Jan. 6, 1953 H. L. RAWLINS ET AL 2,624,817

CIRCUIT INTERRUPTER

Filed July 2, 1945

Fig. 1.

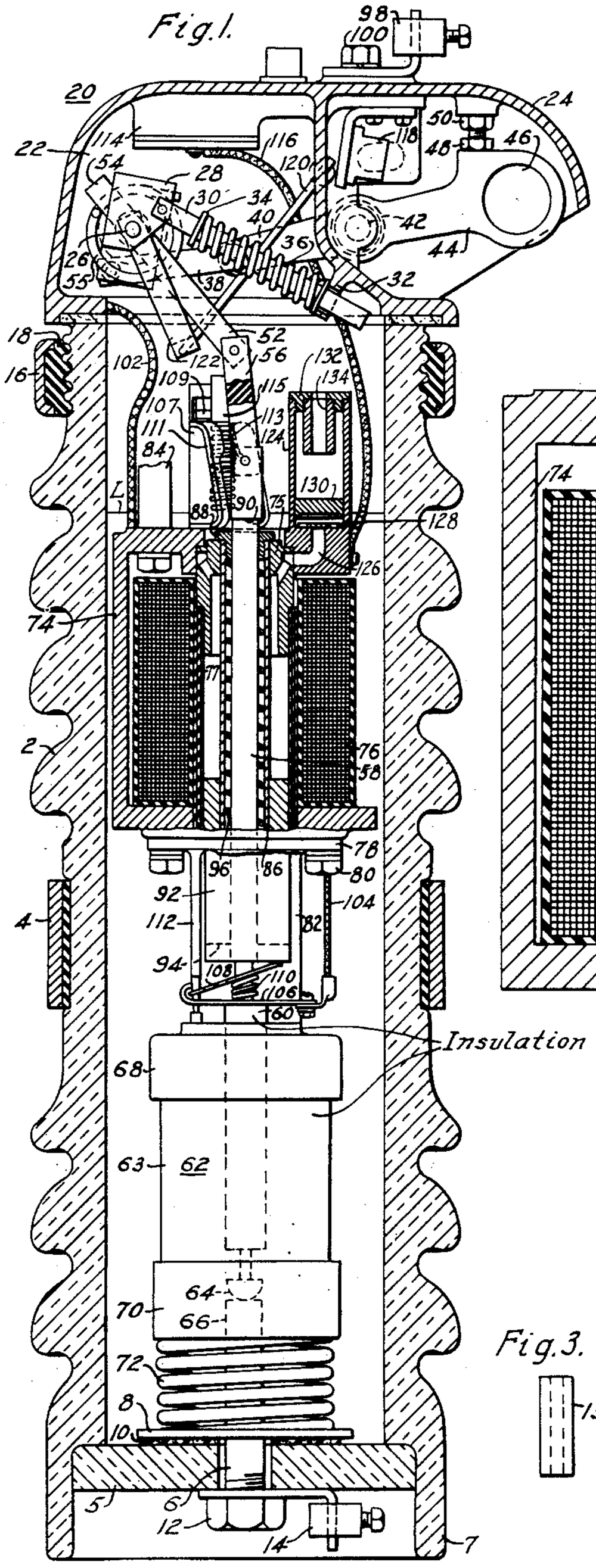


Fig. 2.

