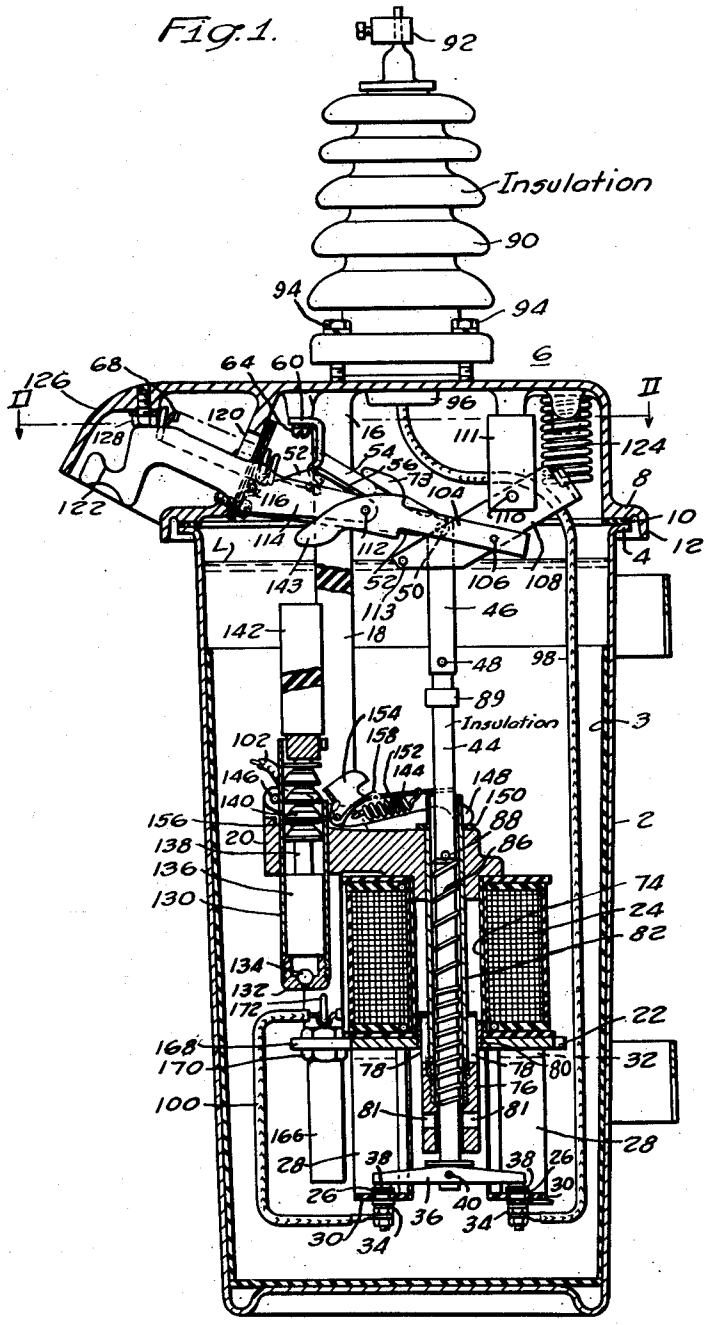
Dec. 16, 1952 H. L. RAWLINS ET AL 2,622,167

CIRCUIT INTERRUPTER

Filed Dec. 31, 1946 2 SHEETS—SHEET 1

Fig. 1.



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CIRCUIT INTERRUPTER

Filed Dec. 31, 1946 2 SHEETS—SHEET 2

Fig. 2.

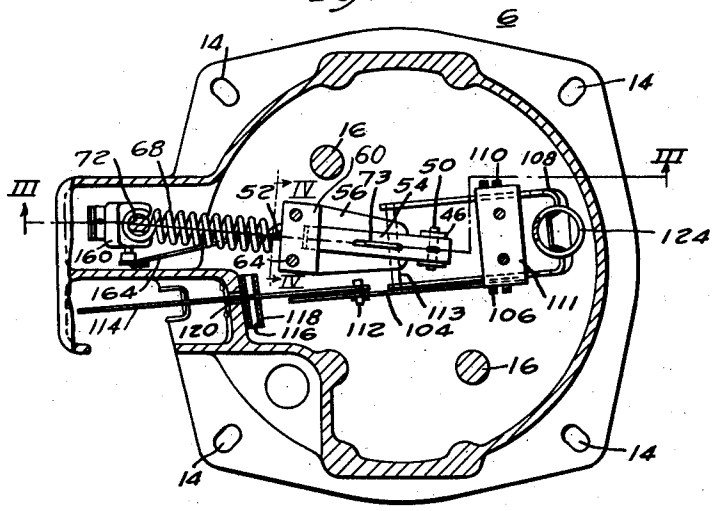


Fig. 3.

