

Nov. 12, 1957

M. E. HORN ET AL
CIRCUIT BREAKER

2,813,170

Filed June 9, 1955

4 Sheets-Sheet 1

Fig. 1.

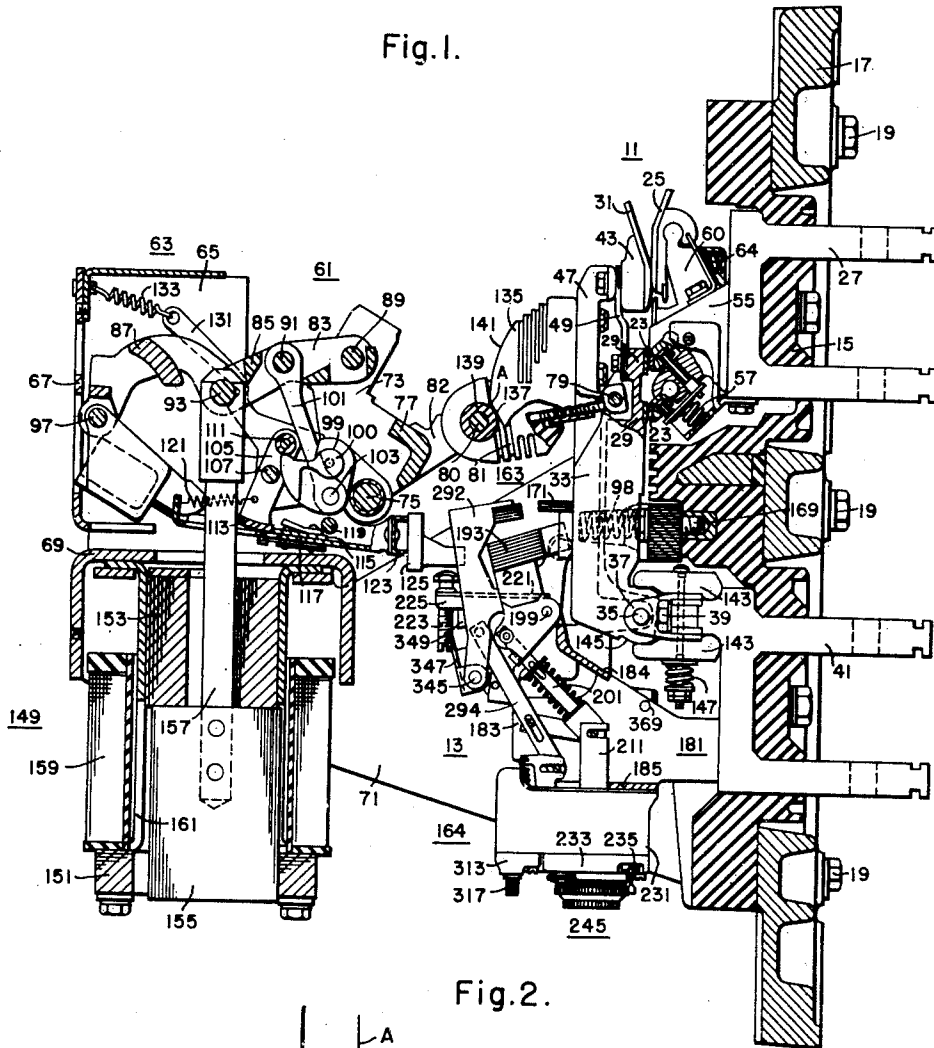


Fig. 2.

WITNESSES

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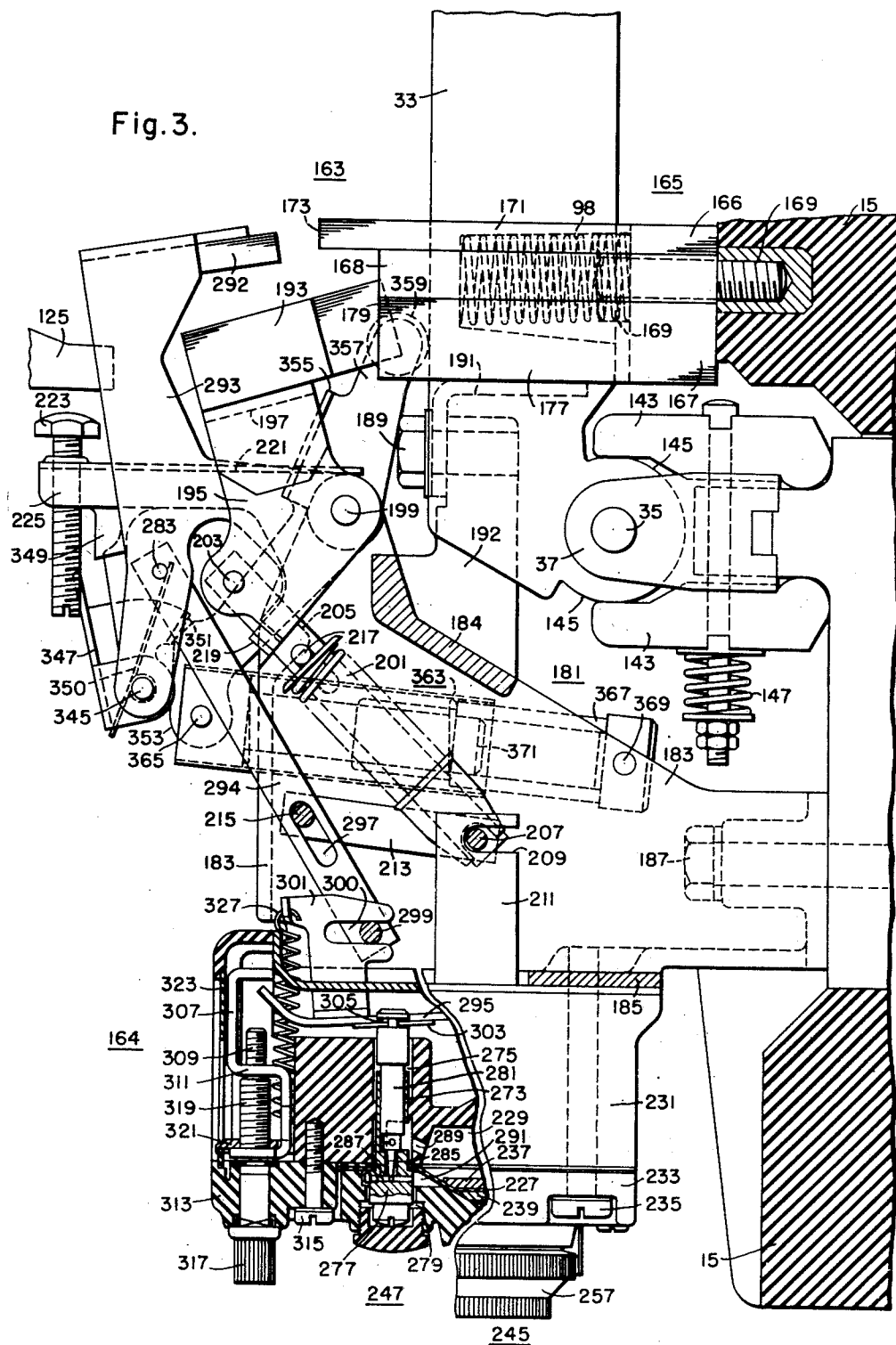
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Fig.3.



