Feb. 16, 1954

J. B. MacNEILL ET AL

2,669,623

CIRCUIT BREAKER

Filed Jan. 28, 1950

4 Sheets-Sheet 1

Fig. I.

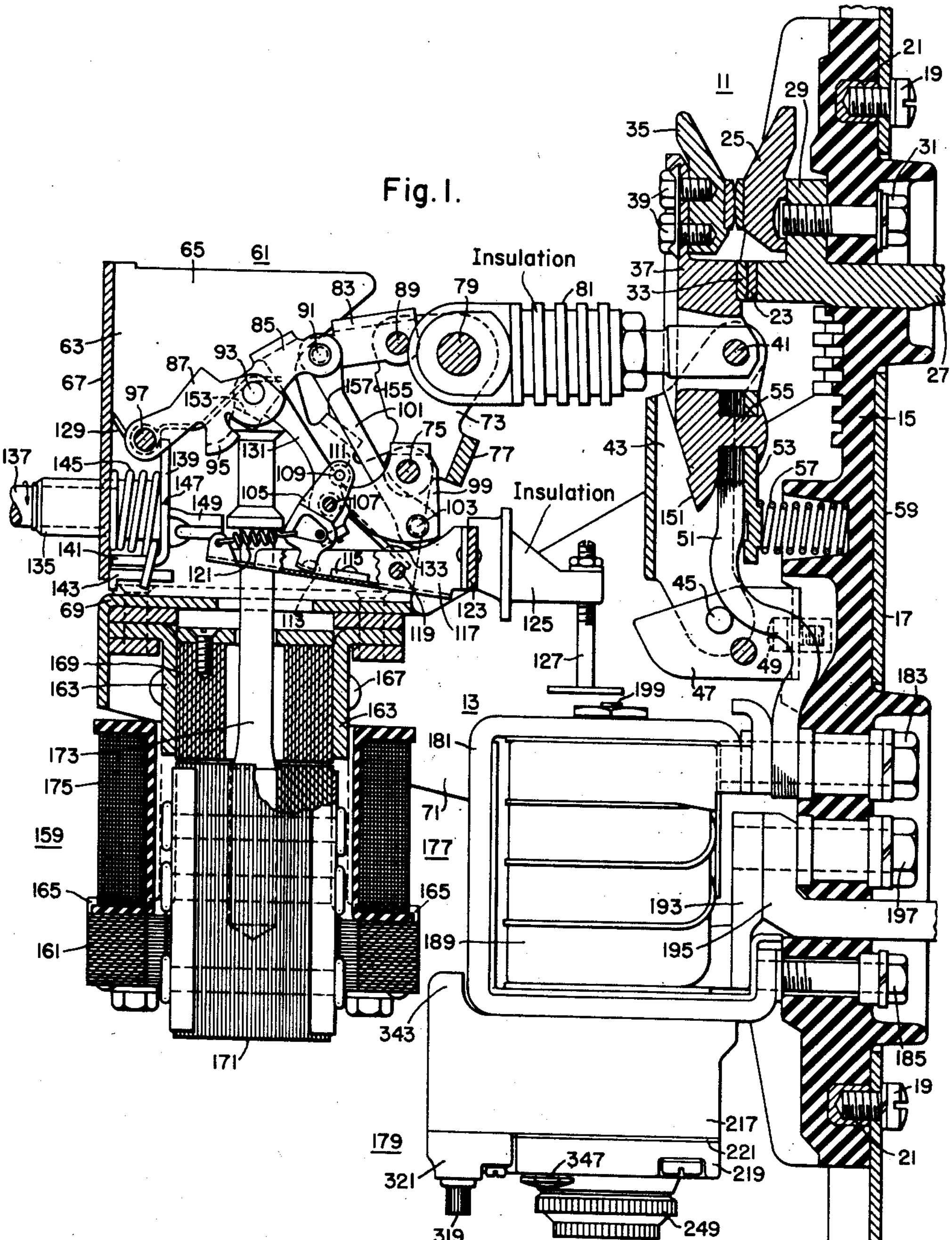

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Fig. 2.

