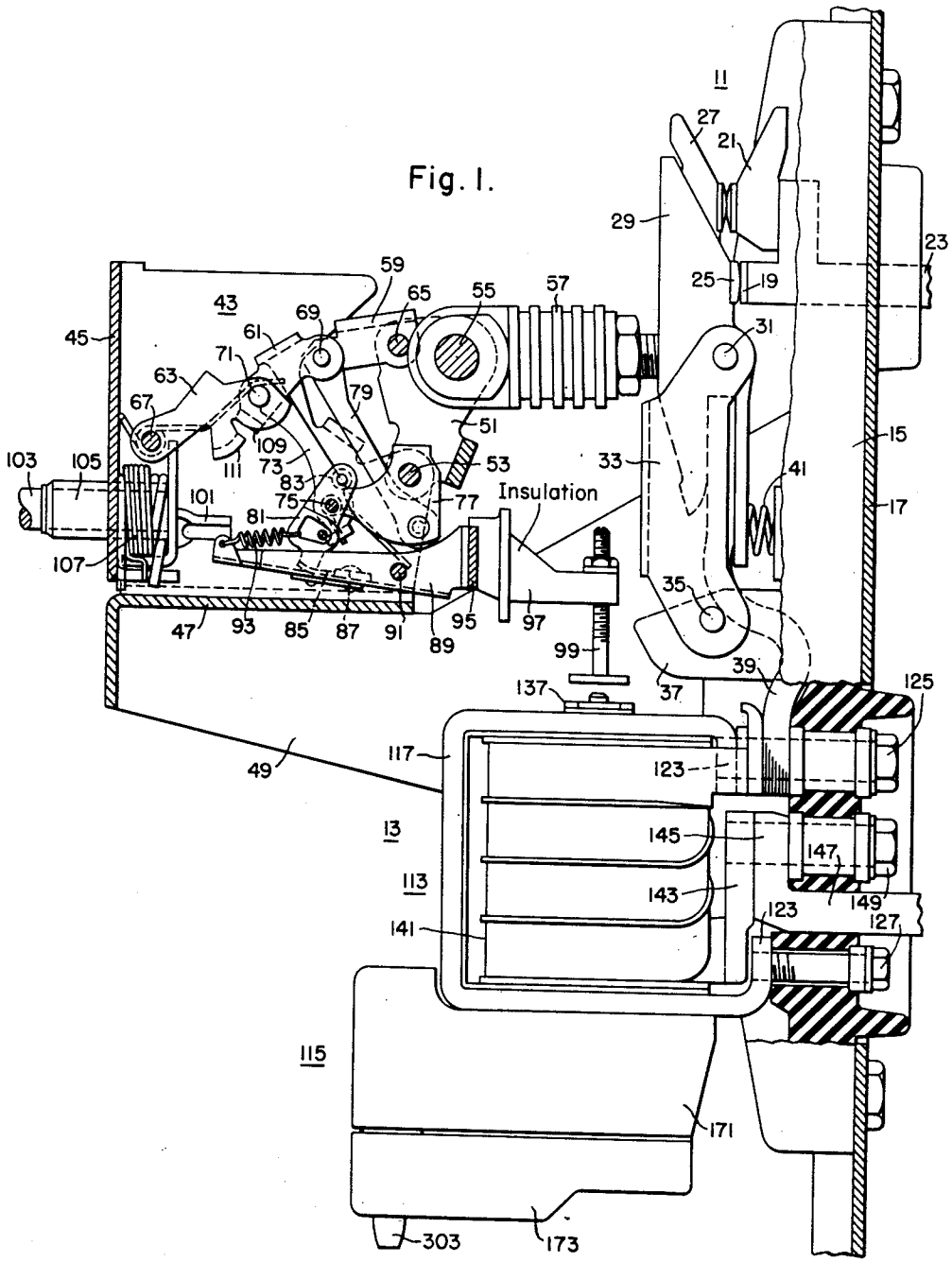
Dec. 22, 1953 J. B. MacNEILL ET AL 2,663,775

CIRCUIT BREAKER

Filed July 22, 1950

5 Sheets-Sheet 1

Fig. 1.



