June 24, 1958 M. E. HORN 2,840,663

CIRCUIT BREAKER

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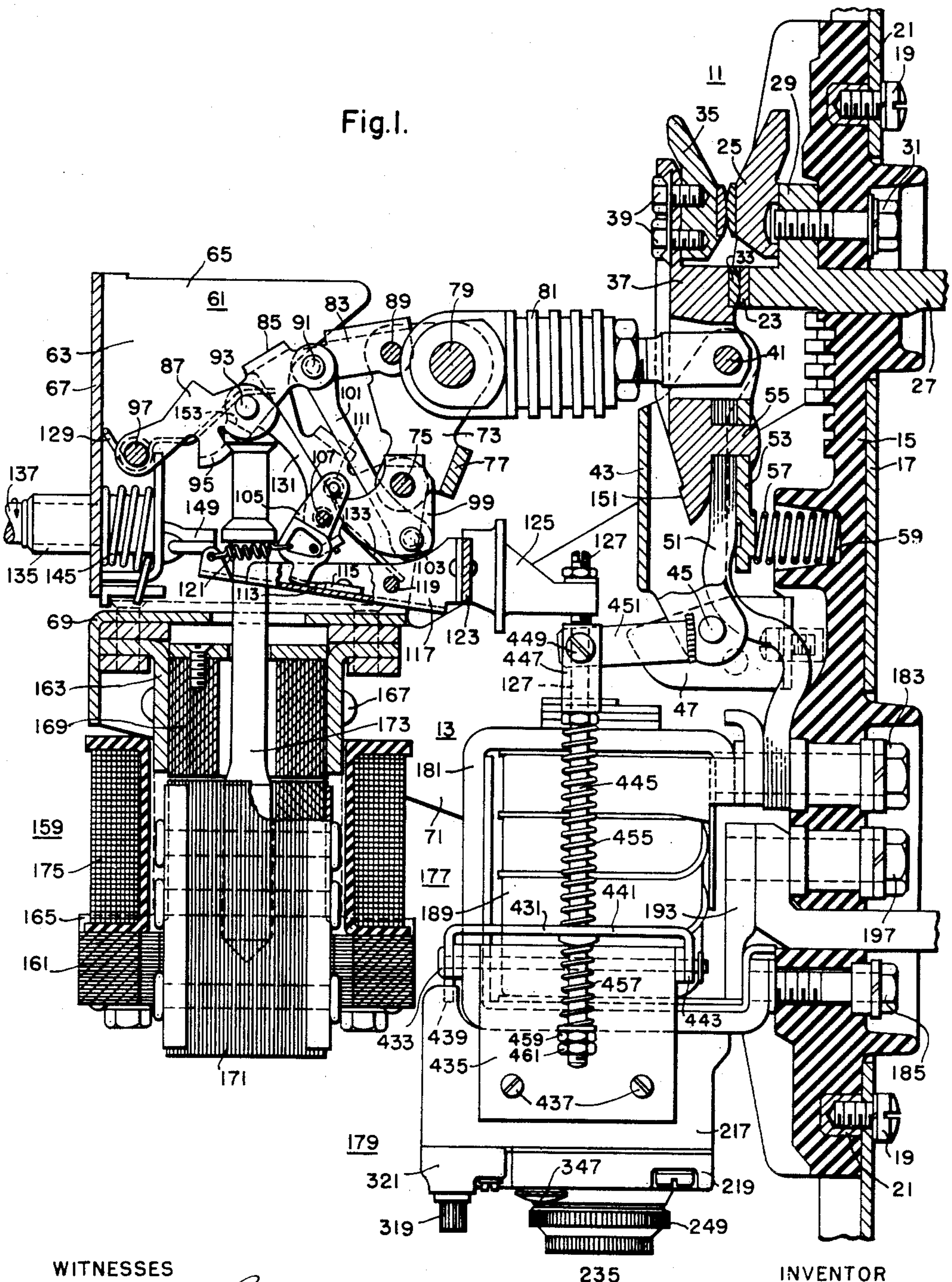
Fig.1.



WITNESSES

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CIRCUIT BREAKER

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Fig. 2.

