1956, all assigned to the assignee of the present invention.

Generally stated, it is an object of our invention to provide a circuit interrupter which is simple and inexpensive to manufacture and is reliable and effective in operation.

More specifically it is an object of our invention to provide a new and novel circuit interrupter structure wherein an operation counter operates to release a lever of the interrupter contact operating mechanism for opening the interrupter, and a handle is provided for manually operating the same lever to open and close the interrupter.

Another object of our invention is to provide in a circuit interrupter an operation counter of the magnetically operated type, using ribs of magnetizable material at spaced intervals on a movable core for effecting a magnetic locking action of the core in different stepped operating positions.

Yet another object of our invention is to provide for more accurate operation of a sectionalizer type of circuit interrupter by providing for magnetically locking the armature of an operation counter used therewith in its different operating positions.

It is also an object of our invention to provide in a circuit interrupter, a counting-mechanism which makes use of a novel principle of operation, using two armatures inside of a single operating-solenoid, with a compression spring between them for normally holding the armatures separated from each other when the solenoid is deenergized, with special fluid-flow valves and special magnetic interlocks which make the mechanism free of previously experienced difficulties resulting in erratic performance and involving excessive burdens on the solenoid.

With the foregoing and other objects in view, our invention consists in the systems, combinations, structures, parts, and method of design and operation, hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a diagrammatic view of circuits and apparatus illustrating the kind of system in which our invention is used, and

Fig. 2 is a simplified cross-sectional view through the counting means and through the operating mechanism of a sectionalizer type of interrupter illustrative of our invention.

In Fig. 1, we show our invention applied to a rural

power-line 5 of the type described, which is fed from a power source 6 through a diagrammatically indicated automatic reclosing circuit breaker or recloser 7, having a normally-closed breaker contact 8, and an operating-coil 9, both connected in series with the line 5. The recloser has an armature 11 which is mechanically connected, at 12, to a block 13 which represents any suitable counter-and-lockout mechanism, which counts the number of rapidly repeated contact-opening-and-reclosing operations, and after a predetermined number of such operations locks out the recloser by thereafter holding the contact 8 in its open position, until the recloser is manually reset. It will be understood that the recloser contact 8 is normally closed but opens in response to a predetermined overcurrent condition in the coil 9. The opening of the contact 8 deenergizes the coil 9, and when the coil 9 is deenergized, the recloser contact 8 automatically recloses itself, until the counter mechanism 13 becomes effectively operative and holds the contact 8 in its open position. There are a number of such reclosers on the market, and their specific construction constitutes no part of our present invention, unless the mechanism 13 is designed so as to include our counter, which will be subsequently described. It is believed, therefore, that the diagrammatic recloser illustration in Fig. 1 is sufficiently clear without further explanation or illustration.

The rural power line 5 may extend out, either in a single branch, or in a plurality of branches 15 and 16, each branch usually supplying a number of customers located at various points distributed along the line. Most of the faults which will occur on such a line are faults which will clear themselves as soon as voltage is removed from the line, although sometimes a fault may require a certain length of time, or a certain number of successive opening and reclosures of the recloser 7, in order to burn off or clear the fault. The recloser 7 protects such a line by more or less rapidly opening and reclosing its breaker contact 8 for a predetermined number of times, such as 4 or 5 times, after which, if the fault has not then cleared itself, the fault is considered to be a permanent fault and the recloser permanently opens its contact 8.

Since a line 5 of the type in question, or its several branch lines 15 and 16, usually serve a considerable number of customers, it has been recognized as being desirable to use one or more circuit interrupters or line sectionalizers for increasing the number of points, along the line, at which the circuit can be disconnected in the event of a permanent fault which will not clear itself, thus limiting the number of customers, or the amount of the circuit affected by any permanent fault.

