Aug. 8, 1944. O. JENSEN. 2,355,075

CIRCUIT BREAKER OPERATING MECHANISM

Filed Jan. 15, 1941 4 Sheets-Sheet 1

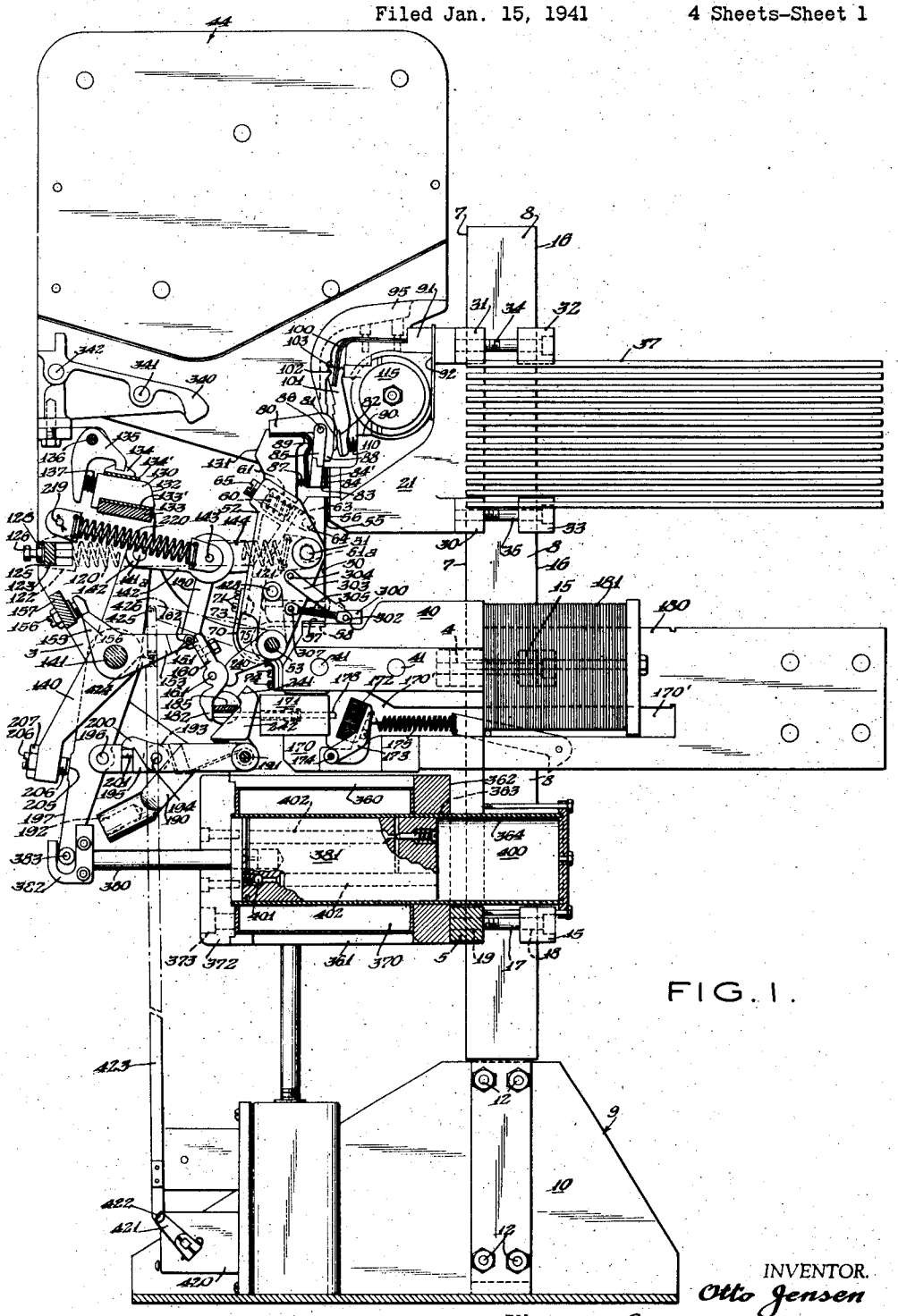


FIG. 1.

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CIRCUIT BREAKER OPERATING MECHANISM

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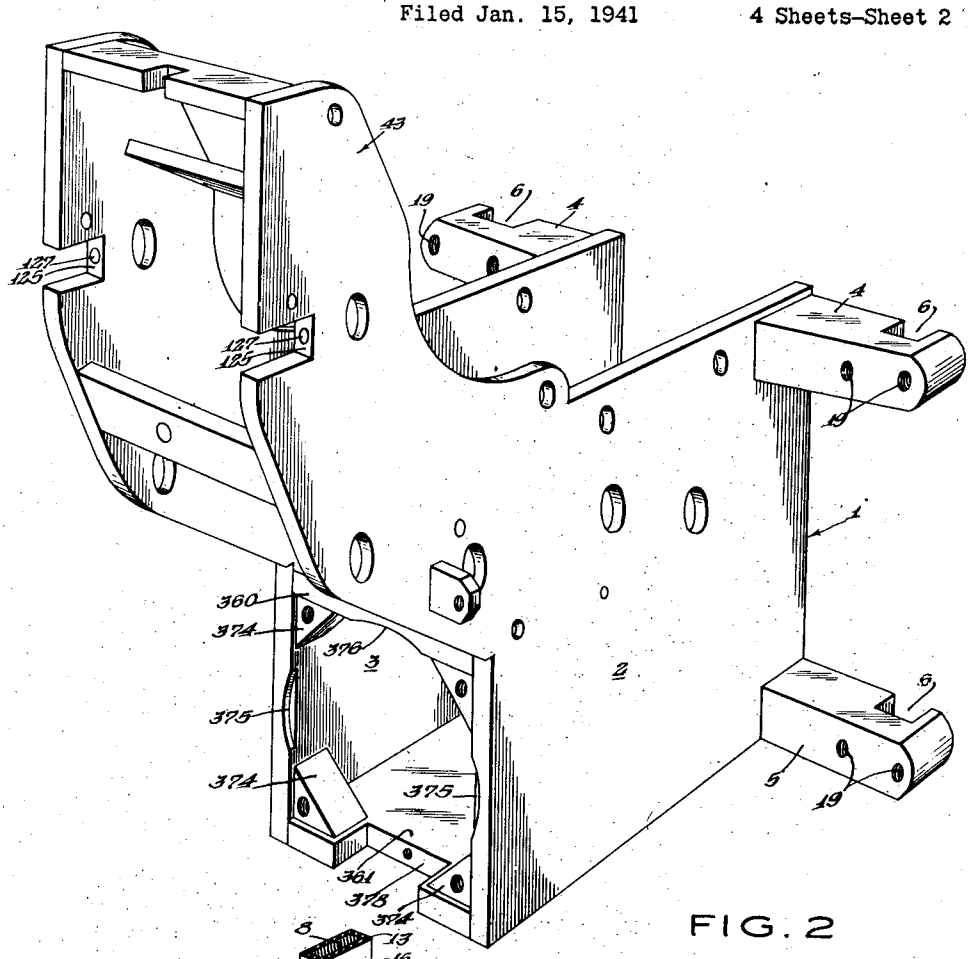



