

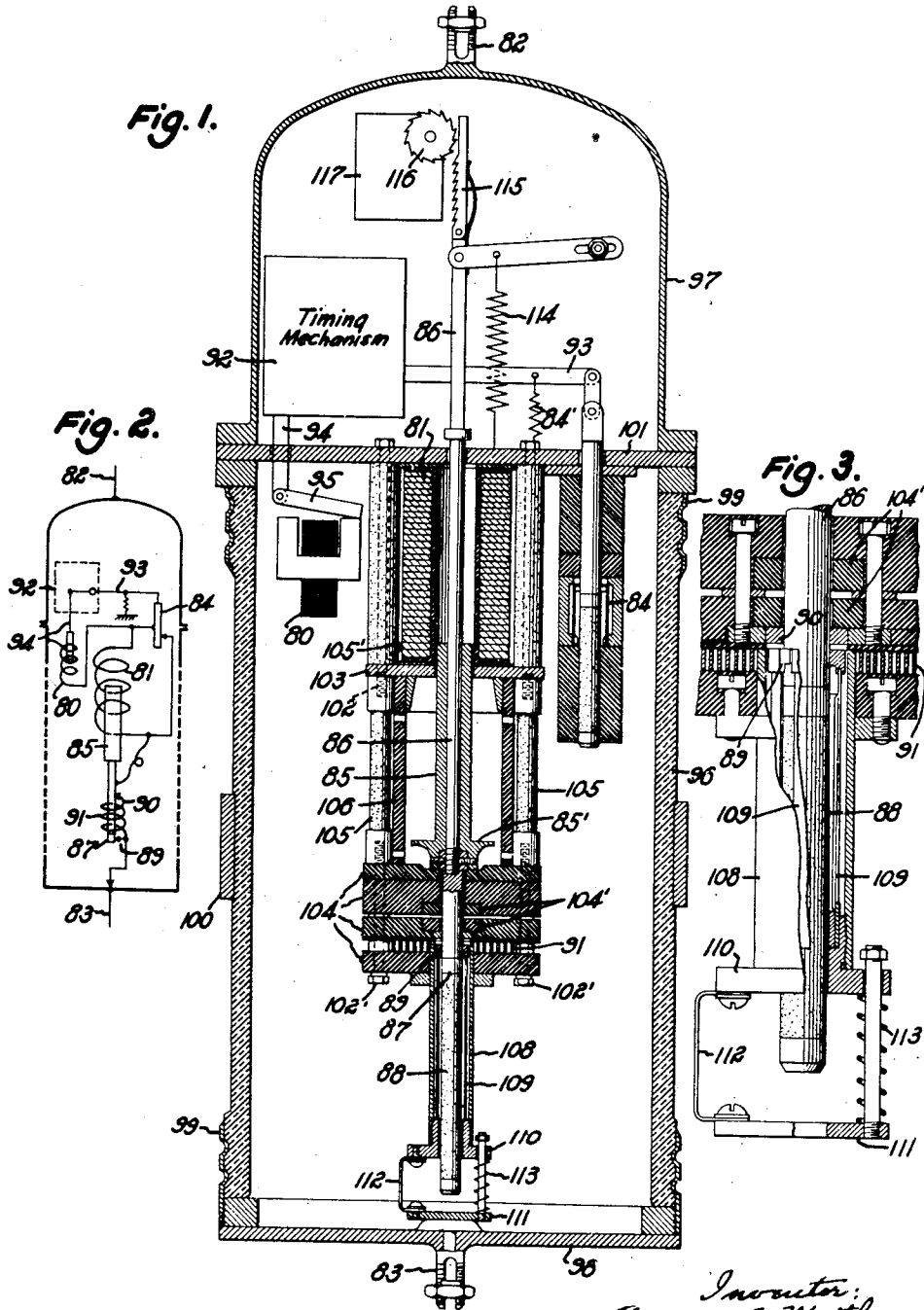
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CIRCUIT BREAKER

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## CIRCUIT BREAKER

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Original application May 7, 1940, Serial No.  
333,875, now Patent No. 2,352,556, dated June  
27, 1944. Divided and this application April  
18, 1942, Serial No. 439,576

15 Claims. (Cl. 175-234)

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This invention relates to circuit breakers and particularly to single-pole reclosing circuit breakers capable of a fast initial opening.