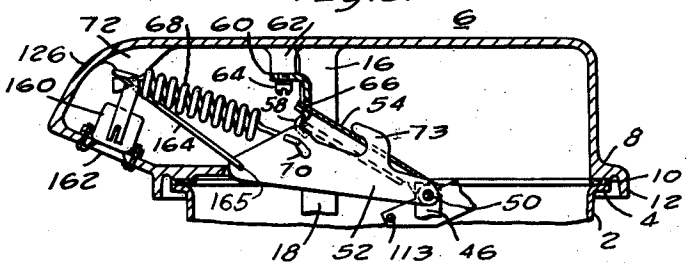
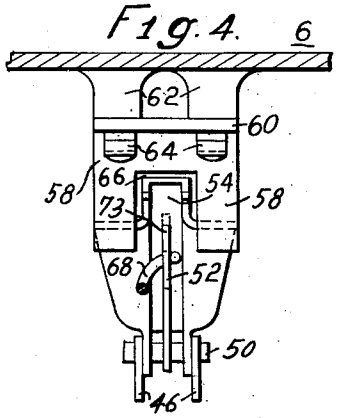


Fig. 4.



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2,622,167

UNITED STATES PATENT OFFICE

2,622,167

CIRCUIT INTERRUPTER

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Application December 31, 1946, Serial No. 719,572

17 Claims. (Cl. 200—89)

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This invention relates in general to electric circuit interrupting devices, and more particularly to automatic reclosing circuit breakers.

In automatic reclosing circuit breakers of the type having contacts which are opened electrically in response to overloads on the circuit and are biased to automatically reclose when the circuit is opened, one problem encountered is that of obtaining adequate contact pressure when the breakage is closed and at the same time obtaining full contact separation regardless of the current value of the overload. In accordance with an important aspect of this invention, this problem is solved by providing a contact pressure spring which is effective only when the breaker contacts are closed and for a very short travel of the movable contact adjacent its closed circuit position, so that the movable contact is free after a very small amount of opening movement to be moved to its full open circuit position.

Accordingly, one general object of this invention is to provide in a circuit breaker of the type which automatically recloses due to a closing bias on its contacts, novel means for obtaining adequate contact pressure at the closed circuit position without interfering with circuit opening movement of the device to a full open circuit position irrespective of the current value of the overload causing the circuit opening operation.

Another object of this invention is to provide a circuit breaker having electro-responsive means to cause separation of its contacts and a closing bias to automatically reclose the circuit, with novel means for applying additional closing pressure on the contacts solely at and closely adjacent to closed circuit position.

A more specific object of this invention is to provide for a device of the type described, a novel contact pressure toggle spring structure arranged to move from an off-center position when the contacts are closed and substantially closed where contact pressure is exerted on the contacts, to a substantially on-center position during contact travel into and out of engagement wherein substantially no force is exerted on the contacts.

Another object of this invention is to provide in an automatic reclosing circuit breaker having means to hold the breaker contacts open in response to the occurrence of a predetermined number of closely successive circuit interrupting operations of the breaker, novel contact pressure means which is maintained ineffective when said contact holding means is operative.

Another general object of this invention is to

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provide a novel automatic reclosing circuit breaker construction which is efficient and reliable in operation, and yet may be economically produced.

Another object of this invention is to provide in a device of the type described wherein a solenoid is employed for separating the circuit breaker contacts and has lost motion relative to the contacts, novel spring means adapted to be compressed upon energization of the solenoid means to actuate the contacts.

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

Figure 1 is a substantially central vertical section view of a circuit breaker constructed in accordance with this invention;

Fig. 2 is a transverse section of the breaker shown in Fig. 1 taken substantially on the line II—II of Fig. 1;

Fig. 3 is a partial vertical section view of the upper end of the breaker shown in Fig. 1, taken substantially on the line III—III of Fig. 2; and

Fig. 4 is an enlarged partial section view of the upper end of the breaker shown in Fig. 1, taken substantially on the line IV—IV of Fig. 2.

The breaker shown on the drawings is illustrated as being mounted in a metal tank 2 having a closed bottom wall and an open top. Preferably, the tank is adapted to be lined at least over the bottom wall and up to a point adjacent the open top of the container with a liner 3 of insulating material such as fiber, or the like, and is filled up to the level L with liquid, preferably a liquid having arc extinguishing ability such as oil. The upper end of tank 2 is provided with an outwardly extending flange 4 on which the flange 8 of a cover casting 6 is adapted to be seated, preferably, with a gasket 10 interposed therebetween. Flange 8 of cover casting 6 may be provided with an integral lip 12, and the cover may be secured to the tank in any desired manner, such for example, as by bolts (not shown) extending through openings 14 in cover flange 8 and secured to suitably formed brackets on the tank.

The breaker contacts and certain of the contact actuating mechanism are adapted to be supported in tank 2 from cover casting 6 by means of a pair of integral supporting lugs 16 depending from the top wall of the cover casting and adapted to engage insulating spacer rods 18 having threaded studs (not shown) engaging

threaded openings in rods 18 and lugs 16 on supporting casting 20. A supporting plate 22 may be supported in a similar manner from casting 20, so that a solenoid coil 24 may be mounted between casting 20 and supporting plate 22, with the central opening in the coil aligned with openings provided in casting 20 and plate 22.

Spaced stationary contacts 26 of the breaker are each supported from plate 22 by a support 28 of insulating material, such as fiber, formed of U-shape, with the stationary contacts being mounted in openings provided in the base portions 30 of each support 28, and with the upper ends of each support 28 having laterally extending flanges 32 by means of which each support is secured to supporting plate 22. As illustrated, each contact 26 is formed as the head of a bolt to which a conductor may be secured, as by the nuts 34.