FIG. 2

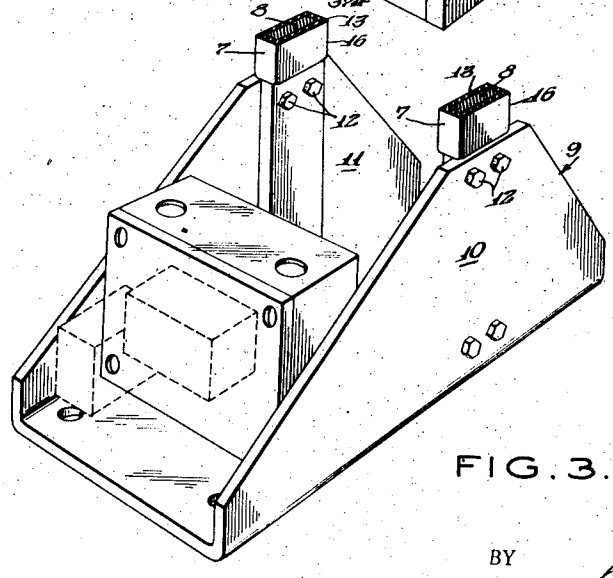



FIG. 3.

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CIRCUIT BREAKER OPERATING MECHANISM

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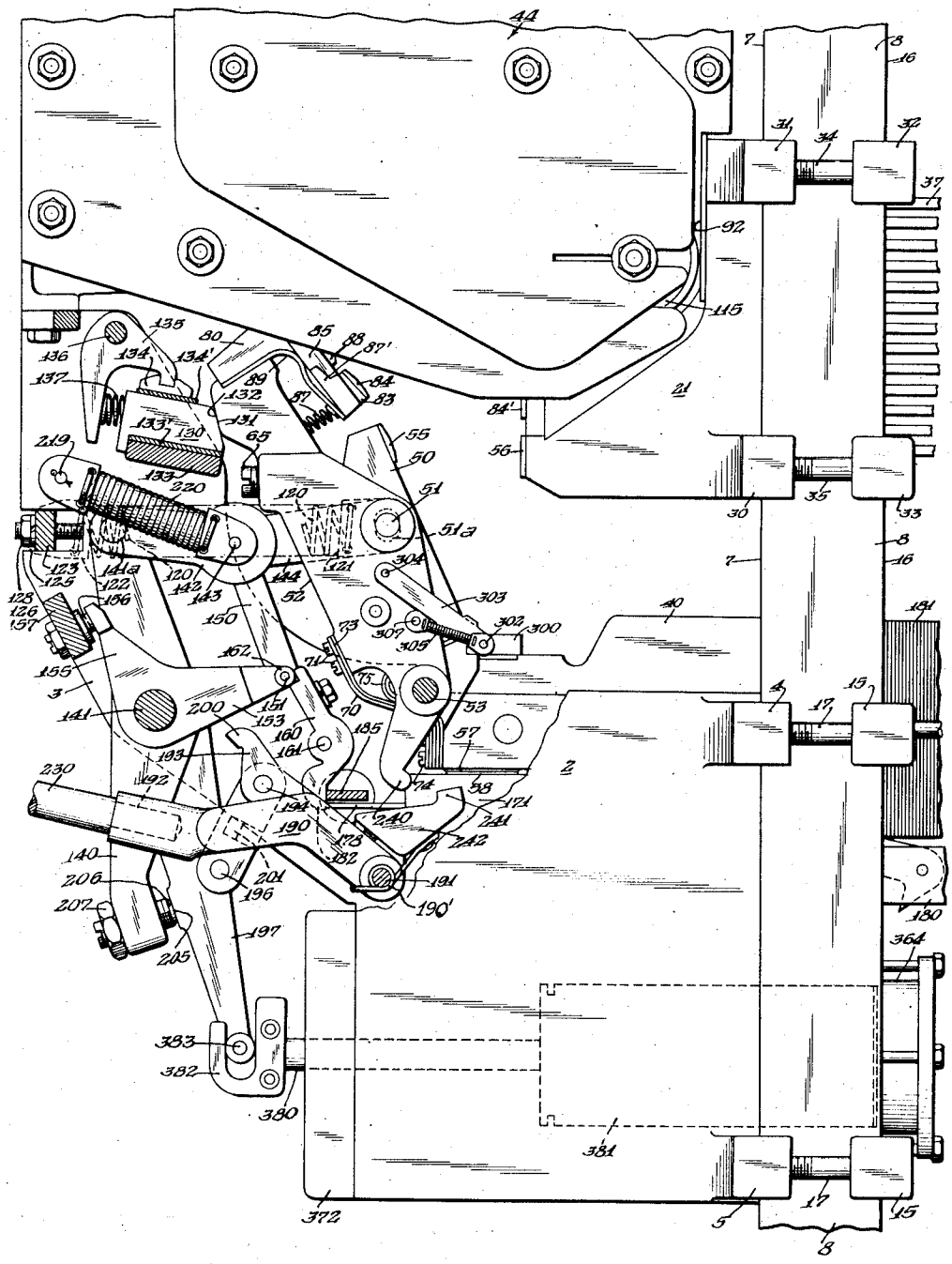


FIG. 4.

