Oct. 30, 1956 J. M. WALLACE ET AL 2,769,055

AUTOMATIC RECLOSING CIRCUIT BREAKERS

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Fig.2.

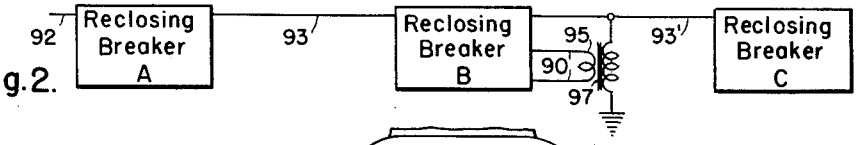

Fig.1.

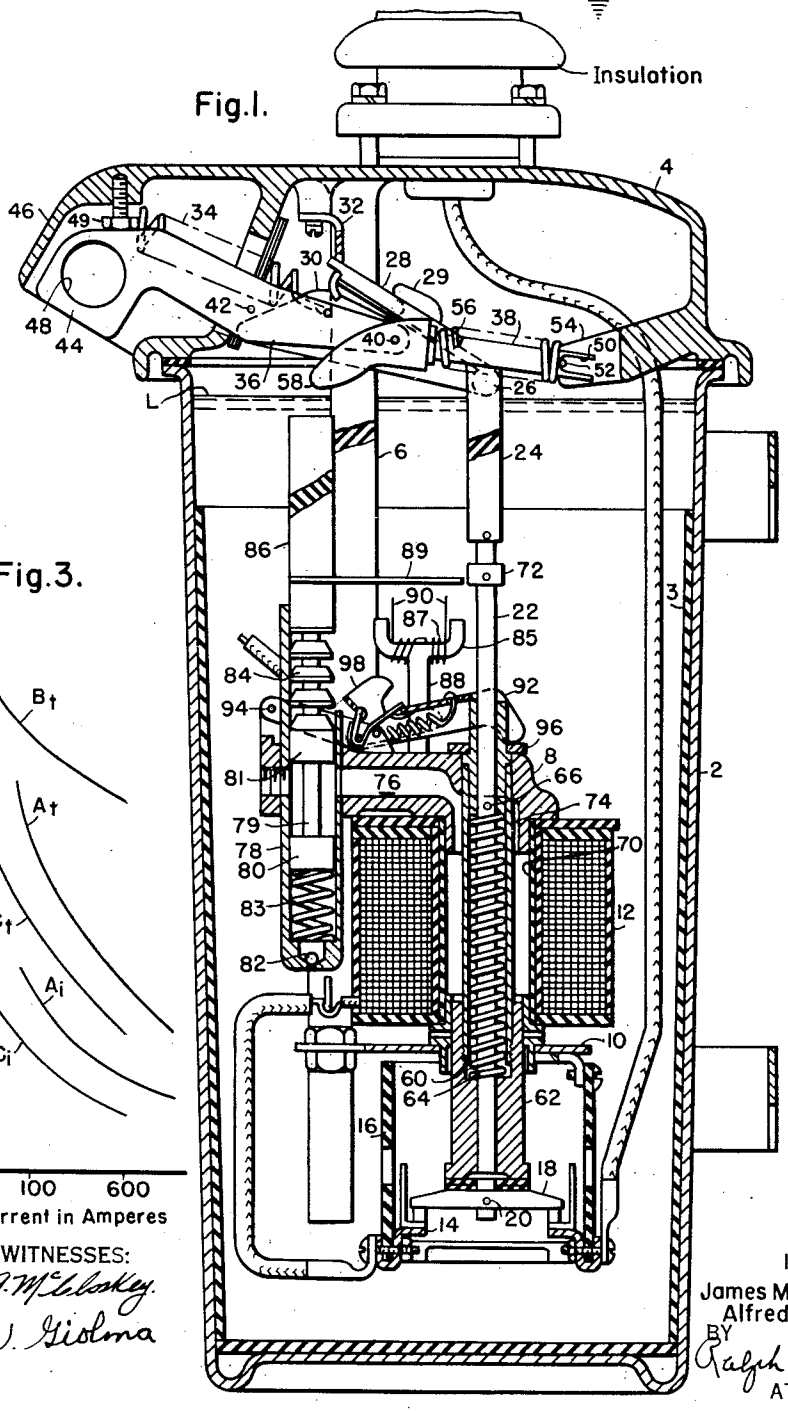

Fig.3.

