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OPERATING MECHANISM FOR CIRCUIT BREAKER

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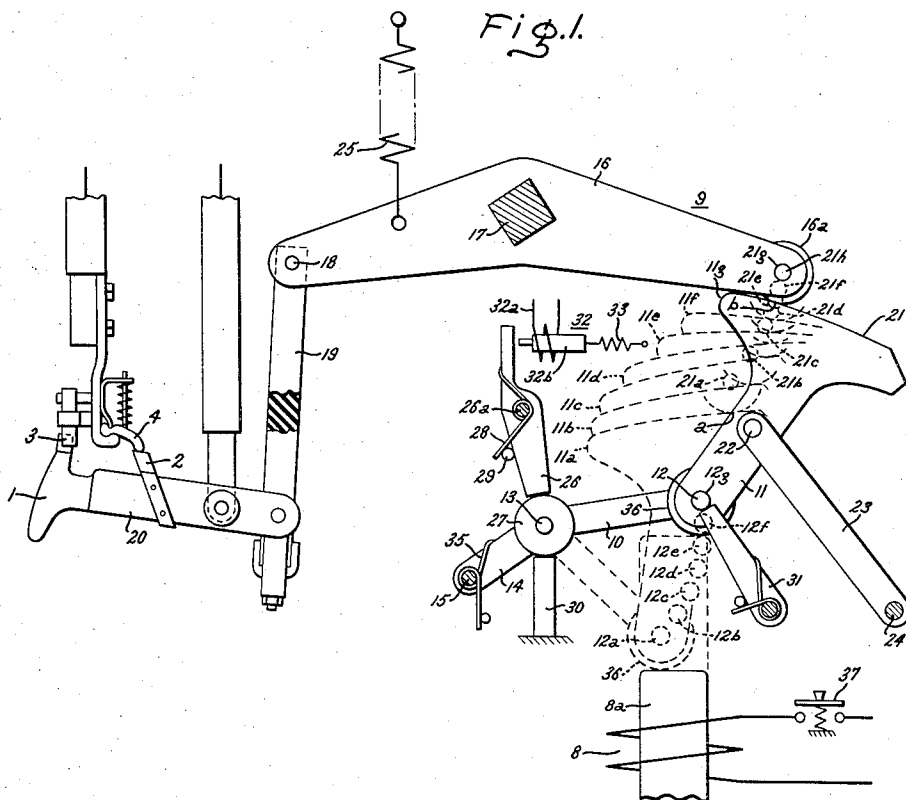
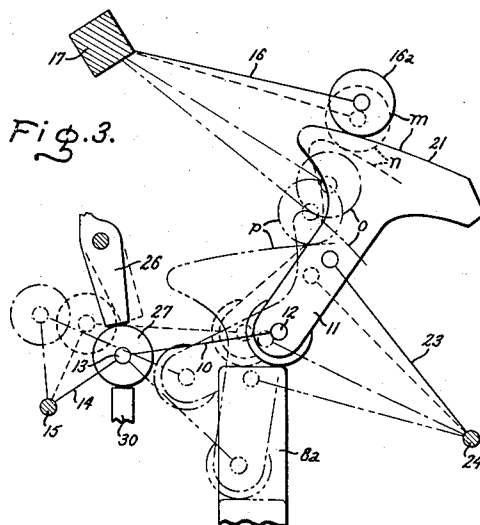
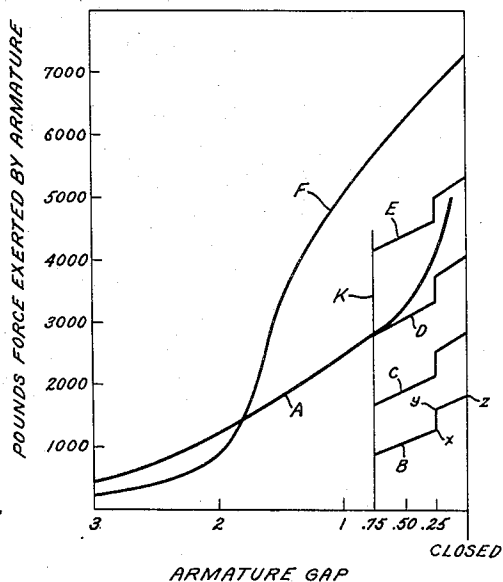


Fig. 2.



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OPERATING MECHANISM FOR CIRCUIT BREAKER

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This invention relates to operating mechanisms for electric circuit breakers, more particularly to circuit breakers in which the breaker closing operation is effected by means of an electromagnetic solenoid, and it has for an object the provision of a simple, reliable, improved and inexpensive mechanism of this character.