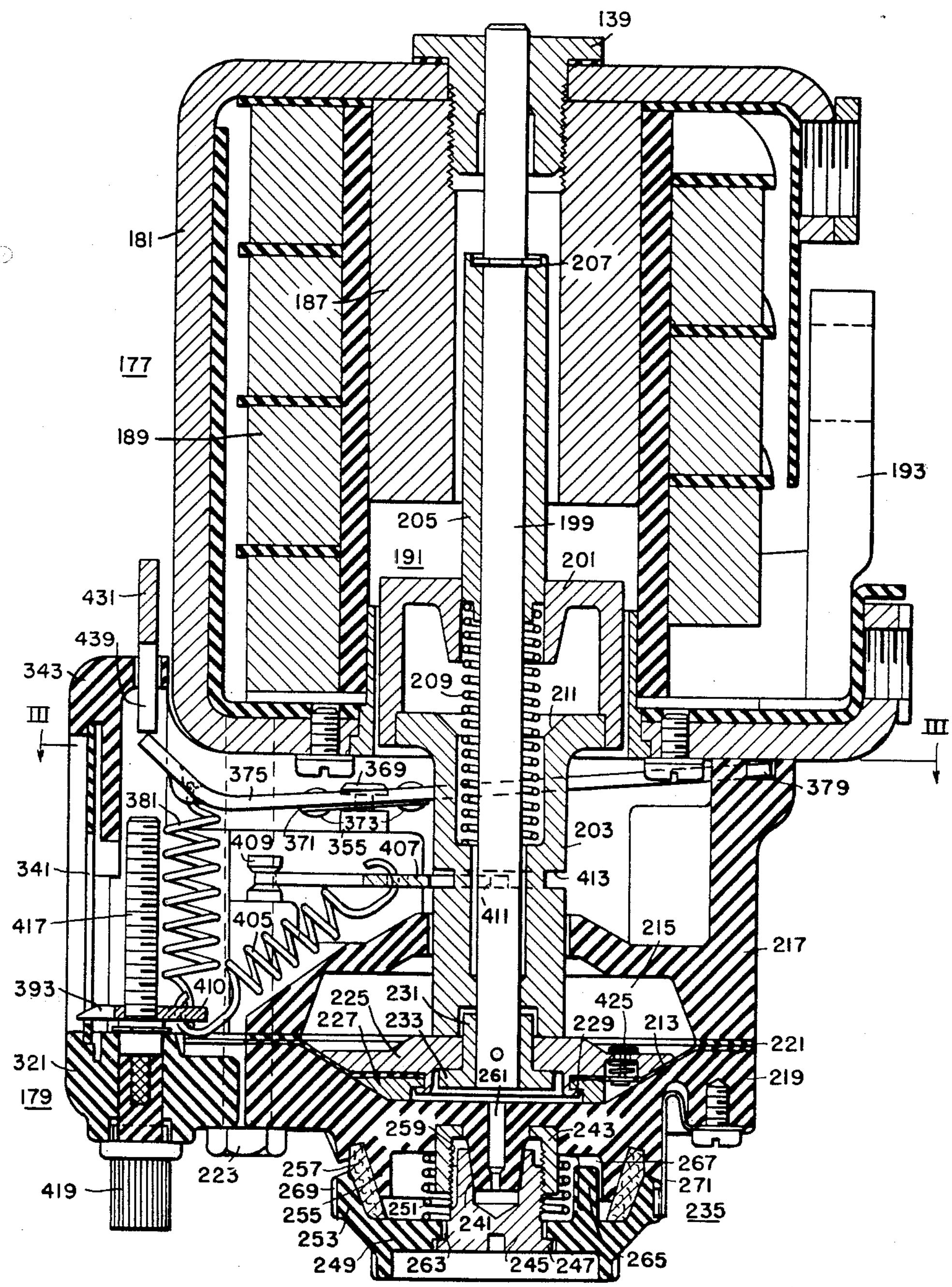

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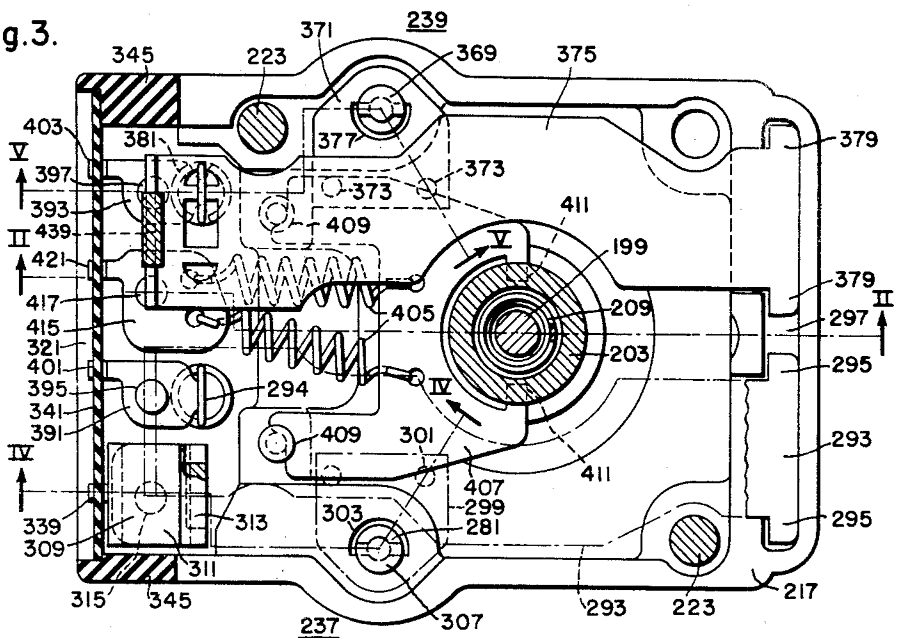
Fig. 3.



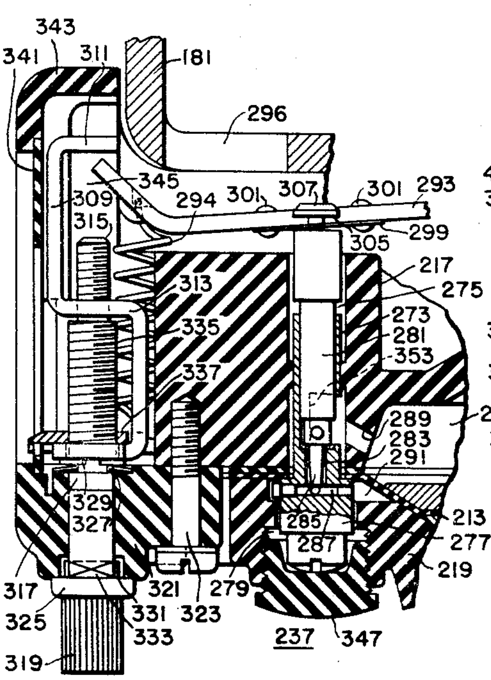


Fig. 4.

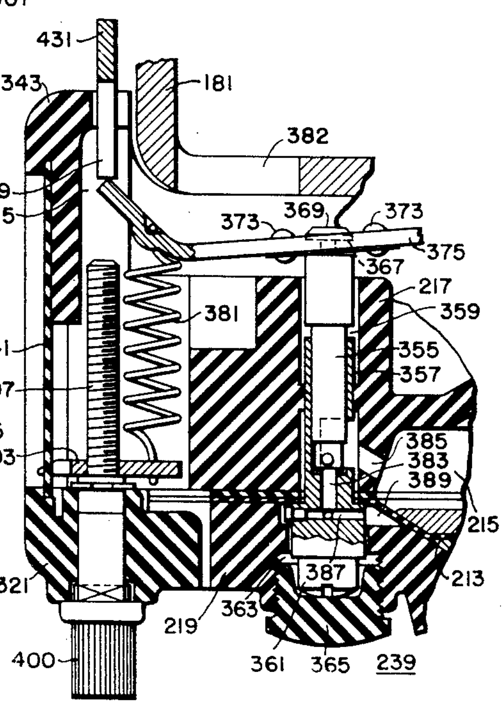


Fig. 5.

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Fig. 6.

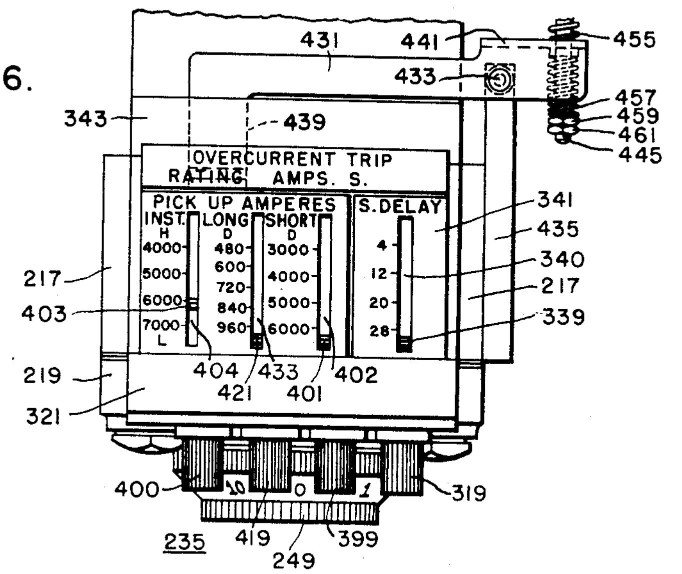

Fig. 7.

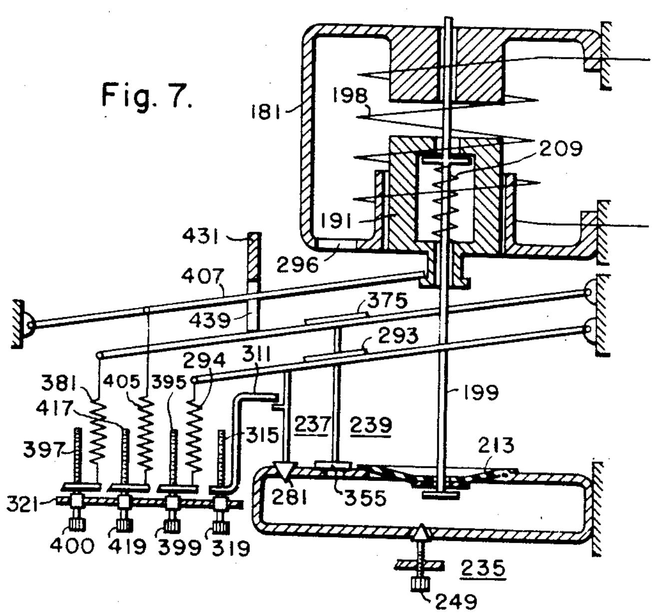

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Fig. 8.

