May 31, 1949. J. A. FAVRE 2,471,815

ELECTRIC SWITCH

Original Filed Sept. 25, 1944 2 Sheets-Sheet 1

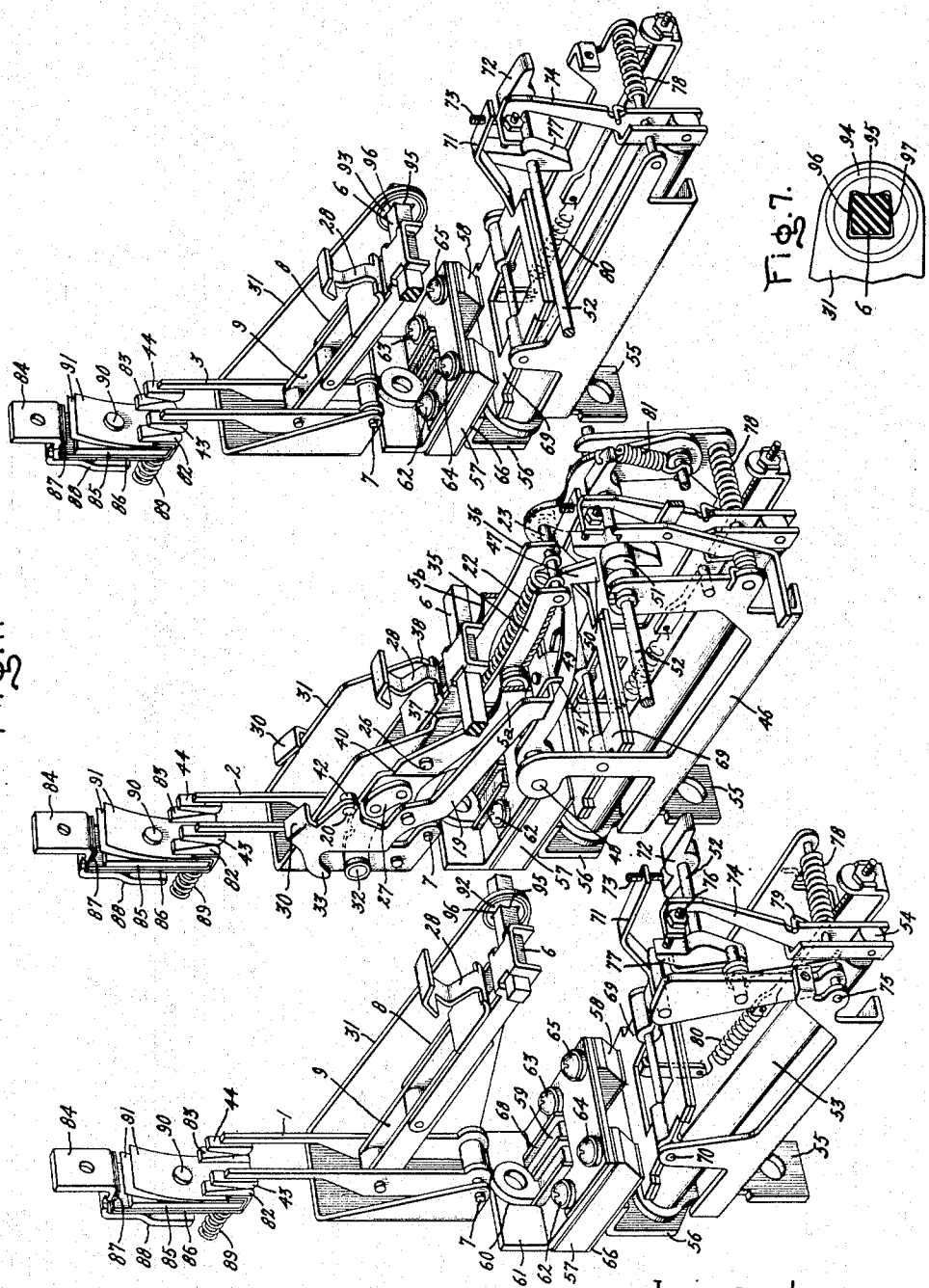


Fig. 1.

