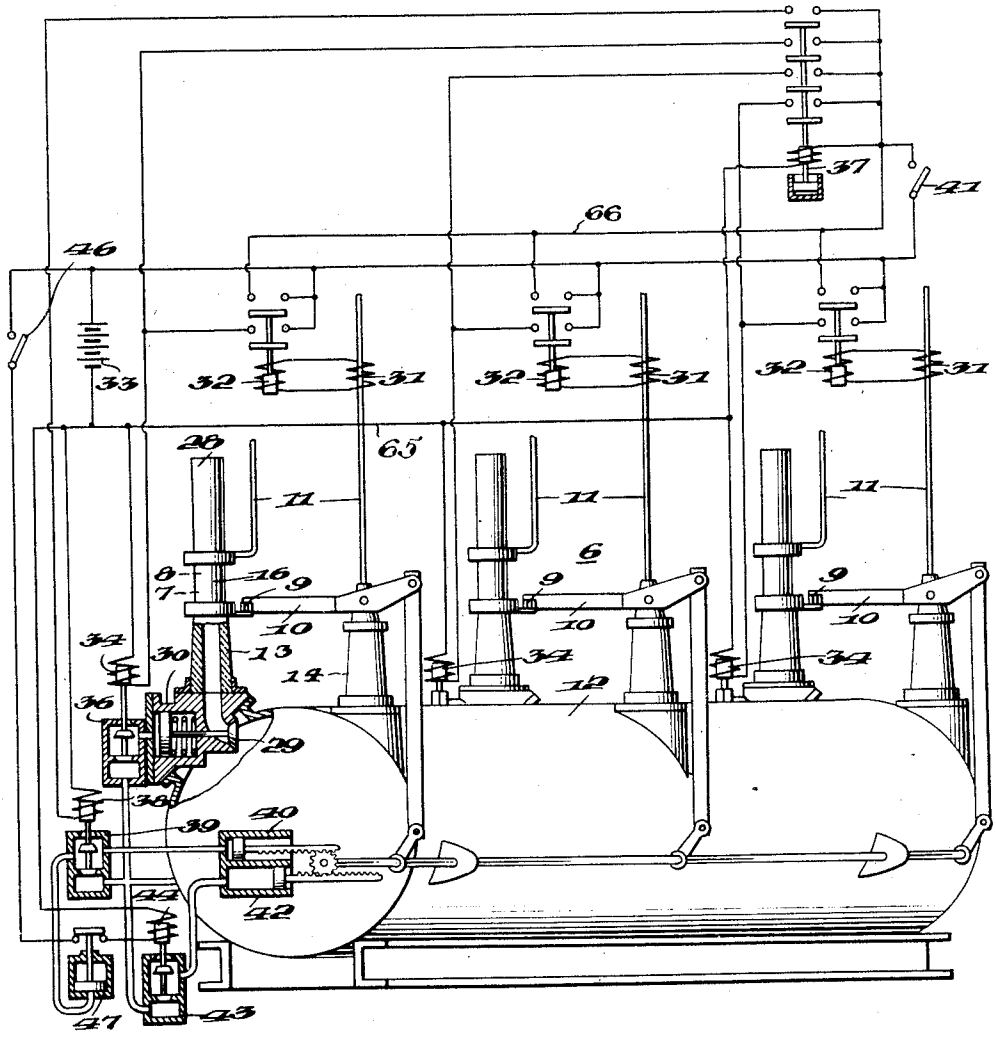
June 23, 1942. D. JOURNEAUX 2,287,041

CIRCUIT BREAKER CONTROL SYSTEM

Filed Feb. 23, 1939 3 Sheets-Sheet 1

Fig. 1.



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CIRCUIT BREAKER CONTROL SYSTEM

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Fig. 4.