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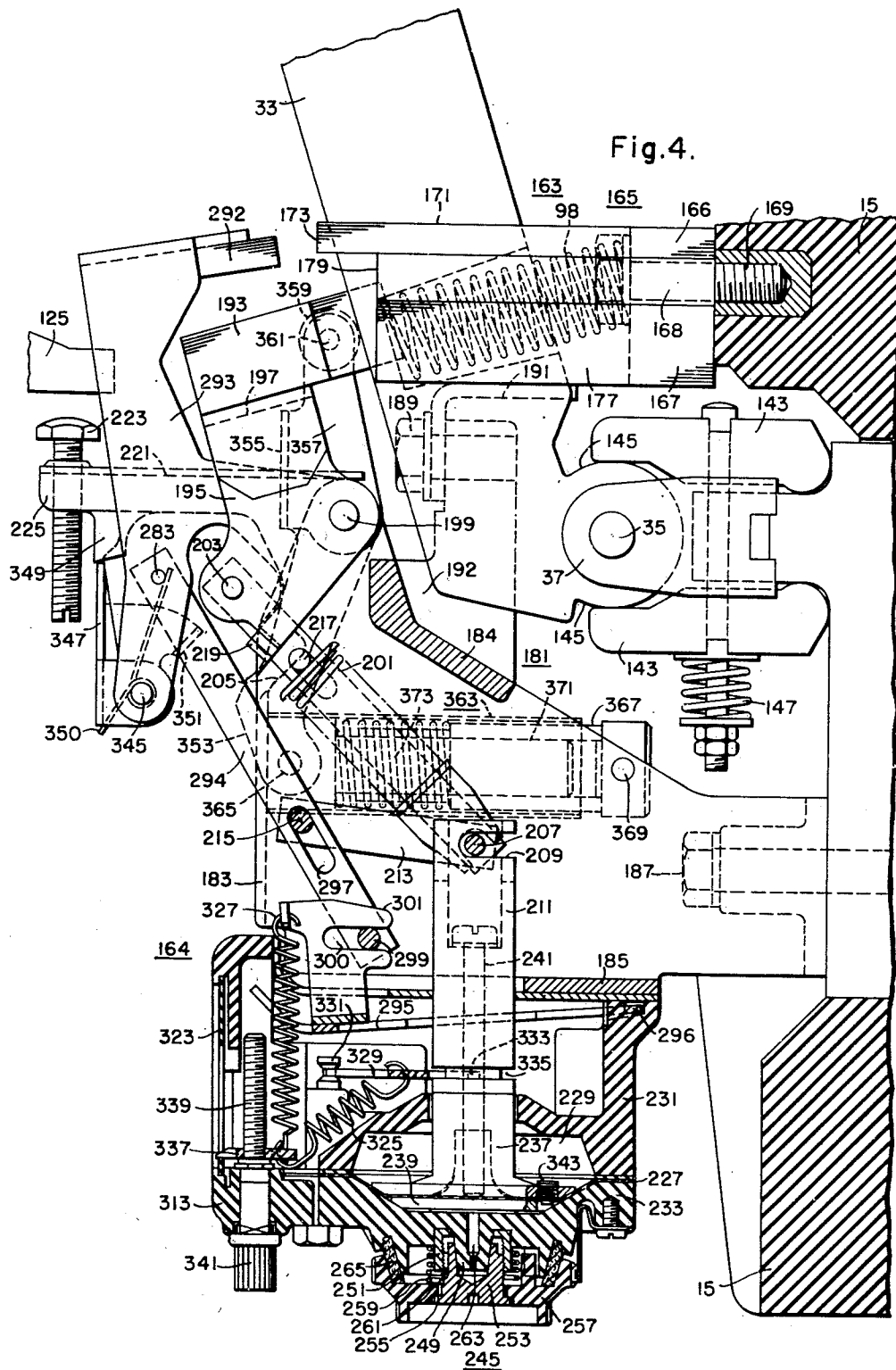
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Fig. 4.



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Fig. 5.

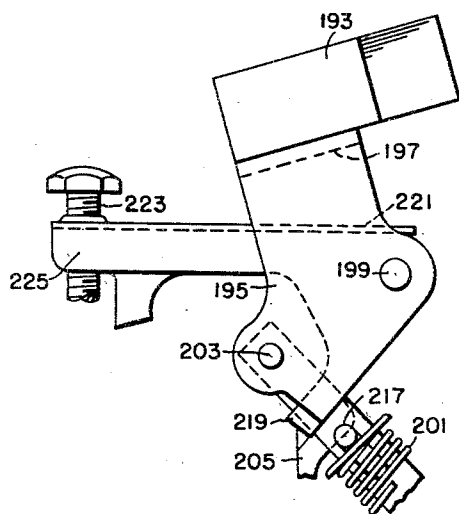


Fig. 6.

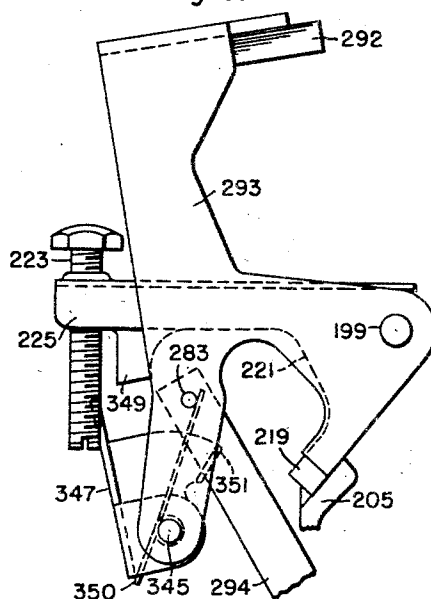
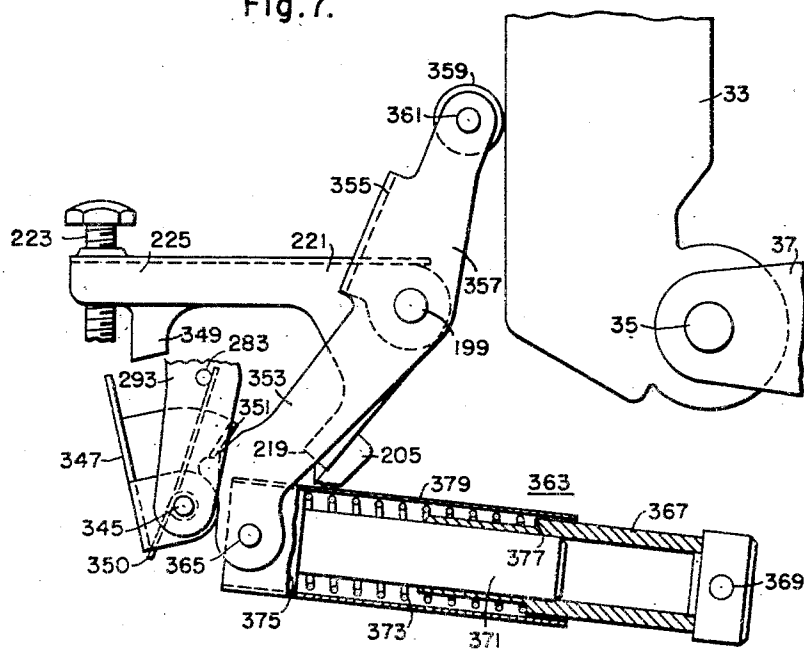