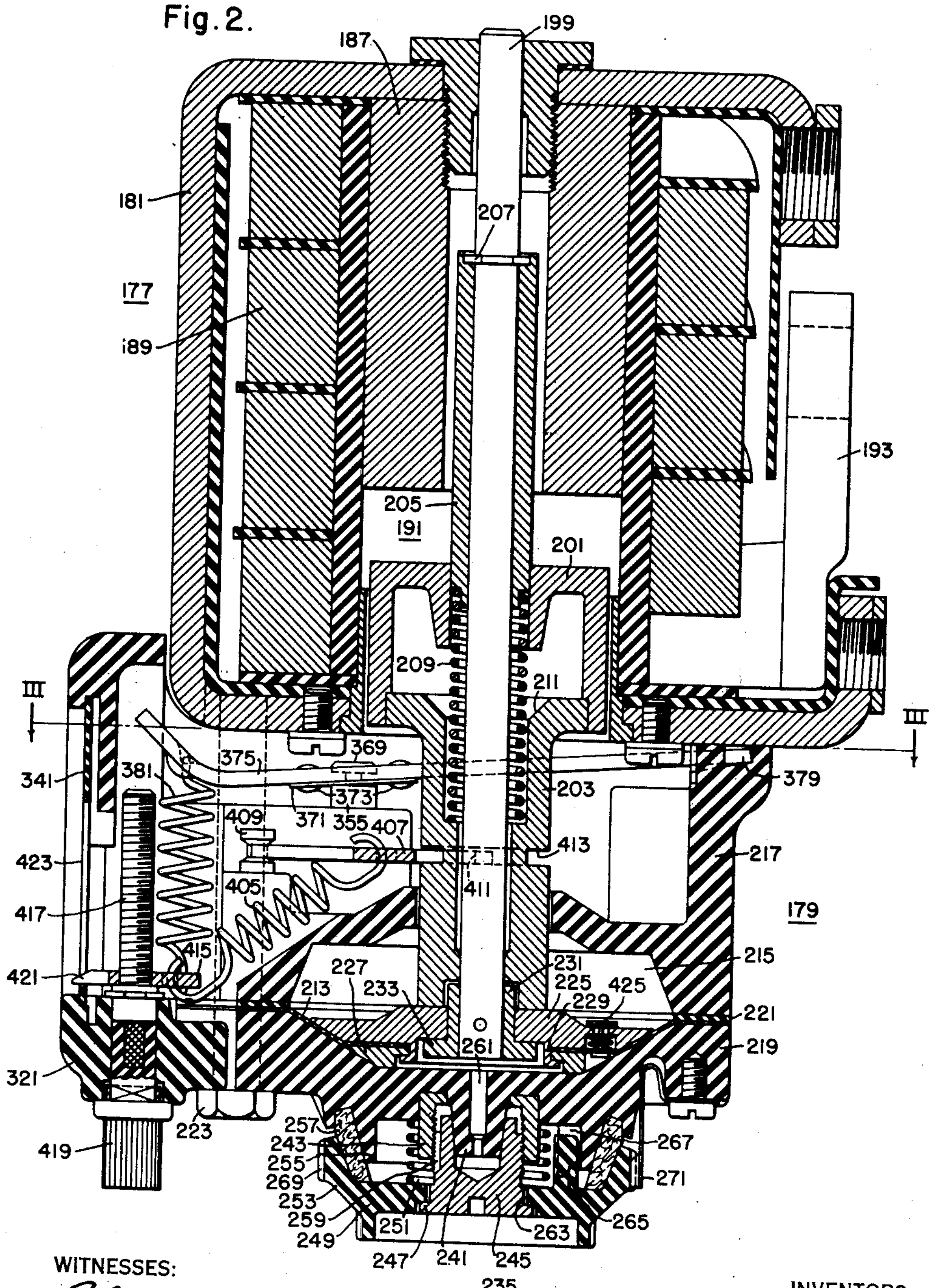

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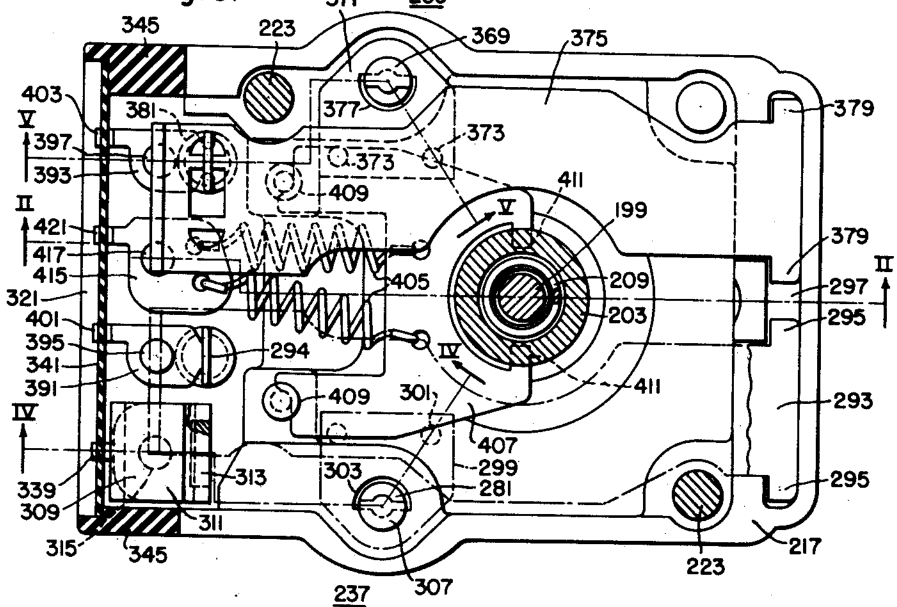
Fig. 3.



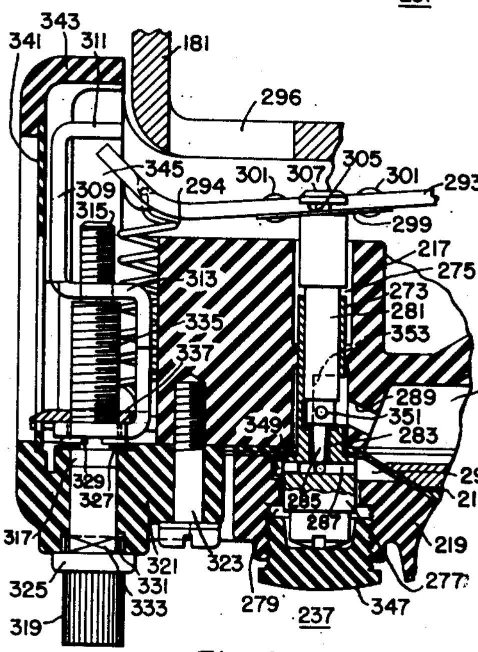


Fig. 4.

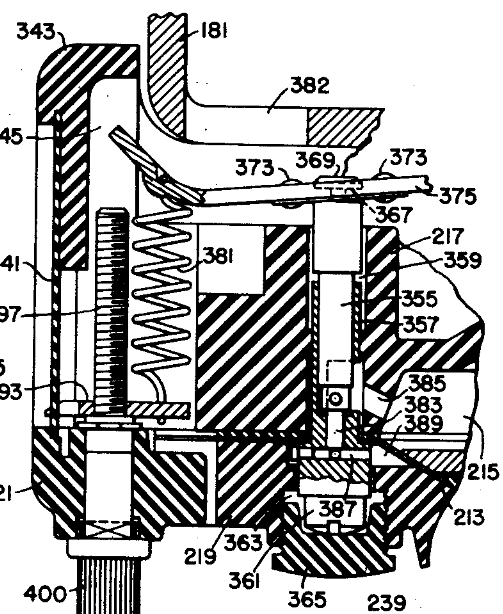


Fig. 5.

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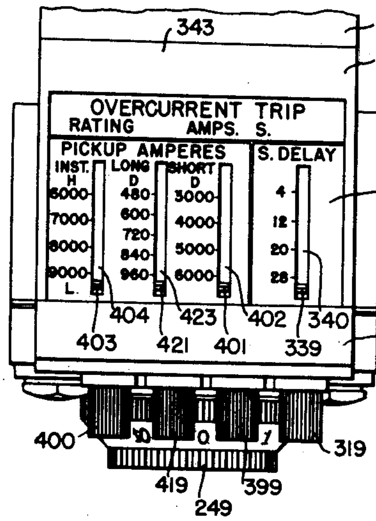
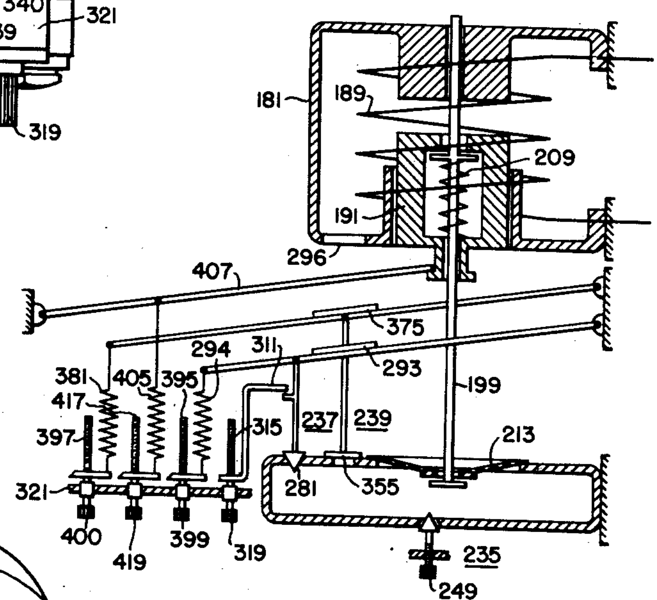


Fig. 6.

Fig. 7.



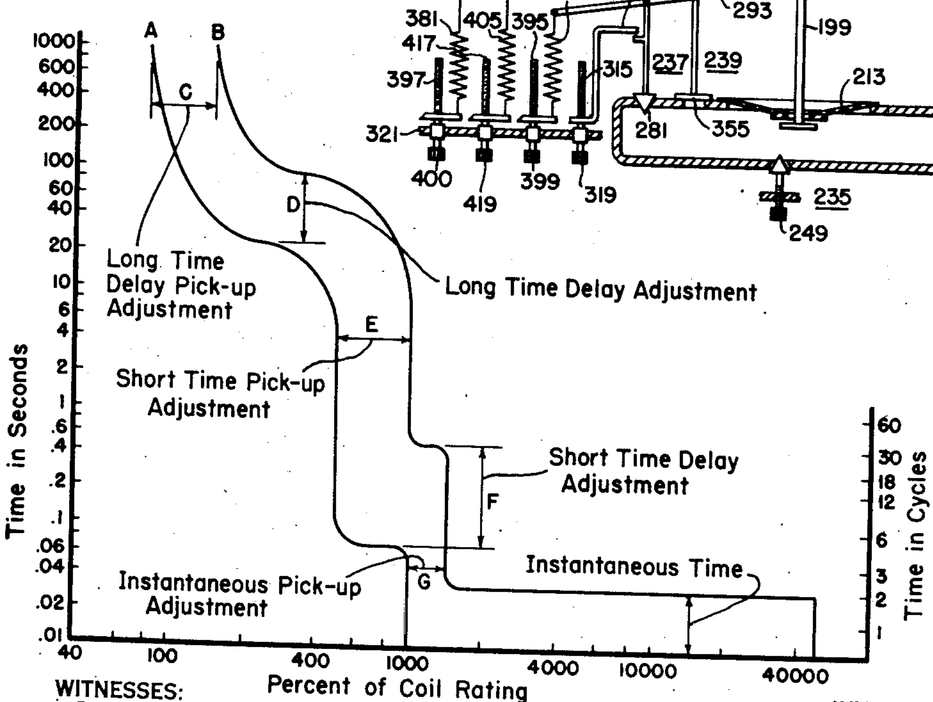


Fig. 8.