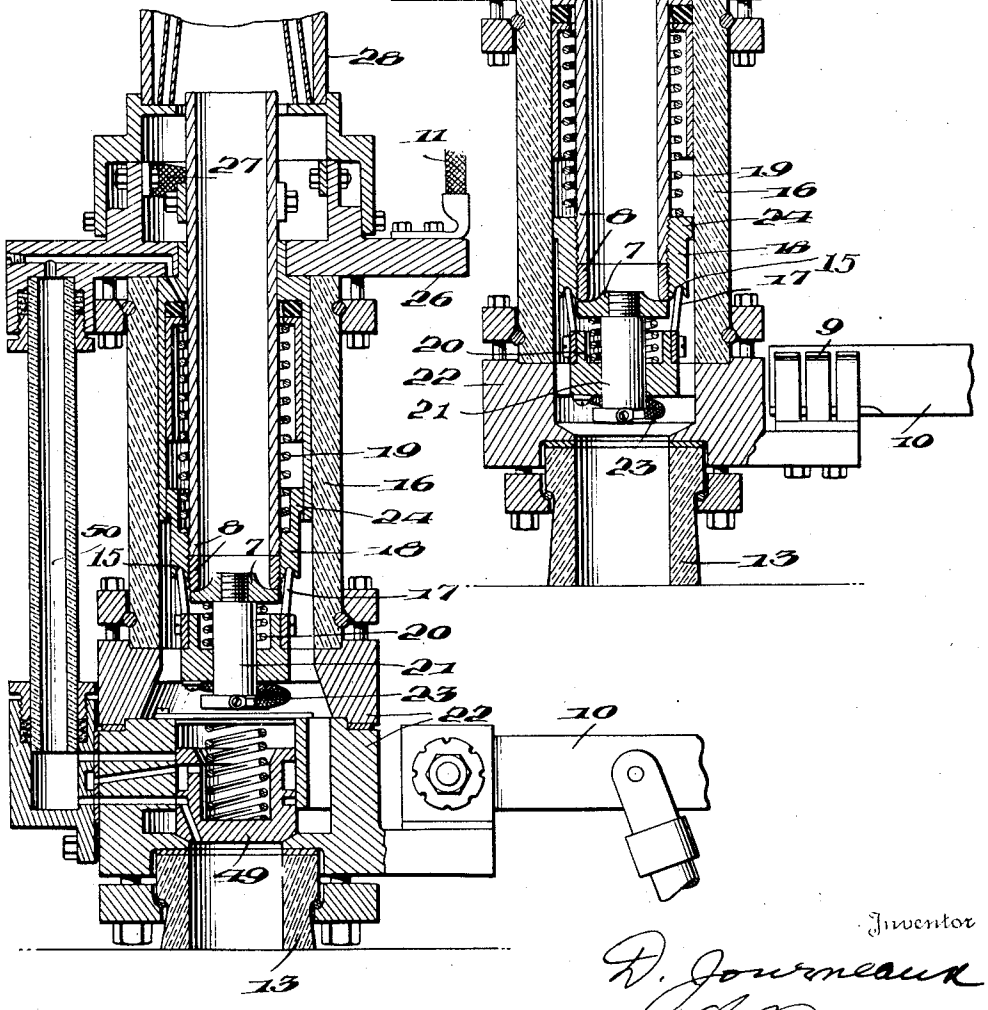

Fig. 2.