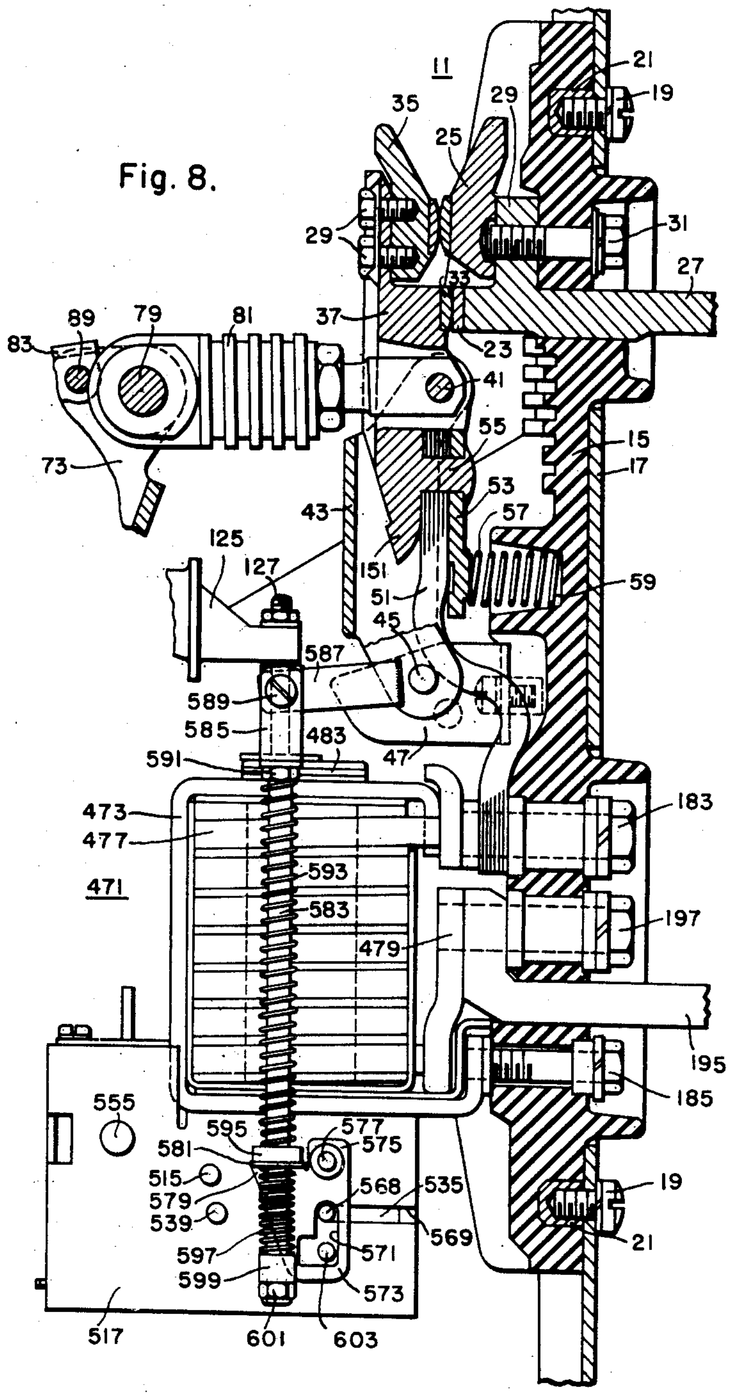

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Fig. 11.

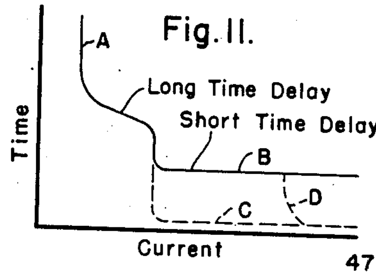


Fig. 9.

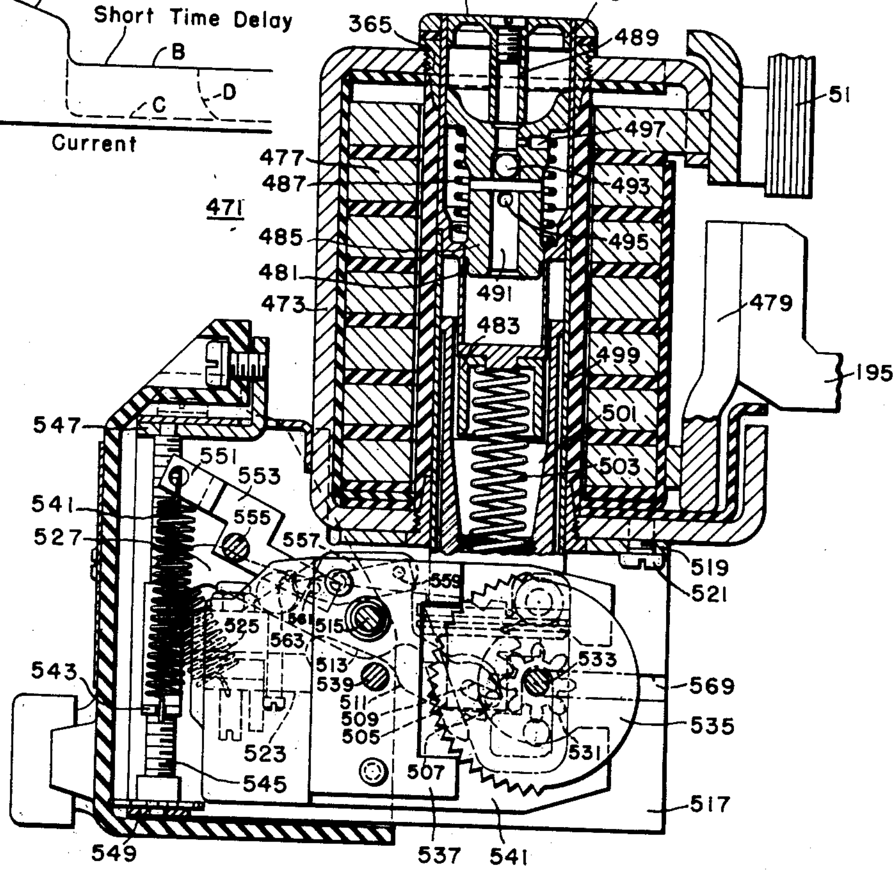
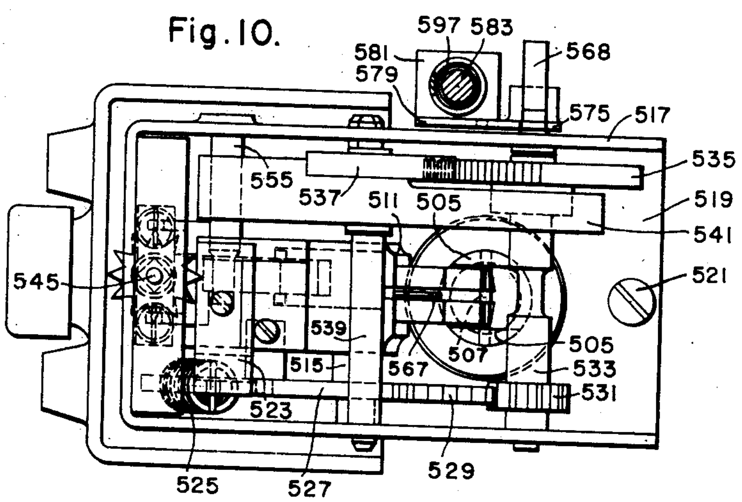


Fig. 10.



United States Patent Office

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CIRCUIT BREAKER

Merl E. Horn, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 5, 1954, Serial No. 427,777

19 Claims. (Cl. 200—108)

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

In certain circuit breaker applications, for instance, where a circuit breaker is to be applied in a selective tripping system as a source or as a bus tie or group feeder breaker, the breaker is equipped with an overcurrent trip device which trips the breaker with a time delay on all values of overload currents up to the interrupting capacity of the breakeer. 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 this circuit.

However, when 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 overcurrent up to the interrupting capacity of the breaker. Breakers thus equipped are deprived of the trip-free feature and are exposed to severe magnetic forces and 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, the sole answer is not to be found in a more powerful closing means. Stronger closing means results in higher closing speeds, shorter operating life, greater demand and regulation 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 breakers because more than 99 percent of the closing operations will occur when the breaker is unfaulted.

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

The invention provides for the addition of a novel feature to a circuit breaker which permits the breaker with conventional closing means to perform all of its necessary functions as a part of 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 breaker has been completely closed.

