Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

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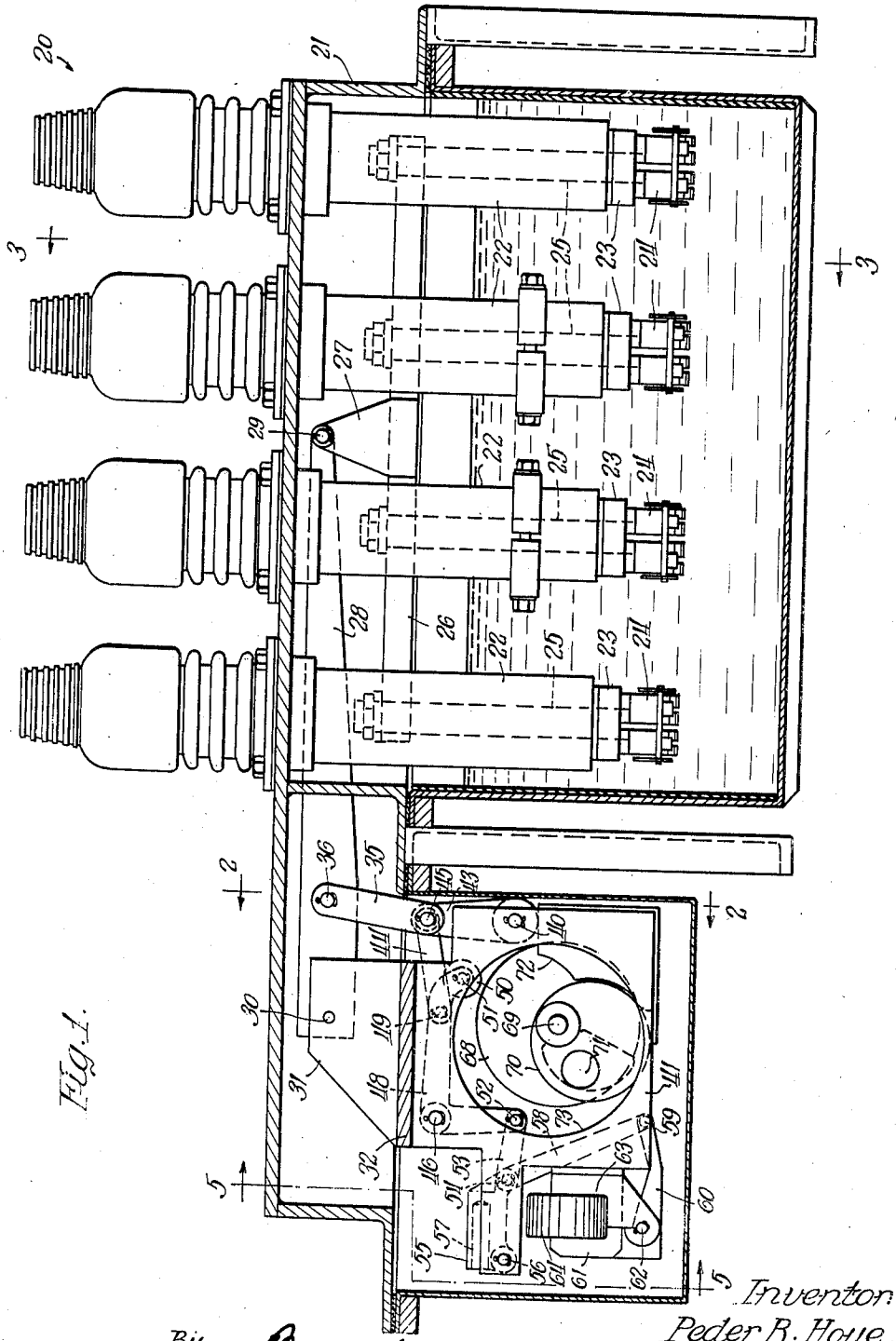


Fig. 1.

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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

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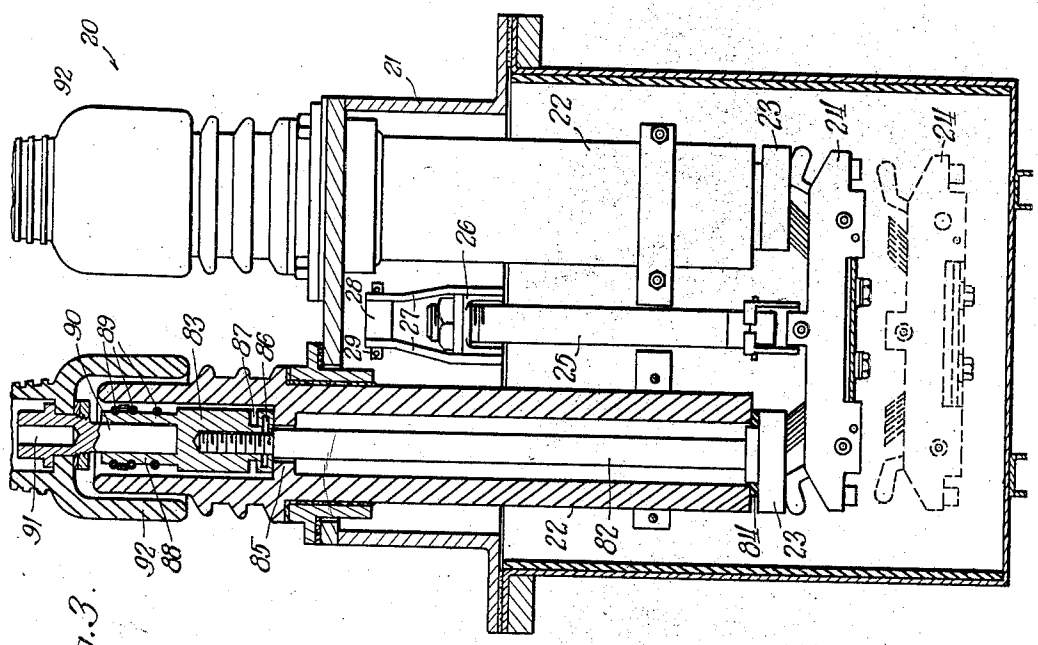


Fig. 3.

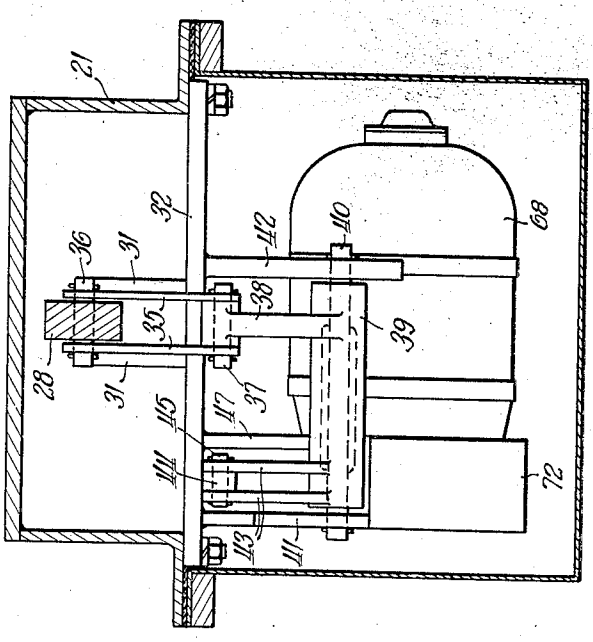


Fig. 2.

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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

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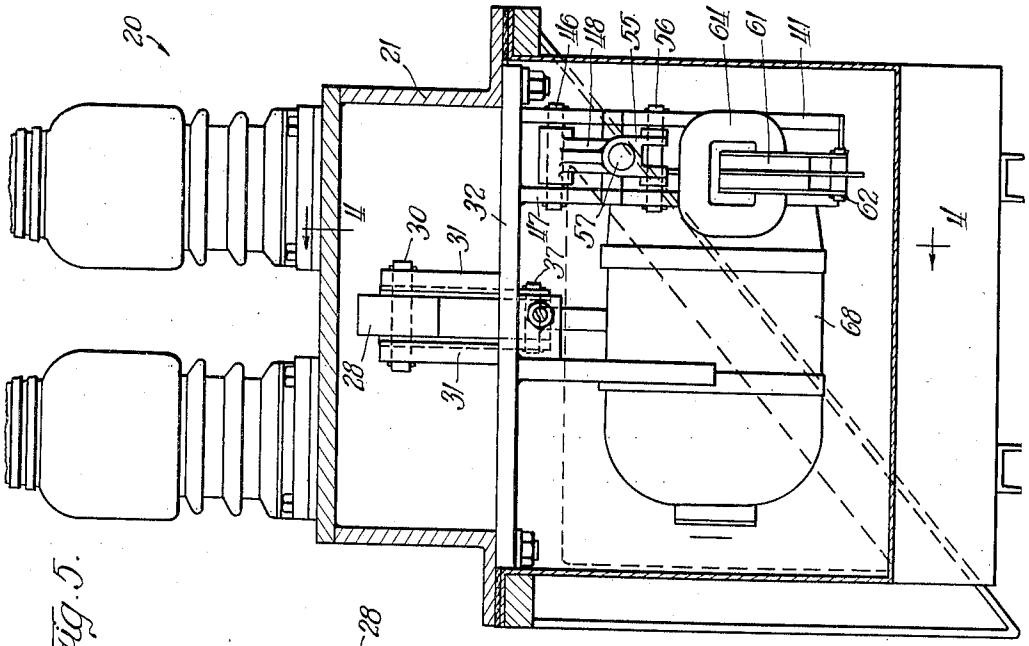


Fig. 5.

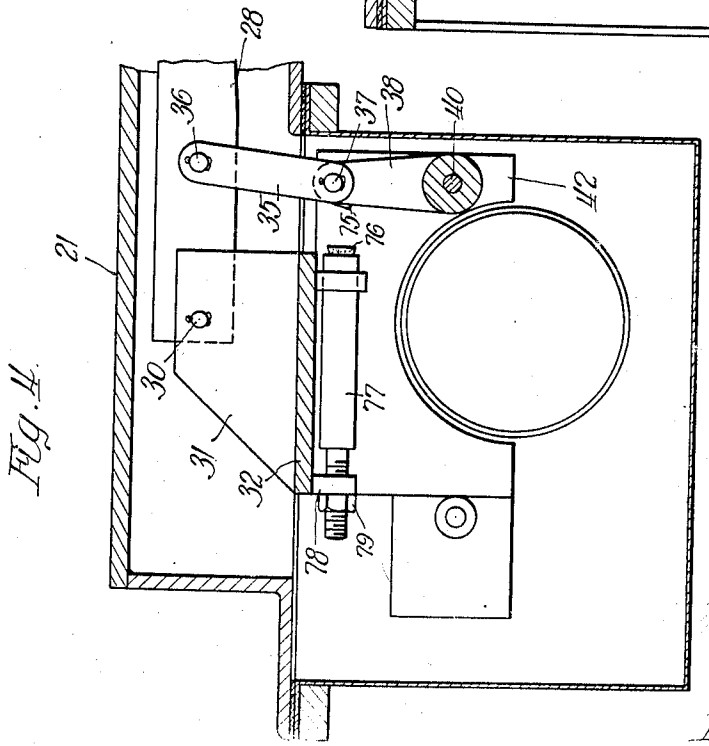


Fig. 4.