WITNESSES:

E. A. McCloskey.

F. V. Giolma

INVENTORS

James M. Wallace and Alfred R. McClung.

BY Ralph W. Swingle

ATTORNEY

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AUTOMATIC RECLOSING CIRCUIT BREAKERS

James M. Wallace, Pittsburgh, Pa., and Alfred R. McClung, Smithers, W. Va., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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Our invention relates, generally, to circuit interrupters, and it has reference in particular to circuit interrupters of the automatic reclosing type which may be connected for sectionalizing a distribution line.

In applying automatic reclosing circuit breakers to distribution lines, it is generally customary to have them operate with one or more instantaneous operations and to arrange them in descending order of ratings, as they are located more distant from the source, so that each will coordinate with the preceding one. Practical limitations are placed on the number of different ratings by the margin between ratings necessary to avoid possible overlap, because of variations due to manufacturing tolerances. If a high degree of sectionalizing of a line is desired, the length of line which may be protected with reclosing breakers of standard ratings will necessarily be short. A device which could be applied between reclosing breakers of the usual ratings would double the possible number of such sectionalizing points on a line.

Accordingly, it is an object of our invention to provide an automatic reclosing circuit breaker whose operating characteristics vary with operating conditions of the circuit.

Another object of our invention is to provide an automatic reclosing circuit breaker which operates in response to currents in excess of a predetermined value under one operating condition, and operates in response to a much lower value of current under another condition.

Yet another object of our invention is to provide in an automatic reclosing circuit breaker for so controlling the operation thereof as to effect delayed operation in response to predetermined current conditions when the line voltage is above a certain value, and instantaneous operation in response to predetermined current conditions when the line voltage drops below a normal value.

We further propose as an object of our invention to provide in an automatic reclosing circuit breaker for utilizing electromagnetic means responsive to the voltage of the circuit at the breaker for maintaining a time delay device in a maximum delay position if the voltage remains at a normal value.

Another important object of our invention is to provide in an automatic reclosing circuit breaker of the type having dashpot delay means with counting means operable to vent the dashpot, for biasing the counting means to the venting position and utilizing electromagnetic restraining means for opposing the action of the biasing means, so as to maintain the timing means in the delayed operation position so long as the voltage of the circuit does not fall below a critical value.

A further object of our invention is to provide in a distribution system for using a recloser which normally has greater time delay than a succeeding breaker of the same rating, but which knows when a breaker ahead of it operates, and thereupon changes its characteristics to provide for instantaneous operations.

These and other objects of this invention will become

apparent upon consideration of the following detailed description of preferred embodiments thereof, when taken in connection with the attached drawing, in which:

Figure 1 is a longitudinal section view through a circuit breaker embodying this invention;

Fig. 2 is a schematic showing of a distribution circuit with a typical arrangement of automatic reclosing circuit breakers illustrating an application of the breaker of Fig. 1;

Fig. 3 is a chart showing typical time-current curves for the circuit breakers of Fig. 2.

The circuit breaker illustrated in Fig. 1 is contained in a metal tank **2** having an open top adapted to be covered by a hollow cover structure **4** which may be secured to tank **2** in any desired manner. Preferably, the major part of the interior of tank **2** is covered by a suitable insulating liner **3**, of any desired insulating material, such as fiber or the like. The tank **2** may be filled with a suitable insulating liquid such as oil or the like, as designated by the liquid level line L. The circuit breaker operating mechanism is all adapted to be mounted on the cover **4**, which may have supports **6** (only one of which is shown), at least partly of insulating material for supporting a supporting casting **8** and a supporting plate **10** between which a solenoid coil **12** may be mounted. Stationary contacts **14** for the breaker may in turn be suspended from supporting plate **10** by means of a tube **16** of insulating material, such as fiber or the like.

A bridging contact bar **18** is adapted to bridge stationary contacts **14**, and is mounted on the lower end of a contact rod **22**, as by a pivot **20**, about which the bridging contact may have limited pivotal movement. The upper end of contact rod **22** is connected by a pair of pivoted connecting links **24** of insulating material, such as fiber or the like, to the common pivot **26** of a pair of toggle levers **28** and **30**. Toggle lever **28** is adapted to be held in engagement with a pivot bracket **32** supported from cover **4**, by a coil tension spring **34** secured at one end to cover **4**, and at the other end engaging an opening in toggle lever **30**.