The following are some of the advantages of the use of the invention with a circuit breaker of given interrupting rating:

A substantial reduction in the cost of manufacture,

Reduction in closing current, control bus, copper etc.,

Reduction in cost on some breaker sizes which can be

brought into the range where the closing rectifier may be eliminated,

A substantial reduction in size and weight,

Additional safety to operating personnel if manual closing on a fault current is attempted.

The invention provides means for accomplishing the results set forth previously by mechanically connecting the movable switch arms of the pole unit to the series overcurrent trip device connected to the same pole in such a manner that the time-current characteristic of the overcurrent trip device is changed depending on the position of the breaker contacts. For example, assume the time-current characteristic AB as shown in Fig. 11 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 delay element.

An object of the invention is to provide a circuit breaker embodying a trip device having long and short-time delay elements with means for instantaneously tripping the breaker during a closing operation only when the breaker is closed with an overload current of approximately the value of the pickup setting of the short-time delay element on the line.

Another object of the invention is to provide a circuit breaker for use in a selective tripping system embodying a trip device having long and short-time delay elements for effecting long and short-time delays in the operation of the trip device with means for rendering the short-time delay element only ineffective and only when the breaker is closed with an overload current at or slightly above the value of the pickup setting of the short-time delay on the line.

Another object of the invention is to provide a circuit breaker embodying a trip device having long and short-time delay elements and instantaneous trip means with means for disabling the short-time delay element only when the breaker is being closed with an overload current on the line of a value approximately the value of the pickup setting of the short-time delay element.

Another 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.

Another object of the invention is to provide a circuit breaker for use in a selective tripping system embodying a trip device having long and short-time delay elements for effecting a long and a short-time delay in the operation of the trip device and instantaneous trip means with means for disconnecting the short-time delay element only when the breaker is being closed with an overload of a value in the vicinity of the short-time delay pickup setting on the line to permit the instantaneous trip means to trip the breaker.

Another 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 means except during a closing operation.

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

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

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

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

Fig. 8 is a vertical sectional view through one of the pole units showing the invention applied to another form of trip device;

Fig. 9 is a vertical sectional view through the trip device shown in Fig. 8;

Fig. 10 is a bottom view of the trip device shown in Fig. 9; and

Fig. 11 is a schematic diagram showing the time-current characteristics of trip device when the breaker is in the latched position.

The invention is illustrated as applied to a circuit breaker of the type fully disclosed in Patent No. 2,669,623, issued February 16, 1954, to John B. MacNeill, Fritz E. Florschutz, Ture Lindstrom and Bernard G. Tremblay and assigned to the assignee of this application.

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

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

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

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

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

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

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

The operating mechanism includes a lever **73** pivotally mounted on a pivot pin **75** supported in the side members **65** of the frame **63**. The lever **73** comprises a pair of spaced levers joined by a cross member **77** and between them a rod **79** which extends across all three poles of the breaker. The rod **79** is operatively connected by means of an insulating connecting member **81** to the pivot pin **41** in the free end of the switch member **43** on which the movable contact member **37** is mounted. It will be understood that there is provided a connecting member **81** for each pole of the breaker connecting the rod **79** to the movable contact structure for each pole unit so that upon operation of the rod **79** the movable contacts for all three poles move in unison.

An operating linkage comprising toggle links **83**, **85** and **87** is provided to hold the lever **73** and consequently the movable contacts in the closed position and to operate the movable contacts to open and closed positions. The toggle link **83** is pivotally connected to the lever **73** by a pivot pin **89**. Similarly the toggle link **85** is connected by means of a knee pivot pin **91** to the toggle link **83** and by a pivot pin **93** to the toggle link **87**. The toggle link **87** is pivotally mounted on a fixed pivot **97** supported in the frame **61** and has a cam member **95** thereon.

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

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

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

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

Rigidly secured to the front plate or cross member **67** of the frame **63** is a bearing **135** in which is rotatably mounted a handle shaft **137**. The outer end of the handle shaft **137** carries an operating handle (not shown) and a cam member **149** is secured to the inner end of the shaft **137**. A spring **145** coiled about the bearing **135** biases the shaft **137** and the operating handle in both directions to a central position. The cam member **149** which has the dual function of engaging the free end of the channel-shaped member **117** to manually trip the breaker open upon movement of the handle in one direction and of engaging the cam **95** on the closing toggle **85—87** to manually close the breaker upon movement of the handle in the opposite direction.

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

During the opening movement of the switch arm **43** the springs **57** maintain the arcing contacts in engagement until a tail **151** on the contact member **37** engages the cross member of the switch arm **43**.

The closing toggle **85—87** does not immediately collapse following the release of the latch **99** since it is held by the support **131**. However, during the collapsing movement of the tripping toggle the toggle link **85** rotates counterclockwise about the pivot pin **93**. During this rotation of the link **85**, an ear **153** formed thereon adjacent the pin **93** engages the support member **131** and disengages the shoulder thereon from the pin **93** whereupon the toggle **85—87** collapses downwardly under the bias of the spring **129**. The collapse of the toggle **85—87** is assisted by the weight of the moving armature of a closing solenoid, which will be discussed

later. Collapse of the closing toggle **85—87** causes resetting of the tripping toggle to thrust transmitting position and resetting of the main latch **99** to latching position. As soon as the latch **99** is reset the spring **121** reengages the latch roller **111** with the main latch **99** and also reengages the latch member **115** with the latch element **113** to hold the latch roller **111** in latching position. The mechanism is now in condition for a closing operation.

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

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

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

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

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

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

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

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

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

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

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

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

The short-time delay valve device 237 (Fig. 4) controls a passage for admitting air from the chamber 215 above the diaphragm 213 to the space below the diaphragm at a rate to provide tripping with a very short time delay in the order of alternating-current cycles. The valve device 237 comprises a tubular valve element 273 (Fig. 4) disposed in an opening 275 in the housing member 217 and having an enlarged head portion 277 seated in an opening 279 in the housing member 219 and rigidly held in place by a plug 347. The valve element 273 is provided with a valve seat and a valve 281 slidable in the tubular valve element 273 normally cooperates with the valve seat to close a communication with opposite sides of the diaphragm. The valve element 273 is provided with an axial passage 283 in which is disposed a tapered projection 285 of the valve 281 and which is normally closed by the valve 281. The head 277 of the valve element 273 is provided with horizontal passages 287 disposed at right angles to each other. A passage 289 in the housing member 217 communicates the chamber 215 above the diaphragm 213 to the opening 275 above the valve seat and a passage 291 in the housing member 219 communicates the chamber 215 below the diaphragm 213 with the passages 287.

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

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

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

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

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

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

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

The upper end of the valve **355** is provided with a groove **367** forming a semicircular head **369** (Figs. 3 and 5) adapted to cooperate with a bracket **371** secured by means of rivets **373** to an armature **375**. The bracket **371** is provided with a semicircular opening **377** for receiving the head **369** of the valve **355**.

The armature **375** is similar to the armature **293** and is provided with pivot projections **379** (Fig. 3) for pivotally supporting the armature **375** in the recess **297** in the upper face of the housing member **217**. The free end of the armature **375** is biased by means of a spring **381** to its unattracted position. The magnet yoke **181** is provided with an opening **382** (Fig. 5) which serves as an air gap for the magnetic circuit through the armature **375**.

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

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

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

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

The trip device normally operates with time delays in two ranges of overload currents which may be arbitrarily defined as, for example, a low range up to 500% or 600% of normal rated current, and a high range above 500% or 600% of normal rated current. The instantaneous valve operating armature 375 is adjusted to pick up at approximately the pickup point of the short-time delay armature 293 but is normally prevented from operating as will be hereinafter described.

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

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

When an overcurrent above 500% or 600% of normal rated current occurs, the electromagnet 177 is energized sufficiently to attract the short-time delay armature 293 (Figs. 4 and 7) upwardly against the adjustable stop 311 opening the short-time delay valve 281 an amount determined by the adjustment of the stop 311. This admits air to the space below the diaphragm 213 at a higher rate than the long-time delay valve alone and provides a relatively short-time delay in the order of cycles in the tripping operation.

