Oct. 19, 1948. T. LINDSTROM ET AL 2,451,962

CIRCUIT BREAKER

Filed Oct. 12, 1945

Fig. 1.

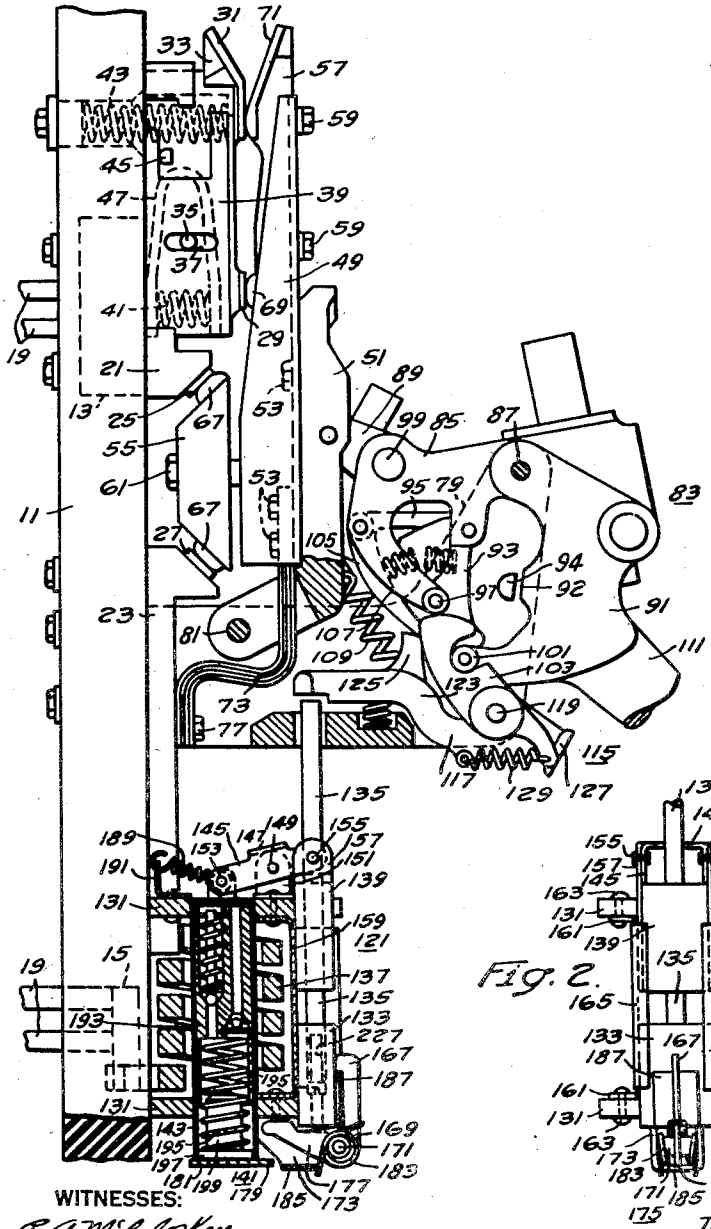


Fig. 3.

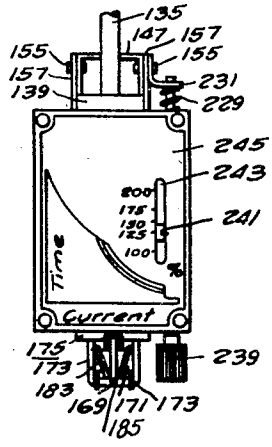


Fig. 4.

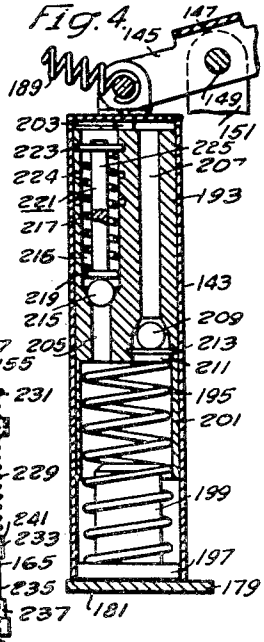


Fig. 2.

WITNESSES:

E. A. McCloskey.

Paul A. Harlow.

INVENTORS

Ture Lindstrom and

Albert H. Baylis.

BY

Ralph L. Swingle

ATTORNEY

Patented Oct. 19, 1948

2,451,962

UNITED STATES PATENT OFFICE

2,451,962

CIRCUIT BREAKER

Ture Lindstrom, Edgewood, Pa., and Albert H. Baylis, Ypsilanti, Mich., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application October 12, 1945, Serial No. 622,048

26 Claims. (Cl. 200—108)

1

This invention relates to circuit breakers and more particularly, to circuit breakers of the type that are tripped instantaneously on overload currents above a predetermined value and after a time delay on lesser overloads.

An object of the invention is to provide a circuit breaker having an improved trip device which is of simple construction, reliable in operation and inexpensive to manufacture.

Another object of the invention is to provide a circuit breaker with an improved electromagnetic trip device having a magnetic piston sealed in a casing containing a body of fluid which is moved relative to the piston by an armature disposed externally of said casing while the magnetic piston is restrained against movement by the magnetic forces to provide time delay tripping of the breaker.