Fig. 7.



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2,813,170

CIRCUIT BREAKER

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Application June 9, 1955, Serial No. 514,304

13 Claims. (Cl. 200—108)

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

In certain circuit breaker applications, for example, when a circuit breaker is to be applied in a selective tripping system as a source breaker, a bus tie breaker or as a group feeder breaker, the breaker is equipped with a series overcurrent trip device which trips the breaker with a time delay on all values of overload currents up to the interrupting capacity of the breaker. Two ranges of time delay are usually provided, that is, a long-time delay and a short-time delay. With the breaker latched in the closed position, the breaker will carry excessive overload currents for some time without damage to the breaker and will then interrupt the circuit.

When, however, circuit breakers are to be applied in selective tripping systems as a source breaker, a bus tie or group feeder breaker, it is equipped with overcurrent tripping devices which provide delayed tripping on all values of overcurrents up to the interrupting capacity of the circuit breaker. Circuit breakers thus equipped are, in effect, deprived of the trip free feature and are exposed to severe magnetic forces and possible contact damage unless they are derated as an interrupter to a value of overcurrent upon which the breaker can positively close and latch.

To offset derating by a more powerful closing means is not the solution. Stronger closing means results in higher closing speeds, shorter operating life, greater demand and regulating problems for the control energy source, etc. To manufacture an improved latching system to conform to a higher closing speed represents a major increase in cost. The economics of this approach is not sound for large circuit breakers because more than 99 percent of all closing operations will occur when the breaker is unfaulted.

Modern circuit breakers must embody contact structures that, in the closed position, will permit a short time (approximately 30 alternating current cycles) current rating equal to the interrupting current rating of the breakers. However, for a given size, weight and cost a much higher interrupting rating (approximately 50%) may be assigned to a circuit breaker if there is no requirement for closing and latching on currents above the motor-starting range.

The instant invention provides for the addition of a novel feature to a circuit breaker which permits the breaker provided with conventional closing means to perform all of its necessary functions in a selective tripping system. When equipped with this additional feature, the electrically trip-free advantages are restored to the closing cycle without impairing the delay characteristics required for selective operation after the circuit breaker has been completely closed.

Some of the advantages of the invention embodied in a circuit breaker of given interrupting rating are:

(1) A substantial reduction in the cost of manufacture.

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(2) Reduction in closing current, control bus, copper, etc.

(3) Reduction in cost on some circuit breaker sizes which can be brought into the range where the closing rectifier can be eliminated.

(4) A substantial reduction in size and weight, and
(5) Additional safety to operating personnel when manual closing on a fault current is attempted.

The invention provides means for accomplishing the results previously set forth by controlling the series overcurrent trip device according to the position of the movable switch arm of the same pole unit so that the time-current characteristics of the overcurrent trip device is changed depending on the position of the breaker contacts. By way of example, assume the time-current characteristic AB as shown in Fig. 2 of the hereinafter described drawings represents the normal tripping characteristic for the breaker when in the latched position. For all positions of the breaker other than the latched position the tripping characteristic becomes AC which allows for instantaneous tripping on all values of overcurrents above the pickup setting of the short time delay element.

An object of the invention is to provide a circuit breaker having a trip device embodying time delay tripping means and means for tripping the breaker instantaneously only when the breaker is closed with a fault on the line.

Another object of the invention is to provide a circuit breaker embodying time delay and instantaneous tripping means with means for disabling the instantaneous tripping except during closing operations.

Another object of the invention is to provide a circuit breaker embodying a normally ineffective instantaneous trip means with means for rendering the instantaneous trip means effective during and only during a closing operation of the breaker.

A further object of the invention is to provide a circuit breaker embodying a trip device having long and short-time delay elements with means for tripping the breaker instantaneously only when the breaker is closed with a fault on the line of a value at or above the pickup setting of the short-time delay element.

The invention, 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:

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

Fig. 2 is a schematic diagram showing the time-current characteristics of the trip device when the circuit breaker is in the closed and latched position.

Fig. 3 is an enlarged elevational view partly in section of the trip device with the moving switch arm in the closed position.

Fig. 4 is a view similar to Fig. 3, but showing the switch arm in the open position.

Fig. 5 is a detail view of the long-time delay armature.

Fig. 6 is a detail view of the short-time delay armature.

Fig. 7 is a detail view partly in section of the discriminator mechanism.

Referring to Fig. 1 of the drawings, the circuit interrupter includes a plurality of pole units each comprising a separable contact structure indicated generally at 11 and an overcurrent trip device indicated generally at 13. The contact structure and trip device for each pole of the circuit interrupter are mounted on separate insulating bases 15 which are rigidly secured to a metal panel 17 by means of screens 19. Since the pole units are alike, only one will be described herein.

The contact structure comprises stationary main contacts 23 and a stationary arcing contact 25 all supported on the inner end of a U-shaped terminal conductor 27 (Fig. 1) the legs of which extend through suitable openings in the base 15 and panel 17. Cooperating with the stationary main contacts 23 and the stationary arcing contact 25, respectively, are movable main contacts 29 and a movable arcing contact 31. The movable main contacts 29 are rigidly mounted on a channel-shaped main switch arm 33 pivotally mounted at its lower end on a pin 35 supported in a bracket 37 which is rigidly mounted by means of bolts 39 (only one being shown) on a lower U shaped terminal conductor 41. The movable arcing contact 31 is mounted on a contact carrying member 43 rigidly mounted on the upper or free end of an arcing contact arm 47 which is also pivoted on the pin 35. A flexible conductor 49 has its upper end secured to the movable arcing contact and its lower end secured to the upper end of the main contact arm 33.