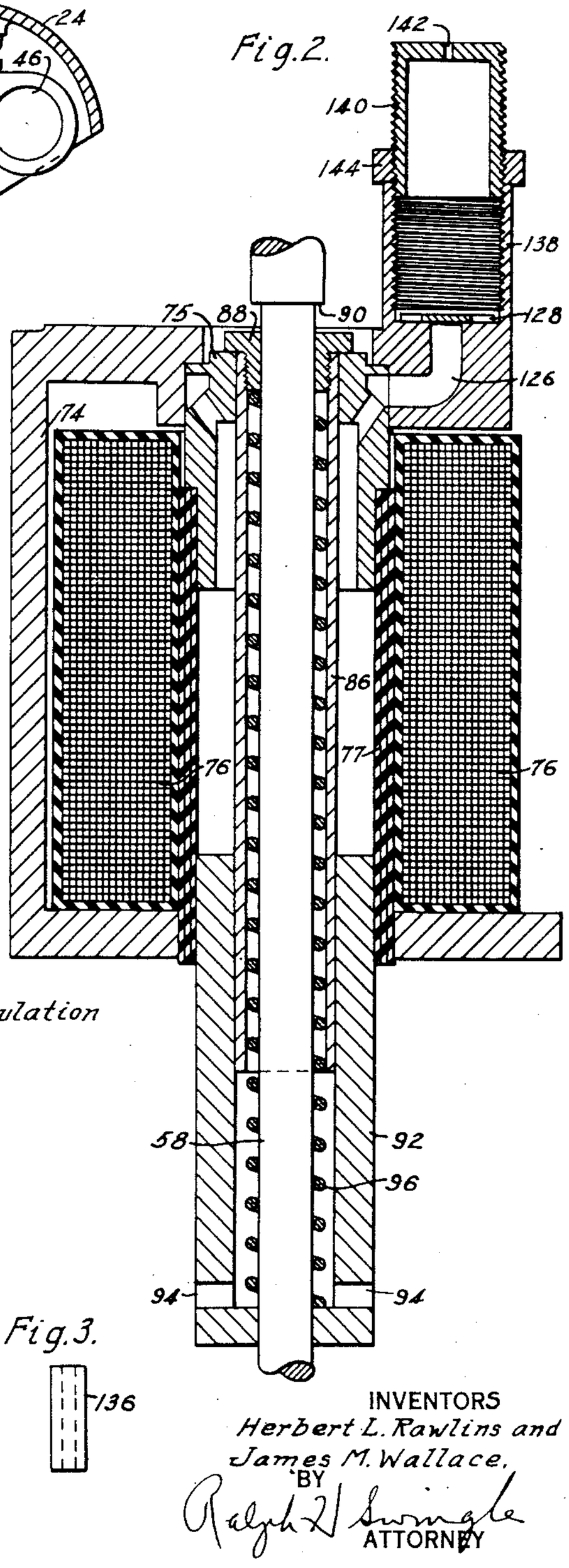


Fig. 3.




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Patented Jan. 6, 1953

2,624,817

# UNITED STATES PATENT OFFICE

2,624,817

## CIRCUIT INTERRUPTER

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Application July 2, 1945, Serial No. 602,876

22 Claims. (Cl. 200—89)

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This invention relates generally to automatic reclosing electric circuit interrupters, and especially to novel means for causing opening of the interrupter at different times after the occurrence of a predetermined circuit condition on predetermined circuit opening operations in any sequence of closely succeeding circuit opening operations.

In our copending application Serial No. 537,760, filed May 27, 1944, now Patent No. 2,549,336, dated April 17, 1951, on Circuit Interrupters, which is assigned to the same assignee as this invention, there is disclosed an automatic reclosing circuit interrupter having fluid dashpot means for delaying circuit closing operations and certain circuit opening operations in any sequence of closely successive operations of the interrupter. This invention relates to an interrupter of the same general type disclosed in our copending application, and especially to certain modifications in the control of means for delaying circuit opening and closing operations.

One object of this invention is to provide in an automatic reclosing circuit interrupter, novel means for delaying at least one predetermined circuit opening operation in any sequence of closely succeeding circuit opening operations, but which is ineffective to delay another predetermined circuit opening operation in any such sequence of operations.

Another object of this invention is to provide in an automatic reclosing circuit interrupter, a single time delay means controlled in a novel manner for delaying each circuit closing operation of the interrupter, and for delaying at least one predetermined circuit opening operation in any sequence of closely successive circuit opening operations, but which is rendered ineffective to delay another predetermined circuit opening operation in any such sequence of operations.

A more specific object of this invention is to provide in an automatic reclosing circuit interrupter having time delay means actuated each time the interrupter operates to open the circuit for delaying opening of the circuit by said interrupter, with means permitting relatively free operation of at least a part of said time delay means on at least one predetermined circuit interrupting operation in any sequence of closely successive circuit interrupting operation, and causing more restrained operation of said time delay means on at least another predetermined circuit opening operation in any such sequence.

Another object of this invention is to provide in an automatic reclosing circuit interrupter having a fluid dashpot adapted to be actuated each time the interrupter operates to open the circuit, novel means for varying the delaying effect of said dashpot.

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Still another object of this invention is to provide in an automatic reclosing circuit interrupter, novel means for predetermining the particular circuit opening operation or operations in any series of closely successive operations which are to be delayed relative to another opening operation in such a series.

Another object of this invention is to provide in an automatic reclosing circuit interrupter having means for causing relatively fast and slow circuit interrupting operations thereof in a predetermined sequence of a plurality of closely successive circuit interrupting operations, novel selective means for causing all circuit interrupting operations of the interrupter to occur at the same rate.

These and other objects of this invention will become more apparent upon consideration of the following description of preferred embodiments thereof, when taken in connection with the attached drawing, in which:

Figure 1 is a longitudinal sectional view of a reclosing circuit interrupter embodying this invention;

Fig. 2 is an enlarged partial longitudinal section view of a reclosing interrupter like that shown in Fig. 1, but illustrating another embodiment of the invention; and

Fig. 3 is an elevation view of a part which may be employed in the interrupter shown in Fig. 1.