Spring **34** acts, at the position of the parts shown in Fig. 1, to bias bridging contact **18** into engagement with stationary contacts **14** of the breaker with a predetermined pressure. However, if contact rod **22** is moved upwardly, the pivot point **26** of toggle levers **28** and **30** moves upwardly with the contact rod and this movement is opposed by contact pressure spring **34**. However, the line of action of contact pressure spring **34** approaches the on-center position of toggle levers **28** and **30** during the first part of contact opening movement, so that the opposition of this spring to such opening movement rapidly decreases to substantially zero when the toggle levers are at their on-center position. The contact separating movement required to move toggle levers **28** and **30** from their positions shown in Fig. 1 to their on-center position is kept small because separation of these levers is limited by a hook portion **29** on toggle lever **30** which extends through an opening in toggle lever **28** to limit separation of the levers to a relatively small amount. Furthermore, during the first part of contact separating movement, the levers **28** and **30** are moved to their on-center position as described above, and at this position, lever **30** engages lever **28** so that further relative movement in the same direction is prevented, and accordingly, contact pressure spring **34** offers substantially no opposition to further contact separation.

After a circuit opening operation by contact rod **22**, the force of gravity acts on bridging contact **18** and contact rod **22** to cause these parts to move downwardly toward stationary contacts **14**. As is the case during the latter part of contact separating movement, contact pres-

sure spring 34 will have substantially no effect on the circuit closing operation, until the line of action of contact pressure spring 34 moves below the pivot point of toggle lever 28 on bracket 32, whereupon this spring becomes effective suddenly to rapidly move the bridging contact 18 into engagement with stationary contacts 14 and to exert the aforementioned contact pressure thereon.

In order to manually operate the circuit breaker contacts, and also to provide for a locked-open condition of the breaker, there is provided a pair of toggle levers 36 and 38 connected by a knee pivot pin 40, with lever 36 being pivotally mounted in cover 4, as by a pivot pin 42, and being extended beyond this pivot pin to the exterior of cover 4 where it normally is positioned beneath a hood portion 46 integral with the cover. A handle extension 44 of lever 36 has an operating eye 48 at the outer end thereof for receiving a hook stick or similar operating member. The other toggle lever 38 is provided with a slot 50 at its outer end for receving a pin 52 mounted between spaced supporting lugs 54 integral with cover 4. A coil compression lock-out spring 56 is mounted on toggle lever 38 so as to react between supporting lugs 54 and a shoulder provided at the inner end of toggle lever 38. Preferably, toggle lever 38 has an inwardly and downwardly extending operating extension 58 adapted to be engaged by automatic counting means, as will be described.

It will be observed that toggle levers 36 and 38 are shown in Fig. 1 of the drawing as being held at a position slightly below center by spring 56, with knee pivot 40 below a line drawn between pivot 42 of lever 36 and supporting pin 52 for lever 38, and that a stop bolt 49 mounted in hood 46 of the cover defines this over-center position of the toggle levers. When it is desired to manually open the breaker contacts, handle 44 may be pulled downwardly to move the knee pivot 40 of toggle levers 36 and 38 upwardly over center, whereupon spring 56 assists in further upward movement of toggle knee pivot 40. Inasmuch as the toggle knee pivot pin 40 is extended to lie beneath a flange on toggle lever 28, upward movement of this pivot pin likewise causes upward movement of toggle lever 28, contact rod 22, and bridging contact 18 to an open circuit position. Following such a manual circuit opening operation, handle 44 may be manually moved upwardly back to the position shown in Fig. 1 where toggle levers 36 and 38 will be maintained by spring 56, to thereby permit reclosing of the breaker contacts in the same manner described above. With toggle levers 36 and 38 in the position thereof shown in Fig. 1, it is obvious that operating extension 58 of lever 38, if moved upwardly, will have the same effect as downward movement of handle 44, that is, to cause opening of the breaker contacts, to a locked-open position at which they are held by spring 56.