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CIRCUIT BREAKER OPERATING MECHANISM

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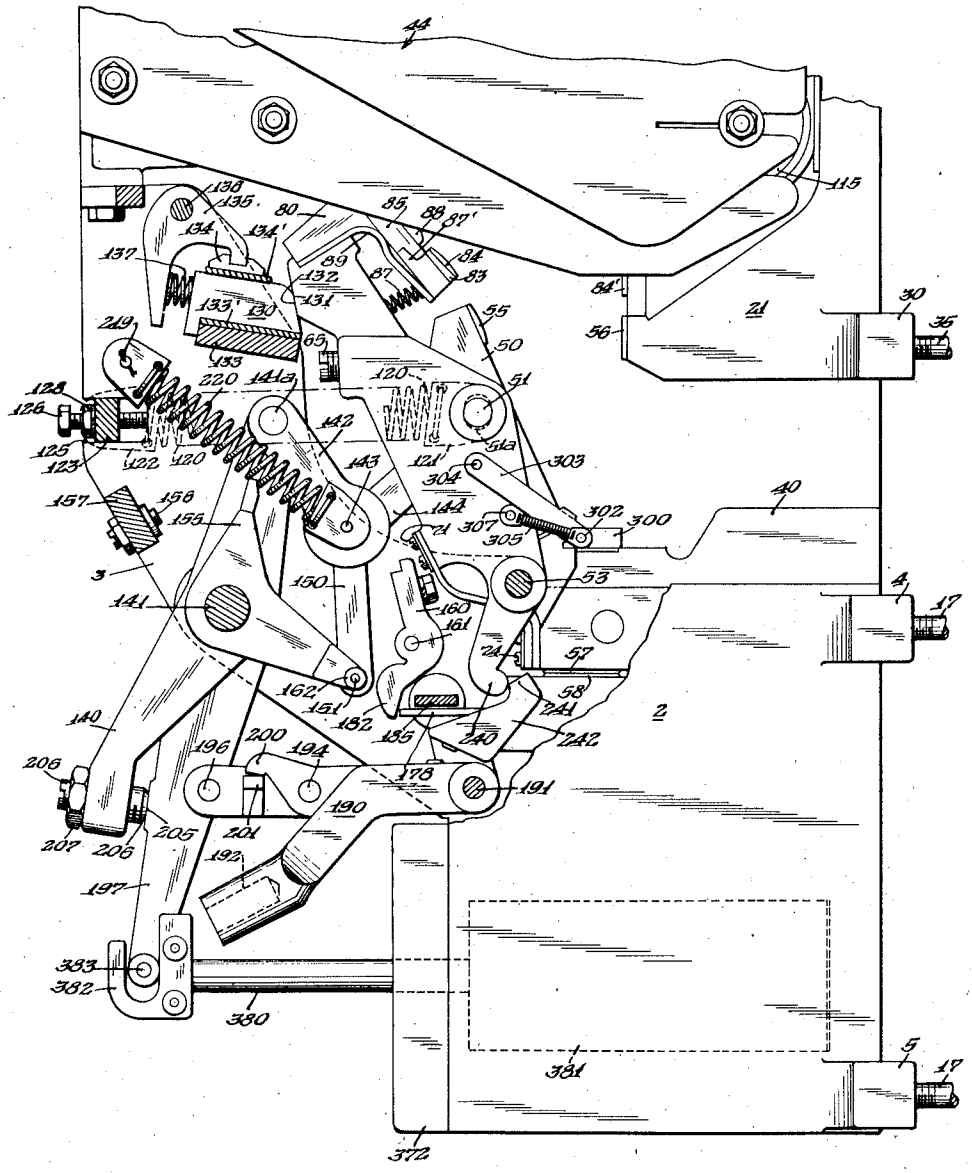



FIG. 5.

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Patented Aug. 8, 1944 2,355,075

# UNITED STATES PATENT OFFICE

2,355,075

## CIRCUIT BREAKER OPERATING MECHANISM

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Application January 15, 1941, Serial No. 374,414

8 Claims. (Cl. 200—89)

This invention relates to circuit breakers and more particularly to operating mechanism therefor. In the construction and operation of circuit breakers, it has long been understood that various toggle arrangements may be utilized to obtain greater leverage during the closing operations of the circuit breaker while permitting, by their collapse, a rapid opening thereof.

In most cases, such toggle arrangements have been complicated in construction and subject to excessive wear owing to the complex linking arrangements required. In the present invention, it has been found that a single collapsible toggle arrangement may be utilized for permitting the tripping of the circuit breaker; while the links forming the toggle arrangement, when in their extended form, may act as a single composite link for transmitting closing forces to the contacts of the circuit breaker.

An object of the present invention, therefore, is the formation of a closing mechanism for a circuit breaker where a single toggle arrangement may be utilized in the extended position of the links to transmit closing pressure to the contacts while the collapse of the toggle may permit opening of the contacts.

Still another object of the present invention is the formation and construction of supporting means for an extended toggle, which means may at all times be pivotally connected to other portions of the mechanism whether or not the toggle is extended or collapsed.

Another object of the present invention is the provision of novel latching means and novel means for removing the latches from supporting position either automatically or manually.

A further object of the present invention is the provision of toggle means which move beyond center for supporting the operating arm of a circuit breaker member in closed circuit position, while nevertheless permitting trip free action of the circuit breaker.

A corollary object of the present invention is the provision of automatic means for moving said closing toggle through center in order to collapse the same and permit complete opening of the circuit breaker.

These and many other objects of the present invention will be in part apparent and in part pointed out in the following description and drawings, in which:

Figure 1 is a cross sectional view of the circuit breaker and mounting and operating means therefor taken along a broken line parallel to the plane of movement of the contacts and showing the entire mechanism in closing position.

Figure 2 is a view in perspective of the circuit breaker housing.

Fig. 3 is a view in perspective of the lower portion of the mounting structure and the base of the circuit breaker.

Figure 4 is a view corresponding to that of Figure 1 showing the contacts and operating mechanism in open circuit position.

Figure 5 is a view corresponding to a portion of that of Figures 1 and 4, showing the contacts and operating mechanism in trip-free position.

Referring now to Figure 1, the contact structure and the operating mechanism therefor are mounted in a housing 1 which (as is seen in Figure 2) comprises a pair of side plates 2 and 3 interconnected by appropriate cross bracing means. The side plates of the housing carry, preferably integrally extended therefrom, a plurality of clamping means 4 and 5, each having a notch 6 arranged and spaced to engage the surface 7 of the vertical posts 8, 8 extending from the base 9 (see also Figure 3).

As is further seen in Figure 3, the vertical posts 8, 8 which support the entire structure, are secured to the side plates 10 and 11 of the base 9 by bolts 12 or any other suitable fastening means. The single simply formed base, shown in Figure 3 serves to support the entire circuit breaker structure. The posts 8 are wrapped with phenolic insulation 13, 13 which insulates those portions of the posts which extend above the top edges of the side plates 10 and 11 of the base 9.

After the posts 8 and notches 6 are placed in registry with each other (Figs. 1 and 2), notched clamping members 15 may be placed over the edges 16 of posts 8 in juxtaposition with the integrally connected clamping members 4 and 5. Bolts 17 may then be passed through suitable openings 18 in clamps 15 to engage the threaded perforations 19 in members 4 and 5 in order effectively to secure the housing 1 to the posts.

The upper terminal 21 is secured in position by means of the clamping members 30 and 31 which have the same form as the clamping members 4—5 of the housing previously described and which are secured to the insulated vertical posts 8 in the same manner by means of the associated clamping members 32 and 33 and the bolts 34 and 35. The upper terminal 21 is connected to any suitable source of current by means of the connection members 37.