Fig. 7.

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Fig. 2.

TRIPPED OPEN
HANDLE IN CLOSED POSITION

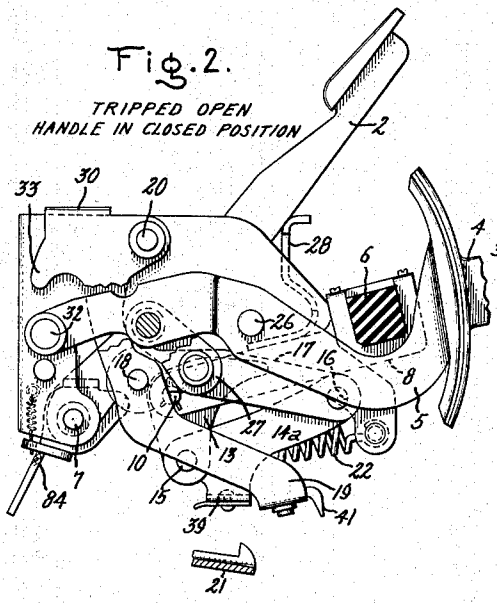


Fig. 3.

TRIPPED OPEN
HANDLE IN INDICATING POSITION

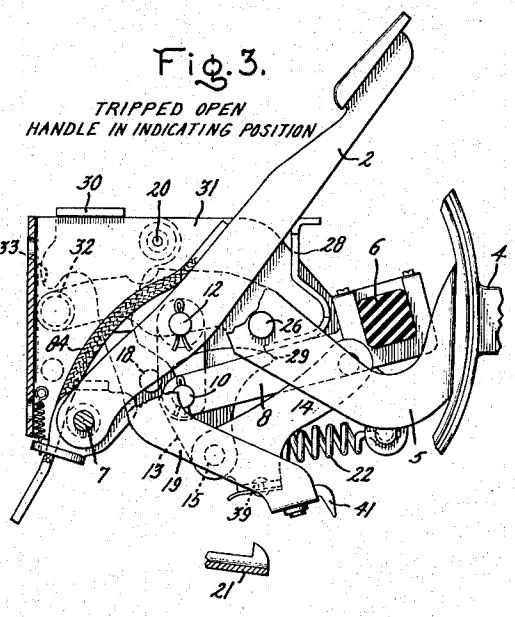


Fig. 4.

OPEN
RESET POSITION

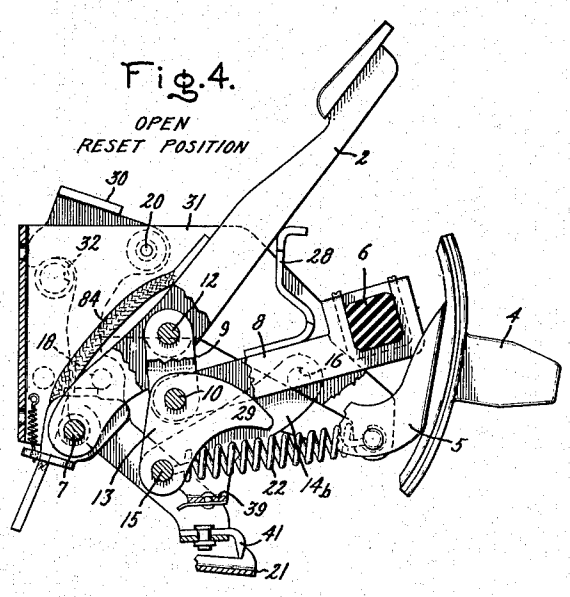


Fig. 5.