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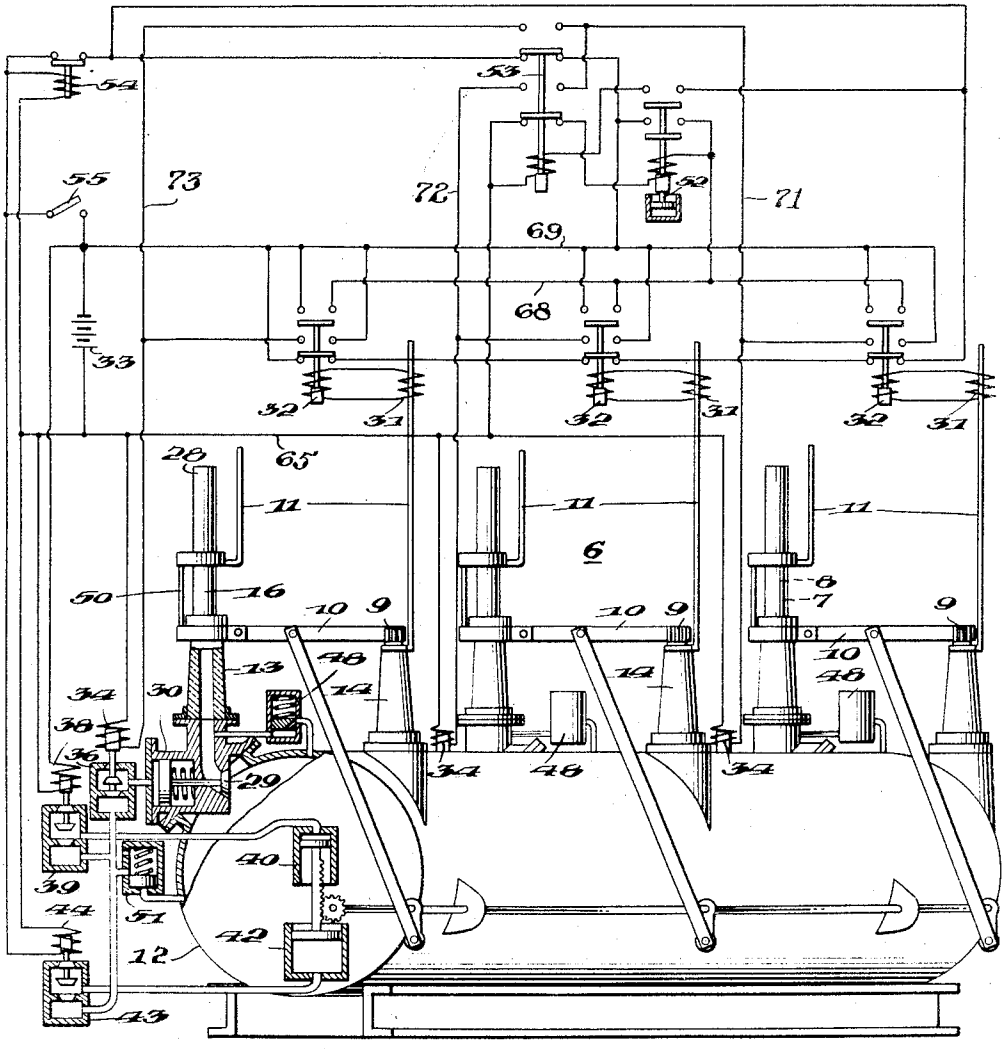

Fig. 3.

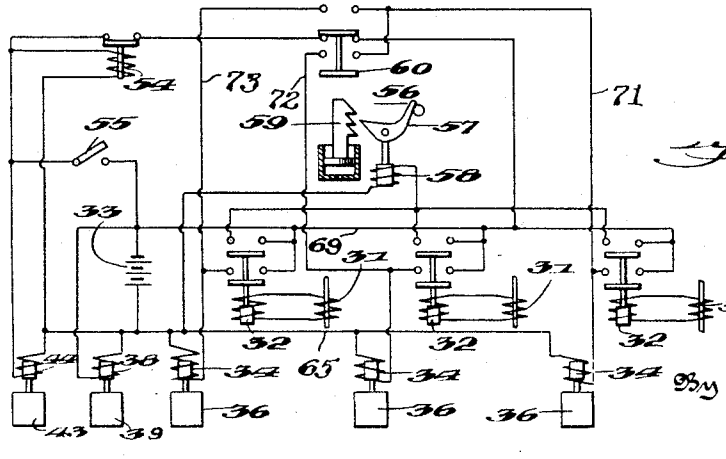

Fig. 5.

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UNITED STATES PATENT OFFICE

2,287,041

CIRCUIT BREAKER CONTROL SYSTEM

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Application February 23, 1939, Serial No. 258,017

18 Claims. (Cl. 175—294)

This invention relates in general to improvements in circuit breaker control systems and more particularly to a control system for causing permanent opening of a circuit breaker after a predetermined number of automatic openings and reclosures thereof within a limited time.

It is frequently desired to control a circuit breaker in such manner that the circuit breaker contacts reclose immediately upon automatic interrupting operation thereof, the circuit breaker, however, being locked in the open position after a predetermined number of automatic openings thereof during a limited time. When the circuit breaker is of the multipole type controlling the flow of current through the several phase conductors of a polyphase electric circuit, it is frequently required to interrupt transient disturbances affecting less than all the conductors of the circuit. Each disturbance is caused to cease by momentary opening of the circuit breaker and normal operating condition of the circuit is restored by reclosure of the circuit breaker. The circuit breaker thus causes unnecessary momentary interruption of the flow of current through the conductors which are not affected by the disturbance and thus unnecessarily disturbs the functioning of the generating and current consuming apparatus connected with the circuit. On the other hand if the disturbance is of a permanent nature and necessitates permanent opening of the circuit breaker, all contacts of the circuit breaker should ultimately be opened to avoid continued operation of the sound conductors of the circuit either as a single phase circuit or at the most as an unbalanced polyphase circuit.