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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 4

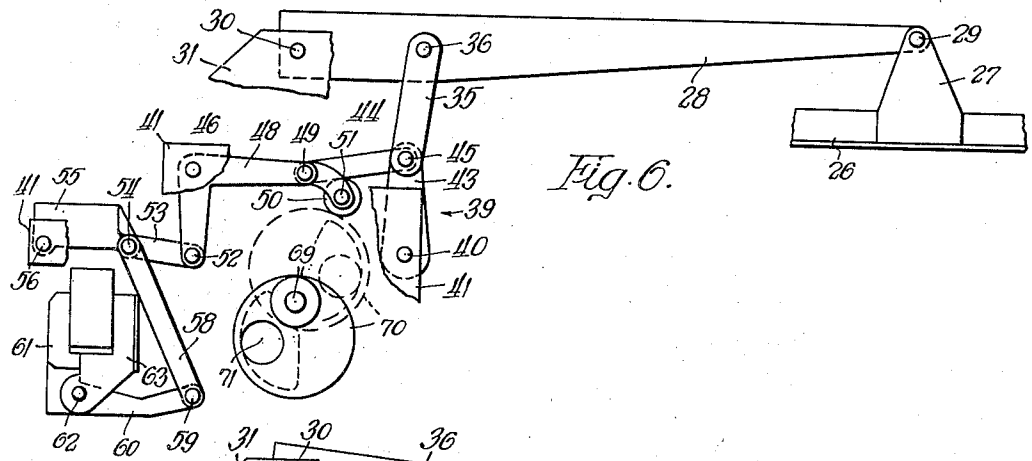


Fig. 6.

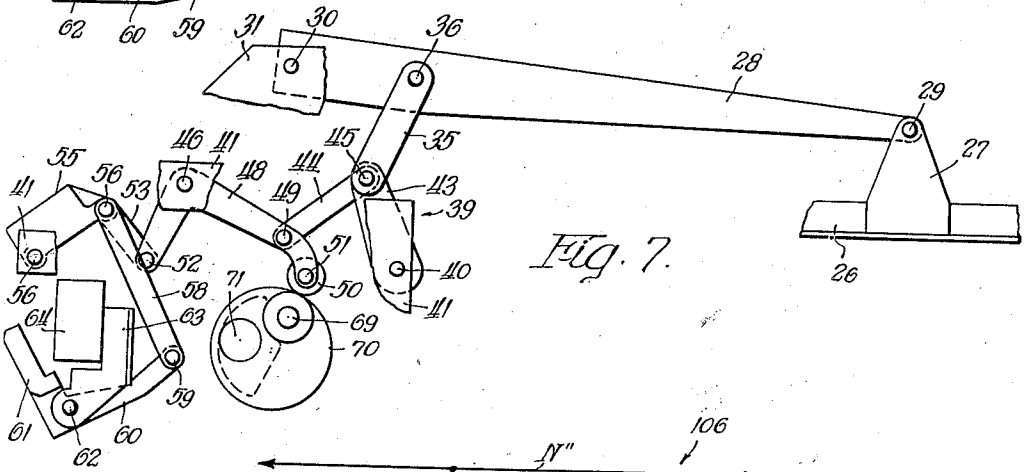


Fig. 7.

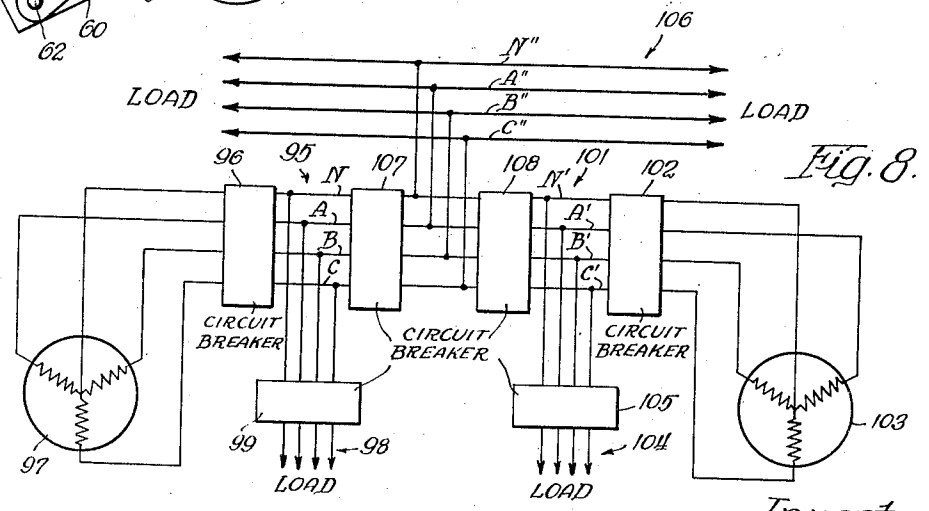


Fig. 8.

Inventor:
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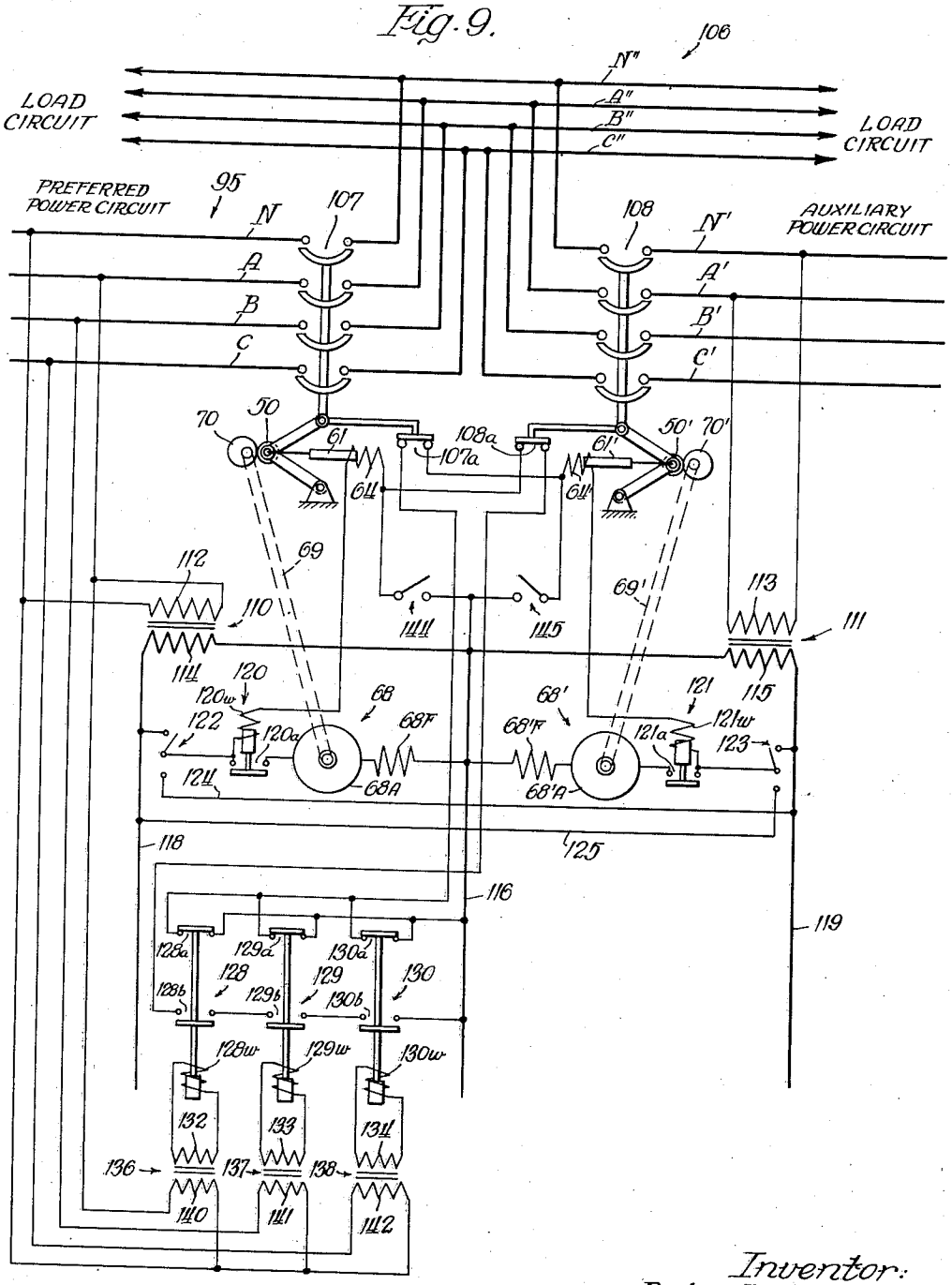
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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 5

Fig. 9.



Inventor:
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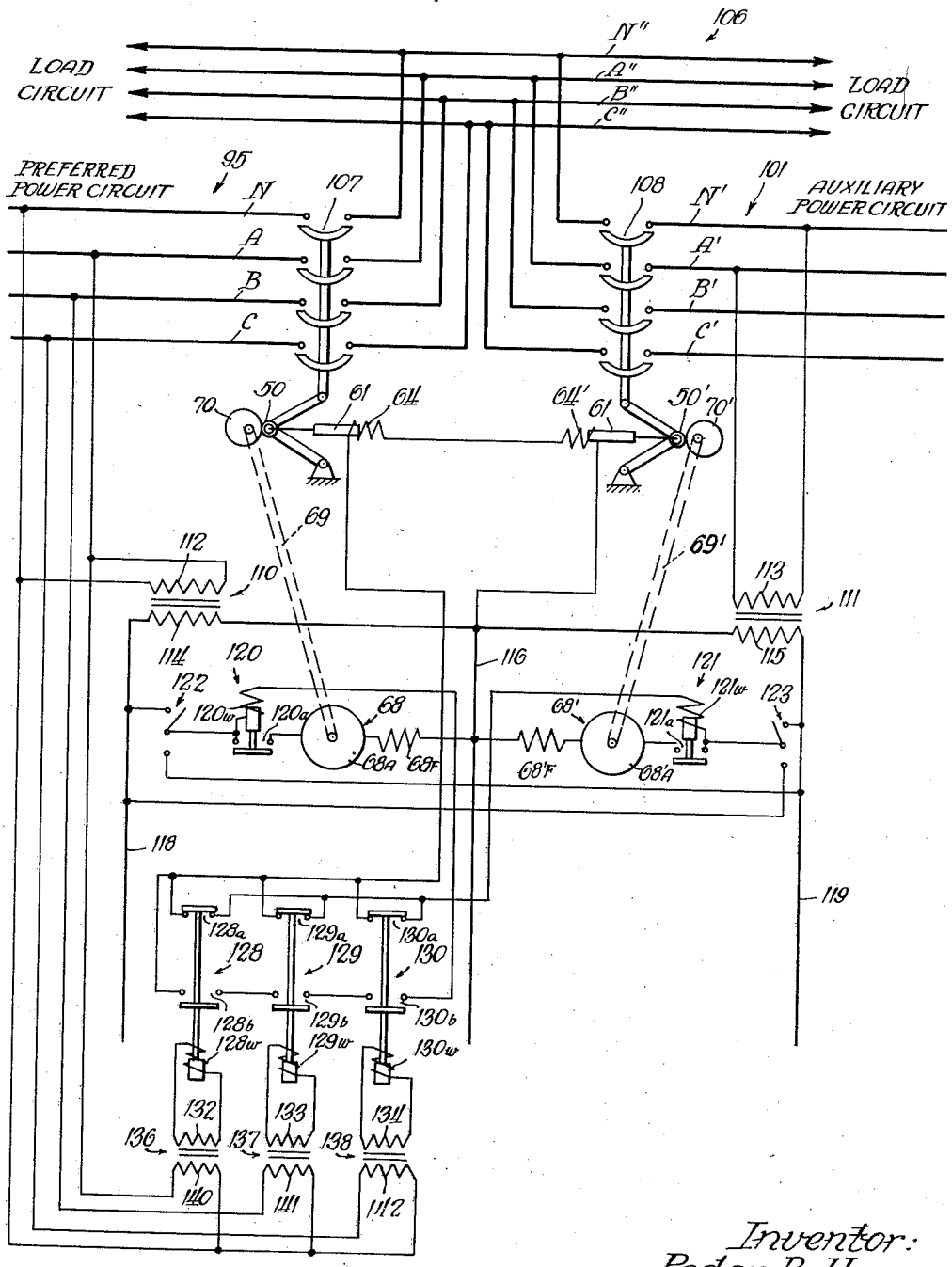
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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 6

Fig. 10.