For the purpose of automatically separating bridging contact 18 from stationary contacts 14 of the breaker in response to overloads, there is provided an actuating sleeve 60 which receives an intermediate portion of contact rod 22, with the lower end of this sleeve being threaded into a solenoid core 62 having a central opening for receiving contact rod 22, and being slidably mounted in a central opening provided in coil supporting plate 10. A light coil compression spring 64 reacts between a pin 66 on contact rod 22 and solenoid core 62 to normally bias the latter to the position shown in Fig. 1. Preferably, solenoid coil 12 is provided with suitable insulation covering the coil, and the interior of the coil additionally has a cylindrical dashpot sleeve 70 of insulating material, such as fiber or a molded insulating material received therein. For the purpose of limiting upward movement of actuating sleeve 60 on contact rod 22, the latter is provided with a flange 72 adjacent the upper end thereof. The upper end of dashpot sleeve 70 is provided with an annular outlet passage 74 formed in supporting casting 8, and communicating with a laterally

extending vent passage 76 also formed in the supporting casting which opens to the interior of casing 2. The outer end of the passage 76 may be threaded for receiving a plug when delayed operation is desired on all breaker openings.

It will now be apparent that upon the passage of currents through solenoid coil 12 of a value sufficiently high to attract core 62, that the latter will be moved upwardly while stressing spring 64. Depending upon whether or not vent passage 76 is open, or closed by a plug or other means to be hereinafter described, upward movement of core 62 and actuating sleeve 60 will be relatively fast (if vent passage 76 is open) or relatively slow (if vent passage 76 is closed), due to the necessity of liquid trapped within the dashpot sleeve 70 escaping through the relatively small clearances between core 62 and the opening in supporting plate 10 when the vent passage is closed. In either case, however, spring 64 eventually becomes compressed to an extent that contact pressure spring 34 is overcome and contact rod 22 then begins to move upwardly to separate bridging contact 18 from stationary contacts 14 in the manner previously described. In the event of any difficulty with spring 64, upward movement of core 62 and actuating sleeve 60 will eventually cause the latter to engage the flange 72 on contact rod 22 to positively separate bridging contact 18 from stationary contacts 14. When solenoid coil 12 becomes deenergized, the contacts may close in the manner previously described, except that the speed of reclosing movement will be dependent, as is the speed of contact opening movement, upon whether or not vent passage 76 is open or closed.

For the purpose of counting closely succeeding circuit interrupting operations of the circuit breaker, there is provided a cylindrical sleeve 78 mounted in an opening provided in supporting casting 8 intersecting vent passage 76, and a counting piston 80 is adapted to be mounted in sleeve 78. The lower end of sleeve 78 is closed by a plug having a small opening for restricting the flow of fluid and being controlled by a ball check valve 82, so that while fluid may be drawn into the lower end of sleeve 78, it cannot escape outwardly from the lower end of the sleeve. Counting piston 80 has a reduced upwardly extending rod portion provided with a plurality of spaced flanges 84 thereon, and above this it has secured thereto an extension 86, for a purpose to be described.

A pawl lever 92 is pivoted at one end as at 94 on supporting casting 8, and has its other end engaging the top of a collar 96 secured to actuating sleeve 60 so that the lever will be moved upwardly each time the breaker contacts separate. Pawl lever 92 has a pawl member 98 mounted thereon which is adapted to engage beneath a flange 84 of the counting piston to move the piston upwardly each time the breaker contacts separate.

It is believed clear that upon the occurrence of a circuit opening operation, counting piston 80 will be moved upwardly a predetermined distance by pawl member 98, and when the breaker contacts are reclosed, counting piston 80 will remain at the position to which it was advanced on the preceding circuit opening operation. Counting piston 80 will return very slowly to its normal lowermost position illustrated in Fig. 1 under the force of gravity, it being retarded in such return movement by the necessity of displacing liquid drawn into the lower end of sleeve 78 when the piston was advanced, through the relatively small clearance space between the piston and sleeve 78. However, if a number of circuit opening operations occur in close succession, counting piston 80 will not have time to return to its normal lowermost position shown in Fig. 1, because when the contacts reclose, they will immediately reopen, and this time pawl member 98 will engage the next lowermost flange 84 of the counting piston to advance the latter a further amount upwardly, and this will continue until the extension 86 of the counting piston engages operating exten-

sion 58 of toggle level 38 to move the knee pivot 40 of toggle levers 36 and 38 upwardly over center, whereupon the breaker contacts will be locked out in the manner previously described.