CLOSED POSITION

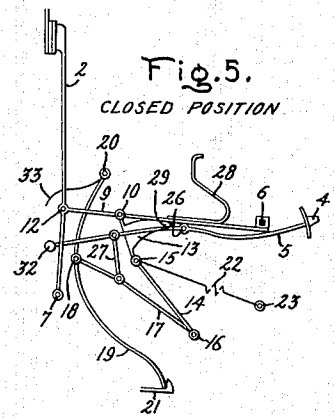
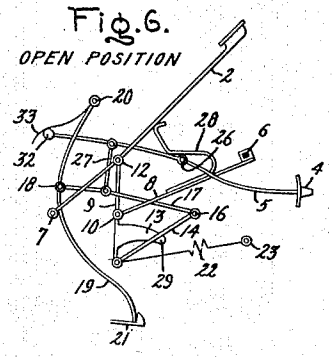


Fig. 6.

OPEN POSITION



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UNITED STATES PATENT OFFICE

2,471,815

ELECTRIC SWITCH

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Original application September 25, 1944, Serial No. 555,630. Divided and this application January 3, 1946, Serial No. 638,779

5 Claims. (Cl. 200—153)

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My invention relates to improvements in electric switches and more particularly to improvements in automatic circuit breakers which are opened in response to abnormal circuit conditions, and an object of my invention is to reduce the time of the opening operation.

This application is a division of my application Serial No. 555,630, filed September 25, 1944, and assigned to the same assignee as this invention.

My invention will be better understood from the following description when considered in connection with the accompanying two sheets of drawings, and its scope will be pointed out in the appended claims.

In the accompanying two sheets of drawings, Fig. 1 is a partially exploded view in perspective of a polyphase circuit breaker embodying my invention; Figs. 2 through 6 are fragmentary views showing the circuit breaker operating mechanism in different positions, Figs. 5 and 6 being diagrammatic; and Fig. 7 is a detail illustrating an embodiment of my invention.

For the purpose of illustrating my invention, I have shown an embodiment thereof as applied to an automatic trip-free circuit breaker for three-phase circuits. As shown in Fig. 1, the circuit breaker comprises three pivoted switch arms 1, 2 and 3, arranged to be connected in the separate legs of a three-phase circuit, and an operating mechanism by means of which the contact arms are moved between their open and closed circuit positions by a handle 4 (Fig. 4) mounted on a pivoted arm 5. This operating mechanism is associated with the middle contact arm 2, the two outer contact arms being operated through a common rotatably mounted cross bar 6.

The operating mechanism may be more clearly understood by first referring to the diagrammatic Figures 5 and 6, showing the contact arm 2 respectively in its closed and open circuit positions. The contact arm 2 is mounted on a stationary pivot 7 and is operated by means of a multiple link toggle consisting of links 8 and 9 having a floating pivot 10. The link 8 is relatively long and has its outer end mounted on the bar 6 which is in effect a stationary pivot, while the relatively short link 9 has its outer end pivotally connected at 12 to the contact arm 2. Thus, by moving the toggle between its made position (shown in Fig. 5) and its collapsed or broken position (shown in Fig. 6), the contact arm is moved between its two positions.

A second multiple link toggle is provided for operating the first toggle 8, 9. This toggle consists of links 13 and 14 having a floating pivot

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15. The relatively short link 13 has its outer end connected to the pivot 10 while the relatively long link 14 has its outer end pivotally connected at 16 to an operating arm 17 whose other or left hand end is pivotally mounted at 18 on a pivoted trip member 19, the pivot 18 being intermediate the length of the trip member 19. The upper end of the trip member 19 is mounted on a stationary pivot 20 while its lower end is normally held by a current responsive latch projection 21.

By means of a helical tension spring 22 having its left hand end connected to the pivot 15 and its upper end connected to a stationary support 23, the various linkages are caused to assume the positions shown in Figs. 5 and 6 and are caused to move between these positions when the handle 4 is moved between the positions shown in Figs. 5 and 6. The handle 4 is mounted on the right hand end of the operating lever or arm 5 which is mounted on a stationary pivot 26 and connected by a link 27 to the operating arm 17, the ends of the link 27 being pivotally connected to the lever 5 and the arm 17.