Stationary contacts 26 are adapted to be closed by engagement therewith of a bridging contact 36 having contact tips 38 at opposite ends thereof for engagement with the stationary contacts, respectively. Bridging contact 36 is supported substantially centrally thereof on a slidable contact actuating rod 44 by pivot pin 40 for limited pivotal movement about a transverse axis on contact actuating rod 44. Contact rod 44 being mounted for longitudinal sliding movement through coil 24 and the aligned openings in plate 22 and casting 20, it will be observed that bridging contact 36 is free to adjust itself to the stationary contacts by restricted pivotal movement about its pivot mounting 40. Contact rod 44 should be of an insulating material such as fiber or a molded insulating material.

The upper end of contact actuating rod 44 has a pair of connecting links 46 positioned at each side thereof and pivoted thereon as by a pivot pin 48, with the upper ends of these connecting links mounted on a common pivot pin 50 for a pair of toggle levers 52 and 54. Toggle levers 52 and 54 are both formed of sheet material, with lever 54 being bent to substantially channel form with outwardly extending flanges 56 adapted to be received at the free ends thereof in recesses 58 provided in the spaced downwardly depending fingers of an angled supporting bracket 60 which, in turn, is secured as by screws 64 to lugs 62 integral with the cover casting. Preferably, the base of the channel part of toggle lever 54 is extended at 66 through the space between the supporting fingers of bracket 60, and at the other end of lever 54 the sides of the channel formation thereof are extended to be mounted on pivot pin 50. A coil tension spring 68 has one end hooked into an opening 70 provided in toggle lever 52, and has the opposite end thereof hooked over an integral spring support 72 on the cover casting.

It will be observed that in the closed circuit position of the breaker illustrated on the drawings in full lines, the line of action of toggle spring 68 is below the pivot supporting recesses 58 for toggle lever 54, and accordingly, the toggle spring acts to bias bridging contact 36 into engagement with stationary contacts 26 of the breaker, under a predetermined pressure. However, as soon as contact operating rod 44 moves upwardly to separate the bridging contact from the fixed contacts of the breaker, toggle lever 54 will pivot about recesses 58 and the line of action of toggle spring 68 will thus be caused to approach that pivot point so that in response to a very small contact separation the line of action of toggle spring 68 will pass through pivot recesses 58 which is the on-center position of the resilient toggle arrangement comprising toggle levers 52 and 54 and toggle spring 68. As a practical matter, the opening movement of the contacts necessary to move toggle levers 52 and 54 to the on-center position mentioned above may be made very small, in one operative device being on the order of one-quarter of an inch. When toggle levers 52 and 54 reach their on-center position referred to above, further relative movement of the two toggle levers in the same direction is prevented because the upper edge of toggle lever 52 engages the base of the central channel formation of toggle lever 54. Moreover, since the point at which toggle spring 68 is hooked into opening 70 of lever 52 then substantially coincides with recesses 58 in which toggle lever 54 pivots during contact opening movement, it will be apparent that the remainder major part of contact opening movement will occur substantially uninfluenced by toggle 68. Substantially the reverse of the above operation occurs when contact operating rod 44 moves downwardly to close the circuit from the full open contact position, because during the first and major part of contact closing movement, levers 52 and 54 will be in engagement so that such movement will be uninfluenced by toggle spring 68. However, as soon as pivot 50 passes below a line drawn from the remote end of toggle spring 68 through pivot recesses 58 for link 54, toggle spring 68 will then be effective to move the toggle levers toward the full line position shown in Figs. 1 and 3, and the force exerted by toggle spring 68 then tending to close the contacts will continue to increase as toggle levers 52 and 54 move further away from their on-center positions. While it is preferred when toggle levers 52 and 54 are in engagement that these levers be engaged as closely as possible to their on-center position, so that toggle spring 68 is ineffective to bias the contacts in either direction, rather than risking that the engagement occur at a position slightly overcenter from that shown in Figs. 2 and 3, it may be desirable to make the engagement occur just prior to attainment by levers 52 and 54 of their on-center position. When this is done, toggle spring 68 will exert some slight bias tending to close the contacts, and this may be desirable in some cases. It will be noted that toggle lever 52 is provided with an integral hook 73 for limiting its separation from toggle lever 54.

Solenoid coil 24 previously mentioned is adapted to be energized under certain conditions for automatically opening the circuit breaker contacts. The central opening through coil 24 preferably is provided with a cylindrical sleeve 74 in which a solenoid core 76 is adapted to be slidably mounted in a piston-like manner. Core 76 is in the form of a cylindrical sleeve having opposed slots 78 in the upper portions thereof adapted in the normal closed circuit position of the device illustrated in Fig. 1 to extend partly above and partly below supporting plate 22, by engagement of an exterior shoulder adjacent the upper end of the core with a sleeve 80 which has an external rib held between the sleeve 74 for the coil and supporting plate 22. The lower end of core 76 is also provided with opposed openings 81, for a purpose to be hereinafter described.

A contact actuating sleeve 82 is telescoped over contact actuating rod 44 and its lower end is received in core 76 and preferably threadably mounted therein. A coil compression spring 86 is provided within actuating sleeve 82 on contact

actuating rod 44 and is adapted to react between a shoulder in the core and a pin 88 extending transversely through actuating rod 44.