This application is a division of my copending application Serial No. 333,875, filed May 7, 1940, "Apparatus for Protecting Power Lines," that matured into Patent No. 2,352,556 on June 27, 1944; which patent was re-issued under No. 22,872 on April 29, 1947. As stated therein, serious damage or complete burn off occurs in the case of even transient faults as commercially available switchgear cannot open the line in less than about  $\frac{1}{2}$  second. The best performance claimed for any prior experimental circuit breaker has been an opening of a 60 cycle circuit in 5 cycles after fault initiation, and it is apparent that faster operation is essential if burn off is to be prevented. The present invention contemplates a reclosing circuit breaker having an initial opening time substantially lower than that attained, or contemplated by, the prior workers in this field. Claims to certain details of switch construction are presented in my divisional application Serial No. 22,620, filed April 22, 1948.

An object of this invention is to provide a circuit breaker of stable operating characteristics that has an initial opening time substantially less than that of prior circuit breakers. An object is to provide a single-pole circuit breaker of light weight that is entirely self-contained and includes timing mechanism for effecting a plurality of timed reclosures before a final lockout in the case of a permanent fault. Another object is to provide a quick-acting circuit breaker that may be subjected to overloads approximating its tripping values for long periods without damage from overheating or change in operating characteristics. More specifically, an object is to provide a circuit breaker including an operating coil or winding in series with the line for opening the circuit breaker, a normally closed control switch shunted across the operating winding, and a control coil traversed by the line current, or a pre-selected fraction of the line current, whereby the line current is normally shunted around the operating winding and flows through the operating winding only upon the opening of the control switch.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a central section through a single-pole, oil insulated circuit breaker embodying the invention;

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Fig. 2 is a schematic diagram of the same; and Fig. 3 is an enlarged fragmentary view of the circuit breaker contacts.

The circuit breakers contemplated by this invention, as employed for the protection of the conventional three-phase electrical distribution systems, are light weight, fully automatic, single-pole circuit breakers that each includes its own mechanical timing equipment and requires no auxiliary circuits or devices for full automatic operation. As shown in Figs. 1 and 2, the circuit breaker includes a control coil 80 and operating coil 81 in series between terminals 82, 83, the operating coil 81 being normally shunted by the switch 84 that is opened by the control coil 80 against a spring 84'. This switch and the main breaker switch are of the reciprocating rod type, as described and claimed in my prior Patent No. 2,167,665, granted August 1, 1939, "Circuit Breaker," in which an arc-extinguishing chamber of annular cross-section is formed by horn fiber or other organic material.

The core or plunger 85 of coil 81 is secured to a metal rod 86 which carries the movable contact 87 of the circuit breaker and terminates in a rod 88 of horn fiber or the like. The stationary breaker contacts include a main contact 89 that is normally engaged by the rod 86 or its movable contact 87, and an arcing contact 90 above and spaced from the main contacts. The arcing contact 90 is connected to the main contact 89 through a spiral coil 91 coaxial with the rod 86 and the contacts. The function of coil 91 is to rotate the arc that is drawn between the moving contact 87 and the arcing contact 90 when the breaker opens, and the coil is wound in the sense opposite that of the operating coil 81. The shunt or control switch 84 is of simpler design as the arc drawn across its contacts can be extinguished without the aid of an arc-spinning coil.

Timing mechanism 92 is provided to delay the second and subsequent openings of the breaker, but the first opening takes place with no delay. The timing mechanism is indicated generally by the block diagram overlying the junction of the operating lever 93 of switch 84 and the link 94 that connects lever 93 to the armature 95 of the control coil 80. Any desired type of mechanism may be employed to delay the opening of the shunt switch 84 for intervals of 60 cycles or upward when the fault is still on the line at the first or subsequent closures of the breaker. The detailed construction is not illustrated since it forms no part of the present invention.