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UNITED STATES PATENT OFFICE

2,669,623

CIRCUIT BREAKER

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Application January 28, 1950, Serial No. 141,136

22 Claims. (Cl. 200—108)

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This invention relates to circuit breakers and more particularly to circuit breakers of the type used for controlling light to moderate power distribution circuits.

An object of the invention is to provide a circuit breaker embodying a novel trip device that is operable to trip the breaker after a relatively long time delay in response to overload currents of relative low value, after a relatively short time delay in response to overload currents of intermediate value below a predetermined value and instantaneously in response to overload currents above said predetermined value as short circuits.

Another object of the invention is to provide a circuit breaker embodying an electromagnetic trip device having a novel time delay device and means for limiting the force applied by the electromagnet to the time delay device.

Another object of the invention is to provide a circuit breaker having a trip device embodying a novel time delay device of the fluid dashpot type in which time delays of different duration in different ranges of overload currents are provided by admitting fluid to the dashpot at different rates.

Another object of the invention is to provide a circuit breaker embodying a novel time delay device of the fluid dashpot type wherein different amounts of time delay are provided by the operation of one or more valves to admit fluid to the dashpot at different rates.

Another object of the invention is to provide a circuit breaker embodying a novel trip device and a time delay device of the fluid dashpot type wherein time delays of different durations are provided by the operation of one or more valves for admitting fluid to said dashpot, at least one of the valves being operated electromagnetically in response to overload currents of a predetermined magnitude.

Another object of the invention is to provide a circuit breaker embodying a novel trip device and a time delay device of the fluid dashpot type having separate valve means for controlling the admission of fluid to said dashpot to provide time delay actions of different durations and having adjusting means for adjusting the amount of opening of the valve means to vary the amount of time delay provided by each valve.

A further object of the invention is to provide a circuit breaker embodying a novel trip device and a time delay device of the fluid dashpot type having a plurality of valves for controlling the admission of fluid to said dashpot, certain of said valves being operated electro-

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magnetically, adjusting means for adjusting the amount of opening of certain of said valves and other adjusting means for selecting the minimum overload current required to operate certain of said valves.

Another object of the invention is to provide a circuit breaker embodying a novel trip device having a time delay device providing time delay tripping of different duration for different ranges of overload currents as well as instantaneous tripping, separate adjusting means for varying the amount of time delay in each range and separate adjusting means for selectively determining the minimum overload current requirement for each range of time delay tripping and instantaneous tripping, all of the adjusting means being disposed for easy access.

The novel features that are considered characteristic of the invention are set forth 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 a preferred embodiment thereof, when read in connection with the accompanying drawings.

In said drawings:

Fig. 1 is an elevational view partly in section of a circuit breaker embodying the principles of the invention;

Fig. 2 is a vertical sectional view through the trip device taken substantally along line II—II of Fig. 3 and looking in the direction of the arrows;

Fig. 3 is a sectional plan view of the time delay device taken substantially along line III—III of Fig. 2 and looking in the direction of the arrows;

Fig. 4 is a fragmentary sectional view taken on line IV—IV of Fig. 3 and showing the short-time delay valve device and the adjusting means therefor;

Fig. 5 is a fragmentary sectional view taken substantially on line V—V of Fig. 3 and showing the instantaneous valve device and the adjusting means therefor;

Fig. 6 is an elevational view of the time delay device showing the scale plate and the several adjusting knobs;

Fig. 7 is a schematic view of the trip device illustrating the several adjusting means for the time delay device; and

Fig. 8 is a schematic diagram showing the range of adjustment of the trip device.

Referring to Fig. 1 of the drawings, the circuit breaker includes a plurality of pole units each comprising a contact structure indicated generally at 11, and an overcurrent trip device indicated generally at 13. The contact structure and the trip device for each pole unit are mounted on a separate insulating base 15 which is rigidly secured to a metal panel 17. Since the pole units are alike, only the center pole unit is illustrated and described.

The insulating base 15 for the center pole unit is secured to the panel 17 by means of screws 19 threadedly engaging metal inserts 21 molded integral with the insulating base 15.

The contact structure 11 comprises a stationary main contact 23 and a stationary arcing contact 25, both of which are secured on the inner end of a terminal conducting bar 27 which extends through a suitable opening in the base 15. The stationary arcing contact 25 is rigidly mounted on an upwardly extending portion 29 of the terminal bar 27 which is secured to the base 15 by means of a bolt 31.

Cooperating with the stationary main and arcing contacts 23 and 25, respectively, is a movable main contact 33 and a movable arcing contact 35. The movable contact 33 is secured in a suitable manner as by welding to a pivoted contact carrying member 37 and the movable arcing contact 35 is secured by means of screws 39 to the contact member 37.

The contact carrying member 37 is pivotally mounted by means of a pivot pin 41 on the upper or free end of a generally U-shaped switch arm 43 having its two legs pivoted by means of separate pivot pins 45 supported in spaced brackets 47 which are mounted on the base 15 by screws 49, there being a separate bracket 47 and pivot pins 45 for each leg of the switch arm 43, only one of each, however, being shown.

The movable contact carrying member 37 is electrically connected by means of a flexible shunt conductor 51 to the energizing coil of the trip device 13 which will be described later. The upper end of the flexible conductor 51 is rigidly clamped to the lower end of the contact member 37 by means of a plate 53 which has an integral portion 55 of the contact member projecting through an opening therein and having its end riveted over against the plate in the manner shown in Fig. 1. A spring 57 compressed between the plate 53 and a spring seat 59 in the insulating base 15 provides contact pressure in the closed position of the breaker and also biases the movable contact structure in opening direction.

The movable contact structure is normally maintained in the closed position by an operating mechanism indicated generally at 61 (Fig. 1) mounted in a U-shaped frame 63. The frame 63 comprises side members 65 (only one being shown) and a cross member 67 and is supported on a platform 69 forming the cross member of a generally U-shaped main bracket comprising a pair of spaced side members 71 (only one being shown) joined at their outer ends by the cross member or platform 69. The platform 69 extends across the width of the breaker and the side members 71 are suitably secured to the metal panel 17 on the outside of the two outer poles of the breaker.

'The operating mechanism includes a lever 73 pivotally mounted on a pivot pin 75 supported in the side members 65 of the frame 63. The lever 73 comprises a pair of spaced levers joined by a cross member 77 and between them supporting a rod 79 which extends across all three poles of the breaker. The rod 79 is operatively connected by

means of an insulating connecting member 81 to the pivot pin 41 in the free end of the switch member 43 on which the movable contact member 37 is mounted. It will be understood that there is provided a connecting member 81 for each pole of the breaker connecting the rod 79 to the movable contact structure for each pole unit so that upon operation of the rod 79 the movable contacts for all three poles move in unison.

An operating linkage comprising toggle links 83, 85 and 87 is provided to hold the lever 73 and consequently the movable contacts in the closed position and to operate the movable contacts to open and closed positions. The toggle link 83 comprises a pair of spaced links joined by a cross member and is pivotally connected to the lever 73 by a pivot pin 89. Similarly the toggle link 85 comprises a pair of spaced links and is connected by means of a knee pivot pin 91 to the toggle link 83 and by a pivot pin 93 to the toggle link 87. The toggle link 87 comprises a pair of links joined by a cam shaped cross member 95 and is pivotally mounted on a fixed pivot 97 supported in the frame 63.

The linkage 83, 85 and 87 comprises two toggles, one of which 83—85 may be designated as the tripping toggle and the other 85—87 as the closing toggle. The tripping toggle 83—85 is normally slightly underset above a line drawn through the pivot pins 89—93 and the closing toggle 85—87 is normally under set below a line drawn through the pivots 91—97.

The tripping toggle 83—85 is normally biased in a direction to cause its collapse by a component of the springs 57 which bias the movable contact structures for the three poles of the breaker in opening direction and bias the connecting member 81 toward the left (Fig. 1). The tripping toggle 83—85 is normally prevented from collapsing by means of a main latch member 99 pivoted on the pivot pin 75 and connected by means of a link 101 to the knee pin 91 of the tripping toggle, the link 101 being connected to the latch member 99 by a pivot pin 103.