The main stationary contacts 23 (Fig. 1) are pivotally supported in bearing openings in an extension 55 of the terminal 27, and are biased by means of a common spring 57 into engagement with the movable main contacts 29 in the closed position of the circuit interrupter. The stationary arcing contact 25 is pivotally supported on a bracket 60 secured to the terminal extension 55, and is biased by means of a spring 64 into engagement with the movable arcing contact 31.

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 spaced side members 65 and a connecting cross member 67 and is supported on a platform 69 which forms a cross member of a main bracket comprising a pair of spaced side members 71 joined at their outer ends by the cross member or platform 69. The platform extends substantially across the width of the circuit interrupter and the side members 71 are rigidly secured to the panel 17 on the outer sides of the two outer pole units.

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 rigidly joined by an angle member 77 which extends across all of the poles of the interrupter. The angle member 77 is operatively connected to the main movable switch arm 33 by means of an insulating connecting member 81 and a pivot pin 79 in the main switch arm. The other end of the connecting member 81 is pivotally connected to the angle member 77 by means of a pivot pin 80 and a bracket 82 rigid with the angle member 77. There is a connecting member 81 for each pole of the circuit interrupter connecting the angle member 77 to the main moving contact member 33 for each pole unit so that, upon operation of the lever 73, the movable contact structure for all these 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 is pivotally connected to lever 73 by a pivot pin 89 and the toggle link 85 is connected by a knee pivot pin 91 to the toggle link 83 and by a knee pivot pin 93 to the toggle link 87. The toggle link 87 is pivotally mounted on a fixed pivot 97 in the frame 63.

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

The tripping toggle 83, 85 is normally biased in a direction to cause its collapse by components of the springs 57 and 64 and springs 98 (only one being shown) which

bias the moving main contact structure for the several poles of the interrupter in opening direction and bias the connecting members 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 a pin 100 and connected by a link 101 to the knee pin 91 of the tripping toggle, the link 101 being connected to the latch member 99 by a pin 103.

The main latch 99 is held in latching position by an intermediate latch lever 105 pivoted on a pin 107 in the frame 63. The latch lever 105 carries a latch roller 111 which normally engages the main latch 99 to releasably hold the latter in holding position. The latch lever 105 at its lower end carries a latch member 113 which normally engages a latch member 115 on a light-load latch member 117 pivoted on a pin 119 in the frame 63. The latch lever 105 and the member 117 are biased to their latching position by a spring 121 tensioned between the parts. Rigidly mounted on the right-hand end of member 117 is a trip bar 123 which extends across all of the poles of the interrupter and has secured thereto an insulating bracket 125 (Figs. 1, 3 and 4) for each pole of the interrupter cooperating with the trip device 13 for the corresponding pole unit.

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 interrupter contacts are held in closed position. The closing toggle 85, 87 is normally prevented from collapsing by a shouldered support member 131 pivoted on the pin 107 and biased by a spring 133 into supporting engagement with the knee pin 93 of the closing toggle.

The circuit interrupter is tripped open by operation of the trip device 13, to be described later, for any pole of the interrupter. Operation of the trip device actuates the trip bar 123 to effect release of the latch lever 105 which, in turn, releases the main latch 99. When the main latch 99 is released, the force of the springs 57 and 98 biasing the main movable switch arm 33 in opening direction and which is transmitted through the connecting members 81 to the lever 73, causes the tripping toggle 83, 85 to collapse upwardly and effects opening movement of the movable main switch arms 33 for all of the poles of the breaker.

The closing toggle 85—87 does not immediately collapse following release of the latch mechanism since it is held by the support member 131. During the unlatching movement of the main latch 99, a cam (not shown) thereon engages the tail of the support member 131 and moves this member in a clockwise direction about its pivot 107 to disengage the shoulder thereon from beneath the pin 93 whereupon the closing toggle 85—87, being no longer supported, collapses downwardly under its own weight and the weight of the moving armature of the closing solenoid which will be described later. Collapse of the closing toggle 85—87 causes the tripping toggle 83—85 to be reset to thrust transmitting position and also effects resetting of the latch mechanism to latching position. The operating mechanism is now in condition for a closing operation.

Means is provided to hold the movable arcing contact arm 47 stationary with full contact pressure until the movable main contacts have separated a predetermined distance from the stationary main contacts. This means comprises a cam member 135 (Fig. 1) rigidly secured to the moving arcing contact arm 47. Cooperating with a cam surface 137 on the cam member 135 is a roller 139 rotatable on the pin 80 which pivotally connects the lever 73 to the connecting member 81. It will be remembered that the connecting member 81 is connected by the pin 79 to the moving main contact arm 33. In order to open the contacts the lever 73 moves in a counterclockwise direction about the pivot 75 moving the roller along the cam surface 137. The configuration of the cam surface 137

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is such that during the early part of the opening movement and until the roller 139 reaches a point A on the cam member 135, the roller 139 holds the cam member and, hence, the movable arcing contact arm 47 stationary in the fully closed position. During this early movement, the counterclockwise movement of the lever 73 and the leftward movement of the connecting member 81 moves the moving main contact arm 33 in opening direction until the pin 79 engages the arcing contact arm 47. At this time the roller 139 is at the point A. Thereafter, during the opening movement it moves along an arcuate surface 141 of the cam member 135 which it will be noted is struck around the center of the pin 79 with the pin in contact with the arcing contact arm 47. By this means, the two moving contact arms 33 and 47 are locked together for unitary movement during the rest of the opening operation.

During opening and closing operations and in the closed position, good electrical contact is provided at the pivoted end of the movable main contact arm 33 by means of spring biased contact members 143 (Figs. 1, 3 and 4) which are pivoted on the bracket 37 adjacent the terminal conductor 41 and biased into engagement with opposed arcuate surfaces 145 on the contact arm 33 by a spring 147.

The main current path through the interrupter is from the upper terminal 27, through the main stationary contacts 23, the main moving contacts 29, the main contact arm 33 and through the contact members 143 to the lower terminal 41. A parallel current path is formed from the upper terminal 27 through the stationary arcing contact 25, the moving arcing contact 31, through the flexible conductor 49, the main moving contact arm 33 and the contact members 143 to the lower terminal 41. The magnetic effect of the current loop through the arcing contacts in the closed contact position tends to blow the arcing contacts on, thus permitting the interrupter to carry its rated interrupting current for the duration of the short time delay provided by the short time delay means of the trip device 13.

The circuit interrupter is closed automatically by energization of a closing solenoid 149 (Fig. 1) which is effected either manually or by automatic means. The closing solenoid 149 comprises a fixed magnet yoke 151 and a fixed core member 153 mounted on the underside of the platform 69. A movable armature 155 is attached to the lower end of an operating rod 157 which extends upwardly and has its upper end pivotally connected to the knee pin 93 of the closing toggle 85—87. An energizing coil 159 is supported on the lower end of a supporting bracket 161 having its upper end fastened to the platform 69.