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The breaker is housed within a chamber comprising a hollow insulator 96 and end closures 97, 98 of metal that carry the terminals 82, 83, respectively. The insulator is provided with metal sleeves 99 to which the closures are bolted, and is recessed to receive a mounting bracket 100. A plate 101 extends across the upper end of the insulator 96 and constitutes the support for the control switch and the breaker assembly, and the control mechanism is located in the domed closure 97 above the plate 101. The insulator 96 is preferably filled with oil to approximately the lower face of the plate 101 which supports all of the switch and control mechanism.

The framework of the breaker assembly includes a series of rods 102, a metal plate 103 on which the coil 81 rests, and a plurality of horn fiber plates or disks 104. Insulating rods 105 are threaded upon rods 102 to secure the plate 103 against spacing sleeves 105' on rods 102, and rods 102' are threaded upon the rods 105 to carry the disks 104. A dashpot for arresting the opening movement of the breaker is formed by the enlarged lower end 85' of the core 85 and a cylinder 106 that is mounted between the plate 103 and the upper disk 104. The top portion of the cylinder flares inwardly above vent openings that permit a free escape of oil from within the cylinder during the major part of the opening movement of the rod 86.

The two intermediate plates 104 are separated slightly and are recessed to receive small horn fiber disks 104' that form the outer wall of the arc-suppressing chamber. The small plates may be replaced when the diameter of the chamber has been appreciably increased by the erosion of the horn fiber. The arc-spinning coil 91 is mounted between the two lower disks 104, and connected between arcing contact 90 that is recessed into the lower face of the upper disk of this pair and a flanged brass tube 108 that is bolted to the bottom disk 104 to support the main contact assembly. The main contact 89 includes a plurality of arcuate segments secured to the upper ends of the several sections of a longitudinally slotted tube 109 of resilient metal. The flanged lower end 110 of the tube 109 is electrically connected to a disk 111 by a jumper 112, and the disk 111 is pressed against a boss on the lower closure 98 by springs 113 coiled about guide rods that extend through the flange 110.

The breaker opens against a spring 114, and displaces a ratchet bar 115 into engagement with the wheel 116 of an escapement mechanism. The spring 114 tends to reclose the breaker as soon as the circuit opens but the downward motion of the switch rod 86 is delayed by the escapement mechanism. The escapement may be of known types, including means for locking the breaker in open position after a predetermined number of reclosures if the fault is still on the line and means for resetting from any point in the schedule of reclosures when the breaker closes on a sound line. The time-delay may be of the customary order of from 30 to 60 cycles, but the specific design of the escapement mechanism is not an essential feature of this invention.

The method of operation of the circuit breaker will be apparent from the foregoing description. In the case of a single phase line, a circuit breaker is connected in series with one side of the line at the terminals 82, 83. An ungrounded three-phase circuit can be protected by locating circuit breakers in two of the line conductors.

The tripping value of the circuit breaker may

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be adjusted as desired but will usually be set up to 200% or more of the rated current capacity of the breaker. The tripping current is determined by the design of the coil 80 and the adjustment of the reclosing spring 84' of the shunting switch 84. The line current does not flow through the operating winding under normal operating conditions, and a heavy and sudden current surge flows through the operating winding 81 when the shunting switch 84 opens. The operating winding 81 may therefore be designed to develop a heavy force for displacing the movable contact 87 at high speed.

The invention is distinguished from prior circuit breakers of the series operating winding type in that the load current is normally by-passed around the operating winding. The prior circuit breakers have been open to the objections of serious overheating and coil damage due to the continuous flow through the operating winding of load current approximating but somewhat less than the tripping value. This overheating under overloads short of tripping value is eliminated by the present invention as the control coil 80 need develop only a relatively small force to open the shunting switch 84. It is therefore possible, and entirely practical, to design the coil 81 to develop sufficient force for an exceedingly high speed opening of the breaker as the winding 81 is subjected only to a momentary current surge of high magnitude. The reciprocating rod and arc-extinguishing chamber construction also contribute to high speed operations as a 1 to 2 inch movement of the rod, which movement is sufficient to separate the breaker contacts and suppress the arc, is obtained in about 2 to 3 cycles with operating coils 81 of practical design.