The main latch 99 is held in latching position by an intermediate latch lever 105 pivoted on a pin 107 supported in the frame 63. The latch lever 105 comprises a pair of spaced levers (only one being shown) which between them support a pin 109 upon which is rotatably mounted a latch roller 111. The lower ends of the latch levers are joined by an arcuate cross member 113 which forms a latch element engaging a light load latch 115 to hold the latch roller 111 in engagement with the main latch 99. The latch 115 is rigidly mounted on a channel-shaped member 117 pivotally mounted on a pin 119 supported in the frame 63. The latch lever 105 and the member 117 are biased to their latching positions by a spring 121 tensioned between the parts as shown in Fig. 1. Rigidly mounted on the right hand end of the channel-shaped member 117 is a trip bar 123 which extends across all the poles of the breaker and has secured thereto an insulating bracket 125 for each of the three poles of the breaker. Each of the brackets 125 has a headed screw 127 adjustably mounted therein for cooperation with the trip device 13 in a manner to be presently described.

It will be seen that as long as the main latch 99 is held in latching position by the latching mechanism just described, the tripping toggle 83—85 will, through the link 101, be held in the position shown, in which the breaker contacts are held in the closed position. The closing toggle 85—87 is biased in a direction to cause its collapse by a spring 129 coiled about the pivot pin 97, the spring having one end bearing against the cross member 67 and the other end bearing against the knee pivot pin 93 of the closing toggle. The closing toggle 85—87 is normally prevented from collapsing by a shouldered support member 131 pivoted on the pin 107 and biased by means of a spring 133 into supporting engagement with the knee pin 93 of the closing toggle.

Rigidly secured to the front plate or cross member 67 of the frame 63 is a bearing 135 in which is rotatably mounted a handle shaft 137. The outer end of the handle shaft 137 carries an operating handle (not shown) and a plate member 139 is secured to the inner end of the shaft 137. The plate member 139 has an outwardly formed portion 141 which, in the normal position of the handle, registers with a lug 143 formed inwardly from the cross member 67. A spring 145 coiled about the bearing 135 has its ends bearing against the portion 141 and the lug 143 in a manner to bias the shaft 137 and the operating handle in both directions to a central position. The plate 139 is provided with shouldered portions, one of which is shown at 147, which engage the lug 143 to limit the rotary motion of the handle. Also secured to the plate 139 is a cam member 149 which has the dual function of engaging the free end of the channel-shaped member 117 to manually trip the breaker open upon movement of the handle in one direction and of engaging the cam 95 on the closing toggle 85—87 to manually close the breaker upon movement of the handle in the opposite direction.

Assuming the circuit breaker to be in the closed position as shown in Fig. 1, the breaker is tripped open manually by rotating the handle shaft 137 in the proper direction during which movement the cam member 149 engages and actuates the channel-shaped latch member 117 in unlatching direction. This effects release of the latch member 115 whereupon the force exerted by the springs 57 biasing the switch arm 43 in opening direction, transmitted through the connections 81 and the lever 73, causes the tripping toggle 83—85 to collapse upwardly and effects opening movement of the movable contact structures of all of the poles of the breaker. When the tripping toggle collapses the link 101 rotates the latch 99 clockwise, forcing the latch roller 111 to unlatching position where it is held by the arcuate surface on the latch 99.

During the opening movement of the switch arm 43 the springs 57 maintain the arcing contacts in engagement until a tail 151 on the contact member 37 engages the cross member of the switch arm 43. The opening movement of the switch arm 43 is limited by its engagement with extensions on the brackets 47. The opening movement of the lever 73 is arrested by engagement of surfaces 155 on the two legs thereof with ears 157 struck out from the side members 65 of the frame 63.

The closing toggle 85—87 does not immediately collapse following the release of the latch 99 since it is held by the support 131. However, during the collapsing movement of the tripping toggle the toggle link 85 rotates counterclockwise about the pivot pin 93. During this rotation of the link 85, an ear 153 formed thereon adjacent the pin 93 engages the support member 131 and disengages the shoulder thereon from the pin 93 whereupon the toggle 85—87 collapses downwardly under the bias of the spring 129. The collapse of the toggle 85—87 is assisted by the weight of the moving armature of a closing solenoid, which will be discussed later. Collapse of the closing toggle 85—87 causes resetting of the tripping toggle to thrust transmitting position and resetting of the main latch 99 to latching position. As soon as the latch 99 is reset the spring 121 reengages the latch roller 111 with the main latch 99 and also reengages the latch member 115 with the latch element 113 to hold the latch roller 111 in latching position. The mechanism is now in condition for a closing operation.

The contacts are closed either manually by operation of the shaft 137 by the handle or by a closing solenoid indicated generally at 159. In order to close the contacts manually, the shaft 137 is rotated in the direction of the arrow, that is, clockwise as viewed from the front of the breaker. This operation of shaft 137 engages the eccentric cam 149 with the cam 95 on the toggle link 87, and straightens the toggle 85—87. Since, at this time, the knee of the toggle 83—85 is restrained by the link 101 and the main latch 99, the thrust of straightening the toggle 85—87 is transmitted by the toggle link 83 to rotate the lever 73 in a clockwise direction. This movement of the lever 73 is transmitted by the tie rod 79 and the several connectors 81 to the switch arms 43 to simultaneously close the contacts for all of the poles of the breaker. As the knee pin 93 for the toggle 85—87 arrives at the position shown in Fig. 1, the support 131 is moved by its spring 133 into supporting engagement with the pin 93 to maintain the contacts closed. Upon release of the handle the spring 145 restores the shaft 137 and the cam 149 to their normal position.

The circuit breaker may be closed by energization of the closing solenoid 159 which may be effected either manually or automatically by closing a suitable switch (not shown). The solenoid 159 comprises a fixed laminated magnet yoke 161 supported on a bracket 163 secured to the under side of the platform 69. The bracket 163 extends downwardly and has feet 165 struck outwardly therefrom to which the magnet yoke 161 is rigidly secured. Also secured to the bracket 163 by means of rivets 167 is a fixed core member 169. A movable armature 171 is attached to the lower end of an operating rod 173 which extends upwardly through clearance openings in the fixed core 169, the platform 69 and the channel-shaped trip member 117 and has its upper end pivotally supported on the knee pivot pin 93 of the closing toggle 85—87. An energizing coil 175 wound on an insulating spool is supported on the fixed magnet yoke 161.

In the closed position of the breaker (Fig. 1) the armature 171 is held in its raised position. When the breaker is tripped open, the closing toggle 85—87 collapses downwardly, as previously described, under the influence of the spring 129 and the weight of the armature 171 permitting the armature to assume its lower unattracted position. Thereafter, upon energization of the coil 175, the armature 171 is attracted upwardly straightening the toggle 85—87 and closing the contacts.

The breaker is automatically tripped open by operation of the trip device 13 for any pole of the breaker. The trip device includes a tripping electromagnet indicated generally at 177 (Figs. 1 and 2) and a time delay device indicated generally at 179. The tripping magnet 177 comprises a C-shaped magnet yoke 181 (Figs. 1 and 2) rigidly secured to the base 15 of its corresponding pole by means of bolts 183 and 185, a fixed core member 187 (Fig. 2), an energizing winding 189 and a movable armature 191. The bolt 183 which secures the upper end of the magnet yoke 181 to the base also serves to secure the lower end of the flexible conductor 51 to the upper turn of the winding 189. The lower turn of the winding has a conducting lug 193 electrically and mechanically secured thereto and this lug is secured to a conducting terminal 195 and to the base 15 by means of a bolt 197. The energizing winding 189 is thus electrically connected in series relation in the circuit through the breaker which extends from the terminal 27, the main and arcing contacts 23—33 and 25—35, the contact member 37, flexible conductor 51, energizing coil 189 of the trip magnet to the terminal 195. Upon energization of the tripping magnet the movable armature 191 is attracted upwardly and actuates a trip rod 199 which engages the headed screw 127 to operate the trip bar 123 and trip the breaker.