The lower terminal 40 is mounted in position

by means of the bolts 41 which clamp the side plates 2 and 3 of the housing against it.

The upper extension 43 of the housing furnishes a suitable mounting for the arc quencher 44 which may be secured in position in any suitable manner and may have any appropriate form for extinguishing the arc which may be drawn between the contacts.

The main movable contact 50 is pivotally mounted on the pin 51 which is carried by the movable contact arm 52. This arm preferably comprises a pair of side plates interconnected by a cross plate in order to provide appropriate structural support for the contact mechanisms. The movable contact arm 52 is in turn pivotally mounted on the pin 53 which pin is supported between the side plates 2 and 3 of the housing 1.

The movable contact 50 has a contact surface 55 of suitable material such as a silver alloy which is engageable with a similar contact surface 56 mounted upon the end of the upper terminal block 21. The movable contact 50 also has an additional contact surface 57 of similar material for engagement with a co-acting contact 58 mounted upon the lower terminal block 40.

The main movable contact 50 by this means, in the closed circuit position of the circuit breaker shown in Figure 1, forms an effective bridge contact between the upper terminal block 21 and the lower terminal block 40 for passing the current therethrough. The formation, operation and blow-on characteristics of these contacts are more fully described in Patent No. 2,150,566 of William M. Scott, Jr., assigned to the assignee of this application.

In order to obtain the necessary current carrying pressure between the contact surfaces 55 and 56 as well as between the contact surfaces 57 and 58, a compression spring 60 is provided which is held in a socket 61 in the upper portion of the movable contact arm 52. This compression spring is connected to and bears against link 63 which is pivotally connected at 64 to the main contact 50.

The pressure of the compression spring 60 may be adjusted by the screw 65 in order to exert an appropriate clockwise and downward force upon the contact 50 to ensure the correct contact pressure. The clockwise force obviously ensures contact pressure between contact elements 55 and 56 while the concomitant downward force ensures appropriate contact pressure between the contact surfaces 57 and 58. In order to give effective operation to these forces the opening 51a in the contact 50 through which the pin 51 passes is elongated somewhat in a vertical direction as indicated by the dotted lines.

During the opening movement of the circuit breaker, hereinafter described in connection with the operation of the closing mechanism, it is important that the upper main contact surfaces be protected by adequate contacts electrically in parallel therewith. These latter contacts maintain engagement until after the main contacts have separated. The arc resulting from the separation of the protecting contacts is then transferred to the arc chute and extinguished.

In order to ensure proper passage of the current to these shunt contacts and to limit the flow of current through the hinge pin a flexible conductor 70 is secured in any suitable manner, as, for instance, by the screws 71 to the plate 73 of the movable contact carrying arm, the opposite end of the said flexible conductor being secured by the screws 74 to a portion of the lower terminal block 40.

This conductor carries the current through the shunt and arcing contacts during circuit interruption. A second conductor 75 is also secured at one end between conductor 70 and the lower terminal by screws 74, and its upper end is secured to the bottom of the moving contact 50. This conductor provides a circuit in shunt to the main lower contact 58 during contact opening to prevent arcing at this point as the contact pressure decreases.

An L-shaped arcing contact 80 is secured in any suitable manner to the upper face of the contact carrying arm 52 and carries on a vertical face thereof a contact surface 81 engageable with an appropriate similar contact surface 82 which in turn is connected to the upper terminal block 21 in the manner hereinafter described.

A shunt contact 83 having a contacting surface 84 engageable with a corresponding contact surface 84' on the upper terminal block 21 is movably mounted upon and supported by the movable arcing contact 80 at one end of the lever 85 the opposite end of which pivots about the pin 86 on the movable arcing contact 80. The movable shunt contact 83 is urged into contacting position by the compression spring 87 which is held in any suitable manner as in an appropriate socket in the contact carrying arm 52.

The forward movement of the movable shunt contact 83 in response to the compression of the spring 87 is limited by an upward extension 87' of the movable shunt contact 82 which when the said shunt contact has moved away from the movable contact arm 52 an appropriate distance, engages the downward extension 88 of the arcing contact 80.

A flexible lead 89 secured between the arcing contact 80 and the upper surface of the contact carrying arm 52 extends to and is secured to the movable shunt contact 83 and thus in combination with the conductor 70 ensures a proper circuit connection between the shunt contact 83 and the lower terminal block 40 through the movable contact arm 52.

A magnetic blowout coil 90 is cast integrally with the upper part of the terminal block 21 so that the lower end of the coil is integral therewith; the upper end 91 is secured by screws (not shown) to the terminal block. Special insulating means, including plate 92, electrically isolates that end of the coil from the terminal block itself.

A stationary arcing horn 95 is removably secured to the coil end 91 in any suitable manner and extends around the coil to a position close to the movable arcing contact 80 when the circuit breaker is in closed circuit position. A flexible conductor 100 is clamped between the members 95 and 91 and is secured to the arcing contact 101 which carries the arcing contact surface 82.

An integral projection 102 of the interior of the stationary arcing horn 95 provides a knife edge bearing for the stationary arcing contact 101, the notch 103 in the end of said arcing contact 101 cooperating with the bearing 102.

The compression spring 110 urges the lower end of the stationary arcing contact 101, which carries the contact surface 82 into engagement with the movable arcing contact surface 81. The spring is recessed in a socket in the upper terminal block 21 and is insulated therefrom so that

any current flowing through the arcing contact must necessarily pass through the flexible conductor 100, the coil end 91, and thence from the upper terminal 21.

Within the coil 90 a cylindrical magnetic core 115 provides a path for the flux into the blow-out pole pieces which are hereinafter to be described.

The entire movable contact arm 52 carrying the main movable contact 50, the shunt contact 83 and the arcing contact 80 is urged towards open position by a pair of tension springs 120 which provide for quick opening thereof. The said tension springs 120 are attached by means of the spring eyes 121 to side extensions of the pin 51 which pivots the movable contact 50. The opposite ends 122 of the springs 120 are mounted on and secured to the ends of a cross bar 123. The cross bar is suitably dimensioned to engage in the notches 125 in the front edges of the side plates 2 and 3 of the housing 1 (see also Figure 2).

Adjusting and tensioning screws 126 are threaded through the cross-bars, the ends thereof bearing in sockets 127 in the bases of the notches 125. The adjustment of these screws regulates the tension of the spring and therefore the rapidity with which the contact arm will bring the movable contacts to open circuit position.

When the screws 126 have been adjusted, they may be locked in position by means of the lock nuts 128. It is obvious that when the circuit breaker contacts are open and the movable contact arm 52 has moved to the position shown in Figure 4, the springs 120 are under the least tension.