Another object of the invention is the provision of a breaker closing mechanism having means for modifying the output of the closing solenoid to match the closing force requirements of the breaker.

Still another object of this invention is the provision of a simple and stable breaker closing mechanism which maximizes the useful work output obtainable from the input watts to the solenoid or, conversely, which minimizes the size and cost of the solenoid required for the closing operation.

Another object of the invention is the provision of an operating mechanism that is capable of providing effective closing performance when operating to close the breaker on a faulted line. At the instant at which the breaker contacts begin to close on a faulted line, a current of short circuit magnitude begins to flow which produces large magnetic forces that oppose the completion of the closing stroke of the breaker. These forces may be of such magnitude as to stall or even to reverse the direction of the movable contact and thereby cause destructive burning of the contacts. Accordingly a further object of the invention is the provision of a circuit breaker closing mechanism that is capable of overcoming the high magnetic forces that develop when the circuit breaker contacts close on a faulted line and oppose wiping in the contacts to their fully closed position.

Still another object of the invention is the provision of a circuit breaker operating mechanism in which means are provided for matching the output of the solenoid with the closing force requirements of the breaker without in any way impairing the ability of the breaker to separate its contacts rapidly during an opening operation.

In carrying the invention into effect in one form thereof, the circuit breaker operating mechanism comprises an electromagnetic solenoid having a movable armature together with driving connections between the armature and the operating arm of the circuit breaker including a toggle joint driven by the armature and having the end of one of its links contoured to form a cam surface for engaging the contact operating crank arm. The cam surface is shaped to modify the output of the solenoid to match the closing force requirements of the breaker. For a better and more complete understanding of the invention reference should now be had to the following specification and to the accompanying drawings of which:

FIG. 1 is a simple mechanical diagram sketch of a circuit breaker mechanism embodying the invention;

FIG. 2 is a chart of dynamic pull characteristic curves of an electromagnetic solenoid and other operating characteristics which serve to facilitate an understanding of the invention; and

FIG. 3 is a sketch illustrating important elements of the invention in successive positions which they occupy during a trip free operation of the breaker.

Referring now to FIG. 1, the movable arcing contact 1 and movable main contact 2 cooperate with stationary arcing contact 3 and stationary main contact 4 respec-

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tively. Each of the arcing and main contacts has a predetermined amount of wipe so that when the circuit breaker is being closed the closing stroke continues for a short distance beyond the point at which the movable and stationary contacts first engage.

The contacts 1, 2, 3 and 4 may constitute the contacts of one pole of a multiple pole circuit breaker for controlling a polyphase line. The movable contacts 1 and 2 together with similar assemblies of movable arcing and main contacts of the other poles of the circuit breaker are operated in unison from a fully opened position to the fully closed position illustrated in FIG. 1 by means of a suitable actuating device such as the electromagnetic solenoid 8 and operating mechanism 9. As shown in FIG. 1, the operating mechanism 9 is of the mechanically trip free type. It includes a toggle linkage that comprises two toggle links 10 and 11 pivotally joined together at the knee of the toggle by a pin 12. The toggle link 10 is pivotally connected by means of a pin 13 to a guide link 14 which is mounted for rotational movement about a fixed supporting pin 15. For the purpose of transmitting movement from the toggle linkage to the movable contacts of the circuit breaker an output crank arm 16 is secured to a main operating shaft 17 which is suitably mounted on the circuit breaker frame for rotation about its own longitudinal axis. Pivotally connected to the crank arm 16 by means of a pin 18 is an operating rod 19 that is pivotally connected to the movable contact carrying arm 20 upon which movable contacts 1 and 2 are mounted.

The end of toggle link 11 remote from the knee is not pinned to the crank arm 16 but is profiled to provide a cam surface 21 that engages a roller cam follower 16a rotatably mounted at the end of crank arm 16. At a point intermediate its knee and its cam surface the toggle link 11 is pivotally connected by means of pin 22 to a guide link 23 which, at its opposite end, is pivotally connected to a fixed pin 24.

The contacts of the circuit breaker are biased toward the open position by suitable means such as opening spring 25. A trip latch 26 serves to hold the contacts in a closed position. This trip latch is biased in a clockwise direction about a fulcrum pin 26a into latching position against a latch roller 27 by means of a spring 28. Suitable stops 29 and 30 retain the latch 26 and roller 27 in the latched closed position of FIG. 1. In this latched position, a prop 31 supports the pin 12 at the knee of the toggle and prevents it from collapsing.