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CIRCUIT BREAKER

Filed July 22, 1950

5 Sheets-Sheet 2

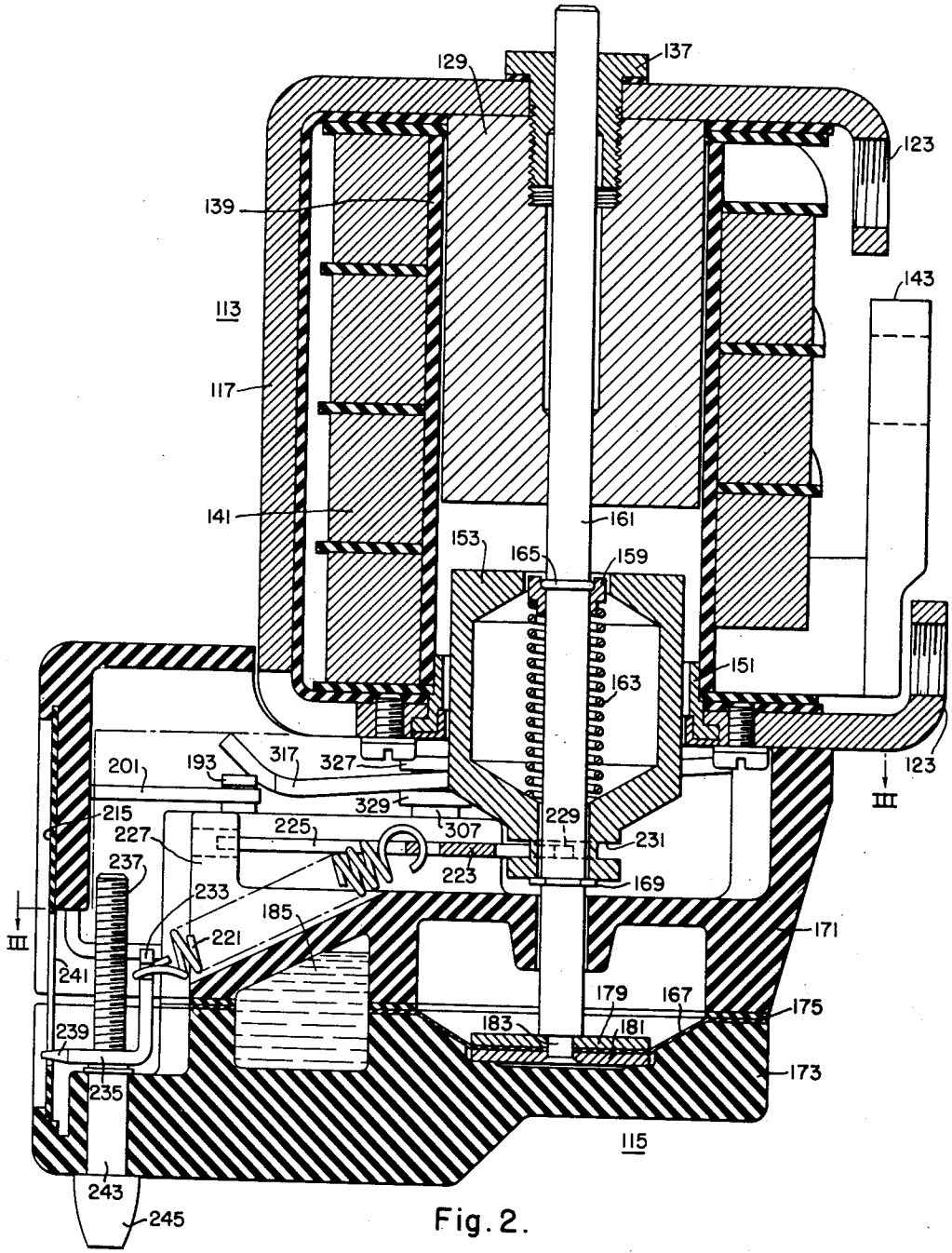


Fig. 2.

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CIRCUIT BREAKER

Filed July 22, 1950 5 Sheets-Sheet 3

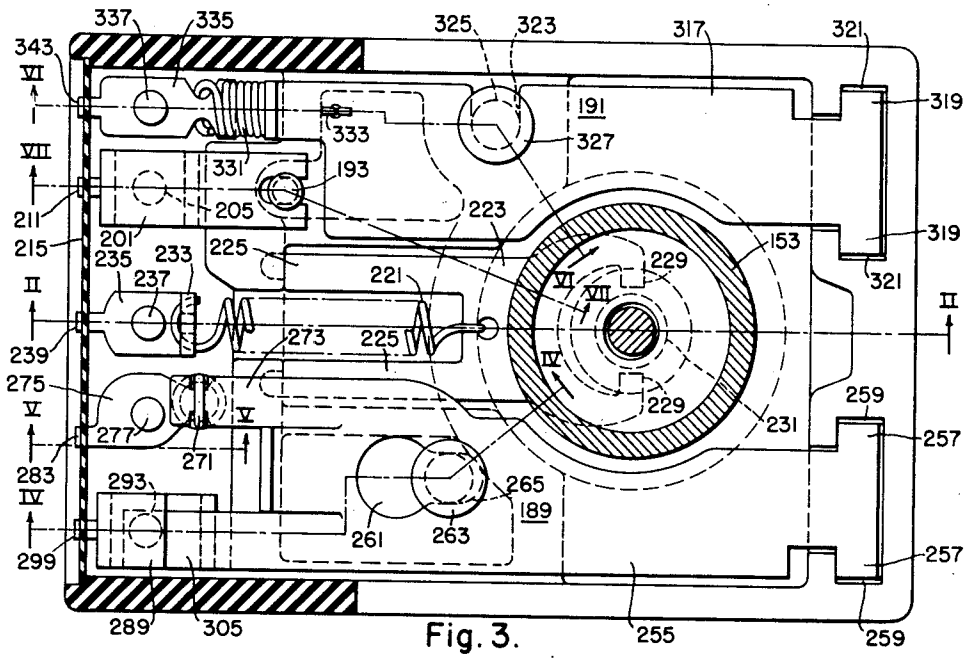


Fig. 3.

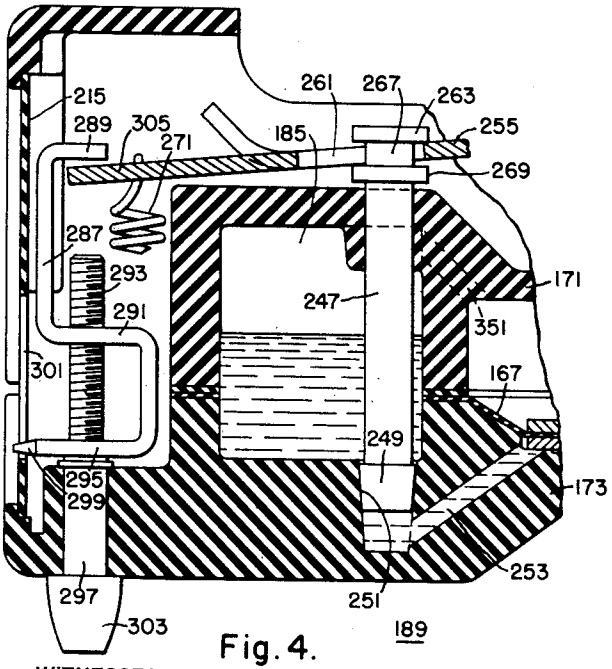


Fig. 4.

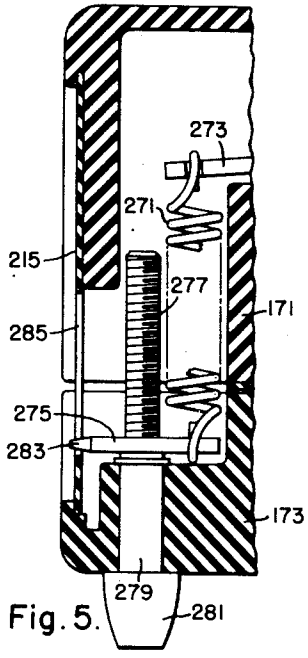


Fig. 5.