Another function of counting piston 80 is to control vent passage 76 leading from the upper end of dashpot sleeve 70. In a normal breaker, the small cross-section area extension of counting piston 80 is positioned in the region of the transverse openings through cylindrical sleeve 78 in alignment with vent passage 76, so that relatively free venting of fluid from the upper end of dashpot sleeve 70 is possible, and accordingly, upward movement of solenoid core 62 is relatively unimpeded so that the first circuit opening operation will occur substantially instantaneously after the current through coil 12 reaches a value sufficient to attract core 62. Assuming that the contacts then reclose and are again immediately reopened due to excess current still being present in the circuit, counting piston 80 itself may be advanced to a position blocking vent passage 76, or this may not occur until the third closely succeeding circuit interrupting operation, depending upon the length of sleeve 78 in which the piston is located, and on the length of the piston and its reduced upward extension. In either case, piston 80 will eventually be advanced to a position where it does block vent passage 76 so that the next closely succeeding circuit interrupting operation will be delayed due to the dashpot action of core 62 in dashpot sleeve 70 located within solenoid coil 12.

Of course, if the excess current condition through solenoid coil 12 causing a circuit opening operation of the breaker does not persist, counting piston 80 will slowly reset as previously described, so that if a permanent condition comes on the circuit at a later time, the normal breaker will again go through the same sequence of one or two fast circuit opening operations followed by time delay operations to lock-out the breaker after the predetermined number of closely successive operations has occurred to cause extension 86 of the counting piston to engage and move operating extension 58 of toggle lever 38 upwardly.

The structure thus far described is substantially the same as that disclosed in detail in the copending application Serial No. 787,206 of James M. Wallace et al., entitled Automatic Reclosing Circuit Breakers, which was filed November 20, 1947, and assigned to the assignee of the present invention. However, in order to provide an automatic reclosing circuit breaker which can be applied to a distribution line between reclosing circuit breakers of the customary type which have adjacent ratings, and so double the length of the line which is protected, the construction of the circuit breaker of the Wallace et al. patent has been modified in several respects.

For the purpose of obtaining the proper coordination of circuit breakers when it is desired to use an additional breaker, intermediate breakers of the usual or normal type, which are of adjacent ratings, it is desirable that the breaker to be thus utilized have greater than the usual time delay. This may be accomplished in any one of several ways, such as, for example, by reducing the radial clearance between the core 62 and the dashpot sleeve 70 from the usual 3 mils or so, to about 1 mil. Other ways would be by using a more viscous fluid in the dashpot, or by designing the dashpot with a greater diameter, so as to require the movement of a greater volume of fluid. Yet another way would be to use a brake of the type such as is disclosed in the copending application Serial No. 113,933 of Andrew W. Edwards, entitled Automatic Reclosing Circuit Breakers, which was filed on September 3, 1949, and assigned to the assignee of the present invention. The delayed time may be compared with that of a normal circuit breaker by comparing the curve B_t of Fig. 3 of a modified 25 ampere reclosing circuit breaker with the curves C_i and C_t, which are, respectively, the instantaneous and delayed curves for a normal 25 ampere reclosing circuit breaker. The curves A_i and A_t represent the instantaneous and delayed curves of the normal 50 ampere reclosing circuit breaker, respectively.

In order to selectively delay the initial opening of the circuit breaker when the circuit voltage is either substantially normal, or has been reduced therefrom by reason of the circuit impedance, by reason of a current flowing, which is less than several times the normal load current, being in the present instance, for example, less than about 200 amperes, the counting piston 80 may be provided with an enlarged section 81 adjacent the upper end of a reduced section 79 for blocking the fluid passage 76.

The piston 80 may be provided with a spring 83 which is disposed to bias the piston upwardly to a position in which the enlarged section 81 is above the passage 76, so as to provide for freely venting the dashpot. Electromagnetic means such as the U-shaped core 85 of magnetic metal having an operating winding 87 thereon, may be mounted on the casting 8 by means of a support 88 for cooperating with an armature 89 mounted on the extension 86 of the counting piston. The core 85 and armature 89 may be so disposed that when the winding 87 is energized with a voltage corresponding to the normal voltage of the circuit, or when the current therein is not more than several times the normal load current, the armature 89 holds the piston 80 down against the bias of the spring 84 so that the enlarged section 81 completely blocks the passage 76 and enables the dashpot 62—70 to provide the maximum time delay for a circuit interrupting operation. The winding 87 may be connected by leads 90 to a suitable source of control voltage.