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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 7

Fig. 11.

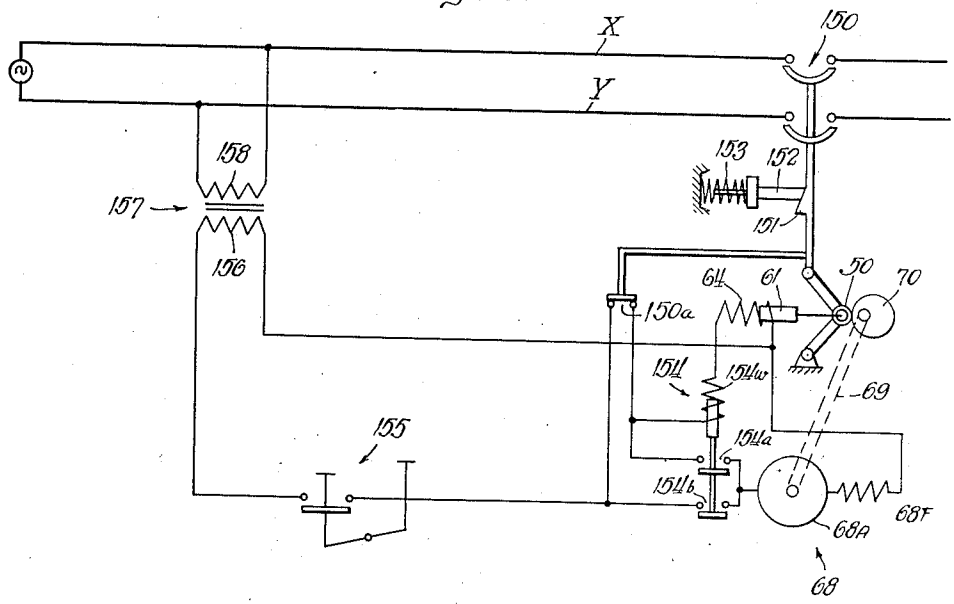
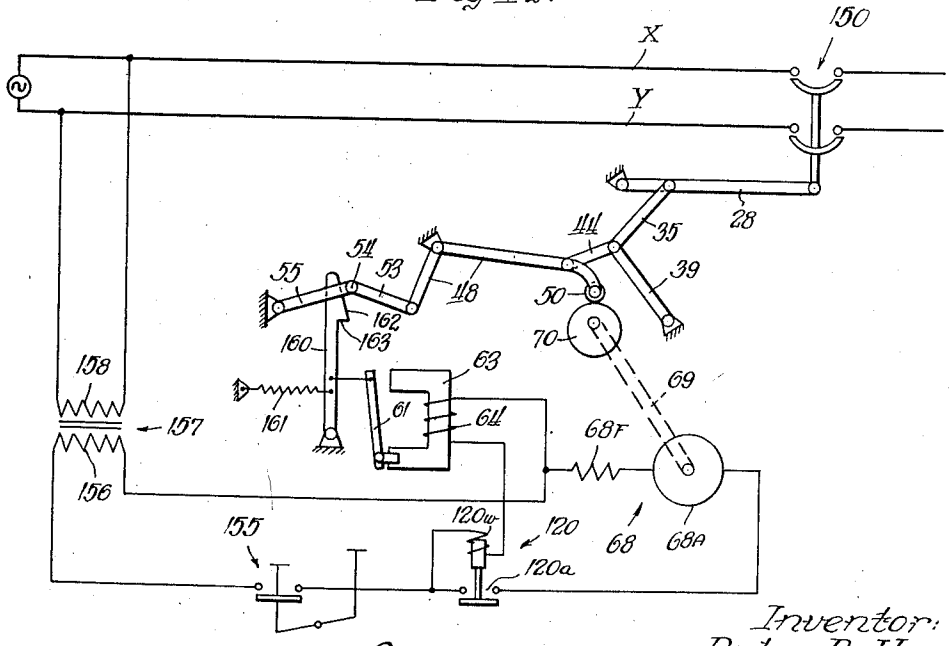


Fig. 12.



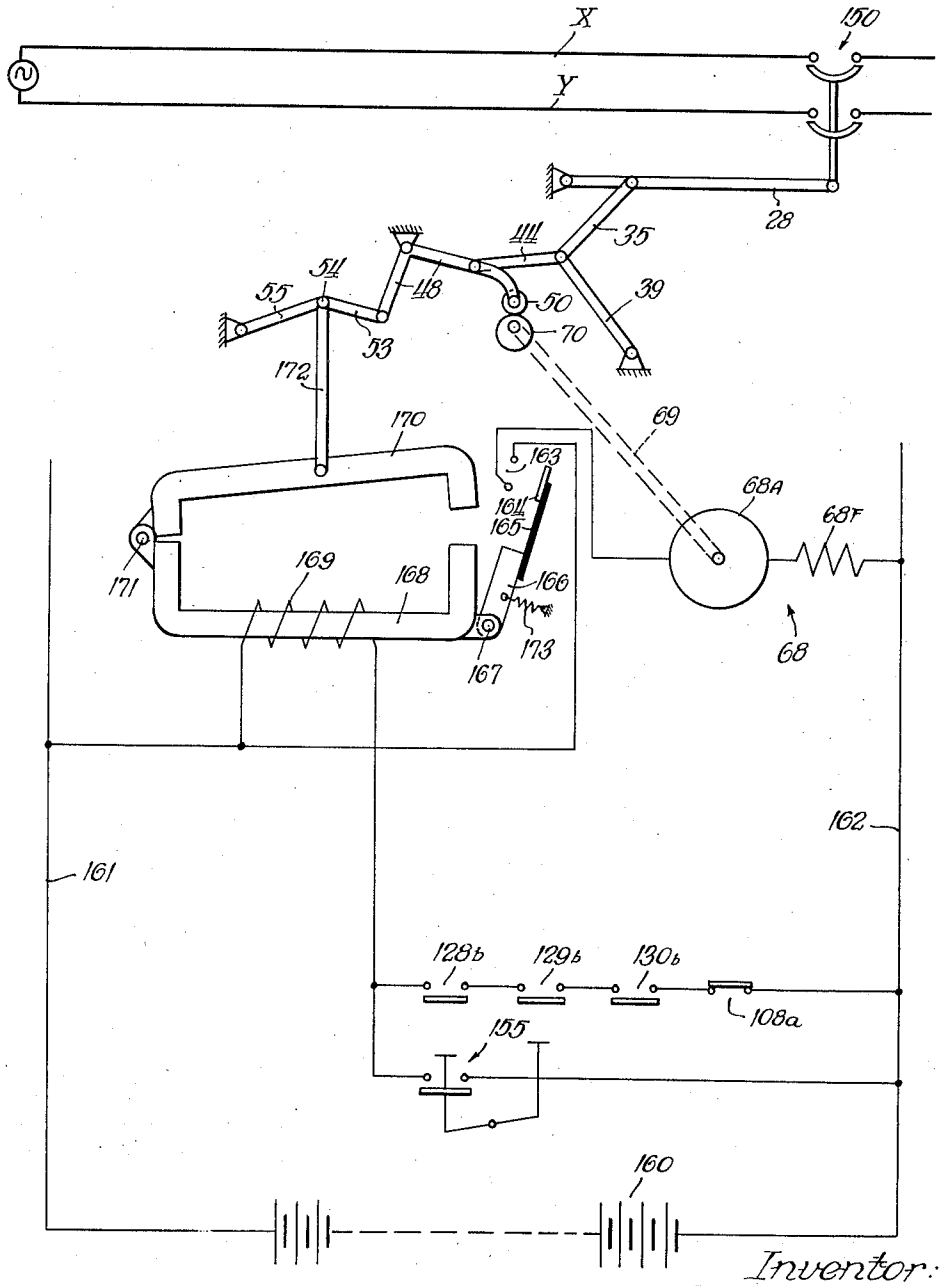
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CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 8

Fig. 13.



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Dec. 17, 1940. P. B. HOYE 2,225,055

CIRCUIT INTERRUPTING MEANS

Filed Feb. 1, 1937 9 Sheets-Sheet 9

Fig. 14.

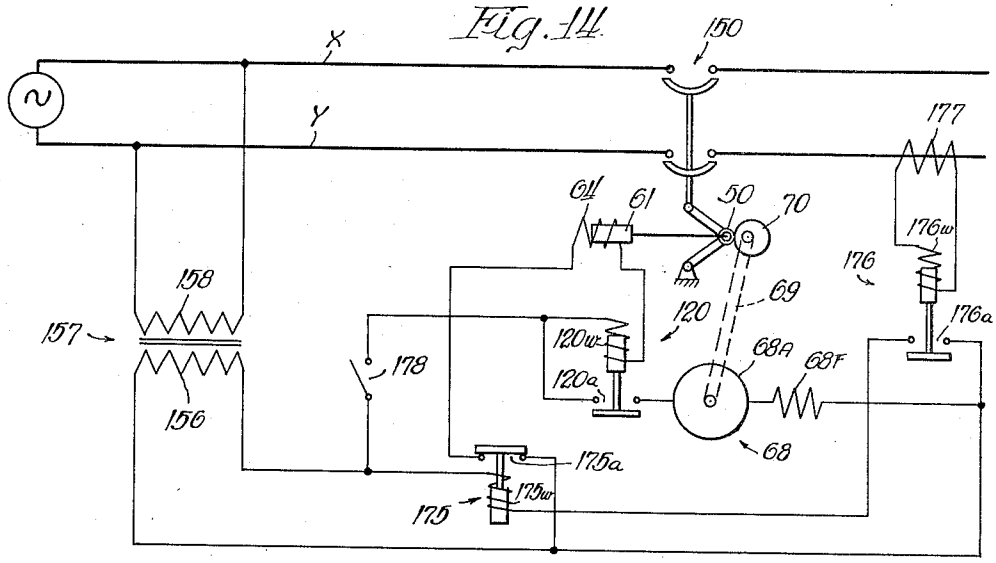
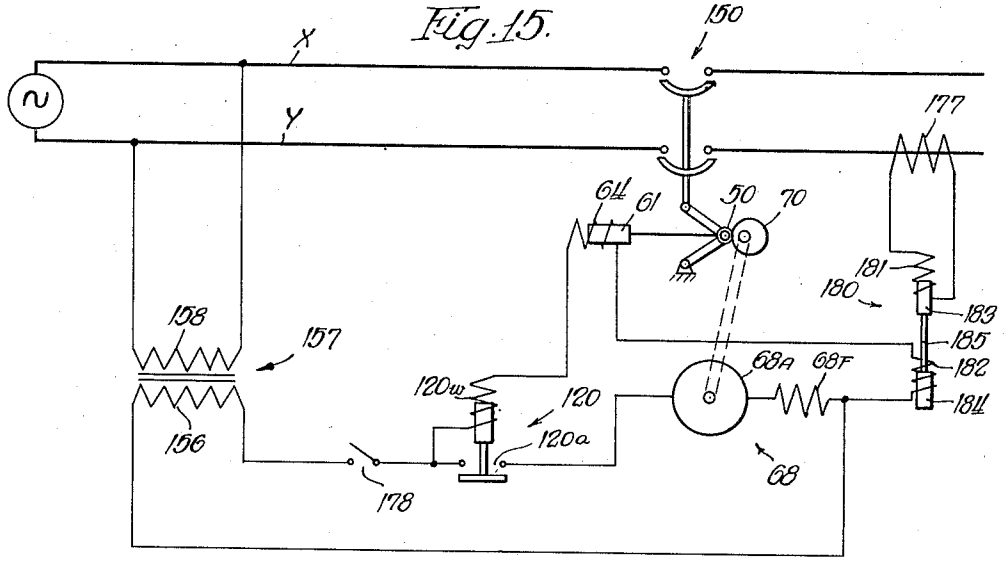


Fig. 15.