Accordingly, the assembly of the springs 120 in connection with the circuit breaker may best be done at this time. In fact, when the circuit breaker contact arm is in the open circuit position, the springs 120 may actually be assembled without the necessity of their being stretched.

The ends 121 of the springs are first connected to the side extensions of the pin 51 and the cross bar 123 is mounted in the notches 125 and the ends 122 of the springs connected thereto. Thereafter the screws 126 may be turned against the sockets 127 thus stretching the springs to provide the required tension.

Obviously the further the cross bar is removed from the base of the notch, the greater the tension on the spring will be. The springs may thus be tensioned appropriately while the contacts are in the open circuit position so that the opening tension will be even greater when the contacts are thereafter closed and the springs further stretched.

The energy of the contact structure at the end of its opening movement is absorbed by a buffing mechanism 130 when the extension 131 of the contact carrying arm 52 strikes the surface of sliding block 132. The block 132 is slidable on cross-bar 133, a band of braking material 133' being interposed between the block and the cross-bar. A braking shoe 134 supported by the bell crank lever 135, which in turn is pivoted on pin 136 bears against the band of braking material 134' on the opposite surface of the block. A compression spring 137 is interposed between the block and an arm of the bell-crank lever. It will be noted that as the end of the contact lever strikes the block causing it to slide, the movement of the block will cause the lever 135 to rotate to increase the braking pressure on the block to halt the same. This provides for a simple buffer which has virtually no rebound and which thus tends to absorb the opening forces. The attributes and operation of this type of buffer are described in Patent No. 2,137,001 to Healis.

The movable contact carrying arm 52 is rotated around its fixed pivot 53 in a clockwise direction and against the tension of the springs 120 in order to close the contacts by the operating mechanism now to be described, which includes the principal operating arm 140.

The principal operating arm 140 is pivotally mounted on the fixed pivot pin 141 which is supported between the side plates of the housing. The upper end of the operating lever or arm carries a pin 141a on which pin is also mounted one end of the link 142. The link 142 carries at its opposite end, a pin 143 to which one end of the link 144 is rotatably secured. The opposite end 145 of the link 144 is pivotally attached to the contact carrying arm 52 by being secured to the pin 51 between the sides of said arm.

Links 142 and 144 constitute a toggle arrangement which, when supported in extended position just beneath center in the manner shown in Figure 1, may be utilized to transmit a closing force from the operating lever 140 to the contact carrying lever 52; and which toggle arrangement may, however, when collapsed, permit the tension springs 120 to pull the contact carrying arm counterclockwise about the pivot 53 in order to effect an opening of the circuit breaker even if the operating lever is held in its circuit closing position.

Thus as seen in Figure 1, a clockwise rotation of the operating lever 140 will result in a corresponding movement of the links 142 and 144, in their extended and supported position as shown, to effect a closing of the circuit breaker. A toggle supporting link 150 is pivotally mounted at one end on the pin 151; and the opposite end is pivotally connected to the knee pin 143 of the toggle.

During the closing movement therefore, the toggle 142—144 is supported in extended position in the manner shown in Figure 1 in approximate alignment. If during this movement or when the contacts are in closed position, the link 150 should for any reason fail to support the knee pin 143 of the toggle arrangement, then the toggles would collapse downwardly under the tension of the springs 120 and thus permit the springs 120 to open the contacts (Fig. 5).

For this purpose, it is essential that during the operation of the circuit breaker, the knee pin 143 of the toggle should not go beyond center that is to say that the toggles should never pass through a 180° angle with respect to each other.

The pivot 151 of the toggle supporting link 150 is mounted on the end of a bell crank lever 153 which is also pivoted on the housing pin 141 which supports the operating arm 140. The arm 155 of the lever 153 engages an adjustable stop 156 on a cross member 157 of the housing.

During the closing movement and while the contacts are closed, the fact that the knee pin 143 of the toggle is slightly below the straight line connecting the centers of the pins 141 and 51 causes a force to be transmitted from knee pin 143 to the link 150 and the lever 153 tending to move these members downward and clockwise. That is, the force exerted by the springs 87, 110, 60 and 120, which tend to collapse the toggle, has a component producing a downward thrust

on the link 150 which component also has a tendency to rotate the link 150 and lever 153 clockwise.

The stop 155 positively limits the upward movement of the pin 151 and its downward movement is normally prevented by the latch lever 160. The angular relation of the toggle links is therefore, defined by three arcs: pin 141a about the fixed pin 141, pin 143 about the pin 151, and pin 51 about the pin 53. Due to the fact that these radii may be unequal and that they need not be parallel, values may be selected which will control the relative angular position of the toggle links and hence, the strength of the component of the closing force that must be resisted by the latch.

The energy of any magnet used to release a circuit breaker latch is limited by its minimum energizing current. In the design of tripping systems it is usual to strive to control the forces required and those available to provide a suitable margin of safety. The acceleration and shock incident to closing may cause a latch to slip out of engagement and must be considered.

The force carried by the toggle system of the present invention is a linear function of the closing movement caused by the stretching of the opening springs and an added function caused by the contact engagement. This overall characteristic produces a curve similar to that produced by the direct current solenoid which actuates the system.

From the above, it is seen that by properly selecting the radii, lengths and relative angles of the three levers, the latch pressure may be increased to the maximum allowable during the early part of the closing movement (to prevent slipping) and maintained at a safe pressure during the final closing action. The latch is therefore free from slipping and yet easily tripped at any time.

The forces described above may be greatly increased when a fault current is flowing through the breaker. Currents of a hundred thousand amperes and more, produce large forces tending to force the contacts open. Under these conditions, there is ample energization of an overcurrent magnet to release the latch.

A latch lever 160 pivotally mounted on the pin 161 is arranged, however, to engage a roller 162 mounted by means of a needle bearing on the pin 151. A torsion spring not shown in the drawings but mounted on the pin 161, urges the latch lever 160 in a counterclockwise direction to maintain its engagement with the roller 162.

The engagement of the latching portion of the latch 160 with the roller 162 is such as to prevent clockwise movement of the bell crank lever 153 and downward movement of the link 150 and therefore is such as to prevent the collapse of the toggle 142—144 thus preventing the springs 120 from causing the contact carrying arm 52 to swing about its pivot 53 to open the circuit breaker.

The use of a needle bearing on the latch roller 162 reduces the energy required to release the latch; and also, since the link 150 rotates about the latch pin during closing movement, the needle bearing minimizes the frictional drag tending to impart this movement to the roller itself, which might affect its engagement with the latch lever.