As previously set forth, the 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 short-circuit current. For this reason, it is desirable to defeat the operation of the instantaneous valve operating armature 375 (Figs. 3 and 5) at all times except during the closing operation and until the breaker is fully closed.

The means for defeating the opening of the instantaneous valve device 239 comprises a lever 431 (Figs. 1, 2, 5 and 6) pivotally mounted by means of a pivot pin 433 on a bracket 435 fastened by screws 437 to the side of the upper housing 217 of the time delay device. As viewed in Figs. 2, 5 and 6, the lever 431 is provided with a downwardly extending portion 439 at its left end (Fig. 6) which extends down through an opening in the cross member 343 and engages the upturned end of the armature 375 which operates the instantaneous valve device 239.

At its right-hand end (Fig. 6), the lever 431 is provided with a yoke 441 which has a leg 443 formed at its right end (Fig. 1), the leg being pivoted on the pin 433. The yoke 441 is provided with a clearance opening at a point between its pivoted ends through which extends a vertically disposed rod 445 having a coupling 447 threadedly mounted on its upper end. The bifurcated end of the coupling 447 has a pin 449 therein for pivotally connecting it to an arm 451 rigidly secured to one leg of the channel-shaped switch arm 43. A lock nut 453 is provided to lock the rod 445 in place on the coupling 447. A coil spring 455 disposed above the yoke 441 surrounds the rod 445 and is compressed between the lock nut 453 and the yoke 441 of the lever 431 and a second coil spring 457 surrounds the rod 445 below the yoke 441 and is compressed between the yoke and a nut 459 threaded onto the lower end of the rod 445 and locked in place by a lock nut 461.

In the closed position of the breaker, the rod 445 is held in its upper position by the switch arm 43 and the arm 451. This compresses the spring 457 which biases the lever 431 in a counterclockwise direction (Fig. 6) biasing the portion 439 of the lever 431 downwardly against the free end of the instantaneous valve operating armature 375. When the breaker is in the closed position, the spring 457 biases the lever 431 with sufficient force to prevent operation of the armature 375 to open the instantaneous valve device 239 in response to excessive fault currents or short-circuit currents. Thus instantaneous tripping of the breaker when the breaker is standing in the closed position is defeated. However, should an excessive fault current or a short-circuit current occur, the short-time delay armature 293 (Figs. 3 and 4) will function to open the short-time delay valve device 237 and effect tripping of the breaker after a short time delay in the manner previously described with a time delay in the order of alternating-current cycles.

When the breaker is opened either manually or by operation of the trip device, the switch arm 43 is moved counterclockwise (Fig. 1) to open the breaker contacts and this movement of the switch arm and the arm 451 secured thereon lowers the rod 445. As the rod 445 moves downwardly, it acts through the spring 455 and the yoke 441 to move the lever 431 clockwise (Fig. 6) a distance sufficient to permit operation of the instantaneous valve armature 375 (Fig. 5) during the following closing operation.

If, at approximately the time the arcing contacts 25—35 touch during a closing operation, there is overload current of 500% to 600% or more of normal rated current or a short-circuit current on the line, the rod 445 will not have moved upwardly a sufficient distance to bring the portion 439 of the lever 431 into engagement with the instantaneous valve armature and will not have compressed the spring 457 sufficiently to prevent operation of the instantaneous valve armature. Consequently, the instantaneous valve armature will function to open the instantaneous valve device 239, thus bypassing the short-time delay and effect instantaneous tripping of the breaker.

If, when the arcing contacts touch during a closing operation, there is no overload current of sufficient magnitude on the line to attract the instantaneous armature 375, the breaker will go to the fully closed and latched position, moving the lever 431 counterclockwise (Fig. 6) into engagement with the instantaneous valve armature 375 and compressing the spring 457 sufficiently to prevent operation of the instantaneous valve armature, thus defeating instantaneous tripping while the breaker is in the closed position.

The device just described in no way interferes with the operation of the short-time delay armature 293 (Fig. 4) when the breaker is in the closed position, hence, the trip device will function in response to overload currents in the two ranges in the manner previously described, that is, with a long or short time delay depending on the magnitude of the overload current.

Figs. 8, 9 and 10 illustrate a different form of trip device in which the long-time delay is effected by a dashpot, the short-time delay by a mechanical escapement and in which the instantaneous trip means is effective both when the breaker is standing closed and during closing operations. In this device, the instantaneous trip is calibrated to pick up at some value above the short-time delay pickup. The arrangement is such, however, that the short-time delay and the instantaneous trip in the closed position of the breaker function normally but the restraining action of the short-time delay is disabled during closing operations to permit instantaneous tripping when the breaker is closed in against a fault in the short-time delay range.

The trip device shown in Figs. 8, 9 and 10 is of the type disclosed in Patent 2,611,013, issued September 16, 1952, to Ture Lindstrom, Jerome Sandin and Herbert L. Rawlins, and assigned to the assignee of this invention.

The trip device comprises an electromagnet indicated generally at **471** including a C-shaped magnet yoke **473**, a movable core structure **475**, and an energizing winding **477**. The magnet yoke **473** is secured to the insulated base **15** by the bolts **183** and **185**, the bolt **183** also securing the flexible conductors **51** and the upper turn of the winding **477** together. The lower turn of the winding **477** is secured to a lug **479** (Fig. 8) which, in turn, is secured to a terminal **195** by means of the bolt **197**.

The movable core structure **475** comprises a sealed casing **481** having an armature **483** secured to the bottom portion thereof. The upper end of the casing **481** is closed by means of a flanged disc **483** which is brazed or soldered to the inner surface of the casing. Disposed within the casing **481** is a magnetic core member **485** which is biased by means of a spring **487** against the inner end of a projection **489**. Extending axially through the core member **485** is a passage **491** in which is disposed a ball check valve **493**. Two other passages **495** and **497** extend through the wall of the core member **485** to permit fluid to bypass the check valve **493**. Secured to the casing **481** is a cylinder **499** of nonmagnetic material which extends downwardly therefrom and has a flanged collar (not shown) on the lower end thereof which normally rests on a stop member (not shown) which serves to support the cylinder **499** and the sealed casing **481** in a predetermined position with relation to the energizing coil **477** and the magnet yoke **473**. The flanged collar also supports a tubular armature **501** which is biased by means of a spring **503** downwardly away from the sealed casing **481** and against the collar on the lower end of the cylindrical member **499**.

Integral with the armature **501** and extending downwardly therefrom is a pair of spaced projections **505** (Figs. 9 and 10) which between them carry a pin **507** which engages a slot **509** in the end of one arm **511** of a lever **513** pivoted on a pin **515**. The pin **515** is supported in the side members of a U-shaped frame **517** (Figs. 8, 9 and 10) having a cross member **519** whereby it is secured to the lower leg of the C-shaped magnet yoke **473** by means of screws **521** (only one being shown).

The other arm **523** of the lever **513** is connected by means of a spring **525** to one end of a lever **527** also pivoted on the pin **515** and having a gear segment **529** on the other end which meshes with a pinion **531** mounted on a shaft **533** for rotation therewith. The shaft **533** is mounted in the side members of the frame **517** and has secured to the other end thereof an escapement ratchet wheel **535** having teeth on the periphery thereof which cooperate with an inertia member **537**. The inertia member **537** is mounted on a shaft **539** and has a mass **541** secured thereto by suitable means.