The circuit should therefore be so controlled that only the faulty conductors of the circuit are disconnected in response to the occurrence of a disturbance in the operation thereof and that all conductors are opened upon a predetermined number of disconnections and reconnections of the faulty conductors within a limited time. If the circuit breaker is of the type having serially connected arcing and disconnecting contacts, only the arcing contacts controlling the faulty conductors should be opened in response to the occurrence of a disturbance therein, and all arcing and disconnecting contacts should be opened after a predetermined number of openings and reclosures of the arcing contacts controlling the faulty conductors. The actuating means for the contacts are preferably operable by fluid under pressure and are preferably provided with interlocks for preventing faulty operation of the contacts when the pressure of the fluid falls below a predetermined value or when the source of energy for actuating the control valves fails, as well as for rendering the circuit breaker trip free. The arcing contacts may be closed as well as opened by fluid actuated means selectively operable by varying the pressure of the fluid supplied thereto.

It is therefore an object of the present invention to provide a circuit breaker control system by means of which the sound conductors of the circuit controlled by the circuit breaker are caused to be unaffected by the termination of a transient disturbance in any faulty conductor thereof.

Another object of the present invention is to provide a circuit breaker control system for rendering the circuit breaker operable in response to a transient disturbance in the circuit controlled thereby to disconnect momentarily only the faulty conductors, and operable in response to a permanent disturbance to disconnect all the conductors of the circuit.

Another object of the present invention is to provide a circuit breaker control system for causing the disconnecting contacts of the circuit breaker to open only upon repeated openings of any of the arcing contacts thereof during a limited time.

Another object of the present invention is to provide a circuit breaker control system for preventing faulty operation of the circuit breaker as a result of an abnormal condition of the control system.

Another object of the present invention is to provide a circuit breaker control system by means of which fluid under pressure above and below a predetermined value may be supplied to the circuit breaker to cause selective actuation thereof.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 diagrammatically illustrates an embodiment of the present invention in which the actuating means for the arcing and disconnecting contacts are interlocked by means of a time delay relay;

Fig. 2 is a view in axial cross-section through one of the arcing chambers of the embodiment illustrated in Fig. 1;

Fig. 3 diagrammatically illustrates a modified embodiment of the present invention in which the disconnecting contacts are controlled by interlocked counting relays and in which the arcing

contacts are selectively actuable in response to variations in the pressure of the fluid supplied thereto;

Fig. 4 is a view in axial cross-section through the arcing chamber of the embodiment illustrated in Fig. 3;

Fig. 5 diagrammatically illustrates a portion of a modified embodiment of the present invention differing from the embodiment illustrated in Figs. 3 and 4 by the use of a single relay of the operation counting type instead of interlocked counting relays.

Elements having the same function in the different embodiments are designated therein by the same reference characters although such elements may be of different configuration in the several embodiments shown. It will be understood that elements illustrated in some of the figures may also be utilized in combination with elements illustrated in other figures to form further embodiments of the present invention.

Referring more particularly to the drawing by characters of reference, reference numeral 6 generally designates a circuit breaker of the fluid actuated type having a plurality of pole portions each comprising cooperating arcing contacts 7, 8 serially connected with cooperating disconnecting contacts 9, 10 in a different one of the phase conductors of a polyphase electric circuit 11. Circuit breaker 6 comprises a reservoir 12 serving as a source of supply of fluid under pressure and preferably also serving as the support for the different pole portions of the circuit breaker. The fluid utilized for actuating the circuit breaker is assumed to be compressed air supplied to reservoir 12 and maintained therein at a substantially constant pressure by a suitable compressor (not shown) but it will be understood that other fluids such as nitrogen or helium may also be utilized instead.