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CIRCUIT BREAKER

Filed July 22, 1950 5 Sheets-Sheet 4

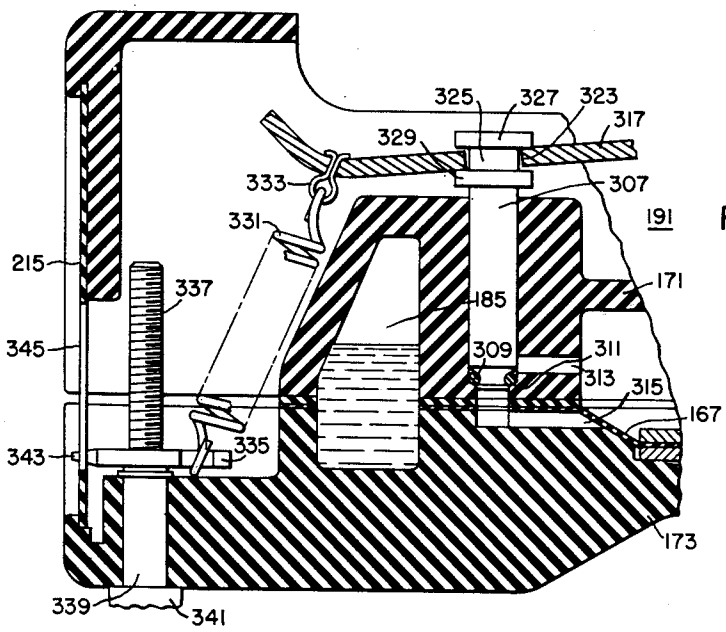


Fig. 6.

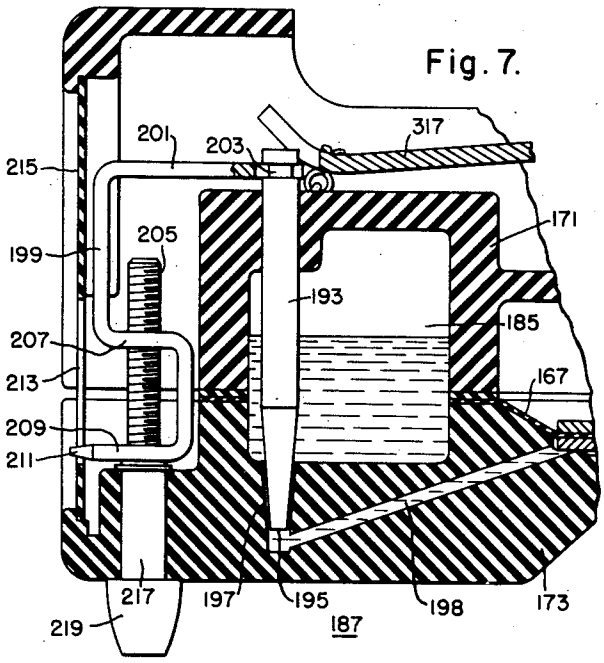
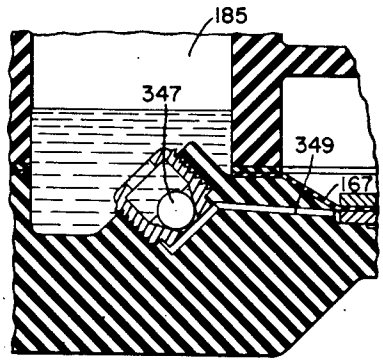


Fig. 7.

Fig. 8.



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CIRCUIT BREAKER

Filed July 22, 1950 5 Sheets-Sheet 5

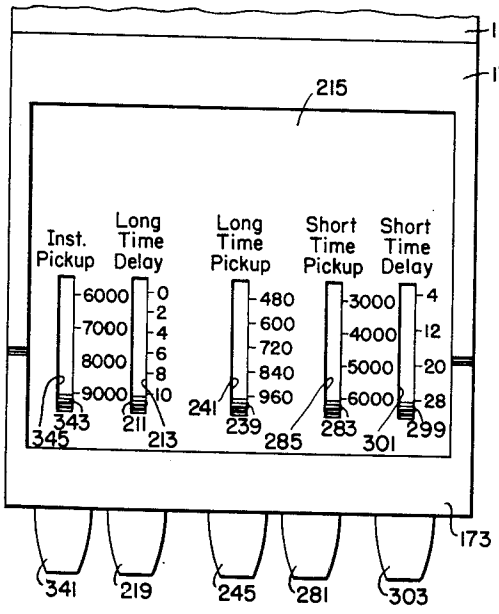
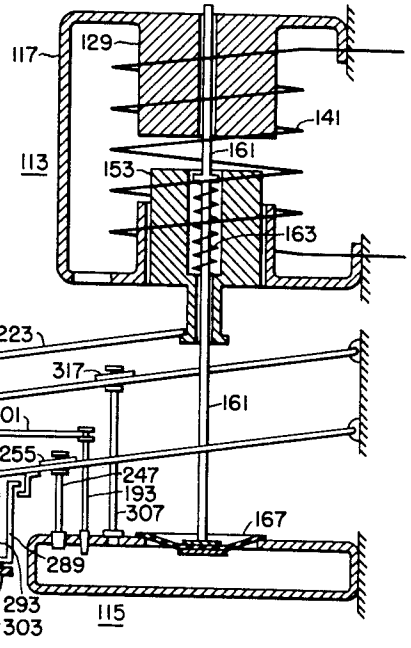


Fig. 9.

Fig. 10.