Another object of the invention is to provide a circuit breaker with an improved electroresponsive trip device comprising a sealed casing containing a body of fluid, the casing being moved by an armature to trip the breaker and having a magnetic piston disposed within the casing to delay movement of the casing.

Another object of the invention is to provide a circuit breaker with an improved electromagnetic trip device wherein the tripping armature is normally latched and is released to trip the breaker after a time delay by the movement of a sealed casing relative to a magnetic piston which is disposed within the casing and held substantially stationary by the magnetic forces during tripping movement of the casing.

Another object of the invention is to provide a circuit breaker according to the preceding paragraphs wherein sealed casings having different operating characteristics are interchangeable in the trip device to vary the tripping characteristics of the breaker.

Another object of the invention is to provide a circuit breaker with an improved electromagnetic trip device wherein the tripping armature is normally latched and is released by movement of a sealed casing operated by a second armature, the sealed casing containing a body of fluid and having a magnetic piston disposed therein to delay movement of the casing and release of the tripping armature.

The novel features that are considered characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to structure and operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of one embodiment thereof when read in conjunction with the accompanying drawing, in which:

2

Figure 1 is a side elevational view, partly in section, of a circuit breaker embodying the invention,

Fig. 2 is a front elevational view of the trip device with the cover plate removed,

Fig. 3 is a front elevational view of the trip device showing the cover plate, and

Fig. 4 is an enlarged sectional view of the movable core structure.

Referring to Figure 1 of the drawings, the reference numeral 11 designates a base of strong insulating material which supports the various parts of the circuit breaker. A pair of terminals 13 and 15 are suitably secured to the base and each terminal has one or more connecting studs 19 which extend through the back of the base 11 and serve to electrically connect the breaker to the circuit which it controls.

The upper terminal 13 has a contact block 21 of rigid conducting material secured thereto; and a rigid contact block 23 secured to the base is electrically connected to the lower terminal 15 through the energizing winding of the trip device of the breaker, which will be hereinafter described.

The contact means and mechanism of the circuit breaker illustrated are similar to the circuit breaker fully disclosed in Patent No. 2,214,471, issued September 10, 1940 to Leon R. Ludwig and Merle E. Horn, and assigned to the assignee of the present invention. Hence only a brief description of these parts will be given in this application.

The main stationary contacts 25 and 27 are rigidly secured to the contact blocks 21 and 23, respectively; and the auxiliary stationary contacts 29 and 31 are secured to a triangularly-shaped contact platform 33 of conducting material which is mounted on the upper portion of the block 21 for limited tilting and rocking movement by means of pins 35 projecting from the opposite sides of the platform which engage in slots 37 provided in a pair of side walls 39 secured to the block 21. The platform 33 is biased outwardly from the base 11 by a plurality of springs 41 and 43, and outward movement of the platform is limited by the engagement of the pins 35 with the outer ends of the slots 37 and by stop projections 45 carried by the platform adjacent its upper end. The platform 33, and consequently, the auxiliary contacts 29 and 31 are electrically connected to the terminal 13 by means of a flexible shunt conductor 47.

The movable contact means of the circuit breaker comprises a channel-shaped contact arm 49 of conducting material which is rigidly secured to a pivoted switch member 51 by means of a plurality of screws 53. The contact arm 49 carries a main contact bridging member 55 for bridging the main contacts 25 and 27, and an auxiliary contact member 57 for engaging the stationary auxiliary contacts 29 and 31, the auxiliary contact membes 57 being secured to the upper end of the channel-shaped contact arm 49 by a plurality of screws 59.

The main contact bridging member 55 is formed of rigid conducting material, and is loosely mounted on the contact arm 49 for limited movement relative to the contact arm toward and away from the main contacts 25 and 27 by means of a pair of studs 61 secured to the contact carrying arm 49, only one stud being shown. A pair of coil springs (not shown) encircle the studs 61, and are disposed between the contact carrying arm 49 and the bridging member 55 for biasing the bridging member toward the stationary main contacts 25 and 27 with a predetermined force. The ends of the bridging member 55 are beveled to lie parallel with the beveled edges of the contact blocks 21 and 23, and have a pair of contacts 67 secured thereto for engaging the main stationary contacts 25 and 27.

The auxiliary contact member 57 is formed of rigid conducting material, and has an intermediate contact 69 and an arcing contact 71 secured thereto for engaging the intermediate and arcing contacts 29 and 31 of the stationary contact means.

A flexible shunt conductor 73 electrically connects the auxiliary contact arm 49 to the main stationary contact block 23. The flexible conductor 73 has its upper end secured to the contact arm 49 by the lower screws 53. The lower end of the flexible shunt conductor 73 is secured to the lower contact block 23 by means of a bolt 77.

The switch member 51 has a yoke-shaped lower end which is pivotally mounted between the side walls of a main frame 79 by means of the pivot pin 81. The switch member 51 is movable about its pivot axis to open and closed circuit positions to open and close the contact means of the breaker by means of an operating mechanism indicated generally at 83.