The lever **513** is biased against counterclockwise movement by means of a pair of springs **541** having their lower ends attached to the opposite ends of a bar **543** which threadedly engages an adjusting screw **545**. The adjusting screw **545** has its upper and lower ends respectively pivoted in cross members **547** and **549**. The upper ends of the springs **541** are attached to the spaced legs **551** of the bifurcated end of a lever **553** which is pivotally supported on a pin **555** mounted on and extending inwardly from one of the side members of the frame **517**. The other end of the lever **553** is pivotally connected to one end of a link **557** which has its other end pivotally connected to the lever **513** by means of a pin **559**. The link **557** is pivotally connected to the lever **553** by means of a pin **561** and together they form a toggle which is biased by the springs **541** to an underset position as shown in Fig. 9, the normal position of the toggle **553—557** and, hence, of the lever **513** being determined by the engagement of the end of the link **557** with a pin **563** in the lever **553**.

The trip device functions within two ranges of overload currents below a predetermined value to trip the breaker with relatively long time delay in the lower range of overload currents, with relatively short time delay in the intermediate range of overload currents and instantaneously in response to overload currents above the predetermined value, or on short circuit currents. These ranges of overload currents may be arbitrarily defined as up to 300% of normal rated current for the low range, 300% to 1000% of rated current for the intermediate range and 1000% or more of rated current for the instantaneous tripping range. The limits of the intermediate range of overload currents are merely by way of example and these limits may be varied considerably to suit particular requirements.

When a persistent overload current occurs in the low range of overload currents, the magnetic circuit is energized, but due to the high density flux across the air gap between the upper end of the core member **485** and the lower end of a bushing **565** threaded into the upper leg of the magnet yoke, the core member **485** will be held in substantially the position shown in Fig. 9 while the armatures **483** and **501** move upwardly. In the low range of current values, the upward pull on the armature **501** is insufficient to compress the spring **503**, consequently the armatures **483** and **501** cause a slow upward movement of the sealed casing **481** forcing fluid to flow from below the core member **485** through the orifice **497** to the chamber above the core member. As soon as the sealed casing starts its upward movement, the pressure of fluid below the core member closes the ball check valve **495** forcing the fluid through the restricted passage **497**, thus providing a relatively long time delay in the operation of the trip device on overload currents within the low range of values. During long time delay tripping operations, the previously described mechanical escapement device is operated, but since the operation is slow, the escapement device imposes little resistance to the tripping operation.

Before the sealed casing can start its upward tripping movement, it is necessary that the forces in the magnetic circuit be great enough to overcome the tension of the calibrating springs **541**. When the forces are sufficient to overcome the springs **541**, the movable core structure, acting through the pin **507** and arm **511**, rotates the lever **513** counterclockwise about its pivot **515**. This action causes collapse of the toggle **553—557** and reduces the effective force of the springs **541** resisting operation of the lever **513**.

After the circuit is opened by opening of the breaker contacts and the winding **477** is deenergized, the movable core structure is returned to its normal position by gravity aided by the springs **541**. The spring **487** at the same time causes opening of the check valve **493** permitting a free flow of fluid to the space below the core member **485** and restores the core member upward to its normal position.

The operation of the trip device in response to overload currents in the intermediate range, that is, between 300% and 1000% of normal rated current, is somewhat different. When the winding 477 is energized by an overload current in the intermediate range, the armature 501 is attracted with sufficient force to overcome the spring 503. This would result in substantially instantaneous tripping if the armature 501 were not otherwise restrained. It is desirable that the time delay provided on intermediate overloads be much shorter than on overloads in the low range of values, but greater than the instantaneous tripping. To this end, the armature 501 is restrained by the mechanical escapement device. When the armature 501 starts to move upward, it acts through the pin 507 to rotate the lever 511 in a counterclockwise direction. The lever 511 through the spring 525 rotates the segmented lever 513 in the same direction and this lever rotates the pinion 531 and the ratchet wheel 535 in a clockwise direction under the control of the inertia members 537—541 which retards the upward movement of the armature 501.

The energization of the trip device in response to overload currents in the intermediate range is not sufficient to displace the core member 485 relative to the magnet yoke. This would provide a relatively long time delay in response to overload currents in the intermediate range. For this reason, other means is provided to actuate the sealed casing in tripping direction. This means comprises the lever 513 and a roller 567 (Fig. 10) mounted on a pin in the bifurcated end of the arm 511 of the lever 513. When the lever 513 is moved counterclockwise by upward movement of the armature 501, the roller 567 engages the lower end of the cylinder 499 and moves the sealed casing 481 upwardly therewith. The rate of upward movement of the casing is about one half that of the armature 501 and gradually closes the air gap between the upper end of the armature 501 and the lower end of the core member 485. This insures that the device will not function to trip the breaker until the ratchet wheel 535 escapes the inertia member 537 which, as can be seen in Fig. 9, has teeth about a portion only of its periphery.

The movable core structure and the escapement time delay device are restored to their normal positions following a short time delay tripping operation by the weight of the movable core structure and the springs 541.

When an overload current of, for instance, 1000% or more of normal rated current, or a short circuit current occurs, the entire movable core structure acts as the armature of a solenoid and functions to instantaneouly trip the breaker. Under this circuit condition, the movable core structure operates the lever 513 but stretches the spring 525 without operating the escapement device. The movable core structure is restored to its normal position following an instantaneous tripping operation by the springs 525 and 541 assisted by the weight of the core structure.

As previously set forth, it is desirable to disable the short time delay device during a closing operation when the breaker closes in against an overload current in the intermediate range or a short circuit current in order to permit the instantaneous trip means to trip the breaker. This is effected by disengaging the ratchet wheel 535 from the inertia device 537 during the closing operation and until the breaker is fully closed and latched.

As viewed in Fig. 8, one end 568 of the shaft 533 on which the ratchet wheel 535 is mounted extends out through the adjacent side of the frame 517 and is mounted in a horizontal slot 569 (shown in dot and dash lines in Fig. 9). The end of the shaft 533 also extends through an angular slot 571 in one arm 573 of a bell crank lever 575 pivoted on a pin 577 in the frame 517. The other arm 579 of the bell crank lever has an ear 581 thereon surrounding a vertically extending rod 583 having a clevis 585 secured to its upper end. The free end of an arm 587 welded or otherwise suitably secured to one leg of the switch arm 43 is pivotally connected by a pivot 589 to the clevis 585.

The rod 583 threadedly engages the clevis 585 and is locked in place by a lock nut 591. A spring 593 is compressed between the lock nut 591 and a spring seat 595 resting on the ear 581 of the bell crank lever 575. A second spring 579 is compressed between the under side of the ear 581 and a spring seat 599 resting on a nut 601 threaded onto the lower end of the rod 583. A stop stud 603 mounted in the frame 517 is provided to limit the disengaging movement of the bell crank lever 575.

When the breaker is in the closed position, the rod 583 is held in its raised position as shown in Fig. 8. In this position, the spring 597 biases the bell crank lever 575 in a clockwise direction thereby holding the end 568 of the shaft against the inner end of the slot 569. In this position of the shaft 533, the ratchet wheel 535 is held in engagement with the inertia member 537, thereby rendering the short time delay device effective should the breaker trip out in response to an overload current in the intermediate range while the breaker is in the closed position.

When the breaker is opened either manually or by operation of the trip device, the switch arm 43 is moved counterclockwise (Fig. 8) to open the breaker contacts and this movement of the switch arm and the arm 587 lowers the rod 583. As the rod moves downwardly, it acts through the spring 593 to move the bell crank lever 575 in a counterclockwise direction (Fig. 8) moving the end 568 of the shaft 533 toward the right (Figs. 8 and 9), the movement of the bell crank lever 575 and, consequently, the movement of the shaft end 568 being limited by engagement of the wall of the enlarged portion of the slot 571 with the stop stud 603. Further downward movement of the rod 583 compresses the spring 593. This movement of the end 568 of the shaft 533 is sufficient to disengage the ratchet wheel 535 from the inertia member 537 and permit instantaneous operation of the core structure during the subsequent closing operation.