In the operation of the mechanism, it will be observed that with the switch closed, as shown in Fig. 5, the spring 22 which pulls the pivot 15 toward the point of support 23 applies a force tending to straighten the toggle 13, 14 whereby an upward force is applied to the floating pivot 10 of the first toggle 8, 9 thereby to secure this toggle in its straightened position with the switch closed. This final position of the toggle 8, 9 is preferably not quite a fully made or straightened position whereby the rapid movement of the contact arm to its open circuit position on overload is facilitated. This underset position of the toggle 8, 9 is defined by the left hand end of the stop 28, as seen in Fig. 5, secured to the link 8 with which engages a projection 29 on the link 13. With the two outside contact arms 1 and 3 (Fig. 1) the links 9 are extended and engage the stops 28. The substantially made position of the toggle 13, 14 is a further assurance against breaking of the toggle 8, 9 in response to a severe shock. In this position it will be noted that the handle 4 and the operating lever 5 are in their extreme upper or counterclockwise positions whereby the operating arm 17 is moved to an extreme clockwise position about the pivot 18 and is held in that position through the link 27 by the lever 5, whereby the pivot 16 is fixed in the position shown.

In order to move the switch from the closed position of Fig. 5 to the open position of Fig. 6, the operating handle 4 is moved through a rela-

tively small angle in a clockwise direction about the pivot 26 whereby the operating arm 17 is moved about its pivot 18 in a counterclockwise direction to bring its end to the upper side of the direction of the force applied by the spring 22. When the end of the arm 17 moves to the upper side of the spring 22, the direction of the force applied by the spring to the link 14 is reversed, the spring then tending to move the link 14 in a counterclockwise direction about the pivot 16 on the end of the arm 17. This counterclockwise movement of the link 14 immediately breaks or collapses the toggle 13, 14, which in turn breaks the toggle 8, 9 whereby the contact arm 2 is moved clockwise by the spring and finally comes to rest against the end of the stop arm 28 secured to the arm 8. It will be understood that this movement of the operating linkages and the switch arm takes place very quickly with a snap action. It begins as soon as the pivot 16 of the floating link 14 moves to the upper side of the direction of force of the spring 22.

The positions of the parts when the switch is opened in response to an overload or overcurrent will be understood from Figs. 2 and 3. It will be observed that the spring 22, when the switch is in its closed circuit position of Fig. 5, applies a force to the operating lever 17, which force is transmitted to the trip arm 19, tending to move the lower end of the trip arm toward the right hand. When the latch 21 is moved in response to overload or short circuit to release the trip arm, this lower end moves counterclockwise about the pivot 20 in response to the force applied by the spring. At the time the projection 29 on the link 13 is in engagement with the link 8 and as a result the two links 8 and 13 swing together about the pivotal axis of the bar 6 whereby the switch arm is moved to its open circuit position, the other parts including the arm 17 and the link 27 moving to the positions shown in Fig. 3.

For purposes of illustration, Fig. 2 shows the manual operating lever 5 as held in its fully closed circuit position during overcurrent opening, although the handle will move from that position to the position of Fig. 3 if it is not held. In this position the handle lever 5 holds the arm 17 in such position that the projection 29 has disengaged the left hand end of the stop 28 (Fig. 2). In the movement from Fig. 2 to Fig. 3, when the handle is released, the link 13 turns through a slight additional angle counterclockwise about its pivot 10 until the projection 29 (Fig. 3) on the link 13 comes to rest against the lower end of the stop 28. In this final movement, the arm 17 is moved through a small angle counterclockwise about its pivot 18 (Fig. 2) and through the link 27 moves the lever 5 through a small angle in a clockwise direction to an intermediate position (shown in Fig. 3) between the closed and open positions. This intermediate position gives an indication to the operator, upon inspection of the position of the handle 4, that the circuit breaker has opened in response to an overload or short circuit. The trip arm 19 is brought to rest by the engagement of a laterally extending projection 30 on its upper end with an edge of the supporting frame 31 for the mechanism.