The circuit through the circuit breaker thus far described may now be traced from the point where it enters tank 2 through one of a pair of terminal bushings 90 (only one being shown), with each bushing secured to cover castings 6 as by bolts 94, and each being provided with a terminal fixture 92 at the upper end thereof mounted on a conductor element which extends through the bushing and emerges from a reduced extension 96 of the bushing seated in an opening provided in the top wall of cover casting 6, and proceeds by conductor 98 directly to one fixed contact 26 of the breaker. When the contacts are in engagement, the circuit then proceeds through bridging contact 36 to the other fixed contact 26, and then by way of a conductor 100 to one terminal of solenoid coil 24. The other terminal of coil 24 is adapted to be connected by a conductor 102 to the conducting means in the other terminal bushing 90. It will be apparent that solenoid coil 24 in this embodiment of the invention is connected in series in the circuit through the circuit breaker so as to be energized at all times when the circuit breaker is closed, an amount dependent upon the value of current flowing in the circuit.

For any given rating of circuit breaker, solenoid coil 24 is designed to become sufficiently energized when the load current in the circuit exceeds its rating as to attract core 76 and move it upwardly within sleeve 74. Core 76 will move upwardly relatively rapidly until the bottom of slot 78 reaches sleeve 80, whereupon there is no longer any vent for fluid contained in cylindrical sleeve 74, and it then becomes necessary upon further upward movement of core 76 to displace the liquid in sleeve 74 above the core through the relatively small clearances between the core and sleeves 74 and 80 and between sleeve 82 and casting 20. Accordingly, opening movement of the core will be slowed up by the aforesaid dashpot action an amount determined by the current value of the overload, and, therefore, an inverse time-current characteristic on opening is obtained. Finally, when openings 81 clear the upper edge of sleeve 80, core 76 will no longer be restrained by the dashpot action, and final opening movement thereof may be relatively rapid. When core 76 commences its upward travel, bridging contact 36 being held engaged by toggle spring 68 does not move, so that spring 86 is compressed until the energy stored in spring 86 is sufficient to overcome the force exerted by toggle spring 68, at which time contact actuating rod 44 will start to move upwardly. As soon as actuating rod 44 moves upwardly, the force exerted by toggle spring 68 begins to decrease and in a very short distance has substantially no value at all, so that the remaining major part of the circuit opening movement of bridging contact 36 occurs extremely rapidly due to expansion of spring 86.

In order to store as much energy as possible in spring 86 during a circuit opening operation, it will be noted that this spring is of a special type being wound on two different pitches, with the upper coils of the spring as viewed in Fig. 1 having a relatively large pitch compared to the pitch of the lower coils of spring 86. Spring 86 may be formed of a single piece of wire which is uniform in diameter, but by making the coils of different pitches, it will be apparent that the force-distance characteristic of such a spring can be made to closely approximate the force-distance characteristic of solenoid coil 24 and its core 76. The reason for this is that an ordinary spring having a uniform pitch has a straight line force-distance characteristic which obviously cannot be matched with the force-distance characteristic of a solenoid. By providing a spring having a number of coil portions differing in pitch, when the coils of small pitch go solid, the deflection of the remaining coils will be increased accordingly so that instead of a straight line force-distance characteristic the resulting characteristic of the spring as a whole, will comprise a series of straight lines at progressively increasing angles, and these obviously can be made to closely follow the characteristic curve of any particular solenoid. Accordingly, it will be apparent that the maximum energy available from the solenoid coil 24 will be stored in compression spring 86 and will thus be available to overcome the closing bias of toggle spring 68, preferably at some point during initial movement of core 76 before actuating sleeve 82 engages flange 89 on actuating rod 44. However, flange 89 is provided to obtain a positive contact separation in the event there is any sticking or welding of the bridging contact to stationary contacts 26. In either case, it is apparent that toggle levers 52 and 54 will be moved to their on-center position in the manner previously described, and bridging contact 36 will be moved by spring 86 to its full open circuit position.

When the breaker contacts have attained their full open circuit position, the parts associated therewith are biased to return by gravity, and as previously pointed out, they may also be biased by toggle spring 68 if it is desired to stop relative movement of toggle levers 52 and 54 just short of attaining their on-center position during opening of the contacts. In either case, the closing bias is relatively light and will be opposed by the dashpot action of core 76 when it has moved downwardly a distance sufficient to bring openings 81 below sleeve 80. Accordingly, the return movement will be relatively slow until pivot point 50 moves below a line extending through pivot recesses 58 and the fixed end of spring 68 at bracket 72, whereupon bridging contact will be rapidly moved to effect a snap-action closing of the breaker contacts by toggle spring 68. Moreover, at about this same time the lower ends of slots 78 in core 76 will clear the lower edge of sleeve 80 so as to vent the dashpot comprising sleeve 74 and core 76.