The operating mechanism 83 is supported by the main frame 79 and comprises an actuating lever 85 pivoted on a pin 87 carried by the frame, and is connected to the switch member 51 by a link 89. An operating member 91 is also pivoted on the pin 87 for movement about the same axis as the actuating lever 85. The actuating lever 85 is normally and releasably connected to the operating member 91 for movement thereby by means of a pair of latches 93 and 95, which are pivotally mounted on the lever 85 at 97 and 99, respectively. The latch 93 engages a roller 101 carried by the operating member 91, and this latch is, in turn, held in latching position by the auxiliary latch 95. The operating member 91 is adapted to be releasably held in closed circuit position by means of a main holding latch 103 pivoted at 119, which releasably engages the roller 101. The auxiliary latch 95 is provided with a curved tailpiece 105 by means of which it is released to cause release of the latch 93 and consequent tripping of the circuit breaker by the release of the actuating lever 85 from its connection with the operating member 91. When

released the actuating member 85 moves in a counterclockwise direction about the pivot axis 87, causing opening of the movable contact means. During this movement, a cam surface 107 of the lever 85 engages the rounded nose of the main holding latch 103, moving the holding latch to released position to effect release of the operating member 91. The switch member 51 and the actuating lever 85 are biased to open position by means of a pair of accelerating springs 109 (only one being shown), which are connected at their upper ends to the switch member 51 and at their lower ends to the sides of the main frame 79.

To close the circuit breaker after it has been tripped open, the operating member 91 is first moved in a counterclockwise direction about the pivot axis 87 to the open position to effect resetting of the latches and reestablishment of the releasable rigid connection between the actuating lever 85 and the operating member 91. After the rigid connection is thus established, the operating member 91 is moved in a clockwise direction to closed position by means of a handle 111 to effect closing of the contact means of the breaker. The clockwise or closing movement of the operating member 91 is limited by a portion 92 thereof striking a fixed stop 94 on the frame 79. When the parts have been moved to closed position, the main holding latch 103 reengages the roller 101 to hold the operating member in closed position. The stop 94 is located to permit a slight overtravel of the member 91 to insure proper engagement of the latch 103 with the roller 101. It will be noted that the construction of the operating mechanism is such that the movable contact means is trip-free of the operating member 91; that is, when the breaker is tripped, the contact means move to open position irrespective of the position of the operating member 91.

The mounting arrangement of the contact means is such that during opening of the breaker the main bridging member 55 is first separated from the stationary contacts 25 and 27, while the auxiliary contacts remain in engagement by reason of the outward movement of the contact platform 33 under the influence of the biasing springs 41 and 43. After the bridging member 55 has separated a predetermined distance from the main stationary contacts, the intermediate contacts 29 and 69 begin to separate. This takes place as soon as the pins 35 engage the ends of the slots 37. During this time, the arcing contacts 31 and 71 remain in engagement due to the rocking movement of the contact platform 33. After the intermediate contacts have separated a predetermined distance, the arcing contacts 31 and 71 begin to separate. During closing, the contacts engage in the reverse order, as will readily be understood. It will thus be seen that the arc formed during separation of the contacts is drawn only between the arcing contacts 31 and 71.

The circuit breaker is adapted to be tripped open either manually, or automatically, in response to predetermined overload conditions in the circuit, by means of a trip device indicated generally at 115.

The trip device comprises a trip lever 117 which is pivotally mounted intermediate its ends on the frame 79 by means of a pivot pin 119, and an electromagnetic trip means, indicated generally at 121, which is operable in response to the predetermined overload conditions to move the trip

lever 117 to tripping position to cause automatic opening of the circuit breaker.

One arm 123 of the trip lever 117 is offset and extends inwardly toward the base 11 of the circuit breaker, and has its inner end disposed immediately above the trip means 121 to be engaged and moved by a plunger of the electromagnet to effect automatic tripping of the breaker. The arm 123 of the trip lever is provided with a projection 125 which is adapted to engage the curved tailpiece 105 of the auxiliary latch 95 to move this latch to released position upon movement of the trip lever to tripping position. The other arm of the trip lever 117 forms a handle 127 whereby the trip lever may be manually moved to tripping position to effect manual opening of the circuit breaker. A spring 129 connects the arm 123 of the trip lever 117 to an extension of the main holding latch 103 so that the spring thus serves to bias the main holding latch to latching position and the trip lever to its normal inoperative position, as shown in Fig. 1.

The electromagnet 121 comprises spaced stationary core members 131, a tripping armature 133 having a trip rod 135 seated in an opening thereon, an energizing winding 137 having one end connected to the contact block 23 and the other end connected to the terminal 15. The trip rod 135 extends through an opening in a movable armature 139 but is not operated directly thereby. Disposed within the energizing winding 137 is a movable core structure indicated generally at 141 (Figs. 1 and 4).