Referring to Fig. 2, it will be seen that a reclosing circuit breaker B embodying the features of our invention may be connected between reclosing circuit breakers A and C which may be of adjacent ratings, for example, 50 amperes and 25 amperes, respectively. The breaker A may, for example, be set for all time lag operation by having the passage 76 plugged. The breaker A may be connected to a suitable source by conductor 92, and the breaker B may be connected between adjacent sections 93 and 93′ of a conductor which connects the breakers A and C. The winding 87 of the electromagnetic means may be energized by connecting the leads 90 to the secondary winding 95 of a transformer 97 connected to the line conductor 93′ on the side of the breaker B adjacent the breaker C.

Since the breaker B normally has a time current characteristic curve as indicated by the curve B_t, which is changed so as to provide a 25 ampere instantaneous trip rating as indicated by the curve C_i, only after either one interruption by the breaker at A, or one interruption at B, the breakers A and C will coordinate in a normal manner for persistent faults beyond the breaker C, the breaker B being unaffected by currents of this magnitude and duration because of its normal greater time delay characteristic B_t. For persistent faults between the breakers A and B, the breaker A will open and operate in a normal manner. For a fault between the breakers B and C, the voltage at the breaker B during the time fault current is flowing will be somewhat dependent on the magnitude of the fault current. For a high fault current, the fault impedance is low and the voltage at B is correspondingly low. Conversely, for relatively low fault currents, the fault impedance is higher, and the voltage at B will be correspondingly greater. The electromagnetic means 85—87 and the spring 83 are so designed that with the voltages available at the breaker B for a fault current of, for example, less than 200 amperes, the electromagnetic means will hold the counting piston 80 in a downward position so as to block the fluid passage 76 and maintain the breaker characteristic on the delayed curve B_t.

In the following examples, the value of 200 amperes

in the case of an automatic reclosing circuit breaker having a 25 ampere rating has been selected as illustrative of one level of overload at which the voltage of the circuit will drop sufficiently, because of the circuit impedance, to permit the electromagnetic means 85—87 to release the piston 80 and permit the spring 83 to move it to its instantaneous operation position. It will be realized that this value of current may vary widely within the concept of the invention, and by using this value for purposes of illustration, we do not intend to be limited thereby.

If the fault current flowing is greater than 100 amperes, but less than 200 amperes, the piston 80 will be held down. Circuit breaker A will then operate to interrupt the circuit, and during the one second reclosing time of circuit breaker A, the voltage at breaker B will be reduced to zero. The pull of electromagnetic means on the piston 80 is removed, and in the one second the spring 83 advances the piston 80 to a point where the enlarged section 81 is clear of the passage 76, and the breaker B will have a 25 ampere instantaneous tripping characteristic corresponding to the curve C_1. As the piston 80 advances, the air gap between the armature 89 and the core 85 is increased and the magnetic pull between them is correspondingly reduced. Accordingly, when the circuit breaker A recloses, the breaker B is conditioned for an instantaneous operation. The downward pull on the piston 80 from the electromagnetic means as a result of the restoration of circuit voltage at the breaker B will be so reduced because of the increased air gap, as to cause substantially no downward motion of the piston during the instantaneous tripping time of the breaker B. The breaker B will then trip instantaneously, and will, if the fault persists, repeat the operation and lock out after a predetermined number of instantaneous operations. The circuit breaker A remains closed after the initial opening operation, and service between A and B is uninterrupted.

For fault currents above 200 amperes, the voltage at the breaker B will not be sufficient for the electromagnetic means 85—87 to maintain the piston 80 in its lowermost position. Since it takes approximately one second for the piston 80 to advance to the instantaneous position, the circuit breaker A will interrupt the circuit while the circuit breaker B still has the delayed time characteristic corresponding to curve B_t. Once the circuit breaker A has operated, however, the breaker B will transfer to instantaneous operation, and if the fault continues, will operate a predetermined number of times and lock out in the usual manner.