In the closed position of the interrupter, the armature 155 is held in its raised position (Fig. 1). When the breaker is tripped open, the closing toggle 85—87 collapses downwardly permitting the armature 155 to assume its lower or unattracted position. Thereafter, upon energization of the coil 159, the armature 155 is attracted upwardly and acts through the rod 157 to straighten the closing toggle 85—87 and close the contacts.

The action of the contact structure during a closing operation is the reverse of that of the opening operation.

The trip device 13 includes a tripping electromagnet indicated generally at 163 (Figs. 1, 3 and 4) and a time delay device indicated generally at 164. The tripping magnet 163 comprises a U-shaped magnet yoke 165 which includes two separate yokes 166 and 167 separated by a spacer 168 of non-magnetic material. The magnet yokes 166 and 167 and the spacer 168 are rigidly secured together and are rigidly secured to the base 15 of the corresponding pole unit by means of bolts 169 (only one being shown). The legs 171 of the magnet yoke 166 extend on opposite sides of the main current carrying switch arm 33 and terminate in pole faces 173. The legs 177 of the magnet yoke 167 also extend on opposite sides of the switch arm 33 and terminate in pole faces 179. The

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electromagnet 165 comprising the magnet yokes 166 and 167 is energized by the current flow through the switch arm 33 which forms a single-turn energizing coil passing through the U of both of the magnet yokes.

The time delay device 164 and the elements on the trip device other than the magnet yoke are supported in a U-shaped frame indicated generally at 181 (Figs. 3 and 4). The frame 181 comprises spaced side members 183 (only one being shown) integrally joined by cross members 184 and 185. The lower portions of each of the side members 183 are rigidly supported on the base 15 by means of bolts 187. The upper end of each of the side members 183 is rigidly secured to the adjacent leg 177 of the magnet yoke 167 by means of a bolt 189 which passes through a bracket 191 rigidly secured to the leg 177 and which threadably engages an upwardly extending portion 192 of the side member 183.

The trip device is actuated by a moving armature 193 (Figs. 3, 4 and 5) rigidly mounted on a pair of space levers 195 (only one being shown) joined by a cross member 197 and pivotally supported on pins 199 in the side members 183. The armature lever 195 is connected to the time delay device 164 by means of a spring linkage 201 pivotally connected at its upper end by a pin 203 to the lever 195. In the unattracted position of the armature the lever 195 rests against a fixed stop 205 formed on the side member 183 of the frame 181. The spring linkage 201 is connected at its lower end by means of a pin and slot connection 207—209 to a member 211 which, in turn, operates the time delay device 164. The pin 207 is guided in its movement by means of a link 213 pivoted on a pin 215.

When the electromagnet 163 is energized in response to overcurrents, the armature 193 is attracted to the pole faces 179 applying an upward force on the spring linkage 201. The linkage 201 moves slowly upwardly under the restraining influence of the time-delay device 164. During the upward movement of the linkage 201, a pin 217 therein engages one arm 219 (see also Fig. 5) of a bell-crank lever 221 and slowly rotates the latter in a clockwise direction. The bell-crank lever 221 is pivoted on the pin 199 and, during its clockwise movement, a headed screw 223 carried by the other arm 225 of the bell crank 221 engages the bracket 125 of its corresponding pole unit and actuates the trip bar 123 (Fig. 1) to trip the breaker in the previously described manner.

The linkage 201 is moved upwardly by the armature 193 to trip the breaker under the control of the time delay device 164 which comprises generally a flexible diaphragm 227 (Fig. 4) attached to the lower end of the member 211 and valve elements for controlling the rate of admission of air to the space below the diaphragm. The flexible diaphragm 227 is disposed in a chamber 229 formed in an upper housing member 231 and a lower housing member 233, both housing members being formed of molded insulating material. The outer edge of the diaphragm 227 is clamped between the housing members 231 and 233 with a sealing gasket to form an air-tight seal. The housing members are secured together and rigidly mounted on the cross member 185 of the frame 181 by means of bolts 235 (Figs. 1 and 3). The central portion of the diaphragm 227 is suitably clamped between upper and lower clamp members 237 and 239 respectively to form an air-tight seal. The clamp members are rigidly secured together and to the member 211 by a screw 241.

Since the spaces above and below the diaphragm 227 are completely sealed off from each other and the space above the diaphragm is at atmospheric pressure, any force tending to raise the members 211 will be restrained by the partial vacuum below the diaphragm. In order to control the rate of tripping movement of the member 211 and the linkage 201, valve devices are provided to admit air to the space below the diaphragm at different rates. The valve devices comprise a long-time delay valve indi-

cated generally at 245 (Fig. 4), and a short-time delay valve indicated generally at 247 (Fig. 3).

The long-time delay valve will be described first. The central bottom portion of the lower housing member 233 is molded to form a valve seat 249 in the shape of an inverted truncated cone. Surrounding the valve seat 249 is a tubular metallic member 251 molded into the housing member 233 and threaded internally to receive a valve 253 having a conical opening therein for cooperating with the valve seat 249. The valve 253 is provided with a flange 255 which supports an adjusting knob 257 of molded insulating material which is biased against the flange by a spring 259. An air passage 261 in the form of a groove is provided along the threaded portion of the valve 253 and a passage 263 is provided axially through the valve seat 249. The flow of air into the chamber 229 below the diaphragm 227 is through a filter 265, the passage 261, the orifice defined by the valve 253 and the valve seat 249 and through the passage 263.

The inner surface of the knob 257 is provided with serrations which engage serrations on the valve 253 whereby rotation of the knob 257 rotates the valve 253 which, due to its threaded engagement with the fixed tubular member 251 moves the valve 253 axially of the valve seat 249 thereby varying the rate of admission of air to the space below the diaphragm and, hence, varies the amount of time delay in the operation of the trip device.

The short-time delay valve device 247 (Fig. 3) controls a passage for admitting air from the chamber 229 above the diaphragm 227 to the space below the diaphragm at a rate to provide a very short time delay, in the order of alternating current cycles, in the operation of the trip device. The valve device 247 comprises a tubular valve element 273 (Fig. 3) disposed in an opening 275 in the upper housing member 231. The valve element 273 is provided with an enlarged head 277 at the lower end thereof which is seated in an opening 279 in the bottom housing member 233. The valve element 273 is also 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 the opposite sides of the diaphragm 227. The valve 273 has an axial passage therethrough in which is disposed a tapered projection 285 of the valve 281, the axial passage being normally closed by the valve 281. The head 277 of the valve element 273 has a horizontal passage 287 therein. A passage 289 in the housing member 231 communicates the chamber 279 above the diaphragm 227 to the opening 275 above the valve seat and a passage 291 in the housing member 233 communicates the chamber 229 below the diaphragm with the passage 287.