The movable core structure comprises a sealed casing 143 of a non-magnetic material containing a body of oil or other liquid of suitable viscosity. The casing 143 is disposed for vertical movement in the winding 137 and has its upper end operatively connected to the movable armature 139 by means of a lever 145. The lever 145 comprises a pair of spaced parallel levers connected by a yoke 147 and pivoted on a pin 149 supported in the spaced, upwardly extending arms of a bracket 151 which is secured to the upper fixed core member 131. The lever 145 is pivotally connected to the upper end of the casing 143 by means of a pin 153 which extends through openings in projections on the upper end of the casing. The opposite end of the lever 145 is connected to the movable armature 139 by means of pins 155 which extend through openings in the arms of the lever 145 and through corresponding openings in projections 157 extending upwardly from each side of the movable armature 139. Thus, when the movable armature 139 moves downward, the sealed casing 143, due to the lever 145, will move upward.

The movable armature 139 and the tripping armature 133 are guided in their vertical reciprocal movement by means of a guide bracket 159 of nonmagnetic material having formed over portions 161 (Fig. 2) secured by means of rivets 163 to bottom and top sides respectively of the upper and lower fixed core members 131. Channel-shaped guides 165 are formed outwardly from the bracket 159, one embracing each side of the armature 139 and the tripping armature 133, to guide said armatures in their vertical movements.

The tripping armature 133 is normally latched in its unattracted position by means of a latch member 167 which forms one arm of a bell crank lever 169 pivoted on a pin 171 supported between the downwardly extending portions 173 of a bracket 175 (see Figs. 2 and 3) secured to the

underside of the lower fixed core 131. The other arm 177 of the bell crank lever 169 extends into the path of travel of a projection 179 extending from the bottom member 181 of the sealed casing 143. The bell crank lever 169 is biased in a counterclockwise direction to latching position by means of a double spring 183 coiled around the pin 171 on either side of the bell crank 169. The bight of the spring 183 engages the latch arm of the bell brank 169 and the two ends of the spring bear against a yoke 185 integral with the side members 173 of the bracket 175. The latch arm 167 engages a latch member 187 secured to the front of the tripping armature 133 to releasably restrain the tripping armature against operation.

A spring 189 tensioned between the pin 153 of the lever 145 and a bracket 191 suitably secured to the upper fixed core member 131 normally biases the movable core structure 141 and the movable armature 139 toward a central position. With normal current flowing in the energizing coil the weight of the movable core structure is sufficient to cause the parts to assume the positions in which they appear in Figure 1.

When an overload current below a predetermined value of, for instance, 1000% of normal rated current occurs the magnetic forces attract the movable armature 139 and the tripping armature 133 toward each other. Since the tripping armature 133 is latched in its retracted position it cannot move, but the movable armature 139 starts to move downward and, through the agency of the pivoted lever 145 draws the sealed casing 143 upwardly and eventually the projection 179 on the bottom member 181 of the casing 143 engages the arm 177 of the bell crank 169 and operates the bell crank and the latch arm 167 to release the tripping armature 133. The tripping armature 133 immediately moves upwardly carrying the trip rod 135 therewith to engage the trip lever 117 and trip the breaker in the manner previously described.

When an overload below the afore-mentioned predetermined magnitude occurs, such, for instance, as is occasioned by the turning on of lights, it is desirable to interpose a time delay between the occurrence of the overload and the tripping of the breaker, so that, should the circuit condition return to normal before tripping is effected, the trip device may return to normal condition without having tripped the breaker.

In the present invention time delay is effected by a piston 193 of magnetic material disposed in the sealed casing 143 and normally biased by means of a compression spring 195 to the upper end of the casing. The spring 195 is compressed between a flange 197 of magnetic material integral with a core member 199 also of magnetic material in the bottom of the casing and the bottom of the piston 193 inside a cylindrical extension 201 of the piston. The piston 193 is spaced from the top of the casing 143 by means of a stop 203 secured to and projecting inwardly from the top of the casing. The piston 193 is provided with two oil passages 205 and 207 extending longitudinally therethrough. The passage 207 is for the purpose of relieving the oil pressure from above the piston to permit its restoration following an operation and to this end is provided with a ball check valve 209 disposed in the enlarged lower end 211 of the passage and loosely retained therein by means of a pin 213. When the casing 143 is moved upwardly past the piston 193 during the occurrence of an overload the oil pressure presses the ball 209

against a conical seat thus closing the passage 207.

A ball valve 215 is disposed in the enlarged upper portion 216 of the passage 205 and is biased downwardly against a conical seat by a spring 217 compressed between the head 219 of a guide rod 221 and a pin 223 inserted in suitable openings in the piston and extending diametrically across the enlarged portion 216 of the passage 205. The guide rod 221 is provided with an axial slot at 225 embracing the pin 223. The pin 223 may be assembled in any one of a plurality of openings 224 (three being shown) provided therefor in the piston to vary the compression of the spring 217 thereby varying the pressure at which the valve 215 will open. The purpose of this adjustment will be more fully described later.

The trip device operates with time delays of different duration in two distinct ranges of overload currents below a predetermined magnitude, and instantaneously in response to an overload above the predetermined magnitude, or a short circuit. These ranges of overload currents may be arbitrarily defined as, for instance, low range up to 200% of normal current, intermediate range between 200% and 1000% of normal, and instantaneous 1000% or more of normal current. Assuming an overload within the low range of overload currents, the operation of the trip device will now be described.