As previously stated, this invention is capable of application to automatic reclosing circuit interrupters generally, and is illustrated herein as being embodied in an interrupter similar to that shown in the aforementioned copending application, certain features of which are more clearly disclosed in J. M. Wallace Patent 2,333,604, on a Circuit Interrupter, issued November 2, 1943, to the same assignee as this invention. This particular type of interrupter is adapted to be housed in a substantially cylindrical casing 2 of insulating material, such for example as porcelain or the like, with the casing adapted to be supported at an intermediate portion as by a supporting bracket 4. As viewed in Fig. 1, the lower end of casing 2 is closed by a closure disk 5 cemented or otherwise secured against a shoulder provided in the lower end of casing 2, at a distance above the lower end of the casing, so as to provide a skirt 7 for concealing the lower terminal connection. Bottom closure disk 5 for casing 2 is provided

with a central aperture for receiving a terminal bolt 6 having an enlarged head 8 adapted to be seated against the closure disk on a compressible gasket 10, of rubber or similar compressible sealing material. Terminal bolt 6 is provided with a nut 12 for securing it in place, and for securing a terminal fixture 14 thereto.

Adjacent the upper end of casing 2 there is provided a channeled supporting ring 16 secured to the casing in any desired manner, such for example as by cast metal 18 interlocking with the channeled ring and with peripheral grooves provided about the upper end of casing 2. A cover casting 20 for the upper end of casing 2 is adapted to be secured on the upper end of casing 2 by any desired means, such as by bolts or the like (not shown) cooperating with the cover casting 20 and supporting ring 16. Cover casting 20 is provided with a hollow chamber 22 opening to the interior of casing 2, and with an integral hood 24, for a purpose to be described.

Within chamber 22 of the cover casting there is provided a supporting shaft 26 extending transversely thereof with its ends mounted in opposite sides of the chamber, for pivotally supporting an inverted U-shaped spring support 28. Support 28 is provided with apertures in the leg portions thereof for pivotal mounting on shaft 26, and one leg is pivotally connected with one end of a rod 30, with the other end of the rod being slidable in the aperture of a lug 32 provided integral with cover casting 20. A spring supporting flange or disk 34 is secured on rod 30, to form the reaction point for one end of a coiled compression lockout spring 36, the other end of which reacts against a washer seated on lug 32. It will be observed that spring 36 acts to bias support 28 in a counterclockwise direction about shaft 26, but such movement of support 28 is normally prevented by toggie means comprising a toggle lever 38 pivotally connected to one leg of support 28 at one end, and pivoted at its other end to another toggle lever 40 which, in turn, is pivotally mounted on cover casting 20, as at 42. Toggle lever 40 is provided with an integral handle extension 44 having a hook-eye 46 in the outer end thereof and adapted, in its normal position shown in Fig. 1, to engage a stop bolt 48 provided beneath hood 24 which may be secured in an adjusted position by means of a lock nut 50. It will be noted that in the normal position of the parts illustrated in Fig. 1, toggle levers 38 and 40 are held at an overcenter position by spring 36, with handle 44 defining this overcenter position by its engagement with stop bolt 48. Moreover, in this position of the parts, handle 44 is located substantially entirely beneath hood 24.

A contact actuating lever 52 is also pivotally mounted on shaft 26 within cover chamber 22 and has its inner end 54 extended so as to be engaged by one end of a spring 55 coiled about shaft 26, with the other end of this spring reacting against the bight portion of support 28. Inasmuch as support 28 is normally held against movement by the toggle levers described above, it is apparent that spring 55 acts to normally bias actuating lever 52 in a clockwise direction about shaft 26. Actuating crank 52 is connected by links 56 of insulating material, such for example as fiber or the like, to the upper end of a contact rod 58. The contact rod extends downwardly through casing 2 and has adjacent its lower end at the point where it enters an interrupter chamber 62, a sleeve 60 thereon which



may be of any desired insulating material, such as fiber or a molded insulating material. The lower end of contact rod 58 is provided with a contact head 64 for engagement with a stationary contact 66 secured in the interrupter chamber. In general, the interrupter chamber 62 comprises a tubular member 63 of insulating material such as fiber or the like, with a top cap 68 apertured to slidably receive the contact rod and its sleeve 60, and a bottom cap 70 is provided to which stationary contact 66 is secured. Bottom cap 70 of the interrupter chamber is electrically connected with terminal bolt 6 by means of a coiled compression spring 72 of a resilient electrical conducting material, which reacts between the head 8 of terminal bolt 6, and bottom cap 70 of the interrupter chamber.

Contact rod 58 also passes downwardly through apertures provided in the legs of a generally U-shaped frame 74 which supports an annular solenoid coil 76. An apertured collar 75 is held against an interior shoulder provided about the aperture in the top leg of supporting frame 74 by a cylindrical dashpot sleeve 77, preferably of a molded insulating material, and this, in turn, is held in place by engagement with the lower end of sleeve 77 of the top plate 78 of a generally rectangular shaped supporting frame, which is secured to the lower leg of solenoid supporting frame 74 by means of bolts 80. Top supporting plate 78 may be integral with spaced side plates 82, and these, in turn, may be integral with top cap 68 of the interrupter chamber. Solenoid supporting frame 74 is thus secured to interrupter chamber 62, and these parts are all adapted to be supported from cover casting 20 by means of supports 84 connected between the top leg of frame 74 and the cover casting, so that all the parts may be inserted or removed from casing 2 as a unit with cover casting 20.