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Patented Dec. 17, 1940 2,225,055

UNITED STATES PATENT OFFICE

2,225,055

CIRCUIT INTERRUPTING MEANS

Peder B. Hoye, Maywood, Ill., assignor to Electrical Engineers Equipment Co., Melrose Park, Ill., a corporation of Illinois

Application February 1, 1937, Serial No. 123,325

11 Claims. (Cl. 175—294)

My invention relates, generally, to electric circuit interrupters or circuit breakers, and has particular relation to the construction and operation thereof.

In order to electrically close a circuit interrupter or circuit breaker, operating devices in the form of solenoid mechanisms and electric motor mechanisms are employed. The solenoid mechanisms are provided with armatures, while the motor mechanisms are arranged to operate either directly or through suitable reduction gearing. On energization of one of these mechanisms, the contact members of the circuit breaker are operated to the closed position through a suitable linkage and they are held in this position by various types of latching or holding devices. On release of the latching or holding device, the contact members are permitted to move to the open position under the biasing force of gravity or of suitable springs or weights, or a combination of these biasing forces in order to quickly extinguish any arcs that may be drawn by separation of the contact members while carrying current.

Accordingly, the object of my invention, generally stated, is to provide a circuit interrupter or circuit breaker and operating means therefor which shall be simple and efficient in operation, and which may be readily and economically manufactured and installed.

It is necessary to provide some means for deenergizing the operating device on closure of the circuit breaker. However, it is equally essential to maintain the operating device energized until the circuit breaker is operated to the fully closed position where it can be held closed by the latching or holding device. When it is recalled that the circuit breaker is closed with considerable force by the operating device and severe shocks and vibrations result, it will be appreciated that a rugged and reliable cut-off mechanism must be provided to effect the deenergization of the operating device at the proper time.

In view of these requirements, an important object of my invention is to provide for deenergizing the operating device employed for closing a circuit breaker at the proper instant when the circuit breaker is operated to the closed position, and which shall not require close adjustment.

Another important object of my invention is to provide for deenergizing the operating device of a circuit breaker at the proper instant without opening the control circuit therefor.

Another important object of my invention is to combine the cut-off mechanism of a circuit breaker with the holding or latching mechanism in such manner as to deenergize the operating device used for moving the contact members of the circuit breaker toward the closed position at the proper instant and to effect the final movement of the contact members by the cut-off mechanism, thereby rendering unnecessary an exact timing of the deenergization of the operating device.

In many industrial applications of electric power, the continuity of power supply is of utmost importance. In the event of a failure of the power supply, valuable time may be lost through the enforced shut-down of electrically driven machines and the like. Also, in some industries, such as those in which electric heating devices and electric furnaces are used, a failure of power supply may cause a loss in material being processed or such change in the material being processed as to render it worthless. In such installations, an auxiliary or emergency power circuit is provided to which the load circuit can be transferred on failure of the main or preferred power circuit. Therefore, another object of my invention is to provide for quickly and automatically transferring a load circuit from a preferred power circuit to an auxiliary power circuit on the occurrence of a fault, such as failure of power, on the preferred power circuit.

A further object of my invention is to provide for automatically transferring the load circuit back to the preferred power circuit as soon as the fault on it is removed.

Still another object of my invention is to interlock the control circuits of the circuit breakers employed to effect this transfer in such manner as to prevent the simultaneous closure thereof.

A further object of my invention is to interlock the holding or latching and cut-off devices of the circuit breakers in such manner as to prevent this simultaneous operation.

Where transfer circuit breakers are provided for connecting a load circuit to an auxiliary power circuit when the main or preferred power circuit fails, it may be desirable in some cases to interconnect the main and auxiliary power circuits. The auxiliary power circuit may form a part of a power system to which other load circuits may be connected. On failure of power on the auxiliary circuit, these load circuits are, of course, deenergized. However, they can be energized by simultaneously operating both of the circuit breakers which normally are employed for transferring the main load circuit from the main

power circuit to the auxiliary power circuit. The reverse operation may also be true and it may be desirable to supply power to the main power circuit from the auxiliary power circuit by a simultaneous operation of both of these circuit breakers.

Thus, another object of my invention is to provide for automatically transferring a load circuit from a main to an auxiliary power circuit on failure of the main power circuit for example, and for interconnecting the two power circuits under certain operating conditions.

On the occurrence of a fault on a power circuit, such as a short circuit, the circuit breaker which is provided for connecting it to a power source is immediately opened by suitable fault responsive relays to clear the system of the fault. Operating experience indicates that faults of this nature are temporary, and clear themselves in most cases within a very short time. The circuit breaker can, therefore, be immediately reclosed and continuity of power substantially maintained despite its temporary interruption. In such case it is highly desirable that the circuit breaker be immediately reclosed with a minimum outage time for the circuit. This time is comparatively short and is of the order of a fractional part of a second or a few cycles, for example three or four, in a 60-cycle system.

Therefore, a further object of my invention is to immediately reclose a circuit breaker that has been opened because of the occurrence of a fault on the circuit in which it is connected.

Another object of my invention is to open the energizing circuit of a variable impedance device, that is used to control the functioning of a circuit breaker operating device and to hold it closed, upon the occurrence of a fault to immediately initiate the reclosure of the circuit breaker within a fractional part of a second.

As set forth hereinbefore, when a circuit breaker is closed, a considerable shock is experienced when the movable contact members are operated to the closed position. The fixed or stationary contact members, cooperating therewith, are ordinarily mounted in tubular insulators which, in turn, are mounted in the circuit breaker housing. Rod-like conductor members extend through the tubular insulators to connect the stationary contact members with external bushings and the external circuits. Considerable difficulty has been experienced in obtaining a satisfactory means for securely holding the rod-like conductors in the insulators because of the shock and vibrations that are set up on closure of the circuit breaker.

Therefore, an ancillary object of my invention is to provide a resilient connection in the external bushing nut between it and the insulator in engagement therewith.

Other objects of my invention will, in part, be obvious and in part appear hereinafter.

My invention, accordingly, is disclosed in the embodiments thereof shown in the accompanying drawings, and it comprises the features of construction, combination of elements and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of my invention, reference may be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a view, in side elevation, of my novel circuit interrupter and operating mechanism therefor, the housing being shown in section;

Figure 2 is a detail sectional view, taken generally on the line 2—2 of Figure 1;

Figure 3 is a sectional view, taken along the line 3—3 of Figure 1;

Figure 4 is a detail sectional view, taken along the line 4—4 of Figure 5, the motor being shown in outline only;

Figure 5 is a sectional view taken along the line 5—5 of Figure 1;

Figures 6 and 7 show different operating positions of the linkage that is employed in interconnecting the motor and the movable contact members of the circuit breaker;

Figure 8 illustrates, diagrammatically, the general arrangement of my novel reclosing circuit breaker system and connections for simultaneously operating both of these circuit breakers to provide an interchange of power between the main and the auxiliary power circuits;

Figure 9 illustrates, diagrammatically, the circuit connections that may be employed in practicing my invention in conjunction with the circuit diagram shown in Figure 8;

Figure 10 illustrates, diagrammatically, a modified circuit arrangement for controlling the transfer system which may be employed in lieu of the circuit connections shown in Figure 9;

Figures 11 and 12 illustrate, diagrammatically, modified arrangements of my novel circuit interrupting means;

Figure 13 illustrates, diagrammatically, how my invention may be embodied in a control system that is energized with direct rather than alternating current; and

Figures 14 and 15 illustrate the novel features of my circuit interrupter as applied to a reclosing circuit breaker system.

According to my invention, I provide for closing a circuit breaker through a suitable linkage by means of a torque motor that is arranged to operate through a partial revolution. It will be understood, however, that other suitable energy translating devices may be employed instead of a torque motor. Since a preferred embodiment of the invention employs a motor of this type, the functioning of my novel circuit interrupter will be set forth in connection therewith.

The torque motor is energized by operation of a suitable control relay which serves to connect it for energization to a suitable current source, such as a source of alternating current. The winding of the control relay is connected for energization through a winding on a core that has associated therewith an armature which is connected to the linkage and moves together with the movable contact members of the circuit breaker. When the circuit breaker is in the open position, the armature is positioned away from the core, and therefore, the impedance of the winding thereon is relatively low. On energization of the relay winding and the winding on the core connected in series circuit relation therewith from a source of alternating current, the control relay is first operated to effect the energization of the torque motor. As the armature approaches the core, the impedance of the winding thereon increases until, at the time that the circuit breaker is closed, the current flowing therethrough and through the relay winding is insufficient to maintain the relay in the operated condition. As a result, the torque motor is deen-

ergized. Sufficient current, however, continues to flow through the winding on the core to hold the armature in engagement therewith. The circuit breaker is thus held in the closed position as long as the winding on the core remains energized. As soon as this winding is deenergized, the armature is no longer attracted to the core, and the movable contact members of the circuit breaker are released for operation to the open position.

Generally speaking, the armature and core, and the winding thereon perform three functions. As the movable contact members approach the closed position, the attraction of the armature to the core is sufficient to effect the final movement thereof, and thus the torque motor is relieved of operating them to the final position. It is, therefore, unnecessary to provide an exact control for the time when the torque motor is deenergized. The second function that is performed is the holding of the circuit breaker in the closed position until the winding on the core is deenergized. The third function is the deenergization of the relay winding to such an extent that its contact members are opened to disconnect the torque motor from its energizing source. It will now be obvious that I have provided a simple and efficient means for controlling the functioning of a circuit interrupter which does not depend for its operation upon the opening of carefully positioned limit switches and the functioning of mechanical latches to deenergize the circuit breaker operating mechanism and to hold it in the closed position.

Various embodiments of the foregoing generally described circuit breaker or circuit interrupter will be presently set forth, together with an indication of the manner in which my invention may be employed in connection with a system for transferring automatically a load circuit from a main power source to an auxiliary power source in the event of a fault on the main power source. In addition, my invention will also be illustrated in connection with a reclosing circuit breaker system that is employed for immediately reconnecting a circuit to a power source after a temporary fault thereon has been cleared.