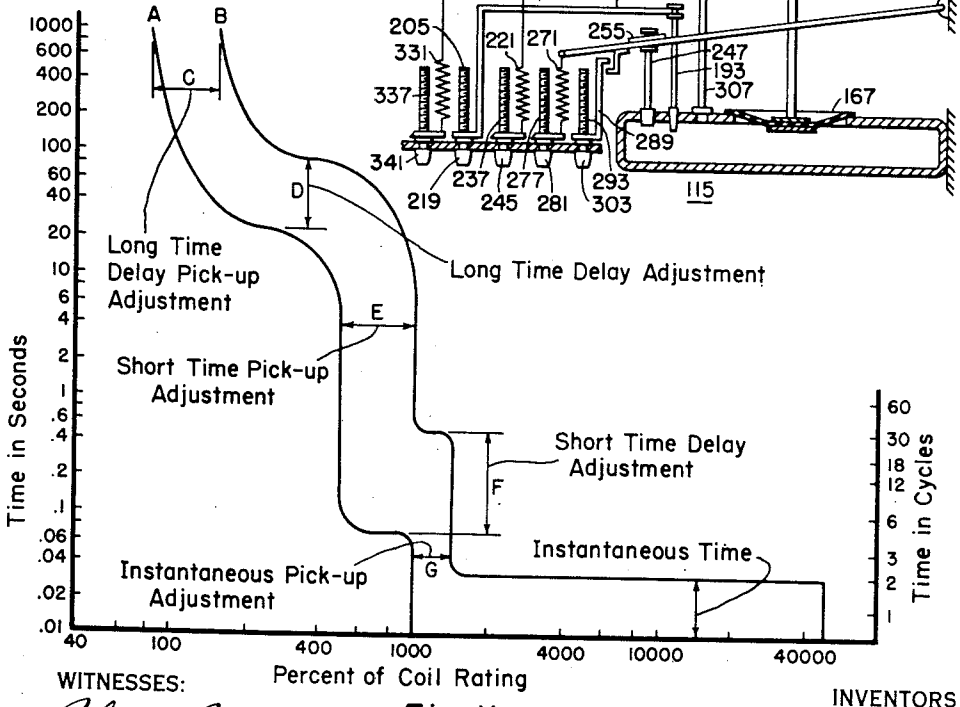


Fig. 11.

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Patented Dec. 22, 1953

2,663,775

UNITED STATES PATENT OFFICE

2,663,775

CIRCUIT BREAKER

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Application July 22, 1950, Serial No. 175,374

14 Claims. (Cl. 200—108)

1

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, an instantaneously in response to overload currents above said predetermined value or 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 liquid dashpot type in which time delays of different duration in different ranges of overload currents are provided by admitting liquid 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 liquid dashpot type wherein different amounts of time delay are provided by the operation of one or more valves to admit liquid 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 liquid dashpot type wherein time delays of different durations are provided by the operation of one or more valves for admitting liquid 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 having a trip device embodying a novel time-delay device comprising a dashpot in which time delays of different durations in different ranges of overload currents are provided by admitting liquid to the dashpot at different rates and in which instantaneous tripping is effected by admitting a gaseous fluid to said dashpot.

Another object of the invention is to provide a circuit breaker embodying a novel time-delay device wherein time-delay tripping is effected by admitting liquid to a dashpot and substantially instantaneous tripping is effected by admitting air to the dashpot.

Another object of the invention is to provide a circuit breaker embodying a novel trip device and a time-delay device of the liquid dashpot type having separate valve means for controlling the admission of liquid from a liquid storage chamber 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.

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Afurther object of the invention is to provide a circuit breaker embodying a novel trip device and a time-delay device of the liquid dashpot type having a liquid storage chamber and a plurality of valves for controlling the admission of liquid from said chamber to said dashpot, certain of said valves being operated electromagnetically, 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:

Figure 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 substantially 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 sectional view taken on line V—V of Fig. 3 and showing the pick-up adjustment for the short-time-delay valve-operating armature;

Fig. 6 is a fragmentary sectional view taken substantially on line VI—VI of Fig. 3 and showing

the instantaneous valve device and the adjusting means therefor;

Fig. 7 is a sectional view taken on line VII—VII of Fig. 3 showing the long-time-delay valve and the adjusting means therefor;

Fig. 8 is a fragmentary sectional view showing the resetting check valve between the liquid storage chamber and the dashpot;

Fig. 9 is an elevational view of the time-delay device showing the scale plate and the several adjusting knobs;

Fig. 10 is a schematic view of the trip device illustrating the several adjusting means for the time-delay device; and

Fig. 11 is a schematic diagram showing the range of adjustments 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 over-current 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 supporting panel 17. Since the pole units are alike, only the center pole unit is illustrated and described herein.

The contact structure 11 comprises stationary main and arcing contacts 19 and 21 both secured on the inner end of a terminal conducting bar 23 and cooperating movable main and arcing contacts 25 and 27. The movable contacts are rigidly secured to a contact-carrying member 29 pivotally mounted by means of a pivot pin 31 on a U-shaped switch arm 33 which, in turn, is pivotally supported by pivot means 35 on brackets 37 rigidly mounted on the insulating base 15.

The movable contact-carrying member 29 is electrically connected by means of a flexible conductor 39 to the energizing coil of the trip device 13. A spring 41 compressed between the movable contact-carrying member 29 below its pivot 31 and 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 means of an operating mechanism indicated generally at 43 mounted in a U-shaped frame 45. The frame 45 is supported on a platform 47 which forms a cross member of a generally U-shaped main bracket comprising a pair of spaced side members 49 rigidly connected at their outer ends by the cross member or platform 47. The platform 47 extends substantially across the width of the breaker, and the side members 49 are suitably secured to the metal panel 17 on the outside of the two outer pole units of the breaker.

The operating mechanism includes a lever 51 mounted on a pivot pin 53 supported in the side members of the frame 45. The lever 51 carries a rod 55 extending across all of the poles of the breaker and is connected by means of insulating connecting members 57 to the pivot pins 31 in the free ends of the switch arms 33 for the several poles of the breaker so that upon operation of the rod 55 the movable contacts of all of the poles move in unison.

An operating linkage comprising toggle links 59, 61 and 63 is provided to releasably hold the lever 51 and consequently the movable contacts in the closed position and to operate the movable contacts to open and closed positions. The toggle link 59 is pivotally connected to the lever 51 by means of a pivot pin 65, and the toggle link 63 is pivoted on a fixed pivot 67 supported in the frame 45. The toggle link 61 is pivotally connected to the links 59 and 63, respectively, by knee pivot pins 69 and 71.