Upon the occurrence of an overload in the low range, the winding 137 becomes energized and the magnetic forces across the air gap between the armature 139 and the tripping armature 133 attracts these armatures toward each other, but, since the tripping armature is latched and cannot immediately move, the armature 139 is drawn downwardly. The downward movement of the armature 139 acting through the lever 145 (Fig. 1) and aided by the spring 189 starts to move the sealed casing 143 upwardly. The piston 193 is so disposed in the magnetic field that the magnetic forces hold it substantially stationary while the casing 143 is drawn upwardly past it by the armature 139. As the casing 143 starts to move upwardly, the pressure of the oil below the piston closes the check valve 209 (Fig. 4) compelling the oil to flow through the passage 205 or between the piston and the wall of the casing. The spring 217 holds the valve 215 closed on overloads up to 200% of normal or in the low range of overloads, consequently, the oil flows around the piston in this range of overloads, thus providing a relatively long time delay.

Continued movement of the armature 139 reduces the air gap between the armatures 139 and 133 and increases the forces acting thereon. This is counteracted to a certain extent after the spring 189 (Fig. 1) passes above center where it opposes upward movement of the sealed casing. Eventually, after at time interval which varies inversely with the magnitude of the overload, the projection 179 (Fig. 1) on the bottom of the casing engages the arm 177 and operates the bell crank 169 to release the tripping armature which then moves upwardly to trip the breaker in the previously described manner. Additional magnetic pull is provided to unlatch the armature 133 by the core member 199. As the casing 143 moves upwardly the core 199 reduces the air gap between itself and the magnetic piston 193 thus increasing the upward pull on the casing.

When the breaker is tripped open the circuit is interrupted and the winding 137 of the trip device becomes deenergized. At this time, the spring 189 exerts a force on the lever 145 biasing the lever in a counterclockwise direction. This force raises the armature 139 and lowers the movable core structure 141 until the spring 189 and the lever 145 are in line. Thereafter the weight of the core structure 141 restores the casing 143 and the armature 139 to the normal unattracted position. During the restoring movement the entire movable core structure moves downwardly as a unit, and, at the same time, the spring 195 forces the piston 193 upwardly against the stop 203 (Fig. 4). The pressure of the oil above the piston, during the restoring action, opens the check valve 209 permitting free flow of oil through the passage 207 to the other side of the piston thus providing for quick resetting of the piston. When the trip device is deenergized upon opening of the breaker, the tripping armature 133 drops immediately to its unattracted position where it is relatched by the latch 167 under the influence of the spring 183.

The operation of the trip device upon the occurrence of an overload current in the intermediate range, that is, between 200% and 1000% of normal current, is the same as the operation just described with the difference that the pressure of the oil in the casing 143 below the piston is greater due to the greater energization of the electromagnet. When the winding 137 is energized in response to an overload of approximately 200% of normal current or more, the pressure is sufficient to compress the spring 217 and open the valve 215 thus providing for a greater flow of oil to the other side of the piston 193 which results in a shorter time delay in the intermediate range of overloads than in the low range where the valve 215 does not open.

The breaker is tripped open instantaneously in response to overload currents above the aforementioned predetermined value, or in response to short circuits by means of a small instantaneous trip armature comprising an iron screw 227 screwed into the lower end of the non-magnetic trip rod 135 and seated in the opening in the trip armature 133. Upon the occurrence of an overload current above the predetermined value or a short circuit, the armature 227 is attracted upwardly to bridge the air gap between armatures 133 and 139 and actuates the trip rod 135 to instantaneously trip the breaker independently of the time-delay mechanism and independently of the armature 133 and 139. When the circuit is interrupted and the trip device deenergized, the trip rod and the armature 227 return to their unattracted positions by their own weight. The trip armature 133 remains latched and is not operated on instantaneous tripping operations.

The minimum overload current required to instantaneously trip the breaker may be varied by varying the size or mass of the screw 227 comprising the instantaneous trip armature.

Means is provided to calibrate the time delay tripping means. This means comprises a compression spring 229 compressed between a bracket 231 (Figs. 2 and 3) mounted on the right hand pin 155 which connects the lever 145 to the armature 139, and a block 233 threadedly engaging a rotatable rod 235. The rod 235 is disposed vertically and the reduced upper end thereof engages a suitable opening in the bracket 231. The lower threaded portion of the rod 235 is rotatably supported on the lower fixed core member 131 by means of a collar 237 secured to the rod and resting on the core member 131. The lower end of the rod 235 below the core member

131 is provided with a knurled knob 239 which is secured thereto for rotating the rod.

Rotation of the rod 235 moves the block 233 up or down depending on the direction of rotation and varies the compression of the spring 229 which opposes operation of the armature 139 thus varying the overload current required to effect tripping of the breaker. The block 233 is prevented from turning with the rod 235 by a projection 241 thereon extending through an elongated slot 243 extending vertically in a scale plate 245. The scale plate 245 is suitably secured to the front of the trip device and bears a scale indicating the percent of overload current required to trip the breaker.