Referring now particularly to Figures 1, 2, 3, 4, and 5, it will be observed that the reference character 20 designates, generally, a circuit interrupter having a housing 21 through the upper side of which insulator bushings or tubes 22 extend for supporting stationary contact members 23 in insulated spaced relation. A four pole circuit breaker has been illustrated for use in connection with a three phase four-wire circuit, but it will be understood that my invention may be practiced by using a circuit breaker having a different number of poles for connection in a different circuit. Movable contact members 24, carried by rods 25 of insulating material, are provided to bridge the pairs of stationary contact members 23. The rods 25 are carried by a common support member 26 which is channel-shaped, and to which is secured a pair of upstanding ears 27 between which a lever 28 is positioned and secured thereto by a pin 29. The other end of the lever 28 is secured by a pin 30 between a pair of support plates 31 that are suitably secured to the upper surface of a top plate 32, which in turn is suitably mounted in the housing 21. The contact members 24 are arranged to move to the position shown by the broken lines in Figure 3 of the drawings under the influence of gravity, and are arranged to be operated into engagement with the stationary contact members 23 by movement of the lever 28 about the pin 30 as a fulcrum by means which will be presently described.

In order to move the lever 28 upwardly about the pin 30 as an axis, a pair of toggle joints is provided. An additional toggle joint is provided for cooperating with the first two toggle joints to hold the movable contact members 24 in the closed position. These toggle joints comprise what may be generally described as a linkage.

The first toggle joint includes a pair of flat links 35 that are secured to the lever 28 by a pin 36 at one end. At the other end the links 35 are secured by a pin 37 to an arm 38 of a cast steel operating member 39 which is rotatably mounted on a transverse shaft 40 that extends between frame plates 41 and 42 that are secured to and depend from the top plate 32, as illustrated more clearly in Figure 2 of the drawings. Integrally formed with the operating member 39 is a pair of arms 43 between which a link 44, forming a part of the second toggle joint, is secured by a pin 45. Pivotally mounted on a pin 46, extending between the frame plate 41 and a frame plate 47 depending from the top plate 32, is a bellcrank 48, one arm of which forms the complementary part of the second toggle joint. The bellcrank 48 comprises a pair of spaced arms between which one end of the link 44 is positioned and secured thereto by a pin 49. A roller 50 is mounted on a pin 51 extending through the two members forming the bell crank 48 for a purpose which will be presently set forth.

By means of a pin 52, the third toggle joint is connected to the other arm of the bellcrank 48. This toggle joint comprises a link 53 which is secured by a pin 54 to a socket member 55 that, in turn, is pivotally mounted on a pin 56 extending between the frame plates 41 and 47. The socket member 55 is provided with a socket 57 into which an operating lever may be inserted for manually operating the circuit breaker.

With a view to holding the circuit breaker in the closed position, a link 58 is connected at one end to the pin 54 of the third toggle joint, and, at the other end, by a pin 59 to the tail piece 60 of an armature 61 which is pivotally mounted on a pin 62 that is carried by a core 63. The core 63 is mounted on the frame 21 in any suitable manner, and has provided thereon a holding winding 64 which, on energization, serves to attract the armature 61 to the core 63. However, the force that is exerted by the holding winding 64 is not sufficient to attract the armature 61 to operate the movable contact members 24 to the closed position from the full open position, but it is sufficient to effect the final closure thereof and to hold them closed when the armature 61 is in close proximity to the core 63. Therefore, it will be understood that the armature 61 is movable through the agency of the three toggle joints, together with the movable contact members 24.

As illustrated in Figure 1 of the drawings, the circuit breaker 20 is in the closed position. In this position, the third toggle joint comprising the link 53 and the socket member 55 are nearly in alignment. That is, the pins 52, 54 and 56 are very nearly positioned in a straight line. Therefore, the force that is required to be exerted by the armature 61, as attracted by the winding 64, is only that which is necessary to provide the slight component of the total force that is required to hold the movable contact members

24 in the closed position. Moreover, when the holding winding 64 is deenergized, this slight component of force no longer exists, and the third toggle joint is no longer restrained. The movable contact members 24 are then free to move to the open circuit position.

The movable contact members 24 are operated toward the stationary contact members 23 initially by a motor 68 that is suitably mounted in the frame 21. The motor 68 is preferably a torque motor of the series type, the shaft 69 of which is rotated only through a partial revolution to effect the movement of the contact members 24 from the open to the closed position. Mounted on the shaft 69 and for rotation therewith is a cam member 70. As illustrated, the cam member 70 is circular in outline and is eccentrically mounted on the shaft 69. A cut-away section 71 is provided in the body of the cam member 70 in order to so position the center of gravity of the cam member that it will be readily biased by gravity to the position shown in Figure 1 of the drawings as soon as the motor 68 is deenergized. A rubber bumper 72 is provided with a suitably curved surface, and is positioned in the path of movement of the cam member 70 as it is restored to its normal position to cushion the shock. The external surface of the cam member 70 is arranged to engage the roller 50 for operating the circuit breaker to the closed position. A circular opening 73 is provided in the frame plate 41 to permit inspection and adjustment of the linkage and the various parts cooperating therewith.

In Figures 6 and 7 of the drawings, I have illustrated the positions to which the linkage interconnecting the motor 68 and the movable contact members 24 is operated. Figure 6 shows the linkage with the circuit breaker closed, and Figure 7 shows the linkage with the circuit breaker opened. In the latter position, it will be observed that the roller 50 is in engagement with the outer surface of the cam member 70 that is closest to the shaft 69. When the motor 68 is energized and the shaft 69 rotates in a clockwise direction carrying with it the cam member 70, the roller 50 is moved upwardly, thereby moving the second toggle joint formed by the link 44 and one arm of the bellcrank 43 toward its position as shown in Figure 6 of the drawings. At the same time, the first toggle joint formed by the links 35 and the operating member 39 is moved to the right to lift the lever 29. When the cam member 70 is rotated to the position indicated by the broken lines in Figure 6 of the drawings, the pins 45, 49 and 46 will nearly be in alignment as will be the pins 36, 45 and 49. Thus, only a small component of force is required to be exerted by the third toggle joint comprising the link 53 and the socket member 55 to hold the movable contact members 24 in the closed position.

By means which will be presently described, the motor 68 is deenergized as the cam member 70 approaches the position shown by the broken lines, and the cam member 70 returns to its original position under the influence of gravity and is stopped by the rubber bumper 72. As long as the winding 64 remains energized and the third toggle joint is restrained by the armature 61, the circuit breaker will remain in the closed position. On deenergization of the holding winding 64, the armature 61 will be released, as previously set forth, thereby releasing the linkage and permitting the circuit breaker to be operated to the open position under the influence of gravity and under the influence of biasing springs, if such springs are employed.

With a view to limiting the travel of the movable contact members 24 in the open position, a boss 75 is provided on the upper end of the arm 38, as illustrated more clearly in Figure 4 of the drawings, and it is arranged to engage a wooden plug 76 that is carried at the right hand end of an adjustable stop member 77. The left hand end of the stop member 77 is threaded into a suitable lug 78 that depends from the top plate 32 and is secured in the desired position by a lock nut 79. If it is desired to hold the circuit breaker in the closed position while the operating mechanism is being repaired or adjusted, the lock nut 79 can be loosened and the stop member 77 rotated until the plug 76 engages the boss 75 in its position as shown in Figure 4. The holding winding 64 may then be deenergized without opening the circuit breaker.

As indicated hereinbefore, a considerable shock is experienced by the stationary contact members 23 on engagement therewith by the movable contact members 24. As a result of repeated impacts, the sealed connection between the stationary contact members 23 and the lower ends of the insulator bushings 22 may be broken. Moisture may then be permitted to enter the interior of the housing 21 and to contaminate the oil therein which surrounds the contact members and in which arcs are drawn when the circuit is opened under load. In order to insure that the sealed connection will not be broken, the construction illustrated more clearly in Figure 3 of the drawings has been provided.

As illustrated in Figure 3, one of the insulator bushings 22 has been shown in section. The stationary contact member 23 has connected thereto a rod-like conductor 82 that extends upwardly through the bushing 22 and has threaded on its upper end a bushing nut 83. A gasket 84 of a suitable compressible material is positioned between the lower end of the bushing 22 and the upper surface of the stationary contact member 23. As originally installed, the bushing nut 83 is turned on the upper end of the conductor 82 against a flange 85, integrally formed near the upper end of the bushing 22, compressing the gasket 84 and providing the desired sealed connection.

If the bushing nut 83 is formed as a solid member of copper and internally threaded, the desired sealed connection will be provided, merely by tightening the bushing nut 83. However, after the stationary contact member 23 has been subjected to several impacts during operation, the gasket 84 becomes further compressed, and no corresponding tightening action takes place with respect to the nut 83 unless it is manually tightened. As a result, the sealed connection may be broken and moisture may enter as previously described.

With a view to automatically taking up this slight slack that is caused by the compression of the gasket 84, I have modified the lower end of the bushing nut 83 by providing an internal groove 86 near the lower end, and an external groove 87 immediately thereabove by a suitable turning operation. A certain degree of flexibility and resiliency is now provided in the lower end of the bushing nut 83 while still maintaining a complete engagement with the upper surface of the flange 85. When the bushing nut 83 is originally installed, it is tightened with sufficient effort

to compress the resilient lower end thereof slightly. Sufficient resiliency is thereby provided to maintain the sealed connection despite repeated impacts on the stationary contact members 23.

It will be observed that the upper end of the bushing nut 83 is provided with a plurality of integrally formed fingers 88 that are surrounded by garter springs 89. A plug-like terminal member 90 is provided for interfitting between the fingers 88. A suitable opening 91 is provided in the plug member 90 into which a circuit conductor may be secured, as by soldering, as will be readily understood. An insulator sleeve 92 surrounds the plug member 90, and extends over the upper end of the insulator bushing 22, as illustrated.

Thus far I have described in detail the construction and functioning of a circuit breaker which operates as a single unit. It will be understood that the circuit breaker may be arranged for individual operation in conjunction with a suitable control mechanism, and that it may be arranged to function in connection with a second circuit breaker of like construction for transferring a load circuit for energization from a main or preferred power circuit to an auxiliary or emergency power circuit. The latter type of arrangement will first be described with a view to illustrating the novel features of my invention as applied to such a system.

When it is desired to insure a continuity of power on a load circuit, it is customary to provide an alternate or emergency power circuit in addition to the main or normal power circuit and to provide the necessary switching devices for automatically transferring the load circuit from one power supply to the other as the case may be. The auxiliary or emergency supply circuit may form a part of a single generating system, and it may be so arranged that it would be unaffected by the occurrence of a fault on the main power circuit. Again, the auxiliary power circuit may be energized from an entirely separate source of power for the purpose of insuring the highest degree of reliability.

For the purposes of description, the alternate power circuit is described as an emergency or auxiliary power circuit. However, this circuit may be employed to supply other loads during the normal course of operation. In like manner, the main or normal power circuit may also be employed to supply other loads than the particular load under consideration which may be supplied from either power circuit. On the failure of power on either of these circuits, it may be desirable to provide for so operating the transfer switching equipment that either circuit may be energized from the other one so that all of the load circuits connected thereto may be energized. For this purpose I have provided the circuit arrangement and system that is disclosed diagrammatically in Figure 8 of the drawings.

As shown in this figure, a preferred power circuit, shown generally at 95, is provided comprising a neutral conductor N and line conductors A, B and C. While a three phase four-wire system is illustrated herein, it will be understood that other types of systems come within the scope of my invention. The preferred power circuit is connected by a circuit breaker 96 to a polyphase generator 97 which is arranged to generate a commercial frequency, such as 60 cycles. A load circuit 98 is arranged to be energized from the preferred power circuit 95 on operation of a circuit breaker 99.