The mechanism is reset from Fig. 3 by moving the handle 4 downward from the position shown in Fig. 3 to the fully open position shown in Fig. 4. During this movement a roller or projection 32 on the left-hand end of the lever 5 engages a projection 33 on the trip arm 19 whereby the trip arm is moved clockwise about its pivot 20 back to the position shown in Fig. 4 where it is secured

by the latch 21. It is assumed that the current responsive means has cooled sufficiently to return the latch 21 to a holding position. The parts are then in the normal open circuit position shown in Figs. 4 and 6. The circuit breaker may thereafter be closed by moving the handle upward to the closed circuit position.

The arrangement of the operating linkages and other parts is shown in further detail in Fig. 1. The operating mechanism, as previously stated, is associated with the middle contact arm 2. The supporting frame 31 is a substantially U-shaped member having its base secured to an insulating support, not shown, for the circuit breaker and with two parallel arms extending outward from the support and terminating in two parallel projections 35 and 36 (Fig. 1). These projections are offset toward each other at the points 37 and 38 to provide space for the links 14 and 17. It should be noted that actually the link 14, for purposes of additional strength, consists of two duplicate parallel links 14*a* and 14*b* (Figs. 2 and 4) which are connected rigidly together by means of a cross member 39. Also, certain other links are provided in duplicate, as will now be pointed out. The operating lever 5 is constructed with duplicate parallel arms 5*a* and 5*b* joined together by a cross member at their right-hand ends, to which the handle 4 is secured.

These two parallel levers 5*a* and 5*b* (Fig. 1) are located on opposite sides of the two arms of the support 31, each being provided with its own pivot 26, only one of which is shown, on opposite sides of the support 31, and the pivots being in alignment with each other. The two levers are spaced apart between the handle and the pivots 26 a somewhat greater distance than the width of the support 31 to provide space for the duplicate links 14 and 17 on each side of the projections 35, 36. At its lower end each lever is bent toward the support 21 at the point 40 so that its lower end is in loose sliding relation with the adjacent sides of the support 31.

Likewise, the trip arm 19 is formed in two parallel identical lengths positioned on opposite sides of the support 31 and connected together at their lower ends by a cross member to which is secured a latching projection 41 engaging the latch 21. Each parallel length of the trip arm 19 has its own pivot 20 (Fig. 1) on the frame 31, a washer 42 being provided between the trip arm and the support so as to space the two apart a distance providing for movement of the left-hand end of the operating lever 5 between them.

The two parallel rigidly connected portions 14*a* and 14*b* of the link 14 are connected at their right-hand ends to duplicate links 17 pivoted respectively on the two sides of the trip arm 19. The left-hand ends of the duplicate links 14*a* and 14*b* are joined together by a pin constituting the pivot 15, and this pin in turn is connected through a single link 13 (Figs. 2 and 4) to the floating pivot 10.

It will be noted that the toggle links 8, 9 (Fig. 1) are each formed in two parallel portions which extend between the two sides of the support 31, and likewise the contact arms are each formed in two parallel portions or arms mounted between the sides of the support 31 and provided with a separate movable contact 43 and 44. Also, the links 27 are provided in duplicate to connect the two portions of the operating lever 5 to the duplicate links 17. Likewise, the spring 22 is provided in duplicate parallel lengths having their right-hand ends connected to the cross pin 23 (Fig. 1) secured to the outer ends of the

extensions 35 and 36. The left-hand ends of these springs are connected to the floating pivot 15.