It will be seen that upward movement of the valve 281 will open the passage comprising passages 289, 287 and 291 and establish a communication from the upper side to the lower side of the diaphragm 227.

The valve 281 (Fig. 3) is actuated upwardly to the open position by means of an armature 292 (Figs. 3, 4 and 6) rigidly mounted on one end of a lever 293 which is pivoted on the pin 199. The lever 293 is connected by a link 294 to a lever 295 pivotally supported at 296 (Fig. 4) on the housing member 231. The link 294 is connected by a pin 283 to the lever 293 and is provided with a slot 297 which cooperates with the pin 215 to guide the link in its movement. The lower end of the link 294 has a pin 299 therein which cooperates with a slot 300 in a bracket 301 rigidly mounted on the lever 295. A bracket 303 secured to the lever 295 engages in a notch 305 in the upper end of the valve 281 so that upon actuation of the lever 295 by the armature 292 acting through the lever 293 and link 294, the valve 281 is instantaneously moved upwardly to the open position. This opens the previously described communication permitting air to pass from the chamber 229 above the diaphragm 227 to the space below the diaphragm to control

the rate of tripping movement of the member 211 and the linkage 201.

The amount of opening of the valve 231 and, hence, the rate of flow of air to the space below the diaphragm is controlled by an adjustable S-shaped stop member 307 (Fig. 3). The upper portion of the stop member 307 is disposed in the path of tripping movement of the up-turned end of the lever 295 to be engaged thereby and thus limit the extent of opening of the valve 231.

The stop member is adjustable to vary the amount of short-time delay by means of an adjusting screw 309 which threadedly engages the center cross bar 311 of the S-shaped member 307. The adjusting screw 309 is rotatably mounted in an insulating cross bar 313 supported on the under side of the housing member 233 by means of screws 315, only one of which is shown. A knurled knob 317 is mounted on the lower end of the screw 309 below the cross bar 313 whereby the adjusting screw 309 may be rotated to provide the proper setting of the stop 307.

A portion 319 of the screw 309 also engages a pointer 321, an end of which projects outward through a slot in a scale plate 323 to give an indication of the setting of the adjustable stop 307 for the short-time delay valve 281.

The pickup point, that is, the magnitude of overload current required to actuate the armatures 193 and 292 may be varied by varying the tension respectively of springs 325 and 327 (Fig. 4). The spring 325 has one end attached to a yoke 329 which has its legs pivotally supported in spaced grooved studs 331 (only one being shown) supported in the housing member 231. The right-hand end of the yoke 329 is provided with inwardly extending projections 333 which engage in an annular groove 335 in the cylindrical member 211. The other end of the spring 325 is attached to a pointer 337 which is threadedly engaged by an adjusting screw 339 rotatably mounted in the cross bar 313 and which is provided with an adjusting knob 341 on the end thereof below the cross bar. Rotation of the screw 339 varies the tension of the spring 325 to thereby vary the pickup point of the armature 193. The tension of the spring 327 for the armature 292 is similarly adjusted by means of a screw and pointer (not shown) like the adjusting means for the spring 325.

The magnet yokes 165 and 167 are separated from each other by the non-magnetic member 168 in order that operation of armature 193, upon energization of its magnet yoke 167, will not shunt part of the flux from the magnet yoke 166 as would be the case if the yokes 166 and 167 formed a single magnet yoke. This prevents changing the calibration of the short time delay armature 292 when the armature 193 is attracted to its pole faces 179.

The trip device functions with time delays of different durations in response to overload currents of different magnitudes. For instance, the device may function with a relatively long time delay in the order of seconds in response to overload currents up to approximately ten times normal rated current and with a relative short time delay in the order of alternating current cycles.

Assuming an overload current below ten times normal rated current, the tripping electromagnet becomes energized by the current flow through the switch arm 33 sufficiently to attract the armature 193 upwardly. The armature 193 acts through the lever 195 and the spring linkage 201 to produce an upward thrust on the member 211, the movement of the member 211 being retarded by the partial vacuum below the diaphragm 227. The linkage 201 moves slowly upwardly in tripping direction as air is drawn into the space below the diaphragm through the long-time delay valve 245. The slow upward movement of the linkage 201 acts through the pin 217 to slowly rotate the bell crank 221 in a clockwise direction until eventually screw 223 in the arm 225 of the bell crank 221 engages and actuates the trip bar and effects

release of the latch mechanism and opening of the interrupter in the previously described manner.

As soon as the interrupter contacts have opened, the tripping electromagnet is deenergized and the armature 193 and the member 211 are restored to their normal positions by the spring 325 (Fig. 4). A spring biased reset or bypass valve 343 (Fig. 4) controls a passage through the diaphragm 213 to provide quick dumping of the air in the space below the diaphragm and quick restoration of the parts.

Energization of the electromagnet in response to overload currents above ten times normal rated current attracts the short-time delay armature 292 which acts through the link 294 to move the lever 295 upwardly against the stop 307 opening the short time delay valve 247 an amount determined by the adjustment of the stop 307. This admits air to the space below the diaphragm 227 at a higher rate than the long-time delay valve 245 alone and provides a short-time delay in the order of cycles in the tripping operation of the device.

As previously set forth, circuit breakers in certain locations in a selective tripping system are capable of carrying excessive currents for a certain length of time without damage to the breaker, the length of time the circuit breaker will carry such excessive overload currents being determined by the setting of the short-time delay device. The critical time in the operation of the breaker when damage is most likely to occur is in closing the breaker in against an excessive fault current or a short-circuit current. For this reason, it is desirable to trip the breaker instantaneously when, but only when, the breaker is closed with an excessive fault or short-circuit current on the line. Means is provided to trip the breaker instantaneously only during closing operations and discriminating means is also provided to permit the instantaneous trip means to function during a closing operation only if the breaker is closed against a fault current.

The instantaneous trip means includes the short-time delay armature 292 (Figs. 3, 4 and 6) which in the closed position of the breaker operates instantaneously on overload currents above ten times normal rated current to open the short-time delay valve 247 (Fig. 3) and effect a short-time delay in the operation of the trip device. Pivotaly mounted by means of a pin 345 on the lower end of the lever 293 which carries the armature 292 is a latch or interposer 347 disposed under certain conditions to cooperate with a projection 349 on the arm 225 of the bell-crank lever 221. The latch 347 is biased by a spring 350 to a position to engage the projection 349 but has an ear 351 thereon which, in the closed position of the breaker, is engaged by one arm 353 of a lever 355 to hold the latch 347 in the unlatched position. The lever 355 is pivoted on the pin 199 and the other arm 357 of the lever 355 carries a roller 359 mounted on a pin 361 in the upper end of the arm 357.