The auxiliary power circuit, shown generally at 101, and comprising a neutral conductor N' and line conductors A', B' and C', may be connected for energization by a circuit breaker 102 to a polyphase generator 103 that may be similar in its operating characteristics to the generator 97. A load circuit, shown generally at 104, may be energized by a circuit breaker 105 from the auxiliary power circuit 101.

The reference character 106 designates, generally, a common load circuit comprising a neutral conductor N'' and line conductors A'', B'' and C'' which are arranged to be connected to the corresponding conductors of the preferred power circuit 95, or of the auxiliary power system 101 by the operation of circuit breakers 107 and 108.

The circuit breakers 96, 99, 102 and 105 may be of the type disclosed herein, or they may be of any other suitable type, well known to those skilled in the art. The circuit breakers 107 and 108 are preferably constructed as disclosed herein and controlled in the manner which will be presently set forth.

Under normal operating conditions, the common load circuit 106 will be energized from the preferred power circuit 95 as energized by the generator 97. For this purpose the circuit breakers 96 and 107 will be closed. In addition, the load circuit 98 will be energized when the circuit breaker 99 is closed. The load circuit 104 will be energized from the auxiliary power circuit 101 when the circuit breakers 102 and 105 are closed.

Assuming now that some fault occurs in the generator 97 or the circuits connected thereto that may be cleared by opening the circuit breaker 96, the preferred power circuit 95 will be deenergized and the circuit breaker 107 will be automatically opened and the circuit breaker 108 will be automatically closed to transfer the common load circuit 106 for energization to the auxiliary power circuit 101. If no further operation takes place, the load circuit 98 will be deenergized because of the deenergization of the preferred power circuit 95. However, if means are provided for closing the circuit breaker 107, which forms a part of the automatic transfer system, this load circuit 98 can still be energized, in this case, from the generator 103. In like manner, on failure of the generator 103, the circuit breaker 108 may be operated to maintain power on the auxiliary power circuit 101 and to energize the load circuit 104. Thus, it will be observed that the transfer system may be arranged to serve a dual purpose; first, to maintain power on the common load circuit 106, and second, to maintain the load circuits connected to the preferred and auxiliary power circuits energized under certain operating conditions. It will be understood that the first function will be performed automatically while the latter function will be performed under manual control, since it is undesirable to interconnect the preferred and auxiliary power circuits when both of the generators 97 and 103 are operating because of the necessity of synchronizing them. However, as is well known to those skilled in the art, suitable synchronizing apparatus may be provided so that the generators 97 and 103 may be interconnected by operation of the circuit breakers 107 and 108, which form a part of the automatic transfer system. The control circuits for effecting the foregoing described operation of the circuit breakers 107 and 108 are illustrated in detail in Figure 9 of the drawings.

In this figure I have illustrated the circuit breakers 107 and 108 in diagrammatic form, together with the operating mechanism therefor, each of which is preferably constructed and arranged as shown in Figure 1 of the drawings and described hereinbefore. Insofar as practical, the same reference characters will be employed in order to indicate the various parts that are identical. The circuit breaker 107 is arranged to be closed by the series motor 68 having an armature 68A and a series field winding 68F. In like manner, the circuit breaker 108 is arranged to be operated to the closed position by a series motor 68' having an armature 68'A and a field winding 68'F. The motors 68 and 68' are arranged to be energized from power transformers 110 and 111 having primary windings 112 and 113 that are connected respectively for energization between the neutral conductor and one of the line conductors of the preferred and auxiliary power circuits 95 and 101. The secondary windings 114 and 115 of these transformers are commonly connected to a control bus 116, while the other terminals are connected to control busses 118 and 119. In one commercial embodiment of my invention, the secondary windings 114 and 115 are arranged to supply a control voltage of 220 volts. Of course other control voltages may be employed if desired.

In order to effect the connection of the motor 68 to the conductors 116 and 118, a control relay 120 is provided having an operating winding 120*w* and make contact members 120*a*. In like manner, a control relay 121 is provided for effecting the energization of the motor 68'. This relay is provided with an operating winding 121*w* and make contact members 121*a*. Single pole double throw switches 122 and 123 are provided for selectively connecting the motors 68 and 68' for energization to the control busses 118 and 119. When the switch 122 is operated to its upper position, the motor 68 will be energized from the conductors 116 and 118. When it is operated to its lower position, the motor 68 will be energized through conductor 124 from the conductors 116 and 119. Likewise, when the switch 123 is operated to its lower position, the motor 68' will be energized through conductor 125 from conductors 118 and 116.

With a view to interlocking the circuit breakers 107 and 108 for the purpose of preventing simultaneous operation thereof, auxiliary break contact members 107*a* and 108*a* are arranged to be operated therewith. When the circuit breakers 107 and 108 are in the open positions, these contact members are closed. However, on operation of one of these circuit breakers to the closed position, its auxiliary contact members are opened and the control circuit for effecting the energization of the other circuit breaker is normally held open.

As has been indicated hereinbefore, it is desirable to provide for automatically transferring the load circuit 106 from the preferred power circuit 95 to the auxiliary power circuit 101 in the event of a fault occurring on the preferred power circuit. This fault will ordinarily be of the nature of a loss of power on one or more of the phases. For the purpose of detecting the failure of voltage on one or more of the phases of the preferred power circuit 95, voltage relays 128, 129 and 130 are provided, each of which is individual to one of the phases, as indicated. Each of the voltage relays is provided with break contact members 128*a*, 129*a* and 130*a* which are connected in parallel circuit relation for a purpose which will be apparent hereinafter. These relays are also provided with make contact members 128*b*, 129*b* and 130*b*. These contact members are connected in series circuit relation for a purpose which will also be set forth hereinafter. Operating windings 128*w*, 129*w* and 130*w* are provided which are connected for individual energization to the secondary windings 132, 133 and 134 of potential transformers 136, 137 and 138, the primary windings 140, 141 and 142 of which are commonly connected for energization to the neutral conductor N and for individual energization from the line conductors A, B and C, as illustrated.

While voltage relays 128, 129 and 130 have been illustrated for connection to the preferred power circuit 95, it will be understood that a similar set of voltage relays may be provided and connected to the auxiliary power circuit 101 for the purpose of making this the preferred power circuit, if such operation is desired. However, since the illustration of these connections would mean merely a duplication of the connections already illustrated and described, and, further, since the connection thereof will be apparent to those skilled in the art, this additional feature has not been shown in detail herein.

For the purpose of interconnecting the preferred and auxiliary power circuits 95 and 101, control switches 144 and 145 are provided. When these switches are closed, as will be described hereinafter, the system will function as set forth hereinbefore in connection with the description of the circuit illustrated in Figure 8 of the drawings.

In describing the operation of the transfer system shown in Figure 9, it will be assumed that the preferred and auxiliary power circuits 95 and 101 are energized, and that the switches 122 and 123 are operated to their upper positions. It will also be assumed that the control switches 144 and 145 are in the open positions. Under these operating conditions, the windings of the voltage relays 128, 129 and 130 will be energized, thereby closing the make contact members 128*b*, 129*b* and 130*b*. The operating winding of the control relay 120 will then be energized to connect the motor 68 for energization across the control bus represented by the conductors 118 and 116 by the closure of contact members 120*a*.

The circuit for energizing the operating winding 120*w* of the control relay 120 may be traced from the energized conductor 118 through the switch 122, operating winding 120*w*, holding winding 64, break contact members 108*a* of the circuit breaker 108, and series connected contact members 128*b*, 129*b* and 130*b* to the energized conductor 116.

It will be recalled that the armature 61 is moved toward the core 63, Figure 1, and toward the holding winding 64 thereon when the motor 68 rotates the cam 70 to operate the toggle linkage by engagement with the roller 50. When the circuit breaker 107 is in the open position and the armature 61 is at its furthest position from the winding 64, the impedance of this winding will be a minimum, and consequently sufficient current will flow through it to energize the operating winding 120*w* of the control relay 120 and close the contact members 120*a*. As the circuit breaker 107 reaches the closed position, the impedance of the holding winding 64 gradually increases because of the movement

of the armature 61. On engagement of the armature 61 with the core 63, the impedance of the holding winding 64 increases to a much higher value, and consequently there is a decrease in the current flowing through it and through the series connected operating winding 120*w* of the control relay 120. While current still continues to flow through the winding 120*w*, it is not sufficient to hold the contact members 120*a* closed and, as a result, the motor 68 is deenergized. The control relay 120 is so constructed that a diminution in energizing current of 50% of the initial value will cause the contact members 120*a* to be opened. The variation in impedance of the holding winding 64 is such as to cause a decrease in the current flow therethrough of approximately 90% of the initial value. While the necessary change in its impedance is of the order of 1 to 2 to effect the deenergization of the control relay 120 to the necessary extent, it actually changes in the ratio of 1 to 10. These figures are taken from a commercial embodiment of my invention, but it will be understood that other ratios may be employed without departing from the scope of my invention.

As the armature 61 approaches the winding 64, sufficient force is exerted on the toggle linkage, as set forth hereinbefore, to effect the final closure of the circuit breaker 107. Therefore it is unnecessary to adjust with a high degree of accuracy the functioning of the control relay 120 in opening the energizing circuit for the motor 68. Furthermore, because of the arrangement and construction of the linkage between the armature 61 and the circuit breaker 107, only a very slight force need be exerted to hold it in the closed position. This force is provided by the greatly diminished current still flowing through the holding winding 64, as will be readily understood.

Since the holding winding 64 is energized from the preferred power circuit 95, it inherently operates as an under-voltage device that will automatically release the circuit breaker 107 for movement to the open position on decrease in voltage on the preferred power circuit 95 to a predetermined value. For the particular circuit connection shown, a decrease in voltage between the line conductor A and the neutral conductor N to a predetermined value will effect a sufficient deenergization of the holding winding 64 as to release the circuit breaker 107. While this control is not as sensitive as that which is provided by the voltage relays 128, 129 and 130, still use may be made of it if desired.

Assuming now that the voltage fails on one or more of the line conductors of the preferred power circuit 95, for example the line conductor B, the operating winding 129*w* of the voltage relay 129 will be deenergized, opening make contact members 129*b* and closing break contact members 129*a*. The previously traced energizing circuit for the holding winding 64 and the operating winding 120*w* of the control relay 120 will then be opened at contact members 129*b* and the circuit breaker 107 will be released for movement to the open position. At the same time at contact members 129*a* a circuit will be completed for effecting the energization of the operating winding 121*w* of the control relay 121 to complete an energizing circuit at its make contact members 121*a* for connecting the motor 68' for energization across the control bus comprising the conductors 116 and 119.

This circuit may be traced from the energized conductor 116 through contact members 129*a*, auxiliary contact members 107*a*, which will be closed when the circuit breaker 107 is operated to the open position, holding winding 64', operating winding 121*w*, and switch 123, to the energized conductor 119.

The circuit breaker 108 will be closed by the motor 68' in a manner similar to that described for the closure of the circuit breaker 107. In like manner, the current flowing through the operating winding 121*w* will be decreased as the circuit breaker 108 approaches the closed position, and the motor 68' will be deenergized. The circuit breaker 108 will be held in the closed position by the continued energization of the holding winding 64', even though the current flow therethrough is reduced to the minimum normal value.

It will now be obvious that as long as the circuit breaker 107 remains in the closed position, the previously traced circuit for effecting the closure of the circuit breaker 108 cannot be completed because the auxiliary contact members 107*a* are open. In like manner, as long as the circuit breaker 108 remains in the closed position, its auxiliary contact member 108*a* are open and the automatic operation of the circuit breaker 107 is prevented.