There is also provided means for changing the low and intermediate ranges of overload currents required to trip the breaker. It was previously set forth that with the pin 223 mounted in the upper one of the holes 224, the low and intermediate ranges of overload currents were respectively 100% to 200% of normal and 200% to 1000% of normal current. If the pin 223 is assembled in the intermediate hole 224, the spring 217 will be given a greater compression and will require a greater pressure and consequently a higher current value to open the valve 215. The low range of overloads with the pin 223 in the intermediate hole 224 may then be 100% to 300% of normal current and the intermediate range may be from 300% to 1000% of normal current value. In the same manner assembling the pin 223 in the lower one of the holes 224 may establish the low range of overload currents at from 100% to 400% of normal and the intermediate range from 400% to 1000% of normal current values. The limits of the low and intermediate ranges of overloads set forth are to be considered merely by way of example and these may be varied considerably to suit particular requirements. For instance, by the provision of a stronger or weaker spring 217 entirely different sets of values may be established.

The movable core structure 141 including the casing 143 is readily removable from the trip device by removing the pin 153 and dropping the casing assemblage out of the magnet. Another casing assemblage having different operating characteristics may then be inserted. For instance, three different casing assemblages may be provided and interchangeably installed in the breaker, each of the casing assemblages having the pin 223 inserted in a different hole 224 and/or having different strength springs 217 assembled therein. Each of the casings may be marked with identification corresponding to one of the three time-current curves marked on the scale plate 245 (Fig. 3).

By latching the tripping armature against movement and then releasing it after the magnetic airgap is substantially reduced the maximum magnetic pull is utilized to trip the breaker. When released, the tripping armature 133 is actuated to trip the breaker unopposed by the calibrating spring 229.

Having described the invention in accordance with the patent statutes, it is to be understood that various changes and modifications may be made in the structural details and combination of elements disclosed without departing from some of the essential features of the invention. It is therefore, desired that the language of the appended claims be given as reasonably broad interpretation as the prior art permits.

We claim as our invention:

1. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of said trip member, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature for moving said casing, and means disposed in said casing and responsive to energization of said electromagnet to delay tripping movement of said first armature.

2. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of said trip member, means comprising a sealed casing disposed in said winding and movable to cause tripping operation of said first armature, a second armature disposed outside of said winding for operating said casing, and means disposed in said casing and responsive to energization of said electromagnet to delay tripping operation of said first armature.

3. In a circuit breaker comprising relatively movable contact and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device for operating said trip member comprising an energizing winding, a tripping armature operable to cause operation of said trip member, a nonmagnetic casing movable to effect operation of said tripping armature, a second armature movable relative to said casing by said electromagnet to move said casing, and a magnetic member disposed in said casing and responsive to energization of said winding to oppose movement of said tube.

4. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect an operation of said operating mechanism, a trip device for operating said trip member comprising an energizing winding, a first armature movable to trip the breaker, means releasably restraining said first armature against tripping movement, a casing movable to operate said restraining means to release said first armature, a second armature operatively related to said casing and operable upon energization of said winding to move said casing, and means disposed in said casing responsive to energization of said winding to retard movement of said casing.

5. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device for operating said trip member comprising an energizing winding, a tripping armature, means releasably restraining said tripping armature against movement, means comprising a sealed casing movable to operate said restraining means to permit operation of said tripping armature, a movable armature for moving said sealed casing, and means comprising a piston of magnetic ma-

terial disposed in said casing for delaying movement of said casing.

6. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect operation of said operating mechanism, an electromagnetic trip device for operating said trip member comprising a fixed magnetizable structure, an energizing winding, a releasable member operated by said electromagnet and operable when released to operate said trip member, a casing movable to effect release of said releasable member, an armature operable upon energization of said winding to move said casing to effect release of said releasable member, and a magnetizable member in said casing responsive to energization of said winding to retard movement of said casing.

7. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect operation of said operating mechanism, an electromagnetic trip device for operating said trip member comprising a fixed magnetizable structure, an energizing winding, a releasable member operated by said electromagnet and operable when released to operate said trip member, a casing movable to effect release of said releasable member, an armature operable upon energization of said winding to move said casing to effect release of said releasable member, a magnetizable member in said casing responsive to energization of said winding to retard movement of said casing, and means operable by said electromagnet independently of said releasable member to operate said trip member.

8. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of an electromagnetic trip device for causing an automatic operation of said operating mechanism comprising a magnetic circuit, an energizing winding, a releasable magnetizable member in the magnetic circuit movable when released to effect tripping of the breaker, a sealed element movable to release said releasable member, a second magnetizable member in said magnetic circuit operable in response to overload currents in said winding to move said sealed element to release said releasable member, and time delay means comprising a magnetizable member sealed in said element and disposed in said magnetic circuit to be restrained against movement in response to overload currents to oppose movement of said element.