In order to limit the number of operations of the circuit breaker in close succession upon the occurrence of a continuing overload on the circuit and to provide for manual operation, means are provided for holding the breaker contacts open in response to the occurrence of a predetermined number of closely succeeding circuit interrupting operations, which means can be manually actuated. This means comprises a toggle lever 104 pivoted at one end as at 106 on a U-shaped spring lever 108 which, in turn is pivotally supported as at 110 between the legs of a U-shaped supporting bracket 111 secured to cover casting 6. The other end of toggle lever 104 is pivoted, as by a pivot pin 112, to the adjacent end of a second toggle lever 114, and this, in turn, is mounted on a pivot pin 116 intermediate its ends, with the pin 116 being mounted in a bracket 118 secured to the adjacent wall of cover casting 6. A slot 120 is provided through

the cover casting 6 for receiving the other end of toggle lever 114 which acts as a manual operating handle at the exterior of the circuit breaker casing, being provided with an angled hook end 122. A coil compression spring 124 is mounted to react between the bight of lever 108 and cover casting 6. Normally, toggle levers 104 and 114 are held by spring 124 with pivot 112 below the center line connecting pins 106 and 116, with the outer end of lever 114 positioned in and beneath an integral hood 126 on cover casting 6, in engagement with an adjustable stop screw 128 mounted in the hood.

In the position of toggle levers 104 and 114 illustrated, they have no effect on operation of the circuit breaker as previously described, being normally inactive in this respect. However, lever 108 has a connecting pin 113 extending beneath toggle levers 52 and 54. Accordingly, if it is desired to manually open the circuit breaker contacts, a hook stick or similar operating member may be engaged with the upper side of angle hook 122 of toggle lever 114 and pulled downwardly to rotate the toggle lever in a counterclockwise direction about its supporting pivot 116 to move toggle levers 104 and 114 overcenter in an upward direction, and in doing this, pin 113 engages toggle levers 52 and 54 and moves them upwardly in a counterclockwise direction, thus carrying contact actuating rod 44 upwardly to separate bridging contact 36 from stationary contacts 26. The contacts will be held open by spring 124 which maintains toggle levers 104 and 114 in their upper overcenter position. In thus manually opening the circuit after toggle spring 68 is moved to its on-center position, it will be observed that the spring 124 is only required to maintain the contacts of the breaker open against the relatively light closing bias due to gravity, and such light bias as may be due to toggle spring 68 in the event that toggle levers 52 and 54 are stopped just prior to reaching their on-center position. With the breaker contacts maintained at their open circuit position following the manual circuit opening operation described above, it will be apparent that the outer end of toggle lever 114 projects below hood 126 of cover casting 6 so as to provide a readily visible indication that the breaker contacts are maintained at open circuit position. It will further be apparent that the breaker contacts may then be closed only by manual operation of toggle lever 114 in the opposite direction, that is, by exerting an upward force on the outer end of the toggle lever by engagement of a hook stick or the like with the underside of hook 122, to rotate lever 114 in a clockwise direction to move it and toggle lever 104 back overcenter to the position illustrated on the drawings. This manual operation of toggle lever 114 does not directly close the breaker contacts but merely permits closure of the contacts in the manner previously described, that is, initial closing movement of the contacts being due to the bias of gravity and possibly some slight bias due to toggle spring 68, until bridging contact 36 is closely adjacent stationary contacts 26 when toggle spring 68 is moved below its on-center position and suddenly becomes effective to finally move the contacts into engagement rapidly. It will be observed that on manual opening of the circuit, the full force of spring 124 becomes effective to open the contacts as soon as levers 104 and 114 move overcenter, and actual opening of the contacts by spring 124 is independent of the operating hook stick. Similarly in manually resetting toggle levers 104 and 114 there is no possibility that withdrawal of the hook stick after resetting can disturb the position of the toggle levers because in resetting the hook stick engages only a lower edge surface of hook 122.

An integrating mechanism for automatically moving toggle levers 104 and 114 upwardly overcenter and thus preventing reclosure of the circuit breaker in response to a predetermined number of closely successive circuit interrupting operations is provided comprising a cylindrical tube 130 clamped or otherwise secured in a lateral extension of casting 20 at the top of solenoid coil 24, and this tube has a plug 132 threaded into the lower end thereof with the plug having a small central opening controlled by a ball-check valve 134, which permits flow of fluid into the lower end of tube 130 but prevents out-flow. An integrating piston 136 is mounted in tube 130 and normally rests on the upper end of plug 132, being provided with a reduced extension 138 at the upper end thereof having a plurality of spaced circular flanges 140 forming rack teeth thereon, and having an elongated extension 142 of insulating material on the extreme outer end thereof which is positioned below an extension 143 on toggle lever 104. A pawl lever 144 is pivotally mounted at one end as at 146, this end of pawl lever 144 being split with legs located at each side of tube 130 and with pivot 146 supported on spaced supporting flanges 140 integral with casting 20. Pawl lever 144 has a connecting web intermediate its ends, and at the other end thereof the sides of the lever are extended outwardly and laterally as at 148, to normally be in engagement with a washer 150 mounted on actuating tube 82 in engagement with a shoulder adjacent the outer end of this tube. Pawl lever 144 is normally biased into engagement with washer 150 by a coil tension spring 152 hooked over the remote edge of the web of the pawl lever at one end and anchored to an ear integral with casting 20 at its other end. Pawl lever 144 is provided with a pawl member 154 pivoted thereon as at 156, and biased by a spring 158 in a counterclockwise direction to a position wherein a portion of pawl member 154 engages the connecting web of pawl lever 144.