If, at approximately the time the arcing contacts touch during a closing operation, there is an overload current in either the intermediate or short circuit ranges on the line, the rod 583 (Fig. 8) will not have moved upwardly a distance sufficient to compress the spring 597 sufficiently to actuate the bell crank lever 575 and re-engage the ratchet wheel 535 with the inertia member 537. Consequently, the core structure will function without the restraint of the short time delay device to instantaneously trip the breaker.

If, when the arcing contacts touch during a closing operation, there is no overload current on the line in the intermediate range of overload values or above, the breaker will go to its fully closed and latched position, actuating the bell crank lever 575 and re-engaging the ratchet wheel 535 with the inertia member 537 so that, in the closed position, the breaker will trip out with a short time delay in response to overload currents in the intermediate range.

The device just described in no way interferes with the function of the long-time delay element in response to overload currents of lower value in addition to the short-time delay and instantaneous tripping when the breaker is in the closed position.

Referring to Fig. 11 of the drawing which schematically illustrates, by the lines A—B, the time-current characteristic of the trip device shown in Figs. 1 to 7, inclusive, when the breaker is in the closed latched position. For all positions of the breaker other than the latched position, the time-current characteristic is illustrated by the lines A—C which permits instantaneous tripping during a closing operation on all current values above the pickup setting of the short-time delay valve operating armature (Figs. 3 and 4).

Lines A—B—D illustrates the time-current characteristic of the trip device shown in Figs. 8, 9 and 10 when the breaker is in the closed and latched position. The time-current characteristic for all positions of the breaker other than the closed and latched position is again shown by the lines A—C permitting the breaker to trip instantaneously during a closing operation on all current values above the pickup setting of the short-time delay mechanism (Fig. 9).

It will thus be seen that the short-time delay element only of each of the modifications of the invention is defeated and the instantaneous trip element takes precedence on all current values above the pickup setting of the short-time delay element during but only during a closing operation of the breaker. The long-time delay element of each modification is free to function in all positions of the breaker.

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 the spirit of the invention.

I claim as my invention:

1. In a circuit breaker comprising relatively movable contacts and operating means for closing said contacts, a trip device comprising a single trip member movable to effect automatic opening of said contacts, an electromagnet for moving said trip member, time delay means operable to effect a time delay in the tripping movement of said single trip member, time delay control means comprising a first control means operable in response to overload currents below a predetermined value to effect a relatively long time delay in the tripping movement of said single trip member, a second control means operable in response to overload currents above said predetermined value to effect a relatively short time delay in the tripping movement of said trip member, and a third control means operable in response to overload currents above said predetermined value to effect instantaneous tripping movement of said single trip member, and a device operated by said operating means permitting said third time delay control means to take precedence over said second time delay control means during closing operations to effect instantaneous tripping movement of said single trip member.

2. In a circuit breaker comprising relatively movable contacts and operating means for closing said contacts, latch means operable to effect automatic opening of said contacts, a trip device comprising a single trip member movable to operate said latch means, an electromagnet operable in response to overload currents to move said single trip member to effect unlatching operation of said latch means, time delay means operable to effect a time delay in the tripping movement of said single trip member, time delay control means comprising a first control means operable to effect a relatively long time delay in the tripping movement of said single trip member in response to overload currents below a predetermined value, a second control means operable to effect a relatively short time delay in the tripping movement of said single trip member in response to overload currents above said predetermined value, and a third control means operable to effect instantaneous tripping movement of said single trip member in response to overload currents above said predetermined value, and a device operated by said operating means to permit said third time delay control means to take precedence over said second time delay control means during closing operations to effect instantaneous tripping of said single trip member.

3. In a circuit breaker comprising relatively movable contacts and operating means for closing said contacts, a trip device comprising a single trip member movable to effect automatic opening of said contacts, an electromagnet operable to move said trip member, time delay means operable to effect a time delay in the tripping movement of said trip members, time delay control means comprising a first control means operable in response to overload currents below a predetermined value to effect a relatively long time delay in the tripping movement of said single trip member, a second control means operable in response to overload currents above said predetermined value to effect a relatively short time delay in the tripping movement of said single trip member, and a third control element operable in response to overload currents above said predetermined value to effect instantaneous tripping movement of said single trip member, and a mechanism operated by said operating means to render said second time delay control means ineffective only during closing operations to permit said third time delay control means to effect instantaneous tripping movement of said single trip member.

4. In a circuit breaker comprising relatively movable contacts, a switch arm movable to open and close said contacts, operating means for said switch arm, pivoted latch means operable to effect automatic opening movement of said switch arm, a trip device comprising a single trip member movable to operate said pivoted latch means, an electromagnet operable to move said trip member, time delay means effecting a time delay in the tripping movement of said single trip member, control means for said time delay means comprising a first control means for said time delay means operable to effect a relatively long time delay in the tripping movement of said single trip member in response to overload currents below a predetermined value, a second control means for said time delay means operable to effect a relatively short time delay in the tripping movement of said single trip member in response to overload currents above said predetermined value, and a third control means operable to effect instantaneous tripping movement of said single trip member in response to overload currents above said predetermined value, and a mechanism responsive to the position of said switch arm to cause said third time delay control means to take precedence over said second time delay control means at least during closing movement of said switch arm.

5. In a circuit breaker comprising relatively movable contacts and operating means for closing said contacts, a trip device comprising a single trip member movable to effect automatic opening of said contacts, an electro-magnet including an armature for moving said trip member, time delay means operable to effect a time delay in the tripping movement of said single trip member, control means for said time delay means comprising a first control means operable in response to overload currents below a predetermined value to effect a relatively long time delay in the tripping movement of said single trip member, a second control means operable in response to overload currents above said predetermined value to effect a relatively short time delay in the tripping movement of said single trip member, and a third control means operable in response to overload currents above said predetermined value to effect instantaneous tripping movement of said single trip member, a member normally preventing operation of said third time delay control means, and a device responsive to the position of said operating means to cause said member to permit operation of said third time delay control means on closing operations to effect instantaneous tripping movement of said trip member.

6. In a circuit breaker comprising relatively movable contacts and operating means therefor, an electromagnetic trip device operable to effect automatic opening of the breaker comprising a trip member, an energizing winding, an armature operable upon energization of said winding to actuate said trip member, a time delay element for retarding tripping movement of said trip member having a chamber, control means for said time delay element

comprising a first valve device for admitting fluid to said chamber at a rate to effect a time delay in the tripping operation of said trip member, and a second valve device operable to admit fluid to said chamber at a rate to permit substantially instantaneous operation of said trip member, and means responsive to the position of said operating means for preventing operation of said second valve device in the closed position of said breaker.

7. In a circuit breaker comprising relatively movable contacts, a switch arm movable to open and close said contacts, operating means for said switch arm, a trip device comprising a trip member movable to effect automatic opening of said switch arm, an electromagnet for moving said trip member, time delay means comprising a fluid dashpot for retarding tripping movement of said trip member, time delay control means comprising a first valve for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the tripping movement of said trip member, a second valve for admitting fluid to said dashpot at a rate to permit instantaneous tripping movement of said trip member, and a device responsive to the position of said switch arm for permitting opening of said second valve only when said switch arm is in a position other than the closed position.

8. In a circuit breaker comprising relatively movable contacts and operating means therefor, an electromagnetic trip device for effecting automatic opening of said contacts comprising a trip member, an energizing winding, an armature operable upon energization of said winding to actuate said trip member, a time delay element for retarding tripping movement of said trip member having a chamber, time delay control means comprising a first valve device for admitting fluid to said chamber at a predetermined rate for retarding tripping movement of said trip member with a predetermined time delay, a second valve device automatically operated in response to predetermined circuit conditions to increase the rate of admission of fluid to said chamber to thereby decrease the amount of time delay, and a third valve device operated in response to said predetermined circuit conditions for admitting fluid to said chamber at a rate to permit instantaneous tripping movement of said trip member, and a device responsive to the position of said breaker for preventing operation of said third valve device in the closed position of said breaker.