The linkage 59, 61, 63 comprises two toggles, one of which 59—61 may be designated as the tripping toggle and the other 61—63 as the closing toggle. The tripping toggle 59—61 is normally slightly underset above a line drawn through the centers of the pivot pins 65—71 and the closing toggle 61—63 is normally underset below a line drawn through the centers of pivot pins 67—69. The closing toggle 61—63 is normally prevented from collapsing downward by a support member 73 pivoted on a pivot pin 75 supported in the frame 45 and having shouldered portion engaging under the knee pivot pin 71.

The tripping toggle 59—61 is normally biased in a direction to cause its collapse by a component of the force of the springs 41 which bias the movable contact structures for the three poles of the breaker in opening direction and bias the connecting members 57 toward the left (Fig. 1). The tripping toggle 59—61 is normally prevented from collapsing by means of a main latch member 77 pivoted on the pin 53 and connected by means of a link 79 to the knee pin 69 of the tripping toggle.

The main latch member 77 is held in latching position by an intermediate latch lever 81 pivoted on the pin 75. The intermediate latch lever 81 carries at its upper end a latch roller 83 engaging the main latch 77 and at its lower end has a latching portion 85 normally engaging a latch member 87 on a channel-shaped latch 89 pivoted on a pivot pin 91 in the frame 45. A spring 93 serves to bias the latch lever 81 and the latch 89 to their latching positions.

A trip bar 95, extending across all of the poles of the breaker, is rigidly mounted on the right-hand end of the channel-shaped latch 89 and has insulating brackets 97 (only one being shown) secured thereto, there being a bracket 97 for each pole of the breaker. Each of the brackets 97 has a headed screw 99 adjustably mounted thereon for cooperating with the trip device 13 of its associated pole in a manner to be presently described.

The breaker is tripped open manually by means of a cam member 101 mounted on the inner end of a handle shaft 103 journaled in a bearing 105 mounted in the front piece of the frame 45. The handle is not shown in the drawings but is rigidly secured to the outer end of the shaft 103 and biased in both directions to a central position in a well-known manner by means of a spring 107.

Rotation of the handle shaft 103 in tripping direction causes the cam member 101 to engage and actuate the latch member 89 in counterclockwise or unlatching direction to unlatch the intermediate latch lever 81, which, in turn, releases the main latch 77. This permits the tripping toggle 59—61 to collapse upwardly to effect opening of the breaker contacts. During the collapse of the tripping toggle, a portion 109 of the toggle link 61 engages and actuates the support member 73 to a non-supporting position, thereby freeing the closing toggle 61—63. The closing toggle thereupon collapses downwardly and during its collapse resets and relatches the tripping toggle 59—61.

The breaker contacts may now be operated to the closed position by rotating the shaft 103 and the cam 101 in the direction opposite to the tripping direction. This causes the cam 101 to engage a projection 111 on the closing toggle

link 63 and moves this link counterclockwise about its pivot 67 until the support member 73 resumes its supporting position below the knee pivot pin 71. During the closing operation, the link 79 prevents collapse of the tripping toggle 59—61 which acts as a thrust transmitting means and moves the movable contact structure to the closed position.

The breaker is automatically tripped open by operation of the trip device 13 for any pole of the breaker. The trip device includes generally a tripping electromagnet 113 (Figs. 1 and 2) and a time-delay device 115. The tripping magnet 113 includes a C-shaped magnet yoke 117. The ends 123 of the magnet yoke form mounting feet and are drilled and tapped to receive mounting bolts 125 and 127 as shown in Fig. 1.

The upper end of a stationary magnet core 129 is provided with an internal thread which cooperates with a threaded nipple 137 disposed in an opening in the magnet yoke to rigidly secure the stationary core 129 to the magnet yoke.

Surrounding the stationary core member 129 is an insulating tube 139 around which is disposed the energizing coil 141 of the magnet.

As shown in Fig. 1, the bolt 125 which secures the upper end of the magnet yoke to the base 15 also secures the flexible conductor 39 to the upper turn of the coil 141. The lower turn of the coil 141 is formed into a lug 143 which, together with the inner end 145 of a terminal 147 is secured to the base 15 by means of a bolt 149. A tubular member 151 (Fig. 2) of magnetic material is mounted in an opening in the lower portion of the magnetic yoke 117 and extends upwardly within the insulating tube 139. Disposed within the tubular member 151 is a movable core member or armature 153. The armature 153 is provided with a central opening through which extends a trip rod 161 extending axially through the movable armature 153 and an opening in the nipple 137. A spring 163 coiled about the trip rod 161 is compressed between a counterbore in the armature 153 and a collar 159 held in place on the trip rod by a spring clip 165 seated in an annular groove in the trip rod 161. The armature 153 normally rests on a spring clip 169 seated in a groove in the trip rod 161.

The trip rod 161 is moved upwardly to the trip breaker under the control of the time-delay device 115 which comprises, generally, a movable abutment or flexible diaphragm 167 (Fig. 2) cooperating with the lower end of the trip rod and several valve elements for admitting air to the space below the movable abutment or diaphragm at various rates to provide different amounts of time delay. The flexible diaphragm is disposed in a chamber formed in an upper housing member 171 and a lower housing member 173, both of said housing members being formed of molded insulating material. The outer edge of the diaphragm 167, together with a sealing gasket 175, is clamped between the housing members to form an airtight seal. The housing members 172—173 are secured together and rigidly secured to the magnet yoke 117 by means of bolts (not shown). The central portion of the diaphragm 167 is clamped between upper and lower clamp members 179 and 181, respectively. A reduced end 183 of the trip rod 161, extending downwardly through openings in the clamp members 179 and 181 and in the flexible diaphragm, is formed over against the lower face of the latter to form an airtight seal.