A time delay element comprising a dashpot indicated generally at 363 (Fig. 7) is pivotally connected by means of a pin 365 to the lower end of the arm 353 of the lever 355. The dashpot 363 is disposed on the outside of the frame 181 and comprises a cylinder 367 having one end pivotally mounted on a fixed pivot 369 (Figs. 3, 4 and 7) in the adjacent side member 183. A piston 371 (Fig. 7) having one end pivoted on the pin 365 in the arm 353 extends into the bore of the cylinder 367 and a spring 373 compressed between the head 375 of the piston and a shoulder 377 on the cylinder 367 through the piston 371 biases the lever 355 in a clockwise direction about its pivot 199 and biases the roller 359 into engagement with the switch arm 33. A cylindrical cover 379 having one end secured to the head 375 of the piston 371 and disposed in telescopic relation with the cylinder 367 is provided to cover the spring 373.

Referring particularly to Figs. 3 and 7 of the drawings, it will be seen that with the switch arm 33 in the closed position the lever 355 is biased clockwise with

the roller 359 engaging the switch arm 33. In this position of the lever 355, the arm 353 thereof holds the latch 347 in its retracted or ineffective position.

The occurrence of an overload current above ten times rated current on a short-circuit current when the circuit breaker is in the closed position causes instantaneous operation of the armature 292 and opening of the short-time delay valve 281 (Fig. 3) to provide a short-time delay in the tripping operation. Since, at this time, the latch 347 is in its ineffective position it will not engage the projection 349 and, hence, will not directly operate the lever 221 to instantaneously trip the breaker regardless of the magnitude of the overload current when the breaker is in the closed position.

During an opening operation the moving switch arm 33 acting through the roller 359 rotates the lever 355 counterclockwise to the position shown in Fig. 4 moving the piston 371 of the dashpot 363 farther into the cylinder 367. The counterclockwise movement of the lever 355 causes the arm 353 thereof to free the latch or interposer 347 permitting the spring 350 to move the latch 347 clockwise to a position where the free end thereof is directly beneath the projection 349 of the arm 225.

During a closing operation the switch arm 33 travels at a relatively high speed and the spring 373 (Figs. 4 and 7) causes the lever 355 to follow the switch arm. However, due to the retarding action of the dashpot 363, the lever 355 moves clockwise at a slower speed than the switch arm 33. If the breaker closes on normal current or on a low overload below ten times normal current, the tripping magnet 163 will not be energized sufficiently to attract the armature 292 and the breaker will go to the fully closed and latched position. In this event, the lever 355 will, after a time delay of, for example, approximately one-half to one second, engage and move the interposer 347 to its ineffective position (Figs. 3 and 7) thus defeating instantaneous tripping in the closed position of the breaker.

If, however, the breaker is closed on a fault current greater than ten times normal rated current or a short-circuit current, the tripping magnet 163 will be energized as soon as the arcing contacts 31-25 touch sufficiently to attract the short-time delay armature 292. In this event, the time delay in the clockwise movement of the lever 355 by the dashpot 363 is sufficient to insure that the lever 355 does not disengage the latch 347 from the projection 349 before the armature 292 acting through the latch or interposer 347 moves the bell-crank lever 221 to instantaneously trip the breaker.

Referring to Fig. 2 of the drawing, which schematically illustrates, by line A-B, the time-current characteristic of the trip device when the breaker is in the closed and latched position. For all positions of the breaker other than the closed position, the time-current characteristic of the trip device during the closing operation is illustrated by the line A-C which, it will be seen, permits instantaneous tripping during a closing operation on all current values above the pickup setting of the short-time delay armature.

Having disclosed the invention in accordance with the provisions of the patent statutes, it is to be understood that various changes and modifications may be made in the structural details thereof without departing from the spirit of the invention.

We claim as our invention:

1. A circuit breaker comprising a switch arm movable to open and closed positions to open and close said circuit, means for operating said switch arm, a trip member movable to effect automatic opening movement of said switch arm, a trip device comprising an electromagnet, an armature operable by energization of said electromagnet in response to overcurrents to move said movable trip member, a time delay device retarding tripping movement of said trip member, control means effecting

a relatively long time delay in the tripping movement of said trip member, a control element for said time delay device operable to effect a relatively short-time delay in the tripping movement of said trip member, a control armature operable by energization of said electromagnet in response to overcurrents to instantaneously operate said control element, and biased means responsive to the position of said switch arm to cause a portion on said control armature to engage and instantaneously move said trip member.

2. A circuit breaker comprising a switch arm movable to open and closed positions to open and close the circuit, operating means for said switch arm, a trip member movable to effect automatic opening movement of said switch arm, an overcurrent trip device comprising an electromagnet having an armature operable by energization of said electromagnet to move said trip member, a time delay device retarding tripping operation of said trip member, a control element operable to effect a relatively short-time delay in the tripping movement of said trip member, a control operating armature operable by energization of said electromagnet to instantaneously operate said control element, and a biased mechanism responsive to the position of said switch arm for causing a portion on said control operating armature to engage and instantaneously move said trip member.

3. A circuit breaker comprising a switch arm movable to open and closed positions to open and close said circuit, operating means for said switch arm, a trip device responsive to overload currents comprising a trip member movable to effect automatic opening of said switch arm, an electromagnet including an armature operable by energization of said electromagnet in response to certain overload currents to move said trip member, time delay means comprising a fluid dashpot retarding tripping movement of said trip member, a first valve admitting fluid to said dashpot at a predetermined rate to effect a time delay in the tripping movement of said trip member, a second valve operable to increase the rate of admission of fluid to said dashpot, a valve operating armature operable by energization of said electromagnet in response to certain other overload currents to instantaneously operate said second valve, a member movable with said valve operating armature and engageable with said trip member to at times instantaneously move said trip member, and a mechanism responsive to the position of said switch arm to permit said member to engage said trip member only when said switch arm is in a position other than the closed position.

4. A circuit breaker comprising a switch arm movable to open and closed positions to open and close said circuit, operating means for said switch arm, an overcurrent trip device comprising a trip member movable to effect automatic opening movement of said switch arm, an electromagnet including an armature operable by energization of said electromagnet in response to certain overload currents to move said trip member, a time delay device effecting a time delay in the tripping movement of said trip member, a control element operable to decrease the time delay provided by said time delay device, a second armature operable by energization of said electromagnet in response to certain other overload currents to instantaneously operate said control element, latch means movable by said second armature and biased to engage said trip member to at times instantaneously move said trip member, and a mechanism responsive to the position of said switch arm to permit said latch member to engage and move said trip member only when said switch arm is in a position other than said closed position.