When the circuit breaker operates to open the circuit, washer 150 will be carried upwardly with actuating sleeve 82 and thus carry the free end of pawl lever 144 upwardly with it to move pawl member 154 into engagement with the upper one of flanges 148 on integrating piston 136 to thus carry the piston upwardly a predetermined distance. When the breaker recloses following such a first circuit interrupting operation, integrating piston 136 is left at the position to which it was advanced since pawl member 154 is free to disengage circular flanges 140, and if the breaker remains closed, integrator piston 136 will slowly reset to the position shown in Fig. 1 due to leakage of liquid in cylinder 30 below piston 136 through the relatively small clearance between the cylinder and piston. However, if the breaker immediately reopens after a first opening and reclosing operation, pawl member 154 this time will engage the next lower circular flange 140 on the integrator piston and raise the piston a further amount. Subsequent reclosing will result then in leaving piston 136 at this further advanced position from which it eventually will reset if the breaker remains closed. However, in the event of a continuing overload, the breaker

will continue to open and reclose until finally pawl member 154 advances integrator piston 136 an amount sufficient to cause the upper extension 142 thereof to engage the extension 143 of toggle lever 104 and move this lever upwardly overcenter so that toggle spring 124 will maintain the contacts separated in the manner previously described. It is thus apparent that toggle levers 104 and 114 will be automatically moved upwardly overcenter to maintain the breaker contacts separated only in response to a predetermined number of closely successive circuit opening and closing operations, usually four such operations, however, in the event a lesser number of closely successive opening and closing operations occurs, the integrating mechanism will reset and the breaker contacts will be automatically held open only when the aforesaid predetermined number of opening and closing operations occurs in close succession. Obviously, after the breaker contacts have been automatically actuated to a position where they are held open by toggle spring 124, they can be reclosed only by manual operation of toggle lever 114 in the manner previously described.

If desired, a counter 160 for registering the number of operations of the breaker may be installed in cover casting 6 adjacent hood portion 126, and an opening 162 provided through the cover casting to render the counter register visible from the exterior. The actuating arm of counter 160 is preferably connected by a link 164 pivoted at 165 with the adjacent end of toggle link 52, and it will be apparent that the counter will be operated each time the circuit breaker opens and closes the circuit.

Similarly, a protective gap device 166 preferably of the expulsion type may be provided to prevent operation of the breaker on voltage surges, with the outer tube of the arrester mounted intermediate its ends on an extension 168 of supporting plate 22 at the underside of solenoid coil 24, being secured thereto as by nuts 170 threaded on the arrester tube. One terminal 172 of the arrester may be connected with conductor 100 and one terminal of solenoid coil 24, with the other terminal of the arrester (not shown) connected with the other terminal of coil 24 and conductor 102. This arrester and its particular manner of mounting and connection with this type of apparatus is more particularly disclosed and claimed in our copending application Serial No. 694,074 an Overvoltage Protective Devices, filed August 30, 1946, now Patent No. 2,550,124, April 24, 1951, and assigned to the same assignee of this invention. As stated above, the purpose of providing an arrester 166 connected in the manner described herein and in the aforesaid copending application is to provide a by-pass to protect solenoid coil 24 on voltage surges such, for example, as those due to lightning strokes, which are not overloads on the circuit and, consequently, it is not desired that the breaker open on such surges.

From the foregoing, it is believed apparent that the structure disclosed herein provides in an automatic reclosing circuit breaker of the type having electrical means for causing opening of the breaker contacts and having the contacts biased to automatically reclose when the circuit is opened, a contact pressure spring effective to additionally bias the breaker contacts into engagement, but which bias is substantially entirely destroyed as soon as the contacts separate a very short distance, so that the breaker contacts are substantially free of said spring bias to separate the remaining distance to their full open position. Furthermore, the electrical means for opening the breaker contacts is provided with lost motion relative to the contacts, and this lost motion is employed in a circuit opening operation to delay the opening time with an inverse time-current characteristic and, at the same time stressing a spring whose force-distance characteristic closely matches that of the solenoid opening means and eventually overcomes the bias of the contact pressure spring, or else the lost motion becomes fully taken up so that the contacts are always rapidly separated and moved the predetermined short distance necessary to render the contact pressure spring inoperative, whereupon the lost motion spring becomes effective to rapidly move the breaker contacts to their full open circuit position. It is apparent that toggle spring 68, while providing adequate contact pressure for the particular form of contacts illustrated herein, is also important where contacts other than the butt type contacts illustrated are employed, in order to obtain an extremely rapid final closing movement of the contacts, because in closing the circuit while the initial and major part of the closing movement of the breaker contacts is used to obtain a time delay, toggle spring 68 finally becomes effective closely adjacent the end of closing movement to suddenly exert its bias on the contact to rapidly close the contacts substantially with a snap action, and this function is important whether or not the contact pressure function inherent in this structure is used.

With the particular toggle spring arrangement 68 disclosed herein wherein it is effective to bias the breaker contacts only when they are at or closely adjacent their closed circuit position, it is apparent that the only other bias needed to automatically close the breaker contacts may be merely that exerted by gravity which is extremely light, so as to offer negligible opposition to opening movement of the breaker contacts to their fully opened position. This also has the advantage of simplifying design of the means for obtaining time delay on closing, since the delaying means is subjected only to this relatively light closing bias.