For the purpose of releasing the trip latch 26, a tripping solenoid 32 comprising a coil 32a and a plunger 32b is provided. A spring 33 biases the plunger out of engagement with a cooperating extension of the trip latch. The coil 32a may be energized in accordance with any operating condition such for example, as overcurrent. It is usually actuated by the contacts of protective relays connected in series in the line in which the circuit breaker is connected thereby to provide protection against overcurrent or other abnormal condition. When suitably energized the pull of the coil 32a overcomes the bias of spring 33 and drives the plunger 32b against the latch mechanism thereby rotating the latch in a counterclockwise direction to the tripped position in which the restraint on the latch roller 13 is released. In the tripped position of the latch, the operating mechanism is ineffective to restrain the opening spring 25 and as a result the spring drives the movable contact carrying arm 20 counterclockwise through an opening stroke. During this contact opening stroke the spring 25 drives the unlatched guide link 14 counterclockwise about its pivoted support pin 15 and consequently the toggle knee pin 12 moves in a general leftward and downward direction as viewed in FIG. 1. Also the guide link 23 rotates in a counterclockwise

direction. As a result of the counterclockwise movements of guide links 14 and 23 and the leftward and downward movement of toggle knee pin 12, the movement of the toggle link 11 is in a general longitudinal direction downward and to the left as viewed in FIG. 1 and the toggle 10—11 collapses at its knee. As the opening stroke is completed, the operating mechanism is reset for a subsequent closing operation by a resetting spring 35 which is shown coiled about the pivot 15. The resetting spring 35 carries out this resetting operation by returning guide link 14 to the latched position shown in FIG. 1 with the trip roller 27 resting upon the supporting stop 30. The position of toggle linkage 10, 11 when the mechanism has been tripped and reset is indicated by the dotted line 11a. In this reset position, it is in condition for transmitting thrust from the armature 8a of solenoid 8 to the movable contact carrying arm 20.

An important aspect of the invention is the improved closing and opening operations that result from the contouring of the end of the cam link 11 to provide the cam surface 21 and the addition of link 23 to guide the motion of the cam.

Closing of the breaker is initiated by energizing the solenoid winding 8 to cause the armature 8a to drive the knee of the toggle 11, 12 from the dotted line fully open and reset position upwardly toward the solid line fully closed position. This upward movement of the armature is transmitted to the mechanism 9 by means of a roller 36 on the knee pin 12 that is engaged by the upper end of the armature.

When the contacts of a circuit breaker are closed high electromagnetic forces are abruptly established at the instant at which current begins to flow through the contacts. Since these forces vary in accordance with the square of the current they can attain extremely high magnitudes if the breaker is closed against a fault or a short circuit. For a conventional contact arrangement such as shown in FIG. 1 these electromagnetic forces act in a direction to oppose the circuit breaker closing action and for many applications they are of sufficient magnitude to stall or even to reverse momentarily the closing motion of the breaker. This tends to cause excessive contact burning and other undesirable operating conditions that impair the reliability of the breaker.

In accordance with the invention, these high magnetic retarding forces are overcome by profiling the free end of link 11 to provide it with a cam surface 21 that engages the follower roller 16a on crank arm 16. Since link 11 is not pinned to arm 16 but instead is guided by the link 23 the toggle 10, 11 transmits its force by rocking of the contoured surface 21 against the roller 16a thereby enabling the link to vary its effective length during a closing stroke.

An understanding of the mode of operation of the invention will be facilitated by reference to the characteristic curves shown in FIG. 2 in which ordinates represent pounds force exerted by the armature, and abscissae represent armature gap of the solenoid 8 throughout the range of its travel from the contact fully opened position to the contact fully closed position. In this figure the curve A is the dynamic pull curve of solenoid 8 with the solenoid energized by a direct voltage of suitable magnitude, e.g. 125 volts D.-C. It illustrates the relationship between force measured at the center line of the armature and the travel of the armature as it moves through its closing stroke. The left-hand end of the curve represents the value of the solenoid pull at the fully open position of the breaker and the right-hand end represents the value at the fully closed position.