5. A circuit breaker comprising a switch arm movable to open and closed positions to open and close said circuit, operating means for said switch arm, an overcurrent trip device comprising a trip member movable to effect automatic opening movement of said switch arm, an elec-

tromagnet including an armature operable by energization of said electromagnet in response to certain overload currents to move said trip member, a time delay device effecting a time delay in the tripping movement of said trip member, a control element operable to decrease the time delay provided by said time delay device, a second armature operable by energization of said electromagnet in response to certain other overload currents to instantaneously operate said control element, latch means movable by said second armature and biased to engage said trip member to at times instantaneously move said trip member, and a mechanism responsive to the position of said switch arm to permit said latch member to engage said trip member only when said switch arm is in a position other than said closed position, said mechanism being operable during a closing movement of said switch arm to disengage said latch member from said trip member.

6. A circuit breaker comprising a switch arm movable to open and closed positions to open and close said circuit, operating means for said switch arm, an overcurrent trip device comprising a trip member movable to effect automatic opening movement of said switch arm, an electromagnet including an armature operable by energization of said electromagnet in response to overload currents of certain value to move said trip member, a time delay device effecting a time delay in the tripping movement of said trip member, a control element operable to decrease the time delay provided by said time delay device, a second armature operable by energization of said electromagnet in response to overload currents of certain other value to instantaneously operate said control element, latch means movable by said second armature and biased to engage said trip member to at times instantaneously move said trip member, and a mechanism responsive to the position of said switch arm to permit said latch member to engage said trip member only when said switch arm is in a position other than said closed position, said mechanism being operable during a closing operation to disengage said latch member from said trip member, and time delay means retarding the operation of said mechanism to disengage said latch member.

7. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, an electromagnet operable when energized in response to overload currents to move said movable member, time delay means effecting a time delay in the tripping movement of said movable member, normally disengaged latch means between said electromagnet and said movable member operable by said electromagnet to at times engage and effect instantaneous tripping movement of said movable member, and a mechanism responsive to the position of said operating means to effect engagement of said latch means with said movable member and instantaneous tripping movement of said movable member only when said breaker is in a position other than the closed position.

8. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, an electromagnet operable when energized in response to overload currents to move said movable member, time delay means effecting a time delay in the tripping movement of said movable member, normally disengaged latch means between said electromagnet and said movable member operable by said electromagnet to at times engage and effect instantaneous tripping movement of said movable member, and a biased mechanism responsive to the position of said operating means to effect engagement of said latch means with said movable member and instantaneous tripping movement of said movable member only when said breaker is in a position other than the closed position, said biased mechanism operating during a clos-

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ing operation of said breaker to disengage said latch means from said movable member.

9. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, an electromagnet operable when energized in response to overload currents to move said movable member, time delay means effecting a time delay in the tripping movement of said movable member, normally disengaged latch means operable by said electromagnet to at times effect instantaneous tripping movement of said movable member, and a biased mechanism responsive to the position of said operating means to effect engagement of said latch means with said movable member and instantaneous tripping movement of said movable member only when said breaker is in a position other than the closed position, said biased mechanism operating during a closing operation of said breaker to disengage said latch means, and time delay means retarding the operation of said biased mechanism to thereby delay disengagement of said latch means from said movable member until said breaker is closed.

10. In a circuit breaker comprising relatively movable contacts and operating means therefor including a switch arm movable to open and closed positions, a main current path through said breaker including said contacts, a trip member operable to effect automatic opening of said contacts, a trip device comprising a magnetic circuit surrounding said main current path including an armature operable in response to certain overload currents to engage and operate said trip member, a time delay device retarding tripping operation of said trip member, a control element operable to decrease the amount of time delay provided by said time delay device, electromagnetic means comprising a second magnetic circuit surrounding said main current path including a second armature operable in response to certain other overload currents to operate said control element, an interposer on said second armature biased to at times engage and operate said trip member, and a mechanism responsive to the position of said switch arm to permit said interposer to engage said trip member only when said switch arm is in position other than said closed position.

11. In a circuit breaker comprising relatively movable contacts and operating means therefor including a switch arm movable to open and closed positions, a main current path through said breaker including said contacts, a trip member operable to effect automatic opening of said contacts, a trip device comprising a magnetic circuit surrounding said main current path including an armature operable in response to certain overload currents to engage and operate said trip member, a time delay device retarding tripping operation of said trip member, a control element operable to decrease the amount of time delay provided by said time delay device, electromagnetic means comprising a second magnetic circuit surrounding said main current path including a second armature operable in response to certain other overload currents to operate said control element, an interposer on said second armature biased to at times engage and operate and trip member, a mechanism responsive to the position of said switch arm to permit said interposer to engage said trip member only when said switch arm is in a position other than said closed position, said mechanism being operable during a closing operation to disengage said interposer from said trip member, and time delay means re-

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tarding operation of said mechanism to disengage said interposer.

12. In a circuit breaker comprising a switch arm movable to open and closed positions, operating means for said switch arm, a main current path through said breaker including said switch arm, a trip member operable to effect automatic opening operation of said switch arm, a trip device comprising a pair of magnetic circuits surrounding said main current path, a pair of armatures separately operable by energization of said magnetic circuits in response to overload currents of different values, one of said armatures when operated operating said trip member, time delay means retarding tripping operation of said one armature, a control element operable to decrease the amount of time delay provided by said time delay means, the other of said armatures being connected to operate said control element, an interposer operated by said other armature and biased to at times engage and operate said trip member, and a mechanism responsive to the position of said switch arm restraining said interposer in inoperative position in the closed position of said switch arm, said mechanism being operable during an opening movement of said switch arm to permit said interposer to be moved to an operative position so that when the other armature is operated in response to an overload current occurring during a closing movement of said switch arm the interposer will engage and instantaneously operate said trip member.

13. In a circuit breaker comprising a switch arm movable to open and closed positions, operating means for said switch arm, a main current path through said breaker including said switch arm, a trip member operable to effect automatic opening operation of said switch arm, a trip device comprising a pair of magnetic circuits surrounding said main current path, a pair of armatures separately operable by energization of said magnetic circuits in response to overload currents of different values, one of said armatures when operated operating said trip member, time delay means retarding tripping operation of said one armature, a control element operable to decrease the amount of time delay provided by said time delay means, the other of said armatures being connected to operate said control element, an interposer operated by said other armature and biased to at times engage and operate said trip member, a mechanism responsive to the position of said switch arm restraining said interposer in inoperative position in the closed position of said switch arm, said mechanism being operable during an opening movement of said switch arm to permit said interposer to be moved to an operative position so that when the other armature is operated in response to an overload current occurring during a closing movement of said switch arm the interposer will engage and instantaneously operate said trip member, said mechanism being operable during a closing operation of said switch arm to move said interposer to inoperative position, and time delay means delaying operation of said mechanism to move said interposer to inoperative position until said switch arm is in the closed position.

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