Various manual or automatic means may be utilized to trip the latch. One form which is here illustrated may be of the type now known as a rate-of-rise trip such as that more fully described in Patent 2,092,592 to Scott and which distinguishes between a short circuit and a suddenly applied load. In this form, the arrangement of the lower terminal block 40 provides for two current paths. A vertical extension 170 of the lower terminal block 40, defined by a cut-out 170' therein is surrounded by an overload magnet 171 the degree of energization of which depends on the current flowing through extension 170. An upper extension 180 of the terminal block 40 is surrounded by iron laminations 181. When the circuit breaker is carrying a steady value of current, the extensions 170 and 180 divide the load in proportion to the cross section of copper in the two paths. The iron plates 181 and the overload magnet 171 are energized in proportion to the current which passes through the extensions which they surround. When there is a rapidly increasing current, the inductance, caused by the iron plates 181, produces a counter electro-motive force in the path 180 and a much greater proportion of the current flows through path 170. The tripping current in path 170 will thus be reached and the armature 172 will be attracted before the total current reaches the setting of the breaker. This trip unit differentiates between a short circuit and a suddenly applied load. When a fault occurs the circuit has a very small inductance and consequently the current increases in value very rapidly. When a motor load is suddenly applied, the inductance of the motor windings retards the increase of current so that the plates 181 have little effect.

Armature 172 is secured to a lever 173 which is rotatably mounted on a pin 174, and is restrained from motion towards the magnet 171 by the tension spring 175. During over current conditions, the increasing strength of the magnet will attract the armature 172. When the armature 172 is drawn sufficiently close to the magnet 171 it will strike the end of a tripping pin 178 which extends forward through an opening in the extension 170 and in the magnet 171, to engage the lower end 182 of the latch lever 160. The movement of the tripping pin 178 occasioned thereby will cause a clockwise rotation of the latch 160 so that the upper end of the latch 160 is moved out of engagement with the roller 162 thus permitting the toggles 142—144 to collapse and the circuit breaker contacts to move to the open circuit position shown in Figure 5.

When, by this operation, the support of the latch lever 160 is removed from the roller 162, there is no further support for the bell crank lever 153 or for the link 150 so that the bell crank lever 153 may rotate clockwise and the link 150 may move downwardly in response to the collapsing pressure placed upon the toggles 142—144 by the tension springs 120 which have a component forcing the knee pin 143 downwardly. The collapse of the toggles obviously, therefore removes any possible support which the contact carrying arm 52 may have against the tension of the springs 120 and the contact carrying arm will then rotate about its pivot 53 to the position shown in Figure 4.

A horizontal cross-bar 185 may be provided loosely supported in openings in the housing side plates and adjacent the lower end 182 of the latch lever just above the point with which the tripping pin 178 is in abutment. Movement of this cross bar by hand or by any other suitable tripping apparatus may be utilized to cause the

end 182 of the latch 160 to rotate in a clockwise direction about its pin 161 for the purpose of manually or automatically tripping the circuit breaker contacts open.

When the circuit breaker is in the open position shown in Figure 4, hand operating mechanism or any other suitable mechanism may be utilized for closing the contacts.

A preferred manual operating mechanism comprises the lever 190 which is rotatable about the pin 191 which pin in turn is supported between the side plates of the housing.

The hand operating lever 190 has at its free end a socket 192 into which a handle may be inserted for manual operation. The hand operating lever also has an integral extension 193 carrying a pin 194 to which is pivotally connected the link 195. The opposite end of link 195 is at 196 pivotally connected to the actuating lever 197 which is pivotally mounted on the pin 141 carried between the side plates of the housing.

The lever 190 and the link 195 thus provide a toggle for forcing the actuating lever 197 in a clockwise direction about its pivot 141. The extension 193 of the lever 192 has a stop 200 integral therewith which coacts with a stop 201 on the link 195 in order to limit the movement of the toggle so that the knee pin 194 of the toggle is over center when the stops engage.

The abutment 205 on the outer surface of the actuating lever 197 normally engages the adjustable stop 206 on the lower extension of the operating lever 140. The stop 206 preferably is a screw held in a suitably tapped perforation in the extension of the operating lever 140 and prevented from accidental turning by the lock nut 207.

A toggle re-setting spring 220 is connected at one end to the knee pin 143 of the toggle 142—144 and, at the opposite end, to the stationary pin 219. After the circuit breaker has tripped and the toggle 190—195 has collapsed, in the manner hereinafter described, the spring 220 serves to reset the toggle 142—144 in the position shown in Figure 4 so that the circuit breaker is in position to be closed once more.

The closing action (that is, the movement of the parts from the Figure 4 position to the Figure 1 position) may be either a solenoid closing action or a manual one which causes the actuating lever 197 to rotate in a clockwise direction about the pin 141, causing the operating lever 140 likewise to rotate in a clockwise direction about the pin 141, thus forcing the toggle 142—144 in its extended position towards the right (with respect to Figures 4 and 1). The pressure of the extended toggle 142—144 upon the pin 51 of the contact carrying arm 52 will cause the contact carrying arm 52 likewise to rotate in a clockwise direction about the pin 53 and thus force the movable contact members carried by the contact carrying arm against the stationary contact members for the purpose of completing the circuit.

When, therefore, as is seen in Figure 4, a handle 230 is inserted in the socket 192 of the manual closing arm 190 and the manual closing arm 190 is with respect to Figure 4 rotated in a counterclockwise direction about the pin 191, the toggle 190—195 is caused to be extended in the manner shown in Figure 1 and the knee pin 194 of the toggle 190—195 is caused to move beyond center.

The movement beyond center of the knee pin 194 locks the actuating arm 197, and hence the operating arm 140, in closed circuit position and stops 200 and 201 on the toggle 190—195 prevent the toggle from breaking in the opposite direction.

In the trip free position (shown in Figure 5), if for some reason the actuating lever 197 and the operating lever 140 are held in closed circuit position either by the handle member 190 or by any solenoid closing mechanism the re-setting spring 220 is not permitted to contract while nevertheless the toggle 142—144 has collapsed in order to permit a complete opening movement of the contact carrying member 52.

Upon the release of closing pressure from the manual closing lever 190 or from any solenoid mechanism which may be used for closing the circuit breaker, the re-setting spring 220 is permitted once more to extend the toggle 142—144 to permit the link 150 and the bell crank lever 153 to be again supported by the latch 160 and to move the operating arm 140 and the actuating lever 197 back to the position shown in Figure 4.

While there has been no interference in the movement of the circuit breaker contacts to the trip free position shown in Figure 5, the operating arm 140 and the actuating arm 197 cannot return to the original position shown in Figure 4, under the influence of the re-setting spring 220, until the toggle 190—195 is collapsed.