Fig. 1 illustrates a typical situation in which a sectionalizer 17 is inserted at some intermediate point along the length of the branch line 15, while a similar sectionalizer 18 is inserted at some intermediate point along the branch line 16. Each sectionalizer, such as 17, comprises a series-connected operating-coil 19, and a normally closed, series sectionalizer contact 20, both of which are connected in series with the associated branch line, such as 15. The current coil 19 operates on an armature 21 which is mechanically connected, as diagrammatically indicated at 22, with a counter-and-lockout mechanism 23, which is indicated by block diagram in Fig. 1. The counter-and-lockout mechanism 23 is mechanically connected, as diagrammatically indicated at 24, so as to trip out the sectionalizer contact 20 after a predetermined number of "counts" of fault current surges followed by interruptions of the current through the coil or solenoid 19, the mechanism thereupon not only opening the contact 20 but also locking it out, or holding it open, so as to disconnect the power service from the rest of the line, extending beyond the location of the sectionalizer (such as 17), until the

fault can be located and corrected, after which the sectionalizer will be reclosed or reset by hand.

A desirable structural form of the sectionalizers, such as 17 or 18, is shown in Fig. 2. The sectionalizer 17 is here shown as being enclosed within a metal tank 27, which is provided with an insulating liner 28, and which is surmouned by a top casting 29. The incoming line 15 enters through a bushing 31 which terminates inside of the tank. The circuit then continues, through a conductor 32, to the sectionalizer coil 19. From the sectionalizer coil 19, the circuit continues through a conductor 33 back underneath the bushing 31 for the incoming lead 15, and thence to the terminal 34 which constitutes one of the stationary contacts of the sectionalizer. Ordinarily, the sectionalizer has two bushings, each with its lead passing through the bushing, and each bushing terminates, at its bottom in one of the stationary contacts of the sectionalizer, but since Fig. 2 shows an approximately central section through the sectionalizer, the second stationary contact is not visible in Fig. 2, but is indicated in Fig. 1 at 35. The movable contact 20 is shown, in Fig. 2, as a contact bar or bridge which presses up against the underside of the stationary contacts 34 and 35 in the closed position of the sectionalizer, and which is lowered by gravity, to operate the sectionalizer, upon the release of a pull rod 36, which is shown in the form of an upwardly extending insulating tube.

The counter-and-lockout mechanism 23 is segregated in Fig. 2, into its component parts, consisting of the counter 37 and the operating mechanism 38.

The sectionalizer 17 can theoretically operate either in air, or in an insulating oil, or other insulating fluid. It is sometimes desirable for the counter 37 to operate in oil, as it involves dashpot or fluid-flow operation, as subsequently described, which is somewhat more difficult to obtain in air, with the necessary time constants. It is sometimes desirable to have the contents 34—20—35 also operating in oil. We have consequently illustrated our apparatus, by way of example, as having the counter 37 and the contacts 34—20—35 immersed in oil 40 which is contained in the tank 27.

The particular operating mechanism 38 which is shown in the accompanying drawing constitutes the subject matter of a companion application Serial No. 106,886, of J. M. Wallace and A. W. Ogg. In brief, it will perhaps suffice to say that this operating mechanism comprises a triangularly shaped lever 43 to which the pull rod 36 is pivotally connected as by a pivot 42. A lever 47 mounted by a pivot 48 on a frame 41 secured to the casting 29 supports a pivot 44 for one corner of the lever 43. The lever 47 is normally supported by a releasable bellcrank trigger 53 having an arm 52 engaging a roller 49 on a pin 50 at the free end of the lever, and an operating handle 60 pivotally mounted on the casting by a pivot 61 and connected by a pivot 59 so as to provide a toggle arrangement with a lever 46 connected to the other corner of the lever 43 by a pivot 45. An adjustable stop 62 is provided for the handle 60. The trigger 53 has a downwardly extending abutment portion 56 which is adapted to be tripped when an upward movement of a trip pin 57 of the counter 37 raises said abutment point 56 of the trigger, whereupon the pivot 44 drops, permitting pivot 45 to fall and the toggle arrangement of the handle 60 and lever 46 to break, so that the linkage of the operating mechanism permits the pull rod 36 and the movable contact member 20 to drop freely in the opening operation of the mechanism. Eventually lever 43 strikes a roller 63 or pivot 54 of the trigger and rotates counterclockwise to raise pivot 44 and relatch lever 47 with the arm 52 of trigger 53.