9. In a circuit breaker comprising relatively movable contacts and operating means therefor, a switch arm movable to open and closed positions for opening and closing said contacts, an electromagnetic trip device for effecting automatic opening of said contacts comprising a trip member, an energizing winding, an armature operable upon energization of said winding to actuate said trip member, a time delay element for retarding tripping movement of said trip member having a chamber, time delay control means comprising a first valve device for admitting fluid to said chamber at a predetermined rate for retarding tripping movement of said trip member with a predetermined time delay, a second valve device automatically operated in response to predetermined circuit conditions to increase the rate of admission of fluid to said chamber to thereby decrease the amount of time delay, and a third valve device operated in response to said predetermined circuit conditions for admitting fluid to said chamber at a rate to permit instantaneous tripping movement of said trip member, and a device responsive to the position of said switch arm for preventing operation of said third valve device in the closed position of said switch arm.

10. In a circuit breaker comprising relatively movable contacts and operating means therefor, an electromagnetic trip device operable to effect automatic opening of said contacts comprising a trip member, an energizing winding, an armature operable upon energization of said winding to operate said trip member, a time delay element for retarding tripping operation of said trip member having a chamber, time delay control means comprising a first valve for admitting fluid to said chamber at a predetermined rate to effect a relatively long time delay in the tripping operation of said trip member, a second valve for admitting fluid to said chamber at a greater rate than said first valve to effect a relatively short time delay in the tripping operation of said trip member, and a third valve for admitting fluid to said chamber at a rate to permit instantaneous tripping operations of said trip member, and a device responsive to the position of said breaker for permitting operation of said third valve only when the breaker is in a position other than the closed position.

11. In a circuit breaker comprising relatively movable contacts and operating means therefor, the combination of a trip member operable to effect automatic opening of said contacts, electromagnetic trip means for operating said trip member, time delay means comprising a fluid dashpot for at times retarding tripping operations of said trip member, means controlling said time delay means comprising a first valve means for admitting fluid to said dashpot at a predetermined rate for effecting a time delay in the operation of said trip member, a first valve operating armature operable when said electromagnet is energized in response to overload currents above a predetermined value for opening said first valve means, a second valve means for admitting fluid to said dashpot at a rate to permit instantaneous operation of said trip member, and a second valve operating armature operable when said electromagnet is energized in response to overload currents above said predetermined value for opening said second valve means, and means restraining said second valve operating armature against operation to prevent opening of second valve means only while said breaker is in the closed position.

12. In a circuit breaker comprising relatively movable contacts, a switch arm movable to open and closed positions for opening and closing said contacts, a trip member operable to effect automatic opening movement of said switch arm, an electromagnetic trip device for operating said trip member, time delay means comprising a fluid dashpot for retarding tripping operation of said trip member, time delay control means comprising a first valve for admitting fluid to said dashpot at a predetermined rate for effecting a relatively long time delay in the tripping operation of said trip member, a second valve for admitting fluid to said dashpot at a greater rate than said first valve for effecting a relatively short time delay in the tripping operation of said trip member, a first valve operating armature operable when said trip device is energized in response to overload currents above a predetermined value for actuating said second valve, a third valve for admitting fluid to said dashpot at a rate to permit instantaneous tripping operation of said trip member, and a second valve operating armature operable when said trip device is energized in response to overload above said predetermined value for actuating said third valve, a preventer for preventing operation of said second valve operating armature, and a mechanism responsive to the position of said switch arm for controlling said preventer to permit operation of said second valve operating armature to open said third valve and permit instantaneous tripping operation of said trip member only when said switch arm is in a position other than the closed position.

13. In a circuit breaker comprising relatively movable contacts and operating means therefor, a trip device comprising a single trip member movable to effect automatic opening of said contacts, an electromagnet for moving said trip member, time delay means effecting a time delay in the tripping movement of said single trip member, time delay control means comprising a first control means operable in response to overload currents below a predetermined value to effect a relatively long time delay in the tripping movement of said single trip

member, a second control means operable in response to overload currents above said predetermined value to effect a relatively short time delay in the tripping movement of said single trip member, and a third control means operable in response to overload currents above said predetermined value to effect instantaneous tripping movement of said single trip member, and mechanism positioned in response to the position of the breaker to render said second time delay control means ineffective when the breaker is in a position other than the closed position.

14. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, an electromagnet for moving said member, time delay means comprising a mechanical escapement connected to effect a time delay in the tripping movement of said movable member in response to overload currents of predetermined value, means permitting instantaneous tripping movement of said movable member, and a mechanism for disconnecting said mechanical escapement to permit instantaneous tripping movement of said movable member when said breaker is in a position other than the closed position.

15. In a circuit breaker comprising relatively movable contacts, a switch arm movable to open and closed positions for opening and closing said contacts, a member movable to effect automatic opening of said contacts, electromagnetic means for moving said movable member, means permitting instantaneous tripping movement of said movable member in response to overload currents of a predetermined value, time delay means comprising a mechanical escapement device connected to effect a time delay in the tripping movement of said movable members in response to overload currents of said predetermined value, and a mechanical device responsive to the position of said switch arm for disconnecting said mechanical escapement device when the switch arm is in a position other than the closed position.

16. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, electromagnetic means for moving said movable member in response to overload currents, time delay means for retarding tripping movement of said movable member with a relatively long time delay in response to overload currents below a predetermined value, means permitting instantaneous tripping movement of said movable member in response to overload currents above said predetermined value, means comprising a mechanical escapement device connected to effect a short time delay in the tripping movement of said movable member in response to overload currents above said predetermined value, and a mechanism operable to disconnect said mechanical escapement when the breaker is opened and until the breaker is closed.

17. In a circuit breaker comprising relatively movable contacts and operating means therefor, a member movable to effect automatic opening of said contacts, an electromagnet for moving said movable member in response to overload currents, a first time delay device for effecting a relatively long time delay in the movement of said movable member in response to overload currents below a predetermined value, means for effecting instantaneous movement of said movable members in response to overload currents above said predetermined value, a second time delay device for effecting a relatively short time delay in the movement of said movable member in response to overload currents of certain value above said predetermined value, and a mechanism operable to permit said instantaneous means to take precedence over said second time delay device in response to overload currents of said certain value above said predetermined value during closing operations of said breaker.

18. In a circuit breaker comprising relatively movable contacts, a switch member movable to open and closed positions to open and close said contacts, a strip member movable to effect automatic opening movement of said switch member, an electromagnet for moving said trip member in response to overload currents, a first time delay device for effecting a relatively long time delay in the movement of said trip member in response to overload currents below a predetermined value, means for effecting instantaneous movement of said trip member in response to overload currents above said predetermined value, a second time delay device connected to effect a relatively short time delay in the movement of said trip member in response to overload currents of certain value above said predetermined value, and a mechanism operated by said switch member to disconnect said second time delay device to thereby permit instantaneous movement of said trip member in response to overload currents of said certain value above said predetermined value during closing movement of said switch member.

19. In a circuit breaker comprising relatively movable contact means and operating means therefor, latch means releasably restraining said contacts in closed position, electromagnet means responsive to overload currents, a member movable by said electromagnet to operate said latch means to effect opening of said contact means, time delay means effecting a time delay in the movement of said member, a device operable when said electromagnet is energized in response to overload currents of predetermined value to permit said electromagnet to instantaneously move said member, and a mechanism responsive to the position of said contacts to permit operation of said device in response to overload currents below said predetermined value when said contacts are in the open position.

References Cited in the file of this patent

UNITED STATES PATENTS

2,611,013	Lindstrom et al.	Sept. 16, 1952
2,622,167	Rawlins et al.	Dec. 16, 1952
2,632,823	Oppel	Mar. 24, 1953
2,669,623	MacNeill et al.	Feb. 16, 1954
2,709,731	MacNeill	May 31, 1955

FOREIGN PATENTS

2,047 of 1900	Great Britain	Feb. 1, 1900