The structure herein described results in obtaining a full opening stroke of the breaker contacts on every circuit opening operation at a rapid rate, regardless of the current value of the overload causing such operation. Thus, any overload however small which is capable of moving solenoid core 76 upwardly an amount to compress spring 86 sufficiently to overcome the bias of toggle spring 68 will open the contacts at least the amount necessary to render toggle spring 68 ineffective to the extent that spring 86 is able to move the bridging contact 36 to its full open circuit position. Furthermore, although but a light closing bias is exerted on the breaker contacts through the major portion of their closing movement, they are rapidly moved into final engagement by a relatively heavy bias which may be also employed to provide adequate contact pressure when butt type contacts are employed.

Our invention comprises the novel toggle actuating and lockout mechanism and the novel lost-motion spring arrangement for opening the contacts, taken both separately and collectively, whereas, certain other features disclosed herein are not not our invention; the particular integrator structure including the pawl actuating means therefor comprising the invention of J. M. Wal-

lace, A. W. Edwards and J. Kraft being disclosed and claimed in their copending application Serial No. 719,524, filed December 31, 1946, on Circuit Interrupters; and the particular contact structure and means for extinguishing the arc drawn upon separation of the contacts is the invention of J. M. Wallace and J. Kraft being disclosed and claimed in their copending application Serial No. 718,942, filed December 28, 1946, now Patent No. 2,575,738, November 20, 1951, on Arc Extinguishing Structures.

Having described a preferred embodiment of the invention in accordance with the patent statutes, it is desired that this invention be not limited to this particular construction inasmuch as it will be apparent, particularly to persons skilled in this art, that many modifications and changes may be made in this particular structure without departing from the broad spirit and scope of this invention.

We claim as our invention:

1. In a circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others resilient means reacting between said movable contact and a stationary support for biasing said contacts together to effect at least rapid final closing movement of said contacts and to exert pressure on said contacts when they are in engagement, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, and means connected to said movable contact and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said movable contact for rendering said resilient means inoperative to exert any substantial force on said movable contact, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means.

2. In a circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others resilient means reacting between said movable contact and a stationary support for biasing said contacts together to effect at least rapid final closing movement of said contacts and to exert pressure on said contacts when they are in engagement, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, means connected to said movable contact and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said movable contact for rendering said resilient means inoperative to exert any substantial force on said movable contact, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means, and said last mentioned means also being actuated by said movable contact in its closing movement so as to be responsive to contact closing movement substantially to the point in opening movement where said resilient means was rendered inoperative for rendering said resilient means operative to rapidly close said contacts and to exert a predetermined contact pressure when said contacts are in engagement.

3. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, resilient means additionally biasing said contacts together in the same direction as said reclosing bias to effect at least rapid final closing movement of said contacts and to exert pressure on said contacts when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, and means connected to said contacts and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means.

4. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, resilient means additionally biasing said contacts together in the same direction as said reclosing bias to effect at least rapid final closing movement of said contacts and to exert pressure on said contacts when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, means connected to said contacts and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means, and said last-mentioned means also being actuated in accordance with contact-closing movement so as to be responsive to contact closing movement substantially to the point in opening movement where said resilient means was rendered inoperative for rendering said resilient means operative to rapidly close said contacts and to exert a predetermined contact pressure when said contacts are in engagement.

5. In a circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others resilient means reacting between said movable contact and a stationary support for biasing said contacts together at least when they are in engagement, electro-responsive means having lost motion relative to said movable contact for causing separation of said contacts in response to a predetermined condition of a circuit, spring means stressed to exert a force tending to separate said contacts during circuit opening movement of said electro-responsive means relative to said movable contact, and means connected to said movable contact and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is effected by said spring means and is substantially uninfluenced by said resilient means.

6. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means having lost motion relative to said contacts for causing separation of said contacts in response to a predetermined condition of a cir-

cuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, spring means adapted to be stressed during movement of said electro-responsive means relative to said contacts to exert a force tending to separate said contacts which is considerably greater than that of said bias, resilient means additionally biasing said contacts together in the same direction as said reclosing bias at least when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, and means connected to said contacts and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is effected by said spring means substantially uninfluenced by said resilient means.

7. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means additionally biasing said contacts together in the same direction as said reclosing bias at least when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, said overcenter spring means being moved substantially to its on-center position in response to a predetermined small initial part of the separating movement of said contacts, and stop means preventing further movement of said overcenter spring in the same direction for rendering said overcenter spring means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means.

8. In a circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others overcenter spring means connected between a stationary support and said movable contact for biasing said contacts together at least when they are in engagement, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement of said movable contact substantially to its on-center position, and stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means.

9. In a circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others overcenter spring means connected between a stationary support and said movable contact for biasing said contacts together at least when they are in engagement, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement of said movable contact substantially to its on-center position, stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means, and said overcenter spring means also being moved by said movable contact during its closing movement to become suddenly effective to close said contacts with a snap action only over said small part of contact movement just prior to final engagement of said contacts.