9. In a circuit breaker comprising relatively movable contacts and operating means therefor, the combination of a trip member operable to cause automatic operation of said operating means, an electromagnetic trip device for operating said trip member comprising a magnetic circuit, an energizing winding, a releasable magnetizable member in said magnetic circuit operable in response to overload currents below a predetermined value in said winding to operate said trip member, a sealed casing disposed in said winding and movable to release said releasable member, a first armature in said magnetic circuit operable in response to overload currents below said predetermined value in said winding to move said casing, time delay means comprising a magnetizable member sealed in said casing and disposed in said magnetic circuit to be restrained against movement by energization of said winding in response to overload currents below said predetermined value to retard movement of said casing, and a second armature in said magnetic circuit operable independently of said releasable member in response to overload currents above said predetermined value to instantaneously operate said trip member.

10. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of said trip member, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature for moving said casing, means disposed in said casing and responsive to energization of said electromagnet to delay tripping operation of said first armature, and adjustable means for varying the operating characteristic of said second armature.

11. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of said trip member, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature for operating said casing, means disposed in said casing and responsive to energization of said electromagnet to delay tripping operation of said first armature, resilient means opposing operation of said second armature, and means operable to vary the tension of said resilient means to vary the operating characteristic of said trip device.

12. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of said trip member, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature for operating said casing, spring means biasing said casing against tripping movement during the final part of the tripping movement and thus opposing tripping operation of said casing, and means disposed in said casing and responsive to energization of said electromagnet to delay tripping operation of said first armature.

13. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip device comprising an energizing winding, a first armature operable to effect operation of sad trip member, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature for moving said casing, a spring associated with said casing to first bias said casing in tripping direction and then to oppose tripping movement of said casing, and means disposed in said casing and responsive to energization of said electromagnet to delay tripping operation of said first armature.

14. In a circuit breaker comprising relatively movable contact and operating mechanism therefor, the combination of a trip member operable to effect automatic operation of said operating mechanism, an electromagnetic trip de-

vice for operating said trip member comprising an energizing winding, a tripping armature operable to cause operation of said trip member, latch means normally restraining said tripping armature against movement, a non-magnetic casing movable to operate said latch means to release said tripping armature, a second armature movable relative to said casing by said electromagnet to move said casing, and a magnetic member disposed in said casing and responsive to energization of said winding to oppose movement of said casing.

15. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip member operable to effect operation of said operating mechanism, a tripping electromagnet for operating said trip member comprising a first armature operable in response to overload currents below a predetermined value to operate said trip member, latch means normally restraining said first armature against operation, means comprising a chamber movable to actuate said latch and release said first armature, a second armature operable in response to overload currents below said predetermined value to move said chamber, time delay means comprising a magnetic member disposed in said chamber to be restrained against movement in response to overload currents below said predetermined value to retard tripping operation of said chamber, means operable by said first armature to actuate said trip member, and a third armature on said means operable in response to overload currents above said predetermined value to operate said means independently of said first armature and said second armature to instantaneously operate the trip member.

16. In a circuit breaker comprising relatively movable contacts and operating means therefor, the combination of a trip member operable to effect automatic operation of said breaker, an electromagnetic trip device for operating said trip member comprising an energizing winding, a first armature operable to effect operation of said trip member, an element operable by said first armature to operate said trip member, means comprising a sealed chamber movable to effect tripping operation of said first armature, a second armature operable by said trip device in response to overload currents below a predetermined value to move said chamber, time delay means comprising means disposed in said chamber responsive to energization of said winding to retard tripping movement of said chamber, and magnetic means on said element operable in response to overload currents above said predetermined value to operate said element independently of said first armature to instantaneously operate said trip member.

17. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip device operable to effect automatic operation of said breaker, said trip device comprising an energizing winding, a releasable armature operable to trip said breaker, means comprising a sealed casing containing a body of fluid, said casing being disposed within said winding and movable upon energization thereof to effect release of said releasable armature, time delay means comprising a magnetizable core disposed within said casing and restrained against movement with said casing by energization of said winding, said core having a passage therein for permitting fluid to flow from one side of said core to the other, valve means for controlling the rate of flow of said fluid to thereby control the rate of movement of said casing, and means for adjusting said valve means to vary the rate of flow of said fluid to thereby vary the operating characteristic of the trip device.

18. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip device operable to effect automatic opening of said breaker, said trip device comprising an energizing winding, a releasable armature operable to trip the breaker, means comprising a sealed casing containing a body of fluid, said casing being movable to effect release of said releasable armature, a second armature for moving said casing, time delay means comprising a magnetizable core disposed in said casing and restrained against movement by energization of said winding, said core having a passage therein to permit fluid to pass from one end of said casing to the other, valve means for controlling the rate of flow of said fluid to thereby control the rate of movement of said casing, and means for adjusting said valve means to vary the rate of flow of said fluid to thereby vary the operating characteristics of said trip device.

19. In a circuit breaker comprising relatively movable contacts and operating means therefor, the combination of a trip device operable to effect automatic operation of said breaker, said trip device comprising an energizing winding, an armature operable to effect tripping of said breaker, means comprising a sealed casing containing a body of fluid, said casing being movable upon energization of said winding to effect operation of said armature, time delay means for retarding movement of said casing comprising a magnetizable core within said casing disposed to be restrained against movement by energization of said winding, said core having a passage therein permitting fluid to flow from one end of said casing to the other, valve means for controlling the rate of flow of said fluid to thereby control the rate of movement of said casing, and means for adjusting said valve means to vary the rate of flow of said fluid to thereby vary the operating characteristic of said trip device.