Assuming now that the line conductor B of the preferred power circuit 95 is again energized with the required voltage, the voltage relay 129 will be operated to open at contact members 129*a* the energizing circuit for the holding winding 64', and the circuit breaker 108 will be released for movement to the open position. At contact members 129*b* a circuit will be completed, as previously traced, for again effecting the operation of the circuit breaker 107 to connect the load circuit 106 for energization to the preferred power circuit 95.

If it is desired to effect the simultaneous operation of both of the circuit breakers 107 and 108, one or the other of the switches 144 or 145 may be closed, depending upon which one of the circuit breakers is already closed. Assuming that the circuit breaker 107 is closed and it is desired to close the circuit breaker 108, the switch 145 is closed to connect the holding winding 64' and the operating winding 121*w* of the control relay 121 for energization directly across the control bus formed by the conductors 116 and 119. This circuit is obvious and will not be traced. The closure of the circuit breaker 108 will take place as described hereinbefore.

In like manner, if the circuit breaker 108 is closed and it is desired to close the circuit breaker 107, the switch 144 may be closed. A circuit is then completed for directly energizing the operating winding 120*w* of the control relay 120 and the holding winding 64 from the conductors 118 and 116, thereby shunting the auxiliary contact members 108*a* of the circuit breaker 108 and the make contact members of the voltage relays 128, 129 and 130.

While I have shown a system in Figure 9 of the drawings for operating the circuit breakers 107 and 108 as an automatic transfer system, it will be understood that these circuit breakers may be arranged for independent operation. That is, the auxiliary contact members 107*a* and 108*a* may be omitted together with the voltage relays 128, 129 and 130. The circuit breakers 107 and 108 may then be operated independently under the control of the switches 144 and

145. In addition, as will be hereinafter set forth, suitable fault responsive relays may be provided for operating in conjunction with the circuits completed by the switches 144 and 145 to automatically open the circuit breakers 107 and 108 on the occurrence of a fault on the circuits in which they are connected.

It will now be apparent that when the holding winding 64, operating as a variable impedance device in conjunction with the armature 61, is used, no provision need be made for opening contact members when the circuit breaker controlled thereby reaches the closed position. It is unnecessary to take into consideration the effect of jars and vibrations on such contact members that are set up when the circuit breaker is closed. Moreover, it is unnecessary to provide complicated latch mechanisms that may be likewise affected by the shocks and jars, since the holding winding 64 operates not only as a cut-off mechanism but also as a holding mechanism, and at the same time it provides an added force for effecting the final closure of the circuit breaker associated therewith.

In Figure 10 of the drawings I have illustrated a modified circuit arrangement to provide the interlocking feature between the circuit breakers 107 and 108 without requiring the use of the auxiliary switches 107*a* and 108*a*. The interlocking feature is obtained by connecting the holding windings 64 and 64' in series circuit relation. The remaining circuit connections may be identical with those shown in Figure 9, except for the provision of the control switches 144 and 145.

In operation, assuming that the circuit breaker 107 has been closed, the impedance of the holding winding 64 will be so great that sufficient current would not be permitted to flow through the operating winding 121*w* of the control relay 121 to effect the energization of the motor 68'. In like manner, if the circuit breaker 108 is in the closed position, the impedance of the holding winding 64' is so high that sufficient current would not be permitted to flow through the operating winding 120*w* of the control relay 120 to effect the energization of the motor 68. The automatic transfer of the common load circuit 106 from the preferred power circuit 95 to the auxiliary power circuit 101 on the occurrence of a fault on the preferred circuit will take place as described hereinbefore, as well as the re-transfer to the preferred power circuit on removal of the fault therefrom.

It may be desirable to provide for mechanically latching a circuit breaker in the closed position that is operated to this position by the operating device described hereinbefore. For this purpose the circuit connections and construction illustrated in Figure 11 of the drawings may be employed. As there shown, a circuit breaker 150 is provided for connection in a circuit represented by the conductors X and Y. For the purposes of illustration only, a two pole circuit breaker is shown. The circuit breaker 150 may be operated to the closed position by the motor 68, which is arranged to rotate the cam 70 as described hereinbefore. The armature 61 and winding 64 associated therewith may also be provided, but in this embodiment of my invention, its holding function is not required.

The operating mechanism of the circuit breaker 150 may be provided with a tooth 151 that is arranged to cooperate with a pawl 152 as biased by a compression spring 153. When the circuit breaker 150 is operated to the closed position by the motor 68, the pawl 152 is positioned underneath the tooth 151 and holds the circuit breaker in the closed position. Obviously the circuit breaker 150 may be released by manually moving the pawl 152 from engagement underneath the tooth 151, or suitable electrical means may be provided for withdaawing it. The circuit breaker 150 is also provided with break contact members 150*a*, the function of which will presently be apparent.

The motor 68 may be controlled by a control relay, shown generally at 154, and which is provided with an operating winding 154*w* and make contact members 154*a* and 154*b*. A manually operable control switch 155 is provided for connecting the control mechanism for energization to the secondary winding 156 of a power transformer 157, the primary winding 158 of which may be connected for energization to the conductors X and Y.

In operation, the control switch 155 is closed, thereby completing an energizing circuit through the break contact members 150*a* for the operating winding 154*w* and the winding 64 from the secondary winding 156 of the transformer 157. At contact members 154*b* a circuit is completed for energizing the motor 68, and the cam 70 is rotated thereby to close the circuit breaker 150.

At contact members 150*a* the previously traced energizing circuit for the operating winding 154*w* is opened. However, at contact members 154*a* a holding circuit is provided which maintains this energizing circuit intact. It will be obvious that it is unnecessary to provide for the opening of the contact members 150*a* at a precise instant after the circuit breaker 150 is operated toward the closed position. It is merely necessary to provide for opening these contact members at some time after the circuit breaker 150 is operated toward its closed position and before it reaches this closed position.

The impedance of the winding 64 is increased by movement of the armature 61 toward it, as previously described, and, when the circuit breaker 150 is in the closed position, this impedance value is sufficiently high to reduce the current flowing through the operating winding 154*w* to such an extent that the contact members controlled thereby are opened. At contact members 154*b* the energizing circuit for the motor 68 is opened, and the cam 70 returns to its original position. At contact members 154*a* the holding circuit for the operating winding 154*w* is opened, and this winding and the winding 64 are deenergized. It will now be apparent that no current flows through the windings 154*w* and 64 as long as the circuit breaker 150 remains closed. In this case the circuit breaker 150 is held closed by the mechanical latch comprising the tooth 151 and the associated pawl 152.

In Figure 12 of the drawings I have illustrated, in a diagrammatic manner, the arrangement of the linkage shown in Figure 1 for operating the circuit breaker 150 to the closed position by the motor 68 and for holding it in this position by the continued energization of the winding 64. As previously described, the motor 68 is arranged to rotate the cam 70 in engagement with the roller 50 for operating the linkage in such manner as to close the circuit breaker 150. In this embodiment of the invention, the control relay 120 may be employed, having its operating winding 120*w* connected in series circuit relation with the holding winding 64 on the core 63.

Instead of the armature 61 being arranged to directly hold the pin 54 interconnecting the link 53 and the socket member 55, forming the third toggle joint, in a predetermined position, a latch member 160 is provided and is mechanically connected to the armature 61, as illustrated. A tension spring 161 is provided for biasing the latching member 160 in a counterclockwise direction about its pivot point. The upper end of the latching member 160 is provided with an inclined surface 162 that is arranged to engage the pin 54.

On operation of the control switch 155 the control relay 120 is operated to energize the motor 68 and move the circuit breaker 150 toward its closed position through the linkage. The armature 61 is attracted toward the core 63, but it is prevented from immediately moving into engagement therewith because of the engagement of the inclined surface 162 of the latch member 160 with the pin 54. When the circuit breaker 150 is operated to the closed position, the pin 54 has moved downwardly along the inclined surface 162 until the recessed underside 163 is reached, in which position the armature 61 is permitted to move toward the core 63, carrying with it the latching member 160 against the biasing force of the spring 161. The impedance of the winding 64 correspondingly increases, and the current flowing through the operating winding 120w decreases to such an extent that the contact members 120a are permitted to move to the open position. The motor 68 is deenergized, but the circuit breaker 150 is held in the closed position by the latch member 160 as long as the holding winding 64 remains energized. As soon as the control switch 155 is operated to the open position, the holding winding 64 is deenergized, and the spring 161 operates the latch 160 to release the pin 54. The circuit breaker 150 is then permitted to move to the open position.

In some commercial installations, it is preferable to operate the control mechanism for the circuit breakers from direct current rather than to utilize the alternating current from the circuits in which the circuit breakers are connected. For this purpose, the circuit connections shown in Figure 13 may be employed. As there shown, a suitable source of direct current, such as a battery 60, is provided for energizing a control bus comprising conductors 161 and 162 with direct current. The series motor 68 is arranged to operate the cam 70 to close the circuit breaker 150.

It will be obvious that the circuit breaker 150 may be operated as a single unit, or it may be operated in conjunction with another circuit breaker to provide an automatic transfer system such as that shown in Figure 9 of the drawings. As I have illustrated the embodiment of my invention in Figure 13 for use in such a system, the circuit breaker 150 is used in place of the circuit breaker 107 shown in Figure 9 of the drawings. The voltage relays 128, 129 and 130 could then be used, and the make contact members of these relays have been illustrated together with the auxiliary contact members 108a of the circuit breaker 108 to indicate how the system may be arranged for automatic transfer operation.

The motor 68 is arranged to be energized by contact members 163 that are closed by a suitable bridging contact member 164 that is carried by a suitable insulating member 165 on an auxiliary armature 166 which is pivoted at 167 on a core 168. A winding 169 is positioned around the core 168, as illustrated, and may be energized either by the control switch 155, or by the control circuit formed by the make contact members of the voltage relays and the auxiliary contact members of the associated transfer circuit breaker.

The circuit breaker 150 is held in the closed position by a main armature 170 that is pivoted at 171 to the core 168 and connected by a link 172 to the pin 54.

In operation, on energization of the winding 169 the auxiliary armature 166 is attracted toward the core 168 against the biasing force of a spring 173, and contact members 163 are bridged by the bridging contact member 164. The motor 68 is then connected for energization between the conductors 161 and 162. While the armature 170 is attracted toward the core 168 during this interval, it is prevented from immediately moving into engagement therewith by the link 172 attached to the pin 54, thereby making it movable only with the circuit breaker 150. When the circuit breaker 150 approaches the closed position, the main armature 170 is in engagement with the core 168. The magnetic circuit for the auxiliary armature 166 is then shunted, and it moves outwardly under the influence of the spring 173 to open the contact members 163 and deenergize the motor 68. As long as the winding 169 remains energized, the main armature 170 remains attracted thereby and the circuit breaker 150 remains in the closed position. On deenergization of the winding 169, the main armature 170 is released and the circuit breaker 150 is permitted to operate to the open position, as will be readily understood.

As the main armature 170 approaches the core 168, the increased attractive force exerted thereon assists the motor 68 in operating the circuit breaker 150 to the final closed position. Thus, it is unnecessary to accurately adjust the particular instant in this cycle of operation when the contact members 163 are opened and the motor 68 is deenergized.

The arrangement and construction of my novel circuit interrupter for reclosing purposes are illustrated diagrammatically in Figure 14 of the drawings. As there shown, the circuit breaker 150 is arranged to be closed by the motor 68 on rotation of the cam 70. The holding winding 64, associated with the armature 61, is connected in series circuit relation with the operating winding 120w of the control relay 120, as described hereinbefore.