As shown in Fig. 1, a metal support 46 is provided for the current responsive tripping mechanism which controls the trip lever 19. An arm 47 mounted on this support on a pivot 48 is provided with a projection 49 and also with the projection 21 (Figs. 2–6) with both of which normally the projection 41 on the trip arm 19 engages so that the trip arm is held. The right-hand end of the arm 47 has a downwardly projecting extension 50 which is adapted to move downward through a notch 51 in a rotatable latch member mounted on a trip shaft 52 when the cross shaft and latch member are turned in response to an overcurrent to bring the notch 51 in registering relation with the projection 50. Normally, the shaft 52 is turned in a clockwise direction slightly beyond the registering position so that the left-hand edge of the projection 50 engages the bottom wall of the notch whereby the arm 47 is held in a latching position.

As shown, the trip shaft 52 extends across the three poles or switch arms 1, 2 and 3. Thermal current responsive means 53 is provided in circuit with each switch arm for rotating the shaft 52 through the small angle necessary to trip the circuit breaker when the current in any one or more of the poles exceeds a predetermined minimum value. These three temperature responsive trip mechanisms are identical in construction and interchangeable. Accordingly only the trip mechanism associated with the switch arm 1 will be described in detail.

The thermal current responsive device 53 comprises two concentric electric resistance heater tubes made of a metal having suitable electric resistance heating characteristics and heating a thermal expansion rod 54 (Fig. 1) extending through the inner tube and made of a suitable material having a high temperature coefficient of expansion. The two concentric tubes have their right-hand ends mechanically and electrically connected together and their left-hand ends mechanically and electrically connected respectively to an electric terminal member 55 and a supporting conductor member 56, the outer tube being connected to the terminal member 55. Thus current flows between the two members 55 and 56 through the two tubes in series with each other whereby the rod 45 is heated in response to the current, and its right-hand end moves in accordance with changes in its length. If desired the rod 54 can be heated by current passing directly through it.

The conductor member 56 also forms a support for two magnet pole members 57 and 58 (Fig. 1) made of magnet iron, the left-hand ends of which (not shown) extend laterally into two coil turns 59 electrically connected with the member 56. The magnet members 57 and 58 are additionally supported by a supporting plate 61 made of non-magnetic material such as copper or brass. The plate 61 and the magnet members are secured to the conductor member 56 by means of screws 62 and 63, while screws 64 and 65 additionally secure the plate 61 to the magnet members.

By means of layers of suitable fibrous electrically insulating material 66, 67 and 68, the magnet members 57 and 58 are electrically insulated from the members 51 and 61 and from the turns 59. Also, the lateral extensions (not shown) on the magnet members which extend into the turns 59 are suitably insulated from the

turns by layers of electrically insulating material (not shown).

The right-hand ends of the magnetic members 57 and 58 form pole pieces of a magnet whose magnetic strength depends upon the current in the turns 59. Associated with the pole pieces is a pivoted armature 69 balanced about its pivot support 70 so as to be free from the effect of shocks. This armature carries an arm 71 which extends to a position adjacent an operating arm 72 on the trip shaft 52. An adjustment screw 73 is provided on the end of the arm 71 which engages with the arm 72 when the armature is attracted and turned clockwise as seen in Fig. 1 by the magnet poles in response to a current greater than a predetermined value whereby the shaft 52 is turned in a counterclockwise direction and the circuit breaker tripped open. This electromagnetic tripping of the breaker is responsive to very high currents of short circuit magnitude flowing through the turns 59 to trip the circuit breaker instantaneously before the thermal current responsive device 53 has time to heat and trip the breaker. The device 53 is heated by currents which are not strong enough to attract the armature 69, i. e., currents of overload magnitude, and the device 53 is heated by these currents to operate in inverse time relation with these currents.