The pin 194 of the toggle 190—195 has been caused to move beyond center in order to provide a restraining force for maintaining contact pressure against the influence of tension springs 120. In order to permit the operating arm and actuating lever to move back to open position, the toggle 190—195 must be moved through center to the collapsed position shown in Figure 4.

At the end of the opening movement of the contact carrying arm 52 the downward extension 240 thereof (see Figure 5) strikes the end 241 of an auxiliary lever 242 which is pivoted on the pin 191. A torsion spring 190 surrounding this pin has one end engaging the auxiliary lever 242 and the other end engaging the arm 190 and normally holding them in engagement in the position shown in Figure 1. When this auxiliary lever 242 has by means of the extension 240 of the contact arm 52 been moved in a clockwise direction as shown in Figure 5, the torsion spring above mentioned immediately exerts a force tending to raise the lever 190 and thus collapse the toggle 190—195.

As soon as this is accomplished, the re-setting springs 220 are enabled to act upon the knee pin 143 of the toggle 142—144 in the manner above described and the parts are automatically returned to the position shown in Figure 4 and the contacts can be reclosed manually.

The opening of the contacts is extremely fast and thus the lower extension 240 of the contact carrying arm is moving rapidly. Since the auxiliary lever 242 is extremely light and the torsion spring connecting it to lever 190 is just strong enough to lift this lever, a serious shock due to a hammer blow is avoided.

The re-setting operation is distinct from the opening operation. The opening operation causes a bias tending to initiate the re-setting, but the inertia of the locking toggle and the plunger (hereafter described) causes relatively slow starting of these parts. The re-setting is thus an automatic, subsequent and relatively independent operation.

Various additional means may be utilized to simplify the operation and protect the various elements of the circuit breaker. Thus in order to ensure that the principal contact surfaces **57** of the movable contacts **50** and **58** of the lower terminal block **40** should at all times be protected from dirt and grit, a sliding contact block **300** is provided in connection with the movable contact **50**. The sliding block is so arranged that when, as seen in Figures 4 and 5, the circuit breaker contacts are moved to open circuit position, the under surface of the sliding block **300** is in contact with the contact surface **58** of the lower terminal block **40**.

The sliding block is pivotally mounted at **302** on the link **303**, the opposite end of which link is pivotally supported at **304** on the contact block **50**. Tension spring **305** is attached at one end to the pivotal mount **302** of the sliding block and at the other end to the pin **307** which is carried by the contact block **50**. The force exerted by the tension spring is sufficient to maintain appropriate contact pressure between the sliding block **300** and the contact surface **58** when the circuit breaker is moved to open circuit position.

When the circuit breaker latch is tripped so that the contacts separate, the main contact surfaces **55** and **56** separate first. The shunt contact surfaces **84** and **84'** separate immediately thereafter and the sequence of separation is such as to protect the main current carrying surfaces **55** and **56**. At the same time the surfaces **57** and **58** separate and the sliding block **300** moves into contact with the contact surface **58**.

While the shunt contact surfaces **84** and **84'** are separating the arcing contact surfaces **81** and **82** remain in contact and are the last to separate. An arc is drawn therebetween which by the blow out action of the coil **90** is transferred to the gap between movable arcing contact **81** and the stationary arcing horn **95**.

When the movable arcing contact **81** reaches the limit of its travel as seen in Figures 4 and 5, the arc is transferred to the arcing horn **340** which is in electrical communication with the lower terminal block **40** through the side plates of the housing. The arcing horn **340** is supported between the side plates by the transverse pins **341** and **342**.

As is seen in Figure 4, the arc quencher **44** carries secured to the outside of the side plates thereof, pole pieces **350** of magnetizable material which pole pieces register on each side with the ends of the core **115** of the blow out coil. Any magnetic field thus generated by the coil is transferred to the pole pieces **350** which can then perform the necessary blow out action to cause the arc to travel upwardly on the arcing horns and into the arc quencher to be therein extinguished.

The arc quencher and the pole pieces thereof may have any suitable form for extinguishment of the arc, the construction and operation thereof being varied in accordance with the requirements of the particular circuit breaker.

Magnetic closing means may be provided for the circuit breaker where that is desired, an appropriate closing coil being provided therefor.

A preferred construction illustrated in Figure 1 may be utilized. Since the housing structure of the circuit breaker is preferably formed of welded steel plates having high permeability, adequate flux paths can be provided by these plates with relatively low weight. Horizontal steel cross plates **360** and **361** are welded to the side plates to provide a magnetic coil chamber and also act as cross bracing for the housing of the circuit breaker itself.

A heavy back plate **362** is welded between the side plates and bored out at **363** to receive the plunger guide tube **364**. This tube **364**, the back plate **362** and the plates **360** and **361** define a coil chamber **370** surrounding the tube in which a cylindrical energizing coil may be located. The front end of the solenoid housing is closed by a heavy front plate **372** which is secured in position by cap screws **373** which may be threaded into the triangular lugs **374** (see Figure 2), which are welded into the frame. The side plates **1** and **2** of the frame may be recessed at **375** to receive the front plate **372** and the top cross plate of the solenoid **360** may likewise be recessed for a similar reason at **376**.

A notch **378** may also be provided in the bottom cross plate **361** of the solenoid housing also to provide appropriate clearance for the plate **372**. The front plate **372** or head is drilled for the operating rod **380**, so that the rod may extend into the chamber to connect with the solenoid plunger **381** while the opposite end of the said rod is connected by the yoke **382** to the pin **383** at the lower end of the actuating lever **197**.

The energization of the closing coil **371** will cause the solenoid plunger **381** to be drawn into the coil thus causing the operating rod **381** to move towards the left with respect to the figures, thus causing the actuating lever **197** to rotate in a clockwise direction, in the same manner as previously mentioned in connection with manual closing for effecting a closure of the circuit breaker.

The opening action of the circuit breaker members and the restoration of the actuating lever **197** to the open position shown in Figure 4 will result in a reverse movement of the solenoid plunger causing the same to move towards the right. In order to avoid a hammer blow on the head of the solenoid chamber, the air in portion **400** of the chamber may be effectually sealed therein by the solenoid plunger **381** which acts as a piston. The compression of the air provides a cushioning effect during the latter part of the closing stroke. A pressure relief valve in the back of the plunger permits a gradual escape of this air.

In order to permit a relatively rapid return of the plunger during resetting, a check valve **401** and communicating air passages **402** may be provided in the solenoid plunger itself.

It may be desirable or necessary that the opening or closing of the circuit breaker result in other switching or indicating operations or it may be necessary to energize relays when the circuit breaker is actuated. Accordingly, switching means **420** may be provided. This is secured to the base of the housing and has a rotatable actuating arm **421** connected by a pin **422** to the vertical link **423** which link is adjustable at **424**. The opposite end of the link may at **425** be connected to a pin on the bell crank lever **426** which is pivoted on the stationary pin **53**.