20. In a circuit breaker comprising relatively movable contacts and operating means therefor, the combination of a trip device operable to effect automatic operation of said breaker, said trip device comprising an energizing winding, an armature operable to effect tripping of said breaker, means comprising a sealed casing containing a body of fluid, said casing being movable upon energization of said winding to effect operation of said armature, time delay means for retarding movement of said casing comprising a magnetizable core within said casing disposed to be restrained against movement by energization of said winding, said core having a passage therein permitting fluid to flow from one end of said casing to the other, valve means for controlling the rate of flow of said fluid to thereby control the rate of movement of said casing, spring means biasing said valve means to oppose flow of fluid through said passage, and means for adjusting said spring means to vary the rate of flow of said fluid to thereby vary the operating characteristic of said trip device.

21. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip device operable in response to overload currents to effect automatic opening operation of said circuit breaker, said trip device comprising an energizing winding, a

movable core member operable upon energization of said winding, a sealed casing containing a body of fluid movable by said movable core member to effect tripping of the breaker, time delay means for retarding tripping movement of said casing comprising a secondary core member disposed within said casing to be restrained against movement by energization of said winding, said secondary core member having a passage therein permitting fluid to flow from one end of said casing to the other end and adjustable means associated with said passage to vary the flow of fluid to thereby vary the rate of tripping movement of said casing.

22. In a circuit breaker comprising relatively movable contacts and operating mechanism therefor, the combination of a trip device operable in response to overload currents in the circuit controlled by the breaker to effect automatic operation of said operating mechanism, said trip device comprising an energizing winding, a first armature operable to effect tripping of the breaker, means comprising a sealed casing movable to cause tripping operation of said first armature, a second armature operable upon energization of said winding to move said casing, time delay means comprising a piston within said casing responsive to energization of said winding to retard tripping movement of said casing, calibrating means comprising a spring biasing said second armature against movement, and adjustable means for varying the tension of said spring to thereby vary the minimum overload current required to move said casing, said first armature when operated moving free of said calibrating spring to trip the breaker.

23. In a circuit breaker comprising relatively movable contacts, the combination of an electromagnetic trip device operable to effect automatic opening of said contacts, said trip device comprising an energizing winding, a sealed casing containing a body of fluid and movable to cause tripping of said breaker, an armature operable upon energization of said winding in response to overload currents to move said casing, a second armature disposed in said casing to be held against movement by energization of said winding to restrict displacement of said fluid to thereby retard tripping movement of said casing with a relatively long time delay, and valve means operable to increase the rate of displacement of fluid to thereby retard tripping movement of said casing with a relatively short time delay.

24. In a circuit breaker comprising relatively movable contacts, the combination of an electromagnetic trip device, operable to effect automatic opening of said contacts, said trip device comprising an energizing winding, a sealed casing containing a body of fluid and movable to cause tripping of said breaker, an armature operable upon energization of said winding in response to overload currents to move said casing, a second armature disposed in said casing to be held against movement by energization of said winding to restrict displacement of said fluid to thereby retard tripping movement of said casing with a relatively long time delay, valve means operable to increase the rate of displacement of fluid to thereby retard tripping movement of said casing with a relatively short time delay, and tripping means operable at times independently of said casing to instantaneously trip said breaker.

25. In a circuit breaker comprising relatively movable contacts, the combination of an electromagnetic trip device operable to effect automatic opening of said contacts, said trip device comprising an energizing winding, a sealed casing containing a body of fluid and movable to trip said breaker, a first armature operable upon energization of said winding in response to overload currents to move said casing, a time delay element having a fluid passage therethrough disposed in said casing and restrained against movement by energization of said winding to restrict the flow of fluid to thereby control the rate of tripping movement of said casing in response to overload currents below a predetermined value, and a bypass valve in said passage for controlling the flow of fluid to thereby control the rate of tripping movement of said casing in response to overload currents above said predetermined value.

26. In a circuit breaker comprising relatively movable contacts, the combination of an electromagnetic trip device operable to effect automatic opening of said contacts, said trip device comprising an energizing winding, a sealed casing containing a body of fluid and movable to trip said breaker, a first armature operable upon energization of said winding in response to overload currents to move said casing, a time delay element having a fluid passage therethrough disposed in said casing and restrained against movement by energization of said winding to restrict the flow of fluid to thereby control the rate of tripping movement of said casing in response to overload currents below a predetermined value, a bypass valve in said passage for controlling the flow of fluid to thereby control the rate of tripping movement of said casing in response to overload currents above said predetermined value, and a second armature operable at times independently of said first armature to instantaneously trip said breaker.

TURE LINDSTROM.
ALBERT H. BAYLIS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,072,932	Wilckens	Mar. 9, 1937
2,373,998	Burgwin	Apr. 17, 1945