The movable armature 191 comprises an upper cup-shaped member 201 and a lower tubular member 203 rigidly secured together by suitable means such as brazing. The member 201 has a central opening therein and is adapted to slide over a sleeve 205 surrounding the trip rod. The sleeve 205 is limited in its upward movement relative to the trip rod 199 by means of a spring clip 207 seated in a groove in the trip rod. A spring 209 coiled about the trip rod 199 is compressed between the lower end of the sleeve 205 and the bottom of a counterbore 211 in the lower element 203 of the movable armature.

The trip rod 199 is moved upwardly to trip the breaker under the control of the time relay device 179 which comprises, generally, a flexible diaphragm 213 (Fig. 2) attached to the lower end of the trip rod and several valve elements for admitting air to the space below the diaphragm at various rates to provide for different amounts of time delay. The flexible diaphragm 213 is disposed in a chamber 215 formed in an upper housing member 217 and a lower housing member 219, both of said housing members being of molded insulating material. The outer edge of the diaphragm 213 is clamped between the housing members 217 and 219, together with a sealing gasket 221 to form an airtight seal. The housing members are secured together and rigidly secured to the magnet yoke 181 by means of bolts 223 (Figs. 2 and 3). The central portion of the diaphragm 213 is clamped between upper and lower clamp members 225 and 227, respectively, the upper clamp member 225 having an annular projection 229 extending downwardly through an opening in the lower clamp member 227 and formed over against the lower face of the latter to form an airtight seal.

Secured to the lower end of the trip rod 199 is a sleeve 231 having a flange 233 thereon brazed to the bottom face of the upper clamping member 225. The lower portion 203 of the movable armature extends downwardly through an opening in the upper wall of the chamber 215 above the diaphragm and is seated on the upper face of the clamping member 225. The spring 209 biases the trip rod 199 upwardly and biases the movable armature 191 downwardly. This results in biasing the lower end of the armature member 203 downward against the upper face of member 225.

Since the spaces above and below the diaphragm 213 are completely sealed off from each other and the space above the diaphragm is at atmospheric pressure, any force tending to raise the trip rod 199 will be restrained by the partial vacuum below the diaphragm. In order to control the rate of tripping movement of the trip rod 199 several valve devices are provided to admit air to the space below the diaphragm. The valve devices comprise a long-time delay valve indicated generally at 235 at the bottom of Fig. 2, a short time delay valve device indicated generally at 237 in Figs. 3 and 4 and an instantaneous valve device indicated generally at 239 in Figs. 3 and 5.

The long time delay valve device 235 will be described first. The central bottom portion of the housing member 219 is molded to form a valve seat 241 in the shape of an inverted truncated cone. Surrounding the valve seat 241 is a tubular metallic member 243 molded into the housing member 219 and threaded internally to receive a valve 245 having a conical opening therein for cooperating with the valve seat 241. The valve 245 is provided with a flange 247 for supporting a knurled adjusting knob 249 of molded insulating material which is biased thereagainst by a spring 251 coiled about the tubular member 243 and compressed between the bottom of the housing member 219 and upper surface of the adjusting knob 249. The outer portion of the knob is formed to provide a flange 253 extending outwardly and upwardly and cooperating with a flange 255 molded integral with the housing member to support and retain in place a suitable filter material indicated by the reference numeral 257 through which air is admitted to the chamber 215 below the diaphragm. It will be noted that an air passage 259 in the form of a groove is provided along the threaded surface of the valve 245 and a passage 261 is provided axially through the valve seat 241. The flow of air into the chamber below the diaphragm is through the filter 257, the passage 259, the orifice defined by the valve 245 and the valve seat and through the passage 261.

The inner surface 263 of the knob 249 is provided with serrations which cooperate with corresponding serrations on the valve 245, whereby rotation of the knob 249 also rotates the valve 245 which, due to its threaded engagement with the fixed tubular member, moves the valve axially off the valve seat 241 to thereby vary the rate of admission of air below the diaphragm and, hence, varies the amount of time delay.

The valve device just described is calibrated by pushing upwardly on the knob 249 to disengage it from the valve member 245. The knob 249 is then set to zero and the valve member 245 rotated to the closed position. Thereafter the knob 249 is released and restored to engagement with the valve by the spring 251. The knob 249, together with the valve 245, is then rotated to the position to provide the required time delay. The knob 249 is limited in rotation to approximately 360° by means of a projection 265 molded integral with the knob engaging a projection 267 molded integral with the housing member 219.

The periphery of the knob 249 is provided with serrations as at 269 which are engaged by a spring pressed pawl 271 to retain the knob in its adjusted position.

The short-time delay valve device 237 (Fig. 4) controls a passage for admitting air from the chamber 215 above the diaphragm 213 to the space below the diaphragm at a rate to provide tripping with a very short time delay in the order of alternating current cycles. The valve device 237 comprises a tubular valve element 273 (Fig. 4) disposed in an opening 275 in the housing member 217 and having an enlarged head portion 277 seated in an opening 279 in the housing member 219. The valve element 273 is provided with a valve seat and a valve 281 slidable in the tubular valve element 273 normally cooperates with the valve seat to close a communication with opposite sides of the diaphragm. The valve element 273 is provided with an axial passage 283 in which is disposed a tapered projection 285 of the valve 281 and which is normally closed by the valve 281. The head 277 of the valve element 273 is provided with horizontal passages 287 disposed at right angles to each other. A passage 289 in the housing member 217 communicates the chamber 215 above the diaphragm 213 to the opening 275 above the valve seat and a passage 291 in the housing member 219 communicates the chamber 215 below the diaphragm 213 with the passages 287.

It will be seen that upward or opening movement of the valve 281 will open the passage 283 and establish a communication from the upper side to the lower side of the diaphragm through the passages 289, 283, 287 and 291.

The valve 281 is actuated to open position by means of an armature 293 which is biased to unattracted position by a spring 294 and is attracted upwardly by the tripping magnet 177 when this magnet is energized by overloads in an intermediate range of overloads of, for instance, 200% to 1000% of normal rated current. The armature 293 is shown in Fig. 3 broken away, but with the outline thereof shown by dot and dash lines. A portion of the armature 293 also appears in Fig. 4 of the drawings. An opening 296 (Fig. 4) in the magnet yoke 181 provides an air gap for the magnetic circuit through the armature 293. The armature 293 is provided with outwardly extending projections 295 (Fig. 3) which are seated in a recess 297 in the upper portion of the housing member 217 to pivotally support the armature. A bracket 299 (Fig. 4), secured by means of rivets 301 to the armature 293, has a semi-circular opening 303 (Fig. 3) therein which engages in a notch 305 in the upper end of the valve 281 so that upon actuation of the armature 293 the bracket 299 engages a substantially semi-circular head 307 on the valve 281 and moves the valve to open position. This opens the previously described communication permitting air to pass from the chamber 215 above the diaphragm to the space below the diaphragm to control the tripping movement of the trip rod 199 (Fig. 2). The rate of flow of air to the space below the diaphragm and consequently the rate of tripping movement of the trip rod are controlled by the amount of opening of the valve 281.

The opening movement of the valve 281 is adjustably controlled by means of an adjustable S-shaped stop member 309 (Figs. 3 and 4). The upper portion 311 of the S-shaped member comprises an adjustable stop and is disposed in the path of tripping movement of the upturned end of the armature 293 to be engaged thereby and thus limit the upward movement of the armature 293 and limit the extent of opening of the valve 281. The center cross bar 313 of the S-shaped member 309 has a threaded opening therein which is engaged by a reduced threaded portion 315 of an adjusting screw 317, so that upon rotation of the screw 317 the S-shaped member 309 will be moved up or down, depending upon the direction of rotation, to provide for greater or lesser movement of the armature 293 and, hence, greater or lesser opening movement of the valve 281.

The lower end of the adjusting screw 317 has a reduced fluted portion molded into an insulating knob 319. The knob 319 is rotatably mounted in a cross bar 321 of molded insulating material. The cross bar 321 is supported on the underside of the housing member 217 by means of screws 323 only one of which is shown. The knob 319 is provided with a flanged portion 325 which is pressed against the bottom face of the cross bar 321 by means of a spring washer 327 seated in annular groove in the adjusting screw. The spring washer 327 is compressed between the upper surface of the cross bar 321 and a C-shaped washer 329 also engaging in the groove in the adjusting screw. A spring 331 disposed in a recess in the cross bar 321 engages a square portion 333 of the knob 319 to retain the knob at each quarter rotation thereof.