The counter 37 is suspended from the top of the top casting 29, by means of a plurality of depending insulating supports or tubes 70, which support the base frame 71 of the counter.

The counter 37 proper comprises a vertically disposed tube 72, which is preferably made of brass or other non-magnetizable metal. The lower end of the tube is tightly closed by a plug 73, while the top of the tube 72 is open. The series-current coil 19 surrounds a portion of the tube 72, intermediate between its upper and lower ends. Immediately above and below the coil 19 are two perforated magnetizable plates 74 and 75, respectively, both of which are perforated so as to surround the tube 72. The plates 74 and 75 serve as the two pole pieces of an electromagnetic circuit, the excitation of which is provided by the coil 19.

Inside of the tube 72 are two normally spaced magnetizable cores or armatures 76 and 77, which are slidably movable, with a close fit of say perhaps 3 mils radial clearance, within said tube. The upper armature 76 extends partly above and partly below the level of the upper plate 74, while the lower armature 77 extends partly above and partly below the lower plate 75. Each of these armatures 76 and 77 thus extends partly within and partly without the space between the two plates 74 and 75.

In accordance with an important feature of our invention, at least one of the armatures, such as the upper armature 76, and preferably both of the armatures 76 and 77, are provided with a plurality of annular magnetizable ribs 78 which are vertically spaced from each other by a spacing which is preferably approximately the same distance as the closable distance between the two armatures 76 and 77, or other disposition which will magnetically lock the respective armatures against unwanted vertical displacement or slippage. A compression spring 79 is disposed beween these two armatures, so that, when the coil 19 is sufficiently energized, the two armatures are brought together, storing up energy in the interposed compression spring 79, as will be more fully described hereafter.

Each of these armatures 76 and 77 is provided with a central bore 81, and the lower end of each of these bores, is closable by means of a ball valve 82, so that the fluid which is entrapped within the closed lower end of the tube 72 resists any rapid downward movement of either armature, because of the closure of these ball valves 82, while said valves permit the free upward movement of either armature. The entrapped fluid could be any gas or liquid having the required viscosity in comparison with the mechanical clearances which are provided. The idea is to permit the respective armatures to move freely upwardly, in a step-by-step motion, as will be subsequently described, while permitting said armatures to drift back downwardly again, by fluid leakage, at a very slow rate.

At the top of the upper armature 76, we affix an upstanding pin 84, which extends upwardly to a point above the open top end of the tube 72. This pin 84 is surrounded by a tubular tip or trip pin 57, which is capable of serving as an adjustable extension of the pin 84. This vertical adjustment is effected in any one of a plurality of vertically spaced positions corresponding to the spacing between the armatures 76 and 77, by means of a cotter pin 86, so that adjustment may be made for any desired number of "counts," such as 1, 2, 3 or 4, within the range of the counting mechanism 37.

In the operation of the counting mechanism 37, when the coil 19 is first energized, with a current corresponding to the setting of the counter, the two armatures 76 and 77 are drawn together, so as to close the air gap which separates the inner ends of said armatures. The upper armature 76 cannot move downwardly, in order to bring the two armatures together, because of the presence of its fluid-flow valve 82, and hence the lower armature 77 must move upwardly. The attractive force between the two armatures is greater than the attractive force between the lower plate 75 and the corresponding rib 78 of the lower armature 77, which was at first on the same level as said lower plate 75. When the lower armature completes its upward movement, compressing the

spring 79, its next rib 78 comes into a magnetic interlock with the lower plate 75, thus holding said lower armature from drifting or settling downward, due to gravity and the slow leakage of the fluid filling of the tube 72, this holding action being maintained as long as the coil 19 remains effectively energized.

When there is a fault on the distribution line, within the protective reach of the recloser 7 (Fig. 1), the recloser contact 8 quickly opens, and quickly again recloses, but during the movement (12 cycles or more, in a 60-cycle line) when said recloser contact 8 was open, the sectionalizer coil 19 is deenergized, and the compression spring 79 between the two armatures 76 and 77 expands, and pushes the two armatures apart again, to their normal separation distance. During this action, however, the lower armature 77 cannot move downwardly, because of its fluid-flow valve 82, and hence the upper armature 76 must move upwardly, which it is free to do, so far as fluid action is concerned, because its valve 82 will open during such movement. The magnetic attraction between the upper and lower plates 74 and 75 and the corresponding magnetizable ribs 78 of the upper and lower armatures 76 and 77 is now practically non-existent, because of the deenergization of the coil 19, and hence the upper armature 76 is notched upwardly by a distance corresponding to the amount of compression of the spring 79.