For a conventional operating mechanism of the type to which the invention is applicable the movable arcing contact engages its cooperating stationary contact at a point in the travel of the armature denoted K in FIG. 2. In a typical case the K point might be three-fourth inch from the fully closed and wiped in position of the con-

tacts. Assuming a 1:1 ratio of the linkage between the armature and the pin 21h at the end of the crank arm the force that must be exerted by the armature to complete the closing of the breaker contact with normal load current flowing after the movable arcing contact engages the stationary arcing contact is represented by curve B. The slope of the portion of curve B between K and the vertical portion x—y represents the increasing force due to the gradient of opening spring 25 during the closing of the arcing contacts. The vertical rise portion x—y represents the increase in force due to the springs of the main current carrying contacts and the portion y—z represents the increasing force due to the gradient of the opening spring and the contact spring as the main contacts are wiped in.

Curves C, D and E are similar to curve B for short circuit currents or fault currents of 40,000, 60,000, and 80,000 amperes respectively. For each position of the armature in the closing stroke the available solenoid force equals or exceeds the required closing force for the condition of normal current, 40,000 amperes and 60,000 amperes. However, for the condition of 80,000 amperes short circuit or fault current the available solenoid force with 1:1 ratio linkage is less than the value required to close the contacts. Changing the linkage to shift the K point to the right and thus to bring about initial engagement of the arcing contacts at a point in the armature travel, at which the available solenoid force exceeds the value required at the instant of engagement of the arcing contacts would not provide a solution; the mechanism would be unable to complete the closure of the contacts because the remaining travel of the armature is less than would be required to wipe in the contacts.

However, the contacts can be completely closed on 80,000 amperes short circuit or fault current by profiling the cam surface 21 of the toggle link to provide a relationship between travel of the armature and travel of the pin 21h which is exemplified by the values appearing in columns 2 and 3 of the following table for six successive one half inch increments of travel of the armature from its open position.

Table I

Distance of armature from open position	Increment of travel of armature	Travel of crank arm pin	Ratio of pin force to armature
0.0	0.0	.00	
.5	.5	.65	.77
1.0	.5	.65	.77
1.5	.5	.813	1.6
2.0	.5	.25	2.0
2.5	.5	.25	2.0
3.0	.5	.375	1.33

The successive positions of the toggle pin 12 for six successive increments of solenoid plunger travel are represented by the series of small circles 12a to 12g inclusive and the corresponding positions of the cam profiled end of the toggle link 11 are represented by the series of fragmentary cam outlines 11a—11g inclusive. Likewise the corresponding incremental positions of the crank arm pin are represented by the series of small circles 21a—21g inclusive.

In the zero increment position 11a of the cam contour, i.e. the reset position of link 11, the cam follower roller 16a is in contact with point a of the cam surface whereas in the sixth incremental position the cam roller is in contact with the cam surface at point b. The point b' is closer than point a to the toggle pivot pin 12 and thus the effective length of the toggle link is progressively changed in accordance with the upward progress of the armature during the closing stroke. As a result, the increments of travel of the crank arm 16 have the values

set forth in column 3 of Table I and the ratios of the force on the crank arm pin 16a to the force of the armature for the successive positions of the armature have the values set forth in column 4 of Table I.

The actual force produced on the crank pin 16a by the camming effect of the cam surface is the same as would have been produced if the armature force at each incremental value of armature travel had been multiplied by the corresponding force ratio value in column 4 of Table I, and the mechanical ratio of the linkage between the armature and the crank pin had remained unchanged. Curve F is a plot of the product of such armature forces and ratios. As shown, by curve F, the values of force are greater than are required to be exerted by the armature, as represented by curve E, to complete the closing of the arcing and main contacts against the retarding force of an 80,000 ampere short circuit or fault current. Thus, an advantage of the invention is that it makes possible upgrading the breaker performance without increasing the current consumption of the closing solenoid. A related advantage is that it leaves room for modifying the linkage to advance the K point so that it occurs at a greater armature gap thus leaving more inch pounds of work available for the job of closing and latching at a higher duty level.