The initial opening of the breaker takes place within an interval that depends upon the magnitude of the fault current, as shown graphically by curve B of Fig. 1 of my prior application, but the subsequent openings are delayed by the timing mechanism 92 to supply current to a persistent fault for periods of about 30 cycles and upward, thereby to blow sectionalizing fuses or to burn the conductors down if there are no sectionalizing fuses, in the case of a persistent fault, or to lock-out the breaker in the open position if the persistent fault cannot be otherwise cleared from the system. Time values are stated in cycles on a 60 cycles per second basis since it is the usual practice in this art to measure the operating times of protective switchgear with oscillographs that generate a "timing wave" of the frequency of the electrical distribution system. The novel apparatus has been tested and used on lines supplied with alternating current of a frequency of 60 cycles per second but the protective methods and apparatus may be used on direct current lines or on alternating current lines energized at 25 cycles per second or at other frequencies.

The quick acting circuit breakers are particularly useful in protective systems, as described in my prior application, which include line shorting contactors for a substantially instantaneous suppression of fault currents, but may be used to advantage in any protective system where high operating speed is desirable. The high opening speeds of the new circuit breakers are attained by making the operating coil 81 a series element in the line to be protected, whereby a sudden and heavy current surge traverses the coil 81 upon the opening of the control switch 84 which normally by-passes the line current around the

operating coil 31. The term "operating coil" is employed in the following claims to identify the element which functions, upon energization as just stated, to operate the circuit breaker to open-circuit condition against the closing force developed by the spring 114. The heavy power surge for effecting a quick opening of the circuit breaker is developed by an operating coil in series with the line but there is no overheating of the breaker assembly when the line current is maintained for long periods at approximately the preselected breaker-opening value, since the line current is by-passed around the operating coil 31 until the line current reaches that value at which the control coil 30 opens the by-pass switch 34.

It is to be understood that the invention is not restricted to the particular embodiment herein illustrated and described, and that various changes that may occur to those familiar with the design and construction of circuit breakers fall within the spirit of my invention as set forth in the following claims.

I claim:

1. A circuit breaker comprising a pair of terminals for connecting the circuit breaker in series in the line to be protected, a pair of separable contacts, spring means normally retaining said contacts in engagement, electromagnetic means including an operating coil for opening said contacts, said operating coil and contacts being conductively connected in series between said terminals, a shorting circuit connected across said operating coil, and means responsive to overload current on said line for opening said shorting circuit, thereby to pass the overload line current through said operating coil to develop a power surge for opening said contacts.

2. A circuit breaker comprising a pair of terminals for connecting the circuit breaker in series in the line to be protected, a pair of separable contacts, spring means normally retaining said contacts in engagement, electromagnetic means including an operating coil for opening said contacts, said operating coil and contacts being conductively connected in series between said terminals, a normally closed control switch shunted across said operating coil, and means responsive to a predetermined overload condition for opening said control switch, thereby to pass the line current through said operating coil to develop a force to open said contacts.

3. A circuit breaker comprising a pair of terminals for connecting the circuit breaker in series in the line to be protected, a pair of separable contacts, spring means normally retaining said contacts in engagement, electromagnetic means including an operating coil for opening said contacts, said operating coil and contacts being conductively connected in series between said terminals, a normally closed control switch shunted across said operating coil, and a control coil responsive to a predetermined overload condition for opening said control switch to pass the line current through said operating coil, thereby to develop a power surge to open said contacts.

4. A circuit breaker comprising a pair of terminals for connecting the circuit breaker in series in the line to be protected, a pair of normally closed contacts, spring means yieldingly holding said contacts in engagement, electromagnetic means including an operating coil for

opening said contacts, said operating coil and contacts being connected in series between said terminals, a normally closed control switch shunted across said operating coil, and a control coil for opening said control switch, said control coil being connected between said terminals in series with said operating coil and normally closed contacts.

5. A circuit breaker comprising a rod carrying a contact cooperating with a stationary contact, a core of magnetic material fixed to said rod, spring means yieldingly retaining said rod in contact-closed position, an operating coil for displacing said core and rod axially to open said contacts, a normally closed control switch shunted across the operating coil, and a control coil conductively connected in series with said operating coil for opening said control switch.