If a fault continues on the distribution system, at a point beyond the sectionalizer coil 19, the reclosure of the recloser contact 8 deenergizes the sectionalizer coil 19 and causes a second compression of the spring 79, in a manner already described. If the fault is still on the system, as has just been assumed, the recloser contact 8 again opens, and a second upward stepping movement of the trip pin 57 is obtained. And thus the step-by-step movement of the counter mechanism continues.

When the last upward stepping of the upper armature 76 is obtained, depending upon the vertical positioning of the trip pin or tubular tip 57, this pin 57 comes into contact with the trigger 53 during this last upward movement. The lever 47 is released and falls carrying pivot 44 therewith. The pivot 45 drops also, breaking the toggle arrangement of the lever 46 and handle 60, so the lever 43 rotates in a counterclockwise direction and rod 36 drops and trips out the sectionalizer contact 20. As the pull rod 36 falls, the lever 43 drops and strikes roller 63 on pivot 54 of the trigger. The lever 43 thereupon rotates about the roller 63, raising pivot 44 and lever 47 until the trigger 53 returns to the initial latched position. It will be noted that the last upward movement of the trip pin 57 occurs during a time when the current in the sectionalizer coil 19 is off. In the operation of the recloser 7, the current remains off, that is, the recloser contact 8 remains open, for a minimum of 12 cycles (on a 60-cycle line), before the recloser contact 8 recloses. The opening of the sectionalizer contact 20 requires something like 2 or 3 cycles, so that it is seen that the sectionalizer contact 20 opens during the current-off period, so that the sectionalizer contact 20 does not have to interrupt any substantial current. The sectionalizer may be reclosed by operating the handle 69 to rotate the lever 43 clockwise about pivot 44 and restore the over-center toggle arrangement with lever 46.

By our new counter mechanism, we have thus provided a counter in which the magnitude or distance of the advance-steps, by which the counter is advanced each time it "counts," is fixed. This action is obtained particularly by virtue of the magnetizable ribs 78 of the upper armature 76, which magnetically interlock with the upper magnetizable plate 74 each time the coil 19 is energized, thus accurately lining up the vertical position of the upper armature 6, for each counting operation. In this manner we avoid errors due to slightly different upward lifts, due to various conditions such as the magnitude of the fault current, the dissymmetrical position of the armatures 76 and 77, one of which may be extending further outside of the coil than the other, so that there would normally be a tendency for the two armatures to settle themselves into a central position with an equal amount of extension beyond the confines of the coil 19. Our magnetic interlock also automatically adjusts for small amounts of drift, in case of a timed operation of the recloser contact 8, which is sometimes used instead of the "instantaneous" tripping operations, as is well understood in the art. In short, we have provided a counter mechanism which actually advances the trip pin 57 by a fixed predetermined invariable amount, each time the coil 19 is deenergized, after having been energiezd sufficiently to compress the spring 79.

The magnetizable ribs 78 on the lower armature 77 also assist, although they are not by any means necessary, as in the case of the corresponding ribs on the upper armature 76. In the lower armature 77, if said ribs 78 are used, as shown, they obviously serve to help to hold the two armatures in their proper vertical position, without any downward drifting, throughout the time when adequate energizing current is flowing through the coil 19.

The foregoing and other advantages are obtained in a structure which combines great simplicity, freedom from operational difficulties, and low manufacturing costs.