The adjusting screw 317 has an enlarged threaded portion 335 which passes through a clearance opening in the bottom portion of the S-shaped member and threadedly engages an indicating member 337. The lower vertical portion of the S-shaped member 309 has cut-away portions on opposite edges thereof which are engaged by projections on the member 337 so that the latter will travel up and down without rotating. At the outer edge the member 337 is provided with a pointer 339 extending through a vertical slot 340 (Fig. 6) in an index plate 341 supported at its lower end on the cross bar 321 and having its upper end secured to a cross member 343 molded integral with side members 345, which in turn, are molded integral with the housing member 217.

The thread on the portion 335 of the adjusting screw has approximately twice the lead as the thread on the portion 315, hence, for one rotation of the adjusting screw the member 337 and the pointer 339 will move twice the distance as the S-shaped member 309. This makes possible an expanded dial on the index plate 341 and provides for more accurate setting of the short time delay device.

The valve 281 is removably supported in the opening 275 and may readily be removed for inspection by removing a plug 347 which normally closes the opening 279 in which the head 277 of the valve member 273 is disposed. With the plug 347 removed, the valve member 277 is rotated in a direction to bring a key 349 into alignment with a vertical slot (not shown). By means of a pin 351 in the valve 281 cooperating with a cut-away portion 353 in the valve member 273 the valve 281 is caused to rotate with the member 273 to align the semi-circular head 307 (Fig. 3) thereof with the opening 303 (Fig. 3) in the bracket 299. The valve 281 and the valve member 273 may then be bodily removed from the housing. The valve is inserted in the housing by the reverse of the above procedure. The key 349 is aligned with the vertical key way (not shown) which also aligns the semi-circular head 307 with the opening 303 (Fig. 3). The valve assemblage is then thrust upwardly as far as it will go and given a 180° rotation to engage the groove 305 with the bracket 299 on the armature 293. The plug 347 is then inserted and tightened against the head 277 to retain the valve structure securely in place.

The instantaneous valve device 239 shown in Fig. 5 is essentially the same as the short time delay valve device of Fig. 4, except that the tapered end 285 is omitted. The instantaneous valve device 239 comprises a valve 355 slidable axially in a valve member 357 removably supported in an opening 359 in the housing member 217. The valve member 357 is provided with a head 361 disposed in an opening 363 in the housing member 219 and rigidly held in place by a plug 365 which threadedly engages in the opening 363.

The upper end of the valve 355 is provided with a groove 367 forming a semi-circular head 369 (Figs. 3 and 5) adapted to cooperate with a bracket 371 secured by means of rivets 373 to an armature 375. The bracket 371 is provided with a semi-circular spring 377 for receiving the head 369 of the valve 355. The method of removing and replacing the valve assembly of the instantaneous valve device is the same as that described for the short time delay valve device.

The armature 375 is similar to the armature 293 and is provided with pivot projections 379 for pivotally supporting the armature 375 in the recess 297 in the upper face of the housing member 217. The free end of the armature 375 is biased by means of a spring 381 to its unattracted position. The magnet yoke 181 is provided with an opening 382 (Fig. 5) which serves as an air gap for the magnetic circuit through the armature 375.

The valve member 357 is provided with an axially extending passage 383 which is normally closed by the valve 355. When the valve 355 is moved to its open position it establishes a communication from the chamber 215 above the diaphragm 213 to the space below the diaphragm through a passage 385, the passage 383, a horizontal passage 387 in the head 361 and a passage 389.

The pickup point, that is, the magnitude of overload current required to actuate the armatures 293 and 375 may be varied by varying the tension of their respective springs 294 and 381. The upper end of the springs 294 and 381 are attached to their respective armatures and their lower ends are attached to movable members 391 and 393, respectively. The members 391 and 393 threadedly engage adjusting screws 395 and 397 respectively. The lower ends of the screws 395 and 397 are molded into insulating knobs 399 and 400 (Figs. 6 and 7) rotatably mounted in the cross member 321.

Upon rotation of the screws 395—397 their associated members 391—393 are moved up or down, depending on the direction of rotation to vary the tension of their respective springs, thus varying the pickup points of the armatures 293 and 375. The movable members 391 and 393 are provided with pointers 401 and 403, respectively which extend through vertical slots 402 and 404 (Fig. 6) in the scale plate 341 to prevent rotation of the movable member and to indicate the settings of the devices.

The pickup point for the movable armature 191 (Fig. 2) of the tripping electromagnet 177 may be similarly adjusted. The armature 191 is biased against attraction by means of springs 405 (Figs. 2 and 3) which have their upper ends attached to a U-shaped yoke 407 which has its two legs pivotally supported in spaced, grooved studs 409 supported in the housing member 217 substantially as shown in Figs. 2 and 3. The right hand end of the yoke 407 is provided with inwardly extending projections 411 which engage in an annular groove 413 (Fig. 2) in the lower member 203 of the armature 191. The lower ends of the springs 405 are attached to a movable member 415 which threadedly engages an adjusting screw 417. The lower end of the adjusting screw 417 is molded into an insulating knob 419 rotatably mounted in the cross member 321. The movable member 415 is provided with a pointer 421 extending through a slot 423 (Fig. 2) in the scale plate 341 to prevent the movable members from turning and to indicate the setting. It will be understood that the scale plate 341 bears indicia adjacent the several pointers indicating the settings of the several adjusting devices.

The trip device operates with time delays of different durations in two distinct ranges of overcurrents below a predetermined magnitude, and instantaneously in response to overcurrents above the predetermined magnitude, or in response to short circuit currents. The ranges of overcurrents may be arbitrarily defined as, for example, a low range up to 500% or 600% of normal rated current, an intermediate range between 500% or 600% and 1000% of normal rated current, and instantaneous 1000% or more of normal rated current.

Assuming an overcurrent within the low range of overcurrents the trip device, referring particularly to Fig. 7, will operate as follows: Upon the occurrence of an overcurrent in the low range the tripping electromagnet becomes energized and attracts the armature 191 upwardly. The armature acts through the spring 209 and the sleeve 205 to produce an upward thrust on the trip rod 199, the movement of the trip rod being retarded by the partial vacuum below the diaphragm 213. The trip rod 199 moves slowly in tripping direction as air is drawn into the space below the diaphragm through the long time delay valve 235 until the upper end of the trip rod engages the headed screw 127 (Fig. 1) and actuates the latch mechanism to effect tripping the breaker in the manner previously described. The time delay provided by the long time delay device 235 is in the order of seconds and may be varied by adjusting the valve 241—245 as set forth previously.

As soon as the breaker contacts are opened the tripping magnet 177 is deenergized and the armature 191 and the trip rod 199 are restored by means of the springs 405 and the force of gravity to their Fig. 2 positions. A spring biased bypass valve 425 (Fig. 2) controls a passage through the diaphragm 213 to provide for quick restoration of the armature 191, the trip rod 199 and diaphragm 213 to their normal positions following a tripping operation.

When an overcurrent occurs in the intermediate range of overcurrents, the electromagnet 177 is energized sufficiently to attract the short time delay armature 293 (Figs. 4 and 7) upwardly against the adjustable stop 311 opening the short time delay valve 281 an amount determined by the adjustment of the stop 311. This admits air to the space below the diaphragm 213 at a higher rate than the long time delay valve alone and provides a relatively short time delay in the order of cycles in the tripping operation.

Energization of the tripping magnet 177 in response to an overcurrent in the intermediate range is not sufficient to attract the armature 375 for the instantaneous valve 239 (Fig. 5). However, upon the occurrence of an overcurrent of 1000% or more of rated current both the short time delay armature 293 and the instantaneous armature 375 are actuated and open both the short time delay valve 281 (Figs. 4 and 7) and the instantaneous valve 355 (Figs. 5 and 7), thereby admitting air to the space below the diaphragm 213 at a rate sufficient to permit substantially instantaneous tripping movement of the trip rod 199.