Since the spaces above and below the diaphragm 167 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 161 will be restrained by the partial vacuum below the diaphragm. In order to control the tripping movement of the trip rod 161, several valve devices are provided to admit liquid from a reservoir 185 (Figs. 2, 4, 6, 7 and 8) to the space below the diaphragm 167. The valve devices comprise a long-time-delay valve device indicated generally at 187 (Fig. 7) and a short-time-delay valve device indicated generally at 189 (Fig. 4). There is also provided an instantaneous valve device 191 (Fig. 6) for admitting air from the space above the diaphragm to the space below the diaphragm to permit instantaneous operation of the trip rod 161.

The long-time-delay valve device (Figs. 3 and 7) comprises a valve rod 193 slidable axially in an opening in the upper wall of the reservoir 185 and having a tapered lower end 195 forming a valve which cooperates with a valve seat 197 formed in the lower housing member 173 to control a passage 198 communicating the reservoir 185 with the space below the diaphragm. The amount of opening of the valve 195—197 is manually adjusted by means of an S-shaped adjustable member 199, the upper horizontal portion 201 of which engages an annular groove 203 in the upper end of the valve rod 193. An adjusting screw 205 threadedly engages a central cross member 207 of the adjustable member and passes through an opening (not shown) in a lower horizontal member 209 which has a reduced portion 211 extending through a slot 213 in a scale plate 215 mounted on the housing members 171 and 172. The adjusting screw 205 has a shaft portion 217 rotatably supported in the housing member 173 and has a knob 219 rigid therewith for manually rotating the screw. Rotation of the screw 205 will move the adjustable member 199 up or down, depending on the direction of rotation, and move the long-time-delay valve 193 up or down to vary the amount of opening thereof. This varies the amount of time delay provided by the long-time-delay valve device 187.

The pick-up point of the long-time-delay tripping may be varied by varying the tension of a biasing spring 221 (Figs. 2 and 3) which biases the main armature 153 against attraction. One end of the spring 221 is hooked in an opening in the bight of a U-shaped lever 223, the legs 225 of which are pivotally supported in openings in an upwardly extending portion 227 (Fig. 2) of the housing member 171. At its right-hand end, as viewed in Figs. 2 and 3, the lever 223 is bifurcated and is provided with inwardly extending projections 229 which engage in an annular groove 231 in the armature 153. The other end of the spring 221 is attached to the vertical portion of an angular adjustable member 233 having a horizontal portion 235 threadedly engaged by an adjusting screw 237. The portion 235 is provided with a reduced end 239 which projects through a slot 241 in the scale plate 215 to indicate the setting of the device. The screw 237 has a shaft portion 243 rotatably mounted in the lower housing member 173 and a knob 245 on the lower end of the shaft portion for manually rotating the screw 237. It will be obvious that rotation of the knob 245 and screw 237 will move the member 233 up or down, depending on the direction of rotation, and vary the tension of the spring 221 thereby varying the magnitude of

overload current required to operate the armature 153.

The short-time-delay valve device 189 (Fig. 4) comprises a valve member 247 slidable vertically in an opening in the upper wall of the reservoir 185 and having a valve 249 on the lower end thereof cooperating with a valve seat 251 to control a passage 253 communicating the reservoir 185 with the space below the diaphragm.

The short-time-delay valve 247 is adapted to be opened by means of an armature 255 (Figs. 3 and 4) operated upon energization of the tripping electromagnet 113 (Figs. 1 and 2) in response to overload currents of predetermined value. The armature 255 is pivotally supported at its right-hand end (Fig. 3) by means of projections 257 on the armature engaging in recesses 259 in the housing member 171. The armature 255 is provided with an opening 261 for receiving a head 263 of the valve 247 and the opening 261 has a narrow portion 265 for engaging an annular groove 267 formed by the head 263 and a collar 269 on the valve 247.

The armature 255 is biased against attraction by means of a spring 271 (Fig. 5) having one end attached to a projection 273 of the armature and the other end attached to an adjustable member 275. The adjustable member threadedly engages an adjusting screw 277 having a shaft portion 279 rotatably mounted in the lower housing member 173 and provided with a manual knob 281 for rotating the screw 277 to vary the tension of the spring 271 to thereby vary the minimum overload current required to operate the armature 255. The adjustable member 275 has a reduced pointer 283 extending through a slot 285 in the scale plate 215 to indicate the adjustment of short-time-delay pick-up.

The amount of opening of the short-time-delay valve device 189 and, hence, the amount of time delay provided by the valve device 189 may be varied by varying the extent of movement of the armature 255. This is effected by means of an S-shaped adjustable stop member 287 (Figs. 3 and 4). The upper end of the member 287 is formed over or at 289 to provide an adjustable stop for the armature 255. The central cross member 291 of the member 287 is threadedly engaged by an adjusting screw 293 which extends downwardly through a clearance opening in the lower member 295 of the S-shaped member and has a shaft-portion 297 rotatably mounted in the lower housing member 173. The lower member 295 of the S-shaped member has a reduced end 299 projecting through a slot 301 in the scale plate to act as a pointer for indicating the time-delay setting of the short time delay. A knob 303 is provided on the lower end of the shaft portion 297 for manually rotating the screw to adjust the stop 289. The stop 289 is disposed in the path of a projection 305 (Figs. 3 and 4) of the armature 255 and adjustment of the stop 289 will permit a greater or lesser movement of the armature and opening of the valve 249—251, thus varying the rate of flow of liquid from the reservoir 185 to the space below the diaphragm. This varies the amount of short time delay provided by the valve device 189.

The flow velocity of a liquid such as oil or one of the silicones is relatively low and is well adapted as a medium for providing long and short time delays in the operation of the trip device. On excessive overload currents or short circuit currents, it is desired ot trip the breaker substantially instantaneously. Such liquids are, by reason of their low flow velocity, unsuited for instantaneous tripping operations. In order to provide instantaneous tripping of the breaker, the instantaneous valve device 191 (Fig. 6) is arranged to control a passage for admitting air from the space above the diaphragm to the space below the diaphragm; the high flow velocity of air or other suitable gas permits unretarded tripping operation of the trip device.