An important feature of our invention is related to the choice of brass or other non-magnetizable metal, as a material of construction for the tube 72. It is desirable to use a metal for said tube so that its bore can be accurately machined, so that close radial tolerances may be maintained between said bore and the two armatures 76 and 77. If a metal is used for the tube 72, it has to be non-magnetic in order to prevent sticking of the armatures thereto and to permit the magnetic flux to penetrate to the armatures 76 and 77. But if the tube 72 is of metal or other conducting material, it is sometimes desirable that the central portion of the tube, or more particularly, the portion between the upper and lower magnetizable plates 74 and 75, should have a vertical slit therein, as has been shown at 88. This vertical slit is for the purpose of impeding or breaking up the eddy currents which would otherwise flow around the circumference of the tube, as a result of the axial flow of alternating magnetic fluxes through the center of the tube. The vertical slit 88 extends from a point just below the upper plate 74 to a point just above the lower plate 75.

It is necessary, however, to prevent the flow of oil or other fluid through this vertical slit 88, and hence, in accordance with this phase of our invention, we provide two compressible sealing rings 89, surrounding the tube 72, one above and the other below, said slit 88. The portion of the tube having the slit 88 is further surrounded by a tubular insulating member 90, which is not slit or perforated. The respective sealing rings 89 are compressed between the brass tube 72, the respective ends of the tubular insulating member 90, and the respective plates 74 and 75, thus preventing any leakage of oil or other fluid out of the slit 88.

The coil 19 surrounds the tubular insulating member 90. A return path for the magnetic flux is sometimes provided by one or more magnetizable bolts 91, which join the upper and lower plates 74 and 75, outside of the coil 19.

By using a lever arrangement in which the lever 43 has two pivotal points of support arranged in triangular relation with the point of connection to the contact pull rod, a simple and efficient mechanism is provided. The toggle handle mechanism and the releasable latch operate at different points on the same lever, thus providing an inexpensive and reliable operating mechanism. Since the trigger 53 is reset in the latch position during the opening operation, the sectionalizer is reclosed by reclosing it through operation of the manual operating handle in the same manner as reclosing after a manual opening, merely by replacing the handle and lever 46 is an over-center toggle arrangement as shown. Manual tripping is

effected by simply operating the handle to break this same toggle arrangement, whereupon the lever 43 pivots counterclockwise, dropping the pull rod and opening the contacts.

While we have illustrated our invention in but a single exemplary form of embodiment, which is now preferred, we wish it to be understood that our invention is susceptible of considerable modification, by way of additions, omissions and the substitution of various equivalents, without departing from the essential spirit of our invention, particularly in its broader aspects. We desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

We claim as our invention:

1. In a circuit interrupter, separable contact means, a lever operable to effect separation and engagement of said contact means, releasable means normally disposed to provide a support for said lever to maintain the lever in a position for effecting engagement of said contact means, a handle manually operable to effect movement of said lever means about said support to selectively effect separation or engagement of said contact means, and counter means having electromagnetic fluid pumping means operable in response to a predetermined number of circuit interruptions to cumulatively advance a member to actuate said releasable means and effect operation of said lever means to a position for effecting separation of said contact means.

2. A circuit interrupter comprising, separable contact means, a lever having one point of connection with said contact means and two points of support about either of which it may rotate to effect separation of said contact means when the other point of support is removed, releasable means normally disposed to provide one of said points of support, a counter having a pair of movable magnetic piston members with one way valve means disposed in a fluid responsive to a predetermined number of circuit interruptions to pump measured amounts of fluid against one of the members to progressively advance said one member to actuate said releasable means to remove said one point of support and effect separation of said contact means, and a handle operatively connected to the lever to normally provide the other of said points of support, said handle being operable to remove said other point of support.

3. In a circuit interrupter, a stationary contact means, movable contact means operable to engage said stationary contact means, a lever connected at one point to the movable contact means and having two other points of support about either of which the lever may rotate to effect movement of the movable contact means away from said stationary contact means, releasable latch means disposed to provide one of said points of support for said lever, a counter comprising a solenoid connected in series with the contact means and a pair of relatively movable magnetic core members operable in response to a predetermined number of circuit interruptions to pump measured amounts of fluid against one of the core members to advance said one core member to release said releasable latch means and remove said one point of support, and a toggle mechanism normally disposed to provide said other point of support, including a handle operable to effect operation of the mechanism to remove and replace said other point of support whereby the movable contact means is selectively separated from and moved into engagement with said stationary contact means.