On short time delay and instantaneous tripping operations the spring 209 limits the force applied by the moving armature 191 to the time delay device. On such operations the armature 191 is attracted immediately against the fixed core member 187 compressing the spring 209 which then supplies the force necessary to actuate the trip rod. Thus the pull exerted on the time delay device is limited to the maximum force exerted by the spring 209 when it is compressed. This prevents damage to the time delay device and also provides a uniform pull on the time delay device.

The herein disclosed circuit breaker is well adapted for the protection of distribution systems. Such distribution systems are usually protected by a series of breakers including generator breakers, bus tie-in breakers, feeder breakers and load breakers. The circuit breakers of such a system are usually set for selective tripping, that is, if a fault should occur at any point in the system, the breaker nearest the fault and on the generator side of the fault should open to clear the fault condition.

The time-current requirement of the tripping device varies with the position of the breaker in the selective system for which reason a trip device providing a wide range of adjustment is essential.

As shown in Figure 8, the trip device is capable of a wide range of adjustments. There are five separate adjusting devices all located for ease of accessibility. By way of example of the ranges of adjustment, the following have been arbitrarily selected for illustrative purpose:

1. Range of long time delay pickup, from 80 to 160% of coil rating.

2. Range of long time delay, from 23 to 86 seconds.

3. Range of short time delay pickup, from 500 to 1000% of coil rating.

4. Range of short time delay, from 4 to 30 cycles.

5. Range of instantaneous pickup from 1000 to 1500 per cent of coil rating.

Figure 8 graphically illustrates the ranges of the several adjustments of the trip device. Along the left hand edge of Fig. 8 is indicated the time in seconds. At the bottom is indicated the per cent of coil rating and along the right hand edge is shown the time in cycles based on 60 cycle frequency. The curve A represents the minimum settings of the adjustments and the maximum settings are represented by the curve B. By adjusting the knob 419 (Figs. 2, 6 and 7) the long time delay pickup may be adjusted to pick up at any point in the band of adjustments defined by curves A and B as indicated at C, that is, by way of example, between 80% and 160% of coil rating. Adjusting the knob 249 (Figs. 2, 6 and 7) which controls the long time delay valve 235 varies the amount of long time delay between 23 and 86 seconds as indicated at D in Fig. 8. As indicated at E (Fig. 8) the short time delay pickup may be set to pick up between 500% and 1000% of coil rating. This is effected by adjusting the knob 339 (Figs. 6 and 7). The amount of short time delay may be varied between 4 and 30 cycles, as indicated at F, by adjusting the knob 319 (Figs. 4, 6 and 7). Finally the instantaneous pickup point may be varied between 1000% and 1500% of coil rating, as indicated at G, by adjusting the knob 400 (Figs. 5, 6 and 7) which controls the tension of the biasing spring 381 (Figs. 5 and 7) for the instantaneous valve operating armature 375.

Each of these adjustments may be made by merely turning the adjusting knob associated with the particular adjusting devices previously described. The adjustments are independent of one another and, as shown in Fig. 6, all of the adjusting knobs are conveniently located.

The complete adjustability of the trip device eliminates the necessity of increasing band width of adjustments to compensate for manufacturing variations and different coil ratings. The variation of tripping time due to temperature change is negligible. This is made possible by using air as the delaying medium. The tripping time depends on the velocity with which the air flows through the valve orifices and is not affected by changes in air density.

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.

We claim as our invention:

1. In a circuit breaker, an electromagnetic trip device comprising an energizing winding, an armature operable upon energization of said winding in response to overload currents, a time delay element having a chamber, a movable member connected to said time delay element and movable by said armature, means admitting fluid to said chamber at a predetermined rate to retard movement of said movable member with a predetermined time delay, valve means operable to increase the rate of admission of fluid to said chamber to thereby decrease the amount of time delay, and separate magnetic means responsive to predetermined overload currents in said winding for operating said valve means.

2. In a circuit breaker, an electromagnetic trip device comprising an energizing winding, an armature operable upon energization of said winding in response to overload currents, a time delay element having a chamber, a movable member attached to said time delay element and movable by said armature, adjustable valve means for admitting fluid to said chamber at a predetermined rate to retard movement of said movable member with a relative long time delay, a second valve means operable to increase the rate of admission of fluid to said chamber to retard movement of said movable member with a relative short time delay, and separate electromagnetic means responsive to overload currents of predetermined value in said winding for operating said second valve means.

3. In a circuit breaker, an electromagnetic trip device operable to effect automatic operation of said breaker, said trip device comprising a movable member, an energizing winding, an armature operable upon energization of said winding to actuate said movable member, a time delay element for retarding tripping movement of said movable member having a chamber, a first valve means for admitting fluid to said chamber at a predetermined rate to retard tripping movement of said movable member with a relatively long time delay, adjusting means for adjusting said first valve means to vary the rate of admission

of fluid to said chamber to thereby vary the amount of time delay provided by said first valve means, a second valve means operable automatically by said electromagnetic trip device in response to predetermined abnormal circuit conditions to increase the rate of admission of fluid to said chamber to retard tripping movement of said movable member with a relatively short time delay, and separate magnetic means for operating said second valve means.

4. In a circuit breaker, an electromagnetic trip device operable to effect automatic operation of said breaker, said trip device comprising a movable member, an energizing winding, an armature operable upon energization of said winding to actuate said movable member, a time delay element attached to said movable member for retarding tripping movement of said movable member having a chamber, a first valve means for admitting fluid to said chamber at a predetermined rate to retard tripping movement of said movable member with a relatively long time delay, a second valve means operable automatically by said electromagnetic trip device in response to predetermined abnormal circuit conditions to increase the rate of admission of fluid to said chamber to retard tripping movement of said movable member with a relatively short time delay, and a separate armature for actuating said second valve means.

5. In a circuit breaker, an electromagnetic trip device operable to effect automatic opening of said breaker, said trip device comprising a movable member, an energizing winding, an armature operable upon energization of said winding to actuate said movable member, a time delay element comprising a flexible diaphragm for retarding tripping movement of said movable member, a normally open chamber, a first valve means for admitting fluid to said chamber at a predetermined rate to retard movement of said movable member with a predetermined time delay, a second valve means, and a second armature electromagnetically operated in response to predetermined abnormal circuit conditions for actuating said second valve means to increase the rate of admission of fluid to said chamber.

6. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, a trip device comprising electromagnetic means including an armature operable when energized in response to overload currents to actuate said movable member, time delay means comprising a normally open fluid dashpot for retarding tripping movement of said movable member, means defining a normally open restricted passage admitting fluid to said dashpot to retard tripping movement of said movable member with a relatively long time delay when said electromagnetic means is energized in response to an overload current below a predetermined value, means defining a relatively large passage for admitting fluid to said dashpot, a valve operating armature, and a valve operable by said valve operating armature when said electromagnetic means is energized in response to an overload current above said predetermined value, said valve opening said relatively large passage to permit said electromagnetic means to actuate said trip member substantially instantaneously.

7. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, a trip device comprising electromagnetic means including an armature operable when energized in response to overload currents to actuate said movable member, time delay means comprising a fluid dashpot connected to said movable member for retarding tripping movement of said movable member, means defining a restricted passage admitting fluid to said dashpot to retard tripping movement of said movable member when said electromagnetic means is energized in response to an overload current below a predetermined value, means defining a relatively large passage for admitting fluid to said dashpot, a valve operating armature, and a valve operable by said valve operating armature when said electromagnetic means is energized in response to an overload current above said predetermined value, said valve opening said relatively large passage to permit said electromagnetic means to actuate said movable member substantially instantaneously.

8. In a circuit breaker, a member movable to effect automatic operation of said breaker, electromagnetic means for actuating said movable member, time delay means comprising a fluid dashpot for retarding movement of said movable member, a normally open valve for admitting fluid to said dashpot at a predetermined rate for effecting a long time delay of the order of seconds in the operation of said movable member, a second valve for admitting fluid to said dashpot at a greater rate than said first valve for effecting a short time delay of the order of cycles in the operation of said movable member, a third valve for admitting fluid to said dashpot at a rate to permit substantially instantaneous operation of said movable member, and separate armatures for actuating said second and third valves.