The right-hand end of the rod 54 operates an arm 74 mounted on a pivot 75 and the upper end of this arm carries an adjustment screw 76 cooperating with a second operating arm 77 secured to the trip shaft 52. Thus, in response to excessive currents, the end of the rod 54 moves toward the right hand thereby turning the arm 74 in a counterclockwise direction and turning the trip shaft 52 counterclockwise to trip the circuit breaker. A relatively strong helical spring 78 is provided for the arm 74, this spring surrounding the pivot pin 75 and having one end fixed and its other end 79 engaging the arm 74 and applying a counterclockwise bias to the arm. The spring 78 thus takes up all looseness in the parts and, by biasing the arm 74 in a tripping direction, assures that the arm 74 cannot be moved in a tripping direction by severe shocks.

A helical tension spring 80 is provided for biasing the armature 69 to its unattracted position, this armature being substantially free from shocks because of its balanced construction about its pivot. A helical tension biasing spring 81 is also provided for the shaft 52 whereby the shaft is biased in a clockwise direction to its latching position with the arm 77 against the arm 74. The operating arms 72 and 77 are made of electrically insulating material, preferably a molded electrically insulating material, firmly secured to the metal shaft 52 whereby the current responsive trip mechanism is electrically insulated from the shaft.

The terminals 55 and 60 not only provide for the connection by suitable leads, not shown, of the current responsive mechanism in circuit with the switch arm 1, but also provide means for securing the mechanism to a suitable insulating support, not shown.

Referring to Fig. 1, the two movable contacts 43 and 44 actuated by each of the switch arms respectively cooperate with two stationary contacts 82 and 83 which are mounted on a terminal 84 to give equalized contact pressure between the two pairs of contacts. The two stationary contacts are suitably secured to one end of a steel plate 85 and also to the ends of flexible electric

conductors 86. The opposite ends of the conductors 86 are suitably secured at 87 to the terminal member 84. These various connections may be made by welding or preferably by brazing. The terminal 84 is formed to fit the flexible members 86 up to the point 88 where it is bent away from the flexible members to form a fulcrum point about which the members 86 bend upon engagement of the movable contacts with the stationary contacts.

Pressure is applied to the stationary contacts by means of a helical compression spring 89 just below the flexible members 86 and positioned midway of the length and midway between the stationary contacts. This spring extends into a suitable cavity provided in the insulating support, not shown. Movement of the stationary contacts by the spring 89 is limited by a headed pin 90 extending through holes in the members 85 and 86 and secured to the end of the terminal 84.

With this mounting of the stationary contacts, the two contacts may be depressed against the force applied by the spring 89 about the fulcrum 88 while at the same time the two stationary contacts are free to twist a sufficient amount to equalize the contact pressures between the two pairs of contacts. The steel plate 85 is provided between the stationary contacts and the flexible conductors 86 for the purpose of magnetically shielding the conductors. Two thin sheets 91 of electrically insulating material, such as horn fibre, are provided over the iron member 85 to prevent the arc from striking to the iron member when the switch is opened.

In accordance with my invention, I provide means for reducing the time of the opening operation of the circuit breaker. As shown, this means for speeding up the opening of the circuit breaker in response to an excessive current, comprises special loose bearings for mounting the square operating shaft 6 in the supporting framework 31, two of such bearings 92 and 93 being shown in Fig. 1. As shown more clearly in Fig. 7, each bearing comprises a bushing or sleeve 94 having an irregularly shaped aperture or bore through which the shaft 6 extends, these sleeves being in turn journaled in the framework 31 for the required amount of rotation. The aperture in the sleeve is provided with a raised portion or hump 95 on the normal bearing side to which pressure is applied through the opposing flat face of the shaft 6 by way of the underset and restrained toggle 8, 9 when the switch arms or circuit controlling members 1, 2 and 3 are in their closed circuit positions, while the adjacent sides 96 and 97 of the aperture are slightly diverging thereby to allow for a slight amount of rocking movement of the shaft on the hump 95 independently of the sleeve 94. This freedom of rolling movement of the shaft on the hump 95 is preferably 10 or 15 degrees. This construction permits a limited initially free angular or rocking movement of the shaft 6 whereby to expedite the buckling or collapse of the toggle 8, 9 and also has the effect of eliminating, during this preliminary movement, the static friction of the bushings 94 in their bearings, whereby greater initial freedom of turning of the shaft is provided. Moreover, the shaft is moving when it engages the side of each of the bushings, and consequently more easily overcomes the static friction of the bushing.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination with a switch operating mechanism having an extended toggle for holding the switch closed and means for collapsing the toggle to open the switch, a flat-sided pivot shaft fixedly secured to one end of the toggle to take the holding thrust thereof, and bearing means for said flat-sided pivot shaft including a rotatably mounted bushing provided with an irregularly shaped bore through which said shaft extends loosely and having an inward projection on which said flat-sided shaft pivots during the initial part of the collapsing movement of said toggle to accelerate the opening of the switch.