For the purpose of automatically opening the circuit breaker 150 on the occurrence of a fault on the circuit in which it is connected and for immediately reclosing it, an auxiliary control relay, shown generally at 175, is provided having contact members 175a connected in series circuit relation with the circuit that includes the holding winding 64 and the operating winding 120w. As long as the contact members 175a remain in the closed position, this circuit remains intact, and the circuit breaker 150 remains in the closed position. The auxiliary control relay 175 is controlled by a current responsive relay, shown generally at 176 and having contact members 176a which are connected to effect the energization of the operating winding 175w from the secondary winding 156 of the transformer 157. The relay 176 is provided with an operating winding 176w that is connected for energization across the terminals of a winding 177 of a current

transformer that is associated with the line conductor Y.

The circuit breaker 150 is initially closed by operation of a control switch 178, and it is held closed by the holding winding 64 in the manner described hereinbefore. On the occurrence of a predetermined overload, sufficient current flows through the winding 176*w* of the overcurrent relay 176, and its contact members 176*a* are closed to effect the energization of the operating winding 175*w* of the auxiliary control relay 175. The energizing circuit for the holding winding 64 is opened at contact members 175*a*, and the circuit breaker 150 is permitted to operate toward the open position. As soon as the circuit is cleared, the winding 176*w* is no longer energized, and contact members 176*a* are opened. Contact members 175*a* of the auxiliary control relay 175 are immediately reclosed to reestablish the control circuit through the holding winding 64 and the operating winding 129*w* of the control relay 129. The motor 68 is then energized to reclose the circuit breaker 150.

It will be obvious that the system may be so adjusted that it will be unnecessary for the circuit breaker 150 to be operated to the full open position. That is, the motor 68 may be energized sufficiently soon after the circuit breaker starts to move to the open position to cause the cam member 70 to engage the roller 50 before the latter is operated to the full open position. Thus, the circuit may be reclosed within a very short period of time, and it may even be closed within one cycle of 60-cycle current.

If the fault persists on the circuit, the foregoing reclosing cycle will be repeated. This pumping action may be prevented by any suitable means well known to those skilled in the art, and will not be described in detail herein. It will be obvious, however, that my novel circuit interrupter is inherently well adapted for functioning in connection with a reclosing circuit breaker system.

In Figure 15 of the drawings, I have illustrated another embodiment of the reclosing system illustrated in Figure 14 and described hereinbefore. In this embodiment I have omitted the auxiliary control relay 175 and the overcurrent relay 176 as such. Instead I have provided a relay, shown generally at 180, which operates in a manner similar to the variable impedance device formed by the armature 61 and the holding winding 64. This relay comprises a winding 181 which is connected for energization to the current transformer winding 177 that is associated with the line conductor Y. A second winding 182 is provided on the relay 180, and it is connected in series circuit relation with the holding winding 64. Armatures 183 and 184, connected by a link 185, are associated respectively with the windings 181 and 182.

The circuit breaker 150 is initially closed by operation of the control switch 178. At this time the armature 184 occupies a position with respect to the winding 182 such that the impedance of this winding is a minimum, and consequently the cycle for energizing and deenergizing the motor 68 takes place. The circuit breaker 150 is held in the closed position by the continued energization of the holding winding 64. On the occurrence of a fault, such as a short circuit, on the circuit in which the circuit breaker 150 is connected, sufficient current flows through the winding 181 to attract the armature 183 and to move the armature 184 to a position within the winding 182. In this position, the impedance of the winding 182 is materially increased and the circuit is so proportioned that this increase in impedance is sufficient to further decrease the current flowing through the holding winding 64 to such an extent that it is no longer capable of attracting the armature 61. As a result, the circuit breaker 150 is permitted to operate to the open position.

As soon as the circuit breaker 150 has operated to this position, the winding 181 is deenergized and the armature 184 moves out of the winding 182. The impedance of this winding is correspondingly decreased, and the closing and holding cycle takes place for operating and holding the circuit breaker 150 in the closed position. As long as the fault persists, the circuit breaker 150 will continue to be opened and closed. Suitable anti-pumping means may be provided for limiting the number of reclosures to one or to any desired number.

It will be obvious that the mechanical trip feature shown in Figure 11 of the drawings may be incorporated in either of the systems shown in Figures 14 and 15 of the drawings. With particular reference to Figures 11 and 14, it will be obvious that the over-current relay 176 can be connected to control a tripping winding associated with the pawl 152 to release the mechanical holding mechanism rather than to interrupt the current flowing through the holding winding 64, as in Figure 14.

Since it is obvious that certain further changes may be made in the above constructions and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a circuit interrupter, in combination, relatively movable contact members for opening and closing an electric circuit, motor means for operating said contact members to the closed position, a control relay and a winding therefor for controlling the energization of said motor means, a variable impedance device disposed to operate together with said contact members and a winding therefor, and circuit means for connecting said windings in series circuit relation and to an alternating current source, the impedance of said device being relatively low when said contact members are in the open position and relatively high when they are in the closed position, whereby said control relay is operated to deenergize said motor means.

2. In a circuit interrupter, in combination, relatively movable contact members for opening and closing an electric circuit, motor means for operating said contact members to the closed position, a control relay and a winding therefor for controlling the energization of said motor means, a variable impedance device disposed to operate together with said contact members and a winding therefor, circuit means for connecting said windings in series circuit relation and to an alternating current source, and holding means for said contact members controlled by said variable impedance device, the impedance of said device being relatively low when said contact members are in the open position and relatively high when they are in the closed position, whereby said control relay is operated to deenergize said motor means and said holding means is acted up-

on to maintain said contact members in the closed position.

3. A circuit interrupter comprising, in combination, relatively movable contact members for opening and closing an electric circuit, an electric motor, linkage means interconnecting said contact members and said motor, a control relay connected to effect the energization of said motor for operating said contact members to the closed position, a winding on said relay, an armature connected to said linkage means and movable therewith, a core disposed in cooperative relation with said armature, a holding winding on said core, and circuit means connecting said windings in series circuit relation and for energization to a source of alternating current, the impedance of said holding winding being increased by movement of said armature toward said core on operation of said contact members to the closed position, whereby said relay operates to deenergize said motor and said armature holding said linkage against movement, whereby said contact members are maintained in the closed position.

4. A circuit interrupter comprising, in combination, relatively movable contact members for opening and closing an electric circuit, operating means for moving said contact members to the closed position, latching means for holding said contact members in the closed position, a control relay for effecting the energization of said operating means, a winding for said control relay, an armature movable with said contact members, a winding operatively disposed with said armature in such manner as to have a minimum of inductance when said contact members are open and a maximum of inductance when they are closed, auxiliary contact means disposed to be opened on movement of said contact members to the closed position, contact means on said control relay connected to shunt said auxiliary contact means on energization of the relay winding, a circuit means for connecting said auxiliary contact means, said relay winding and the variable inductance winding for energization to an alternating current source, whereby said control relay is operated to energize said operating means and, whereby said windings and operating means are deenergized when said contact members are operated to the closed position.

5. A circuit interrupter comprising, in combination, relatively movable contact members for opening and closing an electric circuit, an electric motor, linkage means interconnecting said contact members and said motor, latch means for engaging said linkage to hold said contact members in the closed position, said latch means being prevented from operatively engaging said linkage until said contact members are closed, means for biasing said latch means out of engagement with said linkage means, a control relay for effecting the energization of said motor, a winding for said relay, a core, a winding on said core, an armature movable relative to said core and connected to move with said latch means against the force of said biasing means, and circuit means for connecting said windings in series circuit relation and for energization to an alternating current source, whereby said motor is energized to operate said contact members to the closed position, said armature is attracted to said core to cause said latch means to operatively engage said linkage and said relay winding is deenergized to an extent sufficient to effect the deenergization of said motor.

6. A circuit interrupter comprising, in combination, relatively movable contact members for opening and closing an electric circuit, operating means for moving said contact members to the closed position, a core, a winding for energizing said core, a main armature disposed to be attracted to said core on energization of said winding for holding said contact members closed, said main armature being movable toward said core only when said contact members are moved to the closed position, an auxiliary armature disposed to be moved toward said core upon energization of said winding and to be released therefrom on movement of said main armature to a position adjacent said core, contact means carried by said armature for effecting the energization of said operating means, and circuit means for connecting said winding for energization to a current source.

7. A circuit interrupter comprising, in combination, relatively movable contact members for opening and closing an electric circuit, an electric motor, linkage means interconnecting said contact members and said motor, a core, a winding for energizing said core, a main armature connected to and movable only with said linkage means, said armature being attracted toward said core on energization of said winding for holding said contact members closed, an auxiliary armature disposed to be moved toward said core immediately upon energization of said winding and to be released therefrom on shunting of said core by movement of said main armature, contact means carried by said auxiliary armature for completing an energizing circuit for said motor on energization of said winding and for opening said circuit when said auxiliary armature is released, and circuit means for connecting said winding for energization to a source of direct current.

8. In a circuit interrupter, in combination, relatively movable contact members for opening and closing an electric circuit, an electric motor including a rotatable member disposed to move said contact members to the closed position, an armature mechanically connected to said contact members and operable therewith, a winding cooperating with said armature, means for energizing said electric motor and said winding whereby the latter assists the former in operating said contact members to the closed position, means for deenergizing said motor on closure of said contact members, and means for maintaining said winding energized after said motor is deenergized to hold said contact members in the closed position.

9. Apparatus for moving a member from one position to an alternate position comprising, in combination, electric motor means for operating said member to said alternate position, a control relay and a winding therefor for controlling the energization of said motor means, a variable impedance device disposed to operate together with said member and a winding therefor, and circuit means for connecting said windings in series circuit relation and to an alternating current source, the impedance of said device being relatively low when said member occupies said one position and relatively high when it occupies said alternate position, whereby said control relay is operated to deenergize said motor means.

10. In a circuit interrupter, in combination, relatively movable contact members for opening and closing an electric circuit, a torque motor,

a cam driven by said motor and adapted to be rotated through less than one revolution, means for mechanically interconnecting said cam and said contact members to translate rotary movement of the former into translatory movement of the latter for operating the same to the closed position, switch means for energizing said torque motor including an armature and contact members adapted to be closed thereby for connecting said torque motor to an electric power source, an electro-magnet including a winding and an armature disposed to be attracted by the winding and operating together with movement of said contact members to close said circuit, means for connecting said winding for energization to an electric power source, and means arranged and adapted to magnetically attract the armature of said switch means to effect energization of said torque motor on energization of said winding and to substantially reduce the magnetic attraction of the armature of said switch means when the armature of said electromagnet is in a position corresponding to the closed position of said contact members whereby said torque motor is disconnected from said power source.

11. In a circuit interrupter, in combination, relatively movable contact members for opening and closing an electric circuit, a torque motor, a cam driven by said motor and adapted to be rotated through less than one revolution, means for mechanically interconnecting said cam and said contact members to translate rotary movement of the former into translatory movement of the latter for operating the same to the closed position, relay means including a winding and contact means for energizing said torque motor to operate said contact members, to the closed position; an electromagnet including a core, a winding on the core and an armature operatively associated with said contact members and movable toward said core on movement of said contact members to the closed position to hold the same in said position after said torque motor is deenergized; circuit means connecting the winding of said relay and the winding on said core in series circuit relation whereby the impedance of the former is increased to open said contact means and deenergize said torque motor when said armature is moved to a predetermined position with respect to said core, and means for energizing said winding to retain said armature in its holding position.

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