Contact rod 58 is provided with an actuating tube 86 thereon within solenoid coil 76, and the upper end of this tube has a flanged collar 88 adapted to be seated on top of collar 75 and to engage a shoulder 90 provided on the contact rod, for a purpose to be described. A substantially cylindrical core 92 is adapted to be slidably mounted between actuating sleeve 86 and dashpot sleeve 77 in a piston-like manner, and is normally maintained at the position shown on the drawing by a light coil compression spring 96, which reacts between the closed lower end of core 92 and collar 88 on actuating sleeve 86. The lower end of core 92 is provided with lateral vent openings 94, so that any fluid trapped within the core is free to escape during movement of the core.

The circuit through the interrupter thus far described extends from a terminal fixture 98 secured by a bolt 100 to cover casting 20, by way of a flexible conductor 102 to one terminal of solenoid coil 76, and then by a flexible conductor 104 to a supporting plate 106 secured on contact rod 58. The circuit continues in the closed circuit position of the interrupter, to fixed contact 66 through spring 72 to terminal bolt 6 and terminal fixture 14. It will be observed that solenoid coil 76 being connected in series in the circuit through the interrupter will be responsive to overloads above a predetermined value to exert sufficient force to attract solenoid core 92 upwardly. Upward movement of core 92 results first in compressing light coiled spring 96 until the bottom of the core engages the lower

end of actuating sleeve 86 which is then raised into engagement with shoulder 90 on contact rod 58 to separate contact head 64 from fixed contact 66. This causes an arc to form between the contacts and to cause further upward movement of contact rod 58 due to pressure built up within interrupter chamber 62, in a manner more particularly described in the previously mentioned Wallace patent. Upward movement of contact rod 58 stresses spring 55 so that when the arc is finally extinguished and solenoid coil 76 is deenergized, spring 55 is free to move contact rod 58 downwardly to reclose the circuit.

Opening and closing of the interrupter in the manner described above would continue indefinitely on continuing overloads, and to avoid this an integrating means is provided, comprising a tubular member 107 secured on the top leg of solenoid supporting frame 74, with a notched piston 109 therein adapted to be advanced each time the circuit opens by a generally U-shaped pawl 111, guided for sliding and tilting movement on a guide rod 115 also secured to the upper leg of frame 74. Pawl 111 is normally held at a position where a portion thereof overlies flanged collar 88 on actuating sleeve 86, by a coiled compression spring 113 mounted on guide rod 115. A check valve control inlet (not shown) is provided for the lower end of tubular member 107 so that when the interrupter operates to open the circuit and actuating sleeve 86 is moved upwardly, the flanged collar 88 tilts pawl 111 into engagement with a notch of piston 109 and moves it upwardly a predetermined distance where it remains when the contacts reclose. There is some leakage between piston 109 and tubular member 107 so that if the fault clears upon a first circuit reclosing operation, the piston 109 will slowly sink back to its original position. However, if the fault has not cleared upon the first reclosure of the interrupter, it will immediately reopen and this time pawl 111 will engage a lower notch of piston 109 and raise it a further amount. If the fault is still present on the second reclosure of the interrupter, it will continue to open and close the circuit until piston 109 has been advanced an amount sufficient that the upper end thereof engages toggle lever 38 and moves this toggle lever upwardly overcenter so as to permit lockout spring 36 to rotate support 28 counterclockwise and hold contact rod 58 at an open circuit position. Such an operation will cause handle 44 to project beneath hood 24 to present a readily visible indication of the lockout condition of the interrupter.

In order to provide a time delay for a circuit opening and closing operations of the interrupter, use is made of the operation of core 92 in dashpot sleeve 77, and of the liquid displaced by movement of the core. For the purpose of delaying a circuit closing operation, contact rod 58 has a latch plate 108 pivotally mounted on supporting plate 106 of the rod, and latch plate 108 has a relatively large opening for receiving the contact rod to permit pivotal movement thereof, it being normally biased upwardly by a coiled compression spring 110. Latch plate 108 is also provided adjacent its pivot point with an aperture for receiving a latch rod 112 fixedly mounted between cap 68 of the interrupter chamber and support plate 78. The lower end of latch rod 112 is reduced in section, and the aperture in the latch plate which receives rod 112 is of a size such that upon movement of contact rod 58 to an open circuit position, latch plate 108



may pivot in a clockwise direction while compressing spring 110 to relieve any tendency of the aperture therein to bind on latch rod 112. However, upon an attempted reclosing movement of contact rod 58, latch plate 108 will bind on rod 112 due to the action of spring 110, to thereby latch the contact rod in an open circuit position. This latch is adapted to be released by downward movement of solenoid core 92, when the lower end thereof engages the outer end of latch plate 108. However, downward movement of core 92 is relatively slow due to its dashpot action in cooperation with sleeves 77 and 86, so that reclosing movement of contact rod 58 will be correspondingly slow until the reduced section at the lower end of latch rod 112 is reached, whereupon latch plate 108 can no longer bind on latch rod 112 and contact head 64 will rapidly move into final engagement with fixed contact 66.