10. In an automatic reclosing circuit interrupter, separable contacts, at least one of which is mounted for movement into and out of engagement with the others electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said movable contact being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means connected between a stationary support and said movable contact for additionally biasing said contacts together at least when they are in engagement, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement of said movable contact substantially to its on-center position, stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means, and said overcenter spring means also being moved by said movable contact during its closing movement to become suddenly effective to close said contacts with a snap action only over said small part of contact movement just prior to final engagement of said contacts.

11. In an automatic reclosing circuit interrupter, separable contacts at least one of which is mounted for movement into and out of engagement with the others, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said movable contact being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means connected between a stationary support and said movable contact for additionally biasing said contacts together at least when they are in engagement, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement of said movable contact substantially to its on-center position, stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means and said overcenter spring means also being moved by said movable contact during its closing movement to become suddenly effective to close said contacts with a snap action only over said small part of contact movement just prior to final engagement of said contacts, and means responsive to a predetermined number of closely successive circuit opening operations for holding said movable contact separated from the other of said contacts, and said overcenter spring means at its on-center position.

12. In a circuit interrupter, separable contacts, resilient means biasing said contacts together at least when they are in engagement, solenoid means having lost motion relative to said contacts for causing separation of said contacts in response to a predetermined condition of a circuit and having a non-linear force-distance charac-

teristic, spring means comprising a plurality of spring portions having different spring characteristics arranged so that the force-distance characteristic of said spring means substantially matches that of said solenoid means and adapted to be stressed during movement of said electro-responsive means relative to said contacts to separate said contacts, and means connected to said movable contact and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is effected by said spring means and is substantially uninfluenced by said resilient means.

13. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means having lost motion relative to said contacts for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, resilient means additionally biasing said contacts together in the same direction as said reclosing bias at least when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, spring means adapted to be stressed during movement of said electro-responsive means relative to said contacts to exert a force tending to separate said contacts which is greater than the resultant force due to said reclosing bias and said resilient means, and means connected to said contacts and said resilient means so as to be responsive to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is effected by said spring means substantially uninfluenced by said resilient means.

14. In an automatic reclosing circuit interrupter, separable contacts at least one of which is mounted for movement into and out of engagement with the others, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said movable contact being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means connected between a stationary support and said movable contact for additionally biasing said contacts together at least when they are in engagement, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement of said movable contact substantially to its on-center position, stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means, and said overcenter spring means also being moved by said movable contact during its closing movement to become suddenly effective to close said contacts with a snap action only over said small part of contact movement just prior to final engagement of said contacts, contact opening spring means, lockout toggle means normally held at an overcenter position where it maintains said contact opening spring means inactive, said contact opening spring means when released adapted to move said overcenter spring means in a contact opening direction to separate the contacts and hold them separated, and manual means and means responsive to a predetermined number of closely successive circuit opening operations of said interrupter for moving said lockout toggle means overcenter to release said contact opening spring means.

15. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means additionally biasing said contacts together at least when they are in engagement, said overcenter spring means being moved in response to a predetermined small initial part of the contact separating movement substantially to its on-center position, stop means preventing movement of said overcenter spring means overcenter, whereby the remaining contact separating movement is substantially uninfluenced by said overcenter spring means and during closing movement of said contact means said overcenter spring means becomes suddenly effective to close said contacts with a snap action only over said small part of contact movement just prior to final engagement of said contacts, contact opening spring means, lockout toggle means normally held at an overcenter position where it maintains said contact opening spring means inactive, said contact opening spring means when released adapted to separate the contacts and hold them separated, and manual means and means responsive to a predetermined number of closely successive circuit opening operations of said interrupter for moving said lockout toggle means overcenter to release said contact opening spring means, said manual means also being movable in an opposite direction to reset said lockout toggle means to its normal position and having opposed surfaces engageable by a manual operating member to move said manual means in both directions respectively, there being no part of said manual means preventing relative separating movement of said member and manual means during movement thereof in either direction.

16. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, resilient means additionally biasing said contacts together in the same direction as said reclosing bias but with a force greater than that exerted by said reclosing bias at least when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said resilient means, and means movably connected to said contacts and said resilient means and to a relatively stationary point so as to be actuated by said contacts in response to a predetermined small initial part of the separating movement of said contacts for rendering said resilient means inoperative to exert any substantial force on said contacts, whereby the remaining contact separating movement is substantially uninfluenced by said resilient means.

17. In an automatic reclosing circuit interrupter, separable contacts, electro-responsive means for causing separation of said contacts in

response to a predetermined condition of a circuit, said contacts being biased into engagement to automatically close the circuit in response to a circuit opening operation, overcenter spring means additionally biasing said contacts together in the same direction as said reclosing bias at least when they are in engagement so that contact pressure is the sum of the forces exerted by said reclosing bias and said spring means, said overcenter spring means being moved substantially to its on-center position in response to a predetermined small initial part of the separating movement of said contacts for rendering said overcenter spring means inoperative to exert any substantial force on said contacts, and said overcenter spring means having portions relatively pivotally movable about an axis which is substantially coincident with said center when said overcenter spring means is substantially at its on-center position, whereby the remaining contact

separating movement is substantially uninfluenced by said resilient means.

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