The end of the bell crank lever **426** opposite the end **425** thereof may at **428** be connected to a pin on the contact carrying arm. The movement of the contact carrying arm to open position will cause the bell crank lever **426** to rotate in a counter clockwise direction, thus causing the end **425** thereof to be depressed, thus depressing the link **423** and causing the operating arm **421** of the switch **420** to rotate in a counterclockwise direction to actuate the relay

or switch in any appropriate manner. The closing of the circuit breaker will cause a reverse operation of the switch or relay 420.

In the foregoing description, the operation of the various members of the circuit breaker have been set forth in connection with the description of each member.

The various linkage mechanisms which permit the operation of the circuit breaker and the different variations thereof which may be possible should now be clear to those skilled in the art. It is preferred therefore to be bound not by the specific disclosure herein set forth but only by the appended claims.

I claim:

1. In a circuit breaker operating mechanism, a pivoted switch member biased toward open circuit position, a lever for moving said switch member to closed circuit position; a single toggle mechanism for operating said switch member to closed position against its bias, said single toggle comprising a collapsible thrust transmitting mechanism comprising a first link having one end pivotally mounted on said switch member, a second link having one end pivoted to said lever, the other ends of said two links being pivoted together, said first and second links being substantially in a straight line but below the center to center line from the pivot points of said first and second links while said lever transmits power therethrough to operate said switch member to closed position, and a third link connected at one end to the common pivot of said first two links; said third link extending almost at right angles to said first two links; the other end of said third link being connected to a releasably supported pivot; the distance from said common pivot point to the center-to-center line being controlled by said third link in accordance with said bias on said switch member.

2. In a circuit breaker operating mechanism, a contact carrying member biased from a closed to an open position, a lever for actuating said member, collapsible toggle means for connecting said lever and said member for movement thereof against said bias, a manually controlled toggle for moving said lever against said bias, said last named toggle having its knee pin over center at the end of the closing movement to maintain said lever in position, a pivoted member resiliently connected by means of a spring to said toggle; and a member on said contact carrying member engageable with said pivoted member during the opening movement; said last mentioned member engaging said pivot member during the opening movement and through the resilient connection, moving said last named toggle through center and collapsing the same.

3. In a circuit breaker operating mechanism, a contact carrying member biased from a closed circuit to an open position, a lever for actuating said member, a thrust transmitting toggle connecting said member and said lever, disengageable means for supporting the knee pin of said toggle and normally preventing the collapse thereof, a spring connected to said knee pin of said toggle to effect the resetting thereof and the reengagement of said supporting means after disengagement thereof, means for moving said lever against said bias and for maintaining said lever in position comprising a second toggle having its knee pin over center at the end of the closing movement, means associated with said contact carrying member and said last named toggle for effecting collapse of said toggle upon movement of said member to open position, said spring then being effective to cause said resetting and reengaging action.

4. In a circuit breaker operating mechanism, a contact carrying member biased from a closed circuit to an open position, a lever for actuating said member, a thrust transmitting toggle connecting said member and said lever, disengageable means for supporting the knee pin of said toggle and normally preventing the collapse thereof, a spring connected to said knee pin of said toggle to effect the resetting thereof and the reengagement of said supporting means after disengagement thereof, means for moving said lever against said bias and for maintaining said lever in position comprising a second toggle having its knee pin over center at the end of the closing movement, means associated with said contact carrying member and said last named toggle for effecting collapse of said toggle upon movement of said member to open position, said spring then being effective to cause said resetting and reengaging action, said contact carrying member being movable once more to closed circuit position upon resetting of said thrust transmitting toggle and reengagement thereof with its supporting means.

5. In a circuit breaker operating mechanism, a pivoted switch member biased toward open position; a lever for moving said switch member toward closed position; a single toggle mechanism comprising a first and a second link; means whereby said lever operates said switch member to its closed position through said toggle mechanism; said links being in approximate alignment but below the center line connecting the pivot points of said first and second links whereby a downward collapsing force is normally produced at said toggle mechanism during said closing operation of said circuit breaker; a supporting mechanism for said toggle mechanism at its midpoint extending substantially at right angles to said links; said supporting mechanism controlling said toggle during the entire closing movement; and means responsive to circuit conditions for removing said supporting mechanism whereby said toggle mechanism collapses to permit said circuit breaker operating mechanism to operate under its bias to open position.

6. In a circuit breaker operating mechanism, a pivoted contact carrying member biased toward open position; a pivoted operating lever; a toggle mechanism having one end pivotally supported on said operating lever and the other end on said contact carrying member; means for normally locking said operating lever against movement; means for normally supporting said toggle against collapse; means for removing said support; spring means operative on the removal of said support for collapsing said toggle mechanism about said locked operating lever for moving said contact member to contact disengaged position; means responsive to the movement of said contact carrying member for removing the lock on said operating lever, means for rocking said lever about its pivot and for restoring said toggle mechanism for transmitting power to said contact carrying arm, means for thereafter operating said lever about its pivot for operating said contact arm through said toggle to its circuit closing position and means whereby on completion of the movement of said contact carrying arm to closing position said operating lever is again locked in position against rotation.

7. In a circuit breaker operating mechanism,

a pivoted contact carrying member biased toward open position; a pivoted operating lever; a toggle mechanism having one end pivotally supported on said operating lever and the other end on said contact carrying member; means for normally locking said operating lever against movement whereby said toggle mechanism is collapsible about its fixed pivot on said operating lever for moving said contact member to its open position; means responsive to the opening of said contact member for unlocking said operating lever to permit it to rock on its pivot for resetting said toggle mechanism; and means for operating said operating lever to its original locked position for operating said contact member through said toggle to its closed position.

8. In a circuit breaker operating mechanism, a pivoted switch member biased toward open position; a lever for moving said switch member toward closed position; a single toggle mechanism comprising a first and a second link; means whereby said lever operates said switch member to its closed position through said toggle mechanism; said links being in approximate alignment but below the center line connecting the pivot points of said first and second links whereby a downward collapsing force is normally produced at said toggle mechanism during said closing operation of said circuit breaker; a supporting mechanism for said toggle mechanism at its midpoint extending substantially at right angles to said links; said supporting mechanism controlling said toggle during the entire closing movement; means responsive to circuit conditions for removing said supporting mechanism whereby said toggle mechanism collapses to permit said circuit breaker operating mechanism to operate under its bias to open position; and means responsive to the operation of said circuit breaker mechanism to open position for resetting said collapsed toggle mechanism to substantial alignment whereby said lever is operative through said toggle mechanism for operating said circuit breaker to closed position.

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