In the case of a fault between B and C, resulting in a fault current below that of the minimum value for which the breaker A trips, the voltage at B will be sufficient to hold the counting piston 80 down and the breaker B will operate with a time characteristic corresponding to curve B_t. The breaker B will accordingly interrupt the circuit after a time period determined by its characteristic curve. The breaker B operates and advances the piston 80 in the usual manner through operation of the counting mechanism and eventually places itself on instantaneous trip. The piston 80 will not resettle appreciably during the reclosing time of the breaker. Accordingly, when the breaker recloses, it is set for instantaneous operation, and if the fault persists, it will interrupt the circuit a predetermined number of times and then lock out in the usual manner.

In thet case of a fault beyond the breaker C, the breaker B readily coordinates therewith. For fault currents which require a time longer than one second for the breaker C to clear, the voltage at the breaker B will be sufficiently high to permit the electromagnetic means to maintain the counting piston 80 in its lowermost position during the time that the fault current is flowing. For higher currents, the breaker C will open in less than one second, and the piston 80 of the breaker B will not have sufficient time to reach its instantaneous setting before the circuit is interrupted by the breaker C. Thus, for a fault beyond the breaker C, the breaker B does not leave the curve B_t and the reclosing circuit breaker C will coordinate in a normal manner with the breaker A in sectionalizing the distribution line beyond the breaker C.

When the breaker B is reset after locking out, the counting piston 80 retrieves in the usual manner, as a result of leakage of the fluid past the piston, until it reaches an equalized position with the spring 83. If at this time the circuit voltage is normal, the winding 87 is energized and the piston 80 wil be slowly drawn down against the bias of the spring 83 to the fully reset position, ready for another cycle of operation.

From the above description and accompanying drawing, it will be apparent that we have invented a new and novel means for increasing the number of sectionalizing points available with the usual reclosing circuit breaker ratings. By providing a reclosing circuit breaker having an adjustable time characteristic which is responsive to the circuit voltage at the breaker, we have provided a means for telling the breaker whether or not the breaker ahead of it has tripped so that it can adjust its timing characteristics accordingly.

Since certain changes may be made in the above-described construction, and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all the matter contained in the above description and shown in the accompanying drawing shall be considered as illustrative and not in a limiting sense.

We claim as our invention:

1. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for actuating said contacts, electroresponsive means operable in response to an overload on a circuit to effect operation of the operating mechanism to cause separation of said contacts, means for effecting operation of said mechanism for automatically closing said contacts following a circuit opening operation, time delay means operable to delay operation of the electrosponsive means and delay opening operations of said breaker, counting means having a movable part advanced by said electroresponsive means to render the time delay means operable after a predetermined number of opening operations, and electromagnetic means operable to move said part in the opposite direction to render the time delay means operable independently of the counting means.

2. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for actuating said contacts, electroresponsive means operable in response to overload currents to effect operation of the operating mechanism to effect separation of said contacts, time delay means operable to delay operation of said electro responsive means, counting means having a movable part advanced by operation of the electroresponsive means operable after a predetermined number of contact separating operations to render the time delay means effective, and means operated by a circuit voltage of substantially normal value to actuate the movable part of said counting means to render the time delay means effective initially.

3. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means operable in response to an overload current to move a magnetic core a predetermined distance, means actuated by said core for actuating the operating mechanism for causing separation of said contacts, dashpot means operable to delay movement of said core, said dashpot means having a vent, valve means operable in one direction in response to movement of said core to close said vent and render the time delay means operable, means normally biasing the valve means to an intermediate inoperative position,

and electromagnetic means operable to actuate the valve means in the opposite direction to render the time delay means operable in response to a predetermined circuit voltage.

4. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means including a coil connected in series relation with said contacts and a magnetic core movable to effect operation of the mechanism to open them in response to an overload current, means for automatically causing operation of the mechanism to effect engagement of said contacts following a circuit opening operation, dashpot time delay means acting on said core operable to delay separation of said contacts, valve means operable after a predetermined number of circuit opening operations to block venting of the dashpot to render the time delay means operable, means biasing the valve means to an inoperative position, and electromagnetic means energized in accordance with the voltage of the circuit, said electromagnetic means being operable to effect operation of said valve means against said biasing means to initially block venting of the dashpot so long as the circuit voltage is above a predetermined operating value.

5. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means having a movable part operable in response to an overload on a circuit to actuate said mechanism and effect separation of said contacts, dashpot means operable to delay movement of said part and separation of said contacts, valve means normally providing a vent for said dashpot means to render the dashpot means inoperative, counting means advanced by successive operations of said electroresponsive means to effect operation of the valve means to close the vent, means normally biasing the valve means to an inoperative position, and electromagnetic means including an operating winding disposed to be energized in accordance with the voltage of the circuit to effect operation of the valve means against said biasing means to close the vent and render the dashpot means operable independently of the counting means.

6. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means responsive to overload currents to move a core for actuating the mechanism to separate said contacts and effect a circuit interrupting operation, dashpot means operable to delay movement of said core, valve means disposed to control a vent for said dashpot means, means biasing said valve means to an intermediate position to normally open said vent and render the dashpot means ineffective, counting means actuated by closely successive operations of the electroresponsive means operable after a predetermined number of contact separating movements of said core to actuate the valve means in one direction to close said vent, and electromagnetic means including an operating winding disposed to be energized in accordance with the voltage of the circuit to oppose the biasing means and actuate the valve means in the opposite direction to close the vent so long as the voltage is above a value corresponding to a predetermined value of overload current for the circuit.

7. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means having a movable part responsive to overload currents to effect operation of said mechanism to effect separation of said contacts, time delay means operable to delay movement of said part to effect separation of said contacts, a movable member selectively operable to render the time delay means effective or ineffective, biasing means operable to move said member to a position to render the time delay means ineffective, counting means operable to move said member to a different position in response to a predetermined number of operations of said electroresponsive means, and voltage responsive means operable to oppose the operation of the biasing means and move the member to yet another position for rendering the time delay means effective.

8. An automatic reclosing circuit breaker comprising, separable contact means, an operating mechanism therefor, electroresponsive means having a member movable in response to a fault current to actuate said mechanism to effect separation of said contacts for interrupting a circuit, said contacts being biased to reclose following a separation, normally ineffective time delay means operable to delay movement of the member effecting separation of said contact means, counting means having a part advanced by closely successive operations of the electroresponsive means operable only after a predetermined number of contact separations to render the time delay means effective, biasing means normally operable to bias said part of the counting means to a position to render the time delay means ineffective, and means including electromagnetic means opposing the biasing means for moving said part to a different position for rendering the time delay means effective in response to a predetermined electrical condition of the circuit.

9. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means having a member operable to effect movement of said mechanism to effect separation of said contacts to interrupt a circuit in response to a fault current in the circuit, means biasing the mechanism for reclosing said contacts following a separation, time delay means operable to delay movement of said member to effect separation of the contacts, counting means having a part advanceable in one direction to render the delay means operable and to lock the contacts separated after a predetermined number of separations, biasing means biasing said advanceable part to an intermediate position for rendering the time delay means ineffective, and voltage responsive means operable to actuate said advanceable part in the opposite direction to a different position to render the time delay means effective to delay separation of the contacts except when the circuit voltage falls below a predetermined value.

10. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means having a part movable in response to a fault current in a circuit to actuate the operating mechanism to effect separation of the contacts to perform a circuit interrupting operation, said contacts being biased to effect a circuit closing operation upon interruption of the circuit, time delay means operable to delay movement of said part to effect separation of said contacts, a member movable to different positions to render the time delay means effective and ineffective, respectively, biasing means operable to move said member to one position to normally render the time delay means ineffective and provide for substantially instantaneous separation of said contacts, voltage responsive means operable to oppose the biasing means and move the member to a different position for effecting delayed separation of the contacts, and time delay means for delaying operations of the movable member under the influence of voltage responsive means.

11. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism therefor, electroresponsive means having a movable part operable to actuate the operating mechanism to separate the contacts in response to a fault current, time delay means operable to delay movement of said part to effect separation of the contacts, counting means having a part advanced by a predetermined number of closely consecutive operations of the electroresponsive means to effect operation of the time delay means and to effect a locking open of said contacts, and voltage responsive means

operable to retract said part and effect operation of the time delay means independently of the counting means to delay separation of said contacts so long as the voltage of the circuit remains above a predetermined value.

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