The interrupter may be provided with certain accessories, such as a support 114 for a lightning arrester unit electrically connected between the cover casting and frame 74 by a conductor 116, so that lightning surges will by-pass solenoid 76 and operation of the interrupter will be prevented. A counter 118 may also be provided supported beneath hood 24 for actuation by a link 120 connected with an actuating lever 122 which is pivoted on shaft 26. Lever 122 may be movable with actuating lever 52 so as to register the number of operations of the interrupter on counter 118, which is visible from the exterior of the interrupter.

For the purpose of providing a time delay between the occurrence of an overload sufficient to attract core 92 upwardly and cause a circuit interrupting operation, and the time the contacts are actually separated, collar 75 and the upper leg of supporting frame 74 are provided with a passage 126 leading from the upper end of the dashpot space between sleeves 77 and 86 to a tubular chamber 124, which may be integrally formed with the top leg of support 74. Passage 126 is provided at the end thereof within tubular chamber 124 with a check valve disk 128 adapted to be seated thereon and permit flow of fluid solely in a direction into chamber 124. A piston 130 is freely slidably mounted in chamber 124, and the upper end of the chamber is provided with a cap 132 threadedly mounted thereon and having a substantially central aperture adapted to line up with the bore through a short tubular extension 134 threadedly associated with cap 132.

In operation, with casing 2 filled with an arc extinguishing fluid such as oil or the like, up to the level L, it will be observed that normally substantially no liquid will be present in chamber 124, so that when solenoid core 92 is attracted upwardly to interrupt the circuit, the liquid displaced thereby will be forced through passage 126 to unseat check valve 128 and move piston 130 upwardly a distance substantially into engagement with the lower end of tubular extension 134. When core 92 moves downwardly during a circuit closing operation check valve 128 will seat on the upper end of passage 126 to thus close the upper end of the dashpot space between sleeves 77 and 86, so that downward movement of core 92 will be relatively slow since liquid must be drawn into the dashpot space past the relatively small clearances between core 92 and sleeves 77 and 86. If the interrupter remains closed after a first circuit interruption and reclosing operation, piston 130 will gradually sink

back to its normal lower position due to the weight thereof, but this movement will also be quite slow due to the necessity of displacing liquid below the piston past the relatively small clearance between piston 130 and chamber 124. However, if the fault has not cleared and the interrupter immediately reopens the circuit, piston 130 will be in engagement with the lower end of tubular extension 134 to thus block further upward movement of piston 130. This means that upward movement of core 92 will be much slower than on the first interruption due to the necessity of forcing liquid trapped in the dashpot space past the relatively small clearances between core 92 and sleeves 77 and 66. Thus, with the structure disclosed, the interrupter will always operate on closely succeeding interrupting operations to separate the contacts at a relatively rapid rate on the first such interrupting operation, and at a slower rate on succeeding operations. However, if the fault clears before automatic lockout of the breaker occurs, piston 130 will reset so that the next time a continuing fault occurs, the same sequence of a first fast, and subsequent slower interrupting operations will occur.

The structure illustrated in Fig. 1 is also capable of providing other sequential arrangements of fast and slow circuit interruptions on closely succeeding interrupting operations, for example by removing tubular extension 134, it will require two closely successive circuit opening operations to advance piston 130 into engagement with cap 132 to block further upward movement so that with extension 134 removed, a sequence of a first and second relatively rapid circuit interrupting operations will occur followed by subsequent time delayed circuit interrupting operations. Moreover, by removing piston 130 from chamber 124 all circuit interrupting operations will occur relatively rapidly since liquid may freely move out through passage 126. Similarly, all circuit interrupting operations of the interrupter may be caused to be delayed by the dashpot action of the solenoid core 92 by substituting for tubular extension 134 the extension 136 shown in Fig. 3, which is long enough when in place to engage and hold piston 130 at its lowermost position.

A modified arrangement for obtaining different circuit opening times is illustrated in Fig. 2, and since most of the parts illustrated therein are identical with those shown in Fig. 1, like reference numerals are employed to designate such like parts. In this embodiment of the invention, the upper leg of supporting frame 74 is provided with a short tubular chamber 138 having interior threads for cooperation with a chamber extension 140 having exterior threads, so as to be threadedly mounted in chamber 138. The upper end of chamber extension 140 is closed except for a restricted vent opening 142, for a purpose to be described. Chamber extension 140 may be threaded into chamber 138 any desired amount, and be secured at an adjusted position by means of a lock nut 144.