9. In a circuit breaker, trip means operable to effect automatic operation of said breaker, electroresponsive means for operating said trip means, time delay means comprising a fluid dashpot connected to said trip means for retarding tripping operation of said trip means, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a long time delay of the order of seconds in the operation of said trip means, a second valve means for admitting fluid to said dashpot at a greater rate than said first valve for effecting a short time delay of the order of cycles in the operation of said trip means, a first armature operable when said electroresponsive means is energized in response to overload currents below a predetermined value for actuating said second valve, a third valve for admitting fluid to said dashpot at a rate to permit instantaneous operation of said trip means, and a second armature operable when said electroresponsive means is energized in response to overload currents above said predetermined value for actuating said third valve.

10. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, electromagnetic trip means, means for operating said movable member, time delay means comprising a fluid dashpot connected to said movable member for at times retarding tripping operations of said movable member, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said movable member, a first armature operable when said electromagnet is energized in response to overload currents below a predetermined value for opening said first valve means, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said movable member, and a

second armature operable when said electromagnet is energized in response to overload currents above said predetermined value for opening said second valve means.

11. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, electromagnetic trip means, means for operating said movable member, time delay means comprising a fluid dashpot for at times retarding tripping operations of said movable member, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said movable member, a first armature operable when said electromagnet is energized in response to overload currents below a predetermined value for opening said first valve means, adjusting means for selectively determining the extent of opening of said first valve, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said movable member and a second armature operable when said electromagnet is energized in response to overload currents above said predetermined value for opening said second valve means.

12. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, electromagnetic trip means, means for operating said movable member, time delay means comprising a fluid dashpot connected to said movable member for at times retarding tripping operation of said movable member, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said movable member, a first armature operable when said electromagnet is energized in response to overload currents below a predetermined value for opening said first valve means, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said movable member, and a second armature operable when said electromagnet is energized in response to overload currents above said predetermined value for opening said second valve means, and separate adjusting means for said first and second armatures for selectively determining the minimum overload current required to actuate said armatures.

13. In a circuit breaker, a trip rod operable to effect automatic operation of said breaker, an energizing winding, a main armature operable upon energization of said winding in response to overload currents to actuate said trip rod, time delay means comprising a fluid dashpot operated by said trip rod for retarding operation of said trip rod, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip rod when said winding is energized in response to overload currents below a predetermined value, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said trip rod, a second armature operable when said winding is energized in response to overload currents above said predetermined value to open said second valve, and resilient means disposed between said main armature and said trip rod to limit the force applied by said armature to said trip rod.

14. In a circuit breaker, a trip rod operable to effect automatic operation of said breaker, an energizing winding, a main armature operable opon energization of said winding in response to overload currents to actuate said trip rod, means adjustable to selectively determine the minimum overload current required to actuate said main armature, time delay means comprising a fluid dashpot connected to said trip rod for retarding operation of said trip rod, a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip rod when said winding is energized in response to overload currents below a predetermined value, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said trip rod, a second armature operable when said winding is energized in response to overload currents above said predetermined value to open said second valve, and means adjustable to selectively determine the minimum overload current required to actuate said second armature.

15. In a circuit breaker electroresponsive trip means for effecting automatic operation of said breaker comprising a trip rod, an armature operable to actuate said trip rod, spring means disposed between said armature and said trip rod to limit the force applied by said armature to said trip rod, time delay means for retarding tripping operation of said trip rod comprising a fluid dashpot, normally closed valve means for admitting fluid to said dashpot at a predetermined rate, a valve operating armature operable upon energization of said electroresponsive means in response to an overload current of predetermined value to open said valve, an adjustable stop for limiting the opening movement of said valve operating armature, and adjusting means for varying the setting of said adjustable stop to vary the extent of opening of said valve and the amount of time delay provided thereby.

16. In a circuit breaker, electroresponsive trip means for effecting automatic operation of said breaker comprising a trip rod, an armature operable to actuate said trip rod, spring means disposed between said armature and said trip rod to limit the force applied by said armature to said trip rod, time delay means for retarding tripping operation of said trip rod comprising a fluid dashpot, normally closed valve means for admitting fluid to said dashpot at a predetermined rate, a valve operating armature operable upon energization of said electroresponsive means in response to an overload current of predetermined value to open said valve, biasing means for biasing said valve operating armature against operation, and adjusting means for varying the amount of bias of said biasing means to vary the minimum overload current required to operate said valve operating armature.

17. In a circuit breaker, an electromagnetic trip device for effecting automatic operation of said breaker including a trip rod, a main armature movable to actuate said trip rod, said armature at times being movable relative to said trip rod, resilient means disposed between said armature and said trip rod, time delay means for retarding tripping movement of said trip rod comprising a fluid dashpot connected to said trip rod, a plurality of valve means for admitting fluid to said dashpot at different rates, a separate valve operating armature for each of said valve means, and separate adjusting means for said main armature and each of said valve operating armatures for selectively determining the minimum current required to operate each of said armatures.

18. In a circuit breaker, electromagnetic trip means for effecting automatic operation of said breaker including a trip rod, a main armature

movable to actuate said trip rod, time delay means for retarding tripping movement of said trip rod comprising a fluid dashpot connected to said trip rod, a plurality of valve means for admitting fluid to said dashpot at different rates in response to overload currents of different magnitude, separate means for adjusting each of said valve means for varying the rate of admission of fluid to said valve means to thereby vary the amount of time delay provided by each of said valve means, and a separate armature for operating each of said valve means.

19. In a circuit breaker, electromagnetic trip means for effecting automatic operation of said breaker comprising a trip rod, a main armature movable to actuate said trip rod, time delay means for retarding tripping movement of said trip rod comprising a fluid dashpot, a plurality of valve means for admitting fluid to said dashpot at different rates, a separate valve operating armature for operating each of said valve means in response to overload currents of different magnitude, separate biasing means for said main armature and each of said valve operating armatures, and a separate adjusting device for adjusting each of said biasing means to vary the minimum overload current required to operate said main armature and each of said valve operating armatures.

20. In a circuit breaker, having a movable member operable to effect automatic operation of said breaker, electromagnetic means for operating said movable member, a single time delay element for retarding operation of said movable member, a first control element for controlling said time delay element to effect a relatively long time delay in the operation of said movable member, adjusting means for adjusting said first control element to vary the amount of time delay provided by said first control element, biasing means for said electromagnetic means, adjusting means for adjusting said biasing means to vary the minimum overload current requred to operate said movable member, a second control element for controlling said time delay element to effect a relatively short time delay in the operation of said movable member, adjusting means for adjusting said second control element to vary the amount of time delay provided by said second control element, biasing means biasing said second control element against operation, adjusting means for adjusting said biasing means to vary the minimum overload current required to operate said second control element, a third control element for controlling said time delay element to effect instantaneous operation of said movable member, means biasing said third control element against operation, and adjusting means for adjusting said biasing means to vary the minimum current required to operate said third control element.

21. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, electroresponsive means for operating said movable member, a single time delay member for retarding tripping operation of said movable member, a first control element for controlling said time delay member to effect a relatively long time delay in the operation of said movable member, a second control element for controlling said time delay member to effect a relatively short time delay in the operation of said movable member, separate adjusting means for independently adjusting said first and second control elements to vary the amount of time delay provided by each of said control elements, a third control element for controlling said time delay member to effect instantaneous operation of said movable member and separate electroresponsive means for actuating said second and third control elements.

22. In a circuit breaker, a movable member operable to effect automatic operation of said breaker, electroresponsive means for operating said movable member, biasing means biasing said electroresponsive means against operation, adjusting means for adjusting said biasing means to vary the minimum overload current required to operate said movable member, time delay means for retarding operation of said movable member, a control element for controlling said time delay means to effect a predetermined time delay in the operation of said movable member, electromagnetic means for operating said control element, adjusting means for adjusting said electromagnetic means to vary the minimum overload current required to operate said electromagnetic means, a second control element for controlling said time delay means to effect instantaneous operation of said movable member, a second electromagnetic means for operating said second control element, and adjusting means for adjusting said second electromagnetic means to vary the minimum overload current required to operate said second electromagnetic means.

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