2. In combination with a multipole switch operating mechanism having a plurality of extended toggles, each for holding a corresponding pole of the switch closed, and separate means for collapsing one of the toggles to open the switch, a flat-sided pivot shaft fixedly secured to one end of each toggle to take the holding thrust thereof and effect simultaneous extension and collapse of the toggles, and bearing means for said flat-sided pivot shaft including a pair of spaced-apart rotatably mounted bushings, each provided with an irregularly shaped bore through which said shaft extends loosely and having an inward projection on which said flat-sided shaft pivots during the initial part of the collapsing movement of said toggles to accelerate the opening of the switch.

3. An automatic trip-free circuit breaker comprising a movable circuit controlling member biased to an open circuit position, a shaft having a flat side, toggle means interconnecting said circuit controlling member and said shaft, means for operating said toggle means to move said circuit controlling member between open and closed circuit positions, releasable means for holding said toggle in a thrust transmitting condition whereby to maintain said circuit controlling member in the closed circuit position, a support for said shaft, a bearing for said shaft comprising a bushing rotatably mounted in said support and provided with an irregularly shaped bore through which said shaft extends loosely, and means operative for initially expediting the collapse of said toggle upon the release of said holding means comprising a pivotal projection on the wall of said bore opposing the flat side of said shaft, the thrust of said toggle being exerted against said projection when the switch is in the closed circuit position whereby the shaft first turns through a small angle independently of said bushing during the initial opening movement of said circuit controlling member.

4. An automatic trip-free circuit breaker comprising a movable circuit controlling member biased to the open circuit position, a shaft having a flat surface near each end, operating means comprising a toggle interconnecting said circuit controlling member and said shaft for moving the circuit controlling member between open and closed circuit positions, releasable means for holding said toggle in a thrust transmitting condition and a bearing for said shaft near each end thereof, each of said bearings comprising a rotatably mounted bushing provided with an

opening through which the shaft extends loosely and a projection on the interior surface of said bushing against which the flat surface of the respective end of the shaft abuts to transmit the thrust of said toggle while the circuit controlling member is in the closed circuit position and on which the flat surface of the respective end of the shaft rocks through a relatively small angle during the initial portion of the circuit opening movement of the circuit controlling member whereby to expedite the collapse of said toggle upon the release of said holding means.

5. An automatic trip-free circuit breaker comprising a movable circuit controlling member biased to one circuit controlling position, a shaft having a flat surface near one end thereof, operating means comprising a toggle interconnecting said circuit controlling member and said shaft for moving the circuit controlling member between said one circuit controlling position and another circuit controlling position, releasable means for holding said circuit controlling member in one of said circuit controlling positions, and a bearing for said shaft near said one end thereof comprising a rotatably mounted element provided with an opening through which said one end of the shaft extends loosely and a projection on the interior surface of said element against which the flat surface of the shaft abuts to transmit the thrust of said toggle while the circuit controlling member is in said one circuit controlling position and on which the flat surface of said shaft end rocks through a relatively small angle during the initial portion of the movement of the circuit controlling member from said one position to said other position whereby to expedite the collapse of said toggle upon the release of said holding means.

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