6. In a circuit breaker, insulating material defining a cylindrical arc-extinguishing chamber, cooperating contact means comprising a stationary contact and contact means including a cylindrical contact member axially movable in said chamber, a rod of insulating material secured to said cylindrical contact member and movable thereby into the arc-extinguishing chamber upon an opening movement of the cylindrical contact member, a core of magnetic material secured to said contact member, an operating coil for moving said core and member axially to open said contact means, a pair of terminals for connection to a line, circuit elements connecting said coil and contact means in series between said terminals, a normally closed shorting circuit across said operating coil, and means responsive to a predetermined overload condition for opening said shorting circuit, thereby to pass the line current through said operating coil to open said contact means.

7. In a circuit breaker, the invention as set forth in claim 6, wherein said shorting circuit includes a normally closed control switch, and said means for opening said shorting circuit comprises a control coil for opening said control switch.

8. In a circuit breaker, the invention as set forth in claim 6, wherein said shorting circuit includes a normally closed control switch, and said means for opening said shorting circuit comprises a control coil in series with said operating coil for opening said control switch.

9. In a circuit interrupter, the combination with a fluid container having an open end, a line terminal at the opposite closed end of the fluid container including a contact at the interior of the container and line connecting means at the exterior of the fluid container, a metal mounting member extending across the open end of said fluid container, and a second line terminal on said mounting member, of an interrupting assembly supported on and removable as a unit from said fluid container with said mounting member; said assembly comprising separable contacts, a core of magnetic material carrying one of said contacts, an operating coil surrounding said core, a normally closed control switch across said operating coil, a control coil conductively in series with said contacts for opening said control switch under predetermined overload conditions, thereby to pass the line current through said operating coil to energize the same to separate said contacts, means for reclosing said contacts, means connecting said operating coil electrically in series between said mounting member and one of said separable

contacts, and conducting means for electrically connecting the other separable contact with said contact of the first line terminal when said mounting member is in operative position with respect to said fluid container.

10. In a circuit interrupter, a unitary assembly for mounting upon the open top of a hollow insulator having a line terminal at the lower end thereof, said assembly comprising a mounting member to extend across and be secured over the open end of the hollow insulator, a line terminal on said mounting member, a pair of separable contacts, electro-responsive means for separating said separable contacts, means for reclosing said contacts, and resilient means for automatically connecting one of said separable contacts with the line terminal at the lower end of the hollow insulator when said mounting member is in operative position with respect to said hollow insulator; said electro-responsive means including an operating coil conductively connected between said line terminals, a control switch normally closed across said operating coil, and means responsive to a predetermined overload condition to open said control switch.

11. In a circuit interrupter, the invention as recited in claim 10 wherein said means responsive to a predetermined overload condition comprises a control coil conductively connected in series with said separable contacts.

12. In a circuit interrupter, a fluid container having an open end, a terminal cap for said end, a line terminal at the opposite end of said container having a portion extending through the container wall to the interior thereof, an interrupting assembly mounted on said cap including separable contacts, electro-responsive contact separating means and reclosing means for the contacts, so that all of said elements are removable from said container as a unit with said cap, said contacts and electro-responsive means connected in series between said cap and a projecting assembly terminal positioned to be adjacent said line terminal when said cap is secured in operative position with respect to said container, and conducting means engaging a portion of said assembly terminal and resiliently stressed against said line terminal in said operative position of the parts relative to the container; said electro-

responsive means including an operating coil conductively connected in series with said separable contacts, a control switch normally shunted across said operating coil, and means responsive to a predetermined overload condition to open said control switch.

13. In a reclosing circuit breaker, a pair of line terminals for connecting the circuit breaker in series in the line to be protected, a pair of normally closed contacts, spring means yieldingly holding said contacts in engagement, electromagnetic means including an operating coil for opening said contacts, said operating coil and contacts being conductively connected in series between said terminals, a control switch shunted across said operating coil, spring means normally retaining said control switch in closed condition, thereby short-circuiting said operating coil, means responsive to a predetermined overload condition for opening said control switch, and time-delay means to prevent immediate reclosure of said control switch by said spring means.

14. In a reclosing circuit breaker, the invention as recited in claim 13, wherein said means for opening said control switch comprises a control coil in series with said contacts.

15. In a reclosing circuit breaker, the invention as recited in claim 13, in combination with time-delay means to retard the reclosure of said contacts by said spring means upon opening thereof through energization of said operating coil.

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