Referring to Fig. 6, the instantaneous valve device 191 comprises a valve member 307 slidable vertically in an opening in the upper housing member 171. An annular valve facing 309 seated in an annular groove in the lower end of the valve member 307 cooperates with a valve seat 311 formed in the housing member 171 to control a passage 313 communicating with the space above the diaphragm 167 and a passage 315 communicating with the space below the diaphragm. The valve 307 is operated to the open position by means of an armature 317 (Figs. 3 and 6) pivotally supported at its right-hand end by means of projections 319 engaging in recesses 321 in the upper housing member 171. The armature 317 is provided with an open slot 323 which engages an annular groove 325 formed on the valve member 307 by a head 327 and a collar 329. The armature 317 is biased against attraction by a spring 331 having one end attached to the armature 317 by means of a clip 333 and the other end attached to an adjustable member 335. The adjustable member 335 is threadedly engaged by an adjusting screw 337 having a shaft portion 339 rotatably mounted in the housing member 173. A knob 341 is provided on the lower end of the shaft 339. The adjustable member 335 is provided with a reduced portion 343 which extends through a slot 345 in the scale plate 215 to act as a pointer for indicating the pick-up adjustment of the armature 317. The pick-up point of the instantaneous trip armature 317 is adjusted by rotating the knob 341 to vary the tension of the spring 331.

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. 10) will operate as follows: Upon the occurrence of an overcurrent in the low range, the tripping electromagnet 113 becomes energized and attracts the armature 153 upwardly. The armature acts through the spring 163 to produce an upward thrust on the trip rod 161, the movement of the trip rod being retarded by the partial vacuum below the diaphragm 167. The trip rod 161 moves slowly in tripping direction as liquid is drawn into the space below the diaphragm from the reservoir 185 through the long-time-delay valve 195—197 (Fig. 7) until the upper end of the trip rod engages the headed screw 99 (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 187 is in the order

of seconds and may be varied by adjusting the valve 195—197 (Fig. 7) as set forth previously.

As soon as the breaker contacts are opened, the tripping magnet 113 is deenergized and the armature 153 and the trip rod 161 are restored by means of the spring 221 and the force of gravity to their Fig. 2 positions. A ball check valve 347 (Fig. 3) controls a passage 349 from the space below the diaphragm 167 to the reservoir to provide for quick restoration of the armature 153, the trip rod 161 and diaphragm 167 to their normal positions following a tripping operation.

When an overcurrent occurs in the intermediate range of overcurrents, the electromagnet 113 is energized sufficiently to attract the short-time-delay armature 255 (Figs. 3 and 4) upwardly against the adjustable stop 289 opening the short-time-delay valve member 247 an amount determined by the adjustment of the stop 289. This admits liquid from the reservoir 185 to the space below the diaphragm 167 at a much 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 113 in response to an overcurrent in the intermediate range is not sufficient to attract the armature 317 for the instantaneous valve 307 (Figs. 6 and 10). However, upon the occurrence of an overcurrent of 1000% or more of rated current, both the short-time-delay armature 255 and the instantaneous armature 317 are actuated and open both the short-time-delay valve device 189 (Figs. 4 and 10) and the instantaneous valve device 191 (Figs. 6 and 10), thereby admitting both liquid and air to the space below the diaphragm 167 at a rate sufficient to permit substantially instantaneous tripping movement of the trip rod 161. Since the long-time-delay valve device 187 (Fig. 7) and the short-time-delay valve device 189 (Fig. 4), as well as the instantaneous valve device 191 (Fig. 6), are open on instantaneous tripping operation, a certain amount of liquid from the reservoir 185 will be drawn into the space below the diaphragm 167 on such operations. Due to the relatively high flow velocity of air as compared to liquids, the amount of liquid drawn into the space below the diaphragm will be relatively small. It will be seen, by reference to Fig. 8, that the passage 349 will, upon restoration of the trip rod 161 and the diaphragm, bleed off the air admitted to the space below the diaphragm on instantaneous tripping operation so that any negligible quantity of air remaining below the diaphragm will not affect subsequent long- or short-time-delay tripping. A passage 351 (Fig. 4) permits the air flowing out through check valve 347 (Fig. 8) into the reservoir 185, to return to the space above the diaphragm 167.

On short-time-delay and instantaneous tripping operations, the spring 163 limits the force applied by the moving armature 153 to the time-delay device. On such operations the armature 153 is attracted immediately against the fixed core member 129 compressing the spring 163 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 163 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 9, 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 pick-up, from 80 to 160% of coil rating.
2. Range of long time delay, from 23 to 86 seconds.
3. Range of short-time-delay pick-up, from 500 to 1000% of coil rating.
4. Range of short time delay, from 4 to 30 cycles.
5. Range of instantaneous pick-up from 1000 to 1500 per cent of coil rating.

Fig. 11 graphically illustrates the ranges of the several adjustments of the trip device. Along the left-hand edge of Fig. 11 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 245 (Figs. 2, 9 and 10), the long-time-delay pick-up 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 219 (Figs. 7, 9 and 10) which controls the long-time-delay valve 193 varies the amount of long time delay between 23 and 86 seconds as indicated at D in Fig. 11. As indicated at E (Fig. 11) the short-time-delay pick-up may be set to pick up between 500% and 1000% of coil rating. This is effected by adjusting the knob 281 (Figs. 5, 9 and 10). The amount of short time delay may be varied between 4 and 30 cycles, as indicated at F, by adjusting the knob 303 (Figs. 4, 9 and 10). Finally, the instantaneous pick-up point may be varied between 1000% and 1500% of coil rating, as indicated at G, by adjusting the knob 341 (Figs. 6, 9 and 10) which controls the tension of the biasing spring 331 (Figs. 6 and 10) for the instantaneous valve-operating armature 317.

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. 9, 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.

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 an electromagnetic trip device comprising a trip rod, an energizing winding, an armature operable upon energization of said winding in response to overload currents to actuate said trip rod, a time-delay element for retarding tripping operation of said trip rod, a housing defining a chamber for said time-delay element and a separate liquid storage reservoir, a plurality of passages communicating said reservoir and said chamber, valve means controlling said passages to admit liquid from said reservoir to said chamber at different rates to effect time delays of different duration in the operation of said trip rod and electromagnetic means for actuating said valve means.