Another advantage of the invention is that the displaceability of the cam 21 permits a mechanical trip free operation to proceed without interference from the cam. This is illustrated in FIG. 3 by the fragmentary illustrations of the crank arm 16, roller 16a and toggle link 11 in several successive positions *m*, *n*, *o* and *p* occupied during a trip free operation. When these elements are in the position *m* the circuit breaker contacts are in the closed position. During the closing stroke the solenoid 8 is maintained energized, and may be maintained energized even after the closing stroke has been completed if the operator is slow in releasing the manually operated closing switch 37. In response to such maintained energization, the armature is either being attracted to or being held in the fully closed position by the energization of the solenoid, and the knee of the toggle is being supported by the armature. If, while these conditions are present, the trip coil 32a is energized, the force of the opening spring acting through the crank arm against the cam surface causes the toggle links 10 and 11 to move to the left to effect counterclockwise rotation of the guide link 14. As this occurs, the toggle links move rapidly through the successive positions *n*, *o* and *p*. Thus, even though the knee of the toggle is being supported by the armature in its fully closed position, the toggle joint is immediately broken, thereby permitting the clockwise rotation of the crank arm 16 and the opening motion of the breaker contacts to proceed under the force of the opening spring without any resistance from the cam. As shown in FIG. 3, the effect is substantially the same as though the cam were falling away from the follower roller 16a and thereby permitting unretarded contact opening movement of the crank arm 16 under the force of the opening spring. The contact opening operation is thus quite different and much more rapid than it would be if the cam were rotatably mounted on a fixed position pivot and required to be rotated in reverse to permit contact opening movement of the crank arm.

Although this invention has been described as embodied in the apparatus illustrated and the principle of the invention has been described together with the best mode in which it is now contemplated applying that principle it will be understood that the apparatus shown and described is merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of the invention or from the scope of the annexed claims.

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

1. A circuit breaker closing mechanism comprising a toggle having a first link and a second link pivotally connected to each other to form a toggle knee, a follower on said knee movable from a fully open position to a fully closed position as said breaker is moved through its closing stroke, actuating means comprising an electromagnetic solenoid having a movable armature for driving said follower from said fully open position toward said fully closed position, a pivotally mounted first guide link pivotally connected to said first toggle link remote from said knee, a circuit breaker operating arm provided with a cam follower, a cam on said second toggle link remote from said knee for engagement with said cam follower, latching means for holding said first guide link in a predetermined position, and a pivotally mounted second guide link pivotally connected to said second toggle link for maintaining said cam in engagement with said cam follower during the closing stroke of said breaker.

2. A circuit breaker closing mechanism comprising a toggle having a first link and a second link pivotally connected to each other to form a toggle knee, a follower on said knee movable from a fully open position to a fully closed position as said breaker is moved through its closing stroke, actuating means comprising an electromagnetic solenoid having a movable armature for driving said follower from said fully open position toward said fully closed position, a pivotally mounted first guide link pivotally connected to said first toggle link remote from said knee, a circuit breaker operating arm provided with a cam follower, a cam on said second toggle link remote from said knee for engagement with said cam follower to vary the ratio between the movement of said actuating means and the movement of said operating arm to effect a relatively steep increase in the force applied to said operating arm within a predetermined zone in the travel of said armature means.

3. A circuit breaker operating mechanism comprising a pivotally mounted circuit breaker operating arm, means for driving said arm comprising an electromagnetic solenoid provided with a movable armature having a predetermined travel, driving connections between said actuating means and said operating arm comprising a toggle having a knee positioned to be moved toward toggle straightening position by said movable armature, means for latching one end of said toggle against displacement, means for approximately matching the output of said actuating means with the closing force requirements of the breaker comprising a cam surface formed on the unlatched end of the toggle engaging said operating arm and shaped to vary the ratio of the movements of said driving element and said arm and means for releasing said latching means thereby to collapse said toggle and immediately release said arm from its forcible engagement with said cam to permit rapid breaker opening movement unimpeded by said cam.

4. A circuit breaker operating mechanism comprising a pivotally mounted circuit breaker operating arm, means for driving said operating arm comprising an electromagnetic solenoid having a movable armature, driving connections between said armature and said operating arm comprising a toggle actuated by said movable armature, and means for approximately matching the output of said solenoid to the breaker closing force requirements of said operating arm comprising a cam formed on one end of the toggle and engaging said arm, said cam being shaped to vary the ratio of the movements of said armature and said arm.

5. A circuit breaker operating mechanism comprising a pivotally mounted circuit breaker operating arm, means for driving said operating arm comprising an electromagnetic solenoid, provided with a movable armature having a predetermined travel, driving connection between said armature and said operating arm comprising a toggle

having a knee positioned to be moved toward toggle
straightening position by said movable armature, means
for restraining one end of the toggle against displacement,
and means for approximately matching the output of said
solenoid to the breaker closing force requirements com- 5
prising a cam surface on the other end of the toggle en-
gaging said operating arm and shaped to vary the ratio
of the movements of said armature and said arm.

References Cited in the file of this patent

UNITED STATES PATENTS

925,673	Zook	June 22, 1909
2,675,506	Brown et al.	Apr. 13, 1954

FOREIGN PATENTS

364,600	Germany	Sept. 14, 1920
1,137,406	France	May 28, 1957