4. A circuit interrupting device comprising, separable contact means disposed in an arc extinguishing fluid, a contact rod movable longitudinally to effect separation of said contact means, a lever pivotally connected to said rod at one point and having a pair of points of support disposed in triangular relation with said one point, an additional lever pivotally mounted and connected to said lever at one of said pair of support points, releasable means disposed to maintain said additional lever in a predetermined supporting position, a counter disposed in the fluid having an operating coil connected in series with the contacts and a pair of piston-like movable magnetic core members with one way valves operable in response to a predetermined number of circuit interruptions to pump measured amounts of the fluid against one of the core members to cumulatively advance said one core member to engage and actuate said releasable means to release said additional lever from said predetermined supporting position, and toggle means including a toggle lever connected to said lever at said other one of said points of support and a pivotally mounted handle connected to said toggle lever and normally disposed in toggle relation therewith, said handle being operable for rotating said lever about said one point of support to selectively effect separation or engagement of said contact means.

5. A circuit interrupter comprising, a container having an insulating fluid therein, a cover for said container, separable contact means disposed within the container, an insulating rod actuable to effect separation and engagement of said contact means, a lever having a point of connection with said rod for actuating the rod and having a pair of points of support spaced in triangular relation therewith, releasable latch means supported by the cover disposed to provide one of said points of support, toggle means including a handle pivotally mounted in the cover and projecting through an opening therein disposed to provide the other of said points of support, said handle being manually operable to make or break a toggle arrangement of said toggle means and effect rotation of said lever about said one point of support to actuate the rod for effecting separation and engagement of said contact means, and a counter in the fluid having a solenoid connected in series with the contact means with relatively movable piston-like core members of a magnetic material operable in response to a predetermined number of closely succeeding circuit interruptions and having one way valve means providing passages to pump a measured amount of fluid against one of the core members to advance said one core member to release said releasable latch means and move said one point of support whereby said lever rotates initially about said point of connection with said rod and then permits movement of the rod to separate said contact means.

6. A circuit interrupter comprising, separable contact means, a lever connected to effect separation or engagement of said contact means, releasable means normally supporting said lever at one point, toggle means normally supporting the lever at another point, and electroresponsive means including an operating coil connected in series circuit relation with said contact means and a magnetic circuit for said coil including a movable armature of a magnetic material having spaced magnetizable projections disposed to magnetically locate the armature and provide for operation of said releasable means after a predetermined number of circuit interruptions.

7. In a circuit interrupter, separable contact means disposed in an insulating fluid, a lever connected to one of said contact means, releasable means disposed to normally provide a pivotal support for said lever at one point, toggle means normally disposed to provide another pivotal support for said lever, and electroresponsive means including a coil disposed in the fluid and connected in circuit relation with the contact means and a magnetic circuit having a pair of relatively movable armatures therein each provided with one way valve means to pump a measured amount of fluid against one of the armatures to progressively advance said one armature to engage and effect release of said releasable means, only after a predetermined number of circuit interruptions.

8. A circuit interrupter comprising; a pair of relatively movable contact means; a lever connected at one point to

one of said contact means; toggle means providing a pivotal support for the lever at another point; releasable means disposed to provide a pivotal support for the lever at an additional point spaced from said other points; and electroresponsive means operable to actuate said releasable means to remove said pivotal support at said another point after a predetermined number of circuit interruptions including a coil connected in circuit with said contact means, and a magnetic circuit including a movable armature of magnetic material disposed to effect actuation of said releasable means and having a plurality of spaced annular ribs magnetically when said coil is energized to definitely locate the armature in different positions in the magnetic circuit.

9. A circuit interrupter comprising, separable contact means, operating means for said contact means, releasable means normally operable to maintain said operating means in a position for effecting engagement of the contact means and releasable to effect separation thereof, and electroresponsive means including a coil connected in series circuit relation with said contact means and a movable armature of magnetic material operable after a predetermined number of stepped operations to release said releasable means, said armature being disposed in the magnetic field of said coil when energized and having spaced apart annular ribs magnetizable to determine predetermined stepping operations of the armature each time the coil is energized a predetermined amount and deenergized.

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