2. In an electromagnetic trip device comprising a trip rod, an energizing winding, an armature operable upon energization of said winding in response to overload currents to actuate said trip rod, a time-delay element for retarding tripping operation of said trip rod, a housing defining a chamber for said time-delay element and a separate liquid storage reservoir, a plurality of passages communicating said reservoir and said chamber, and valve means controlling said passages to admit liquid from said reservoir to said chamber at different rates to effect time delays of different rates to effect time delays of different duration in the operation of said trip rod, a separate passage communicating said chamber to atmosphere, and valve means controlling said separate passage to admit air to said chamber to effect instantaneous operation of said trip rod.

3. In a trip device comprising a trip rod and an electromagnet operable when energized to effect tripping movement of said trip rod, time-delay means comprising a dashpot attached to said trip rod for retarding tripping movement of said trip rod, an enclosing housing defining a chamber for said dashpot and a liquid reservoir spaced from said chamber, a first valve for admitting liquid from said reservoir to said chamber at a predetermined rate to effect a relatively long time delay in the tripping movement of said trip rod, a second valve, and an armature operable automatically by said electromagnetic trip device in response to abnormal circuit conditions to actuate said second valve and increase the rate of admission of liquid from said reservoir to said chamber to effect a relatively short time delay in the tripping movement of said trip rod.

4. In an electromagnetic trip device comprising a trip member, an energizing winding, an armature operable upon energization of said winding to actuate said trip member, a time-delay element comprising a flexible diaphragm for retarding tripping movement of said trip member, a chamber, a reservoir containing liquid, a first valve means for admitting liquid from said reservoir to said chamber at a predetermined rate to retard movement of said trip member with a predetermined time delay, a second valve means, and a second armature operated in response to predetermined abnormal circuit conditions to actuate said second valve means and increase the rate of admission of liquid from said reservoir to said chamber.

5. A trip device for a circuit breaker comprising a trip member, electromagnetic means operable when energized in response to overload currents to actuate said trip member, time-delay means comprising a dashpot for retarding tripping movement of said trip member, a housing defining a separate reservoir containing a liquid,

means defining a restricted passage admitting liquid from said reservoir to said dashpot to retard tripping movement of said trip 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 second passage communicating said dashpot to atmosphere, and a valve operable by said electromagnetic means when said electromagnetic means is energized in response to an overload current above said predetermined value, said valve opening said second passage to admit air to said dashpot to permit said electromagnetic means to actuate said trip member substantially instantaneously.

6. In a circuit breaker having relatively movable contact means and operating mechanism therefor, the combination of a trip member, a trip device comprising electromagnetic means operable when energized in response to overload currents to actuate said trip member, time-delay means comprising a dashpot for retarding tripping movement of said trip member, a housing for said dashpot defining a separate reservoir containing a liquid, means defining a restricted passage admitting liquid from said reservoir to said dashpot to retard tripping movement of said trip member when said electromagnetic means is energized in response to an overload current below a predetermined value, means defining a second passage communicating said dashpot to the atmosphere, and a valve operable by said electromagnetic means when said electromagnetic means is energized in response to an overload current above said predetermined value, said valve opening said second passage to admit air to said dashpot to permit said electromagnetic means to actuate said trip member substantially instantaneously.

7. In a trip device for a circuit breaker, the combination of a trip rod, electromagnetic means for actuating said trip rod, time-delay means comprising a dashpot for retarding tripping movement of said trip rod, a reservoir containing a supply of liquid, a first valve for admitting liquid from said reservoir to said dashpot at a predetermined rate for effecting a long time delay of the order of seconds in the operation of said trip rod, a second valve for admitting liquid from said reservoir 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 rod, and a third valve for admitting air to said dashpot at a rate to permit substantially instantaneous operation of said trip rod.

8. In a circuit breaker having relatively movable contact means and operating means therefor, the combination of trip means, electroresponsive means for operating said trip means, time-delay means comprising a dashpot for retarding tripping operation of said trip means, a liquid storage chamber, a first valve means for admitting liquid from said storage chamber 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 liquid from said storage chamber 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 air to said dashpot at a rate to permit instanta-

neous 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.

9. In a circuit breaker having relatively movable contact means and operating means therefor, the combination of a trip member, electromagnetic trip means, means for operating said trip member, time-delay means comprising a dashpot for at times retarding tripping operations of said trip member, a first valve means for admitting liquid to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip 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 air to said dashpot at a rate to permit instantaneous operation of said trip 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.

10. An electromagnetic trip device having a trip member, means for operating said trip member, time-delay means comprising a dashpot for at times retarding tripping operations of said trip member, a first valve means for admitting liquid to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip 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 to thereby vary the amount of time delay, a second valve means for admitting air to said dashpot at a rate to permit instantaneous operation of said trip 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 having relatively movable contact means and operating means therefor, the combination of a trip member, electromagnetic trip means, means for operating said trip member, time-delay means comprising a fluid dashpot for at times retarding tripping operation of said trip member, a reservoir separate from said dashpot and containing a liquid, a first valve means for admitting liquid from said reservoir to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip 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 air to said dashpot at a rate to permit instantaneous operation of said trip member, 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.

12. In a circuit breaker having relatively movable contact means and operating means therefor, the combination of a trip rod, 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 storage chamber containing liquid, a first valve means controlling a passage for admitting liquid from said chamber 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 controlling a second passage for admitting air 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.

13. In a trip device for a circuit breaker, the combination of a trip rod, an energizing winding, a main armature operable upon 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 dashpot including a movable abutment attached to said trip rod for retarding operation of said trip rod, a liquid storage chamber separate from said dashpot, a first valve means for admitting liquid from said storage chamber 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 gas 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.

14. In an electroresponsive trip device 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 dashpot, a housing for said dashpot, a liquid storage chamber defined by said housing and containing a liquid, normally closed valve means controlling a passage and operable to admit liquid from said storage chamber 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.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,451,962	Lindstrom et al.	Oct. 19, 1948
2,486,596	Graves	Nov. 1, 1949
2,543,410	Jensen	Feb. 27, 1951