The operation of the embodiment of the invention shown in Fig. 2 is similar to that shown in Fig. 1, in that on a first circuit interrupting operation liquid is forced from the dashpot space by upward movement of core 92, into chamber 138 by displacement of check valve 128. This forcing of liquid into chamber 138 is substantially unopposed, because the air in the chamber may freely escape from vent 142. The adjustment of



chamber extension 140 shown in Fig. 2 is substantially such that two closely successive circuit interrupting operations are required to entirely fill the chamber and extension 140 with liquid. This means that the first two circuit interrupting operations will occur substantially instantaneously, but if a third interrupting operation is attempted immediately after the second, it will be delayed, because chamber 138 and extension 140 being filled with liquid it will be necessary to force this liquid through restricted vent 142, and since the liquid has a much higher viscosity than air, the upward movement of core 92 will be correspondingly delayed. This, of course, will delay the third interrupting operation and any subsequent closely successive circuit interrupting operations. In the event the fault clears before automatic lockout of the interrupter occurs, liquid in chamber 138 may gradually leak back past check valve plate 128 until finally the chamber is again filled with air, so that if a continuing fault occurs at a later time the same sequence of closely successive circuit interrupting operations will occur, namely, a first and second relatively rapid interruption, and subsequent interruptions delayed by the dashpot action of core 92. The liquid level is preferably substantially coincident with plate 128.

It will be observed that in both embodiments of the invention check valve disk 128 operates to cause dashpot control of every circuit closing operation. The control for timing of circuit interrupting operations disclosed in the embodiment of the invention shown in Fig. 2 is capable of adjustment to obtain a different sequence of relatively rapid and slow interrupting operations similar to the adjustments obtainable with the embodiment of the invention shown in Fig. 1. Thus, by turning chamber extension 140 in a direction to telescope further into chamber 138, the chamber and extension may be made small enough so as to be filled with liquid during a first circuit interrupting operation so that the second and closely succeeding interruptions will be delayed. If chamber extension 140 is threaded all the way into chamber 138 to engage check valve disk 128, it is apparent that all circuit interrupting operations will be delayed by the dashpot action of core 92, since check valve 128 will be held closed. Moreover, by entirely removing extension 140 from chamber 138, all circuit interrupting operations will occur substantially instantaneously.

From the foregoing, it is apparent that the invention disclosed herein provides in an automatic reclosing circuit interrupter, a single dashpot means for delaying all closing operations of the interrupter, and for delaying certain opening operations in any series of closely successive opening operations. Moreover, the control for timing the circuit opening operations may be adjusted to obtain a first instantaneous and subsequent time delayed openings, or to provide for the first two circuit openings to be instantaneous in character with the subsequent openings time delayed, or to provide for all openings to be substantially instantaneous, or to be time delayed.

Having described preferred embodiments of the invention, in accordance with the patent statutes, it is desired that this invention be not limited to these particular embodiments inasmuch as it will be readily apparent, especially to persons skilled in the art, that many modifications and changes may be made in these particular struc-

tures without departing from the broad spirit and scope of the invention.

We claim as our invention:

1. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the free passage of fluid displaced by operation of said dashpot means throughout a circuit interrupting operation, means preventing free flow of said displaced fluid in a reverse direction, and means actuated by the fluid displaced through said vent means during a predetermined circuit interrupting operation to close said vent means, whereby the next closely succeeding circuit interrupting operation will be delayed by said dashpot means.

2. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a chamber freely communicating with said dashpot means being of a size to relatively freely receive only a predetermined amount of fluid displaced by operation of said dashpot means, which is greater than the amount of fluid displaced during a single operation, one-way valve means permitting free flow of displaced liquid into said chamber but preventing outflow, whereby said dashpot is substantially ineffective to delay separation of said contacts until a predetermined circuit interrupting operation when said predetermined amount of fluid has been displaced by said dashpot means.

3. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separating of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a vented chamber freely communicating with said dashpot means so as to relatively freely receive fluid displaced by operation of said dashpot means, and means in said chamber responsive to the presence in said chamber of a predetermined quantity of said fluid which is greater than the amount of fluid displaced during a single operation for restricting said chamber vent, one-way valve means permitting free flow of displaced liquid into said chamber but preventing outflow, whereby said contacts are relatively quickly separated until said predetermined quantity of fluid has been displaced by said dashpot means, whereupon the next circuit opening operation will be relatively slow.

4. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a vented chamber freely communicating with said



dashpot means so as to relatively freely receive fluid displaced by operation of said dashpot means, one-way valve means permitting free flow of displaced liquid into said chamber but preventing outflow, said chamber normally containing a less viscous fluid than that employed by said dashpot means, the vent for said chamber being of a size to impede the flow of dashpot fluid therefrom but affording substantially no resistance to the escape of said less viscous fluid, so that said contacts are relatively quickly separated until said chamber is filled with said displaced liquid, after which they are relatively slowly separated.

5. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a chamber freely communicating with said dashpot means so as to relatively freely receive only a predetermined amount of fluid displaced by operation of said dashpot means which is greater than the amount of fluid displaced during a single operation, means whereby said displaced fluid may relatively slowly leak out of said chamber so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid.

6. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a vented chamber freely communicating with said dashpot means so as to relatively freely receive fluid displaced by operation of said dashpot means, means whereby said displaced fluid may relatively slowly leak out of said chamber, and means in said chamber responsive to the presence in said chamber of a predetermined quantity of said fluid which is greater than the amount of fluid displaced during a single operation for restricting said chamber vent, so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid.

7. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a chamber having a restricted vent, said vented chamber freely communicating with said dashpot means so as to relatively freely receive only a predetermined quantity of fluid displaced by operation of said dash pot means which is greater

than the amount of fluid displaced during a single operation, said chamber normally containing a less viscous fluid than that employed by said dashpot means, the vent for said chamber being of a size to impede the flow of dashpot fluid therefrom but affording substantially no resistance to the escape of said less viscous fluid, means whereby said displaced fluid may relatively slowly leak out of said chamber, so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid.

8. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the free passage of fluid displaced by operation of said dashpot means, means preventing free flow of said displaced fluid in a reverse direction, and means responsive to an amount of fluid displaced by said dashpot through said vent means in a predetermined time which is greater than the amount of fluid displaced during a single operation for closing said vent means so that at least one predetermined circuit interrupting operation in any series of relatively closely successive circuit interrupting operations will be delayed by said dashpot means.

9. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the passage therethrough of fluid displaced by operation of said dashpot means, means preventing free flow of said displaced fluid in a reverse direction, means responsive to the amount of fluid displaced by said dashpot means through said vent means in a predetermined time which is greater than the amount of fluid displaced during a single operation for restricting said vent means so that at least one predetermined circuit interrupting operation in any series of relatively closely successive circuit interrupting operations will be delayed by said dashpot means, and said last-mentioned means having a manually adjustable part for determining the number of circuit interrupting operations in any such series of closely successive operations which are delayed by said dashpot means.

10. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a chamber freely communicating with said dashpot means so as to relatively freely receive only a predetermined amount of fluid displaced by operation of said dashpot means, which is greater



than the amount of fluid displaced during a single operation, means whereby said displaced fluid may relatively slowly leak out of said chamber so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid, and means whereby said predetermined amount of fluid may be varied for determining said predetermined circuit interrupting operation.

11. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a vented chamber communicating with said dashpot means so as to relatively freely receive fluid displaced by operation of said dashpot means during a circuit interrupting operation, means whereby said displaced fluid may relatively slowly leak out of said chamber, means in said chamber responsive to the presence in said chamber of a predetermined quantity of said fluid which is greater than the amount of fluid displaced during a single operation for restricting said chamber vent, so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid, and said quantity responsive means being adjustable to thereby determine said predetermined circuit interrupting operation.

12. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, a vented chamber communicating with said dashpot means so as to relatively freely receive fluid displaced by operation of said dashpot means, said chamber normally containing a less viscous fluid than that employed by said dashpot means, the vent for said chamber being of a size to impede the flow of dashpot fluid therefrom but affording substantially no resistance to the escape of said less viscous fluid, means whereby said displaced fluid may relatively slowly leak out of said chamber so that said dashpot means is substantially ineffective to delay widely separated circuit interrupting operations of said interrupter but is operative to delay a predetermined circuit interrupting operation in any series of closely successive circuit interrupting operations when said dashpot means has filled said chamber with said predetermined amount of fluid, and said chamber being adjustable in size to thereby determine said predetermined circuit interrupting operation.

13. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for

automatically reclosing said contacts following circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, means preventing free flow of said displaced fluid in a reverse direction, means responsive to an amount of fluid displaced by said dashpot in a predetermined time which is greater than the amount of fluid displaced during a single operation for restricting said vent means so that at least one predetermined circuit interrupting operation in any series of relatively closely successive circuit interrupting operations will be delayed by said dashpot means, and manually adjustable means for rendering said fluid responsive means inoperative, whereby all circuit opening operations of said interrupter may occur relatively rapidly.

14. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, means preventing free flow of said displaced fluid in a reverse direction, means responsive to an amount of fluid displaced by said dashpot in a predetermined time which is greater than the amount of fluid displaced during a single operation for closing said vent means so that at least one predetermined circuit interrupting operation in any series of relatively closely successive circuit interrupting operations will be delayed by said dashpot means, and manually adjustable means for closing said vent means so that all circuit interrupting operations of said interrupter can be delayed by said dashpot means.

15. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, means preventing free flow of said displaced fluid in a reverse direction, means responsive to an amount of fluid displaced by said dashpot in a predetermined time which is greater than the amount of fluid displaced during a single operation for closing said vent means so that at least one predetermined circuit interrupting operation in any series of relatively closely successive circuit interrupting operations will be delayed by said dashpot means, and manually adjustable means for selectively rendering said fluid responsive means inoperative or for closing said vent means, so that all circuit opening operations may occur relatively rapidly, or all may be delayed by said dashpot means.

16. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, valve means responsive to a circuit interrupting operation of said interrupter to open said vent means and being responsive to a circuit closing operation of said interrupter to substantially close said vent means, whereby at least circuit closing operations of said interrupter are delayed by said dashpot means, means responsive to one predetermined circuit opening operation of said interrupter to restrict said vent means, said operation responsive means being biased to slowly return to its normal position where it is inoperative to restrict said vent means, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, and said operation responsive means having a manually adjustable part for preventing operation of said operation responsive means so that no circuit interrupting operations of said interrupter will be delayed by said dashpot means.

17. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, valve means responsive to a circuit interrupting operation of said interrupter to open said vent means and being responsive to a circuit closing operation of said interrupter to substantially close said vent means, whereby at least circuit closing operations of said interrupter are delayed by said dashpot means, means responsive to one predetermined circuit opening operation of said interrupter to restrict said vent means, said operation responsive means being biased to slowly return to its normal position where it is inoeprative to restrict said vent means, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, and said operation responsive means having a manually adjustable part for closing said vent means at all times so that all opening and closing operations of said interrupter will be delayed by said dashpot means.

18. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith which is open during a circuit interruption operation for the passage therethrough of fluid displaced by operation of said dashpot means, valve means responsive to a cir-

cuit interrupting operation of said interrupter to open said vent means and being responsive to a circuit closing operation of said interrupter to substantially close said vent means, whereby at least circuit closing operations of said interrupter are delayed by said dashpot means, means responsive to one predetermined circuit opening operation of said interrupter to close said vent means, said operation responsive means being biased to slowly return to its normal position where it is inoperative to close said vent, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, and said operation responsive means having a manually adjustable part for closing said vent means at all times or for preventing operation of said operation responsive means, so that all opening and closing operations of said interrupter will be delayed by said dashpot means, or for preventing the delay of any circuit interrupting operation by said dashpot means.

19. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the passage therethrough of fluid displaced by operation of said dashpot means during a circuit interrupting operation, means preventing free flow of said displaced fluid in a reverse direction, means responsive to one predetermined circuit opening operation of said interrupter to restrict said vent means so that the succeeding circuit interrupting operation will be delayed by said dashpot means, said operation responsive means being biased to slowly return to its normal position where it is inoperative to restrict said vent means, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, said operation responsive means having a manually adjustable part, means for preventing operation of said operation responsive means so that no circuit interrupting operations of said interrupter will be delayed by said dashpot means.

20. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the passage therethrough of fluid displaced by operation of said dashpot means during a circuit interrupting operation, means responsive to one predetermined circuit opening operation of said interrupter to restrict said vent means so that the successive circuit interrupting operation will be delayed by said dashpot means, a part of said operation responsive means being biased to slowly return to its normal position where it is inoperative to close said vent, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, and manually adjustable means for closing said vent means at all times so that all opening and closing operations of said interrupter will be delayed by said dashpot means.



21. In an automatic reclosing circuit interrupter having separable contacts, means responsive to a predetermined circuit condition for causing separation of said contacts, means for automatically reclosing said contacts following a circuit interrupting operation, fluid dashpot means for delaying separation of said contacts after the occurrence of said predetermined condition, said dashpot means having vent means associated therewith for the passage therethrough of fluid displaced by operation of said dashpot means during a circuit interrupting operation, means responsive to one predetermined circuit opening operation of said interrupter to restrict said vent means so that the succeeding circuit interrupting operation will be delayed by said dashpot means, a part of said operation responsive means being biased to slowly return to its normal position where it is inoperative to close said vent, whereby only a circuit opening operation closely succeeding said one operation will be delayed by said dashpot means, and manually adjustable means for closing said vent means at all times or for preventing operation of said operation responsive means so that all opening and closing operations of said interrupter will be delayed by said dashpot means, or for preventing the delay of any circuit interrupting operation by said dashpot means.

22. An automatic reclosing circuit breaker comprising, separable contacts, means responsive to an overload on the circuit for automatically separating said contacts to open the circuit, means responsive to a circuit-opening operation for automatically closing said contacts, means responsive to a predetermined number of closely successive circuit opening operations for maintaining said contacts separated, fluid pumping means actuated by said contact separating means for supplying fluid to a counter cylinder, a counting piston in said cylinder biased to a normal position from which it is advanced a predetermined amount by the fluid supplied by said pumping means on each circuit-opening operation of the breaker, and a mechanical stop positioned to be engaged by said piston when advanced a farther amount by a number of closely succeeding circuit-opening operations of said breaker which is less than said predetermined number to prevent further movement of said piston, whereby the next closely succeeding circuit-opening operation will be delayed by the thus imposed resistance to fluid flow from said pumping means to said counting cylinder.

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## REFERENCES CITED

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

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 508,652 | Thomson | Nov. 14, 1893 |
| 640,062 | Winfield | Dec. 26, 1899 |
| 835,025 | Jackson | Nov. 6, 1906 |
| 1,638,517 | Bauer | Aug. 9, 1927 |
| 2,061,170 | Post | Nov. 17, 1936 |
| 2,333,604 | Wallace | Nov. 2, 1943 |
| 2,477,067 | Kyle, Jr., et al. | July 26, 1949 |
| 2,560,529 | Van Ryan et al. | July 10, 1951 |
| 2,560,831 | Van Ryan et al. | July 17, 1951 |