Each pole portion comprises a pair of insulators 13, 14 mounted on reservoir 12 and serving to support contacts 9, 10. Insulator 13 is hollow and also serves to conduct air from reservoir 12 to another insulator 16 defining an arcing chamber containing contacts 7, 8. Contact 8 is preferably of the hollow tubular type forming an outlet from the arcing chamber, contact 7 abutting against one end of contact 8 to substantially close the arcing chamber. Contacts 7, 8 are preferably bridged by cooperating current carrying contacts 17, 18 when the contacts are required to carry relatively large currents. Contact 17 may consist of a length of resilient conducting tubing arranged about contact 7 and divided by saw cuts into a plurality of segmental portions independently engaging contact 18. Contact 18 is preferably fastened to contact 8 and is provided with an annular groove 15 for engaging the tips of the segmental portions of contact 17. Contacts 17, 18 are normally maintained closed by means of a spring 19 operable to reclose the contacts upon opening thereof.

When contacts 17, 18 are closed, contact 7 is urged into engagement with contact 8 by another spring 20 which is not, however, of a sufficient strength to cause separation of contacts 17, 18. Contact 7 is fastened to a plunger type piston 21 arranged for reciprocating movement in an apertured flange 22 joining insulators 13 and 16. Piston 21 is preferably connected with flange 22 through a flexible conductor 23 and is arranged to be actuated by fluid under pressure contained within insulator 13. Piston 21 simultaneously actuates contacts 7, 8 and 18 to impart a joint initial acceleration thereto and to separate contact 18 from contact 17. Contact 18 is provided with further contact separating means such as an enlarged portion thereof forming a piston 24 operable by the fluid under pressure contained within the arcing chamber for continuing the actuation of contacts 8, 18 to cause sequential opening of contacts 17, 18 and of contacts 7, 8.

Insulator 16 is closed by an upper flange 26 cooperating with insulator 16 and with flange 22 in defining the arcing chamber and connected with contact 8 through a flexible conductor 27. Flange 26 preferably supports an arc deionizing and sound muffling device 28. One of the flanges 22, 26 is connected with one of the disconnecting contacts and the other flange is connected with one of the conductors of circuit 11.

Admission of air under pressure from reservoir 12 to pistons 21 and 24 to cause opening of the arcing contacts is controlled by a valve 29 actuable by a suitable motor such as an air motor 30 of the spring biased reciprocating type. Opening of the arcing contacts connected in one of the conductors of circuit 11 is controlled in response to an operating condition, such as the magnitude of the flow of current through the same conductor, by means of a current transformer 31 connected therein and supplying current to the coil of a relay 32. Each relay 32 by the lower of its two sets of contacts controls the connection of a suitable auxiliary source of energy such as a battery 33 with the coil 34 of a magnet valve 36. This circuit extends from the upper side of battery 33 through the lower contacts of any relay 32, any coil 34 to the lower end of battery 33. Valve 36 connects the associated motor 30 with atmosphere when the coil 34 thereof is deenergized and connects the motor with reservoir 12 when the coil is energized from battery 33.

In the embodiment illustrated in Fig. 1 the several relays 32 also control the connection of battery 33 with the coil and with the contacts of a single relay 37 of any suitable known time delay type. This circuit extends from the upper side of battery 33 through the upper contacts of any relay 32, conductor 66, coil 37, conductor 65 to the lower side of battery 33. Relay 37 may be adjusted in a suitable manner as by the conventional dashpot shown to close the contacts thereof in a longer time than the time required for opening of any set of arcing contacts 7, 8 and shorter than the time required for opening and subsequently reclosing contacts 7, 8. Relay 37 may also be adjusted to close the contacts thereof only after a predetermined plurality of reclosures of contacts 7, 8 and of immediate reopenings thereof within a predetermined time as a result of a permanent disturbance in the operation of circuit 11. The dashpot on relay 37 also provides suitable timing means for causing the contacts thereof to remain closed for a predetermined length of time after closing thereof. The contacts of relay 37 control the connection of battery 33, through the contacts of any one of relays 32, with all coils 34 and with the coil 38 of a valve 39 common to all three pole portions of the circuit breaker. This circuit for the coil 38 extends from the upper side of battery 33 through the upper contacts of any relay 32, conductor 66, the upper contacts of relay 37, coil 38 to the lower side of battery 33. The circuits for the coils 34 similarly extend through the second, third and fourth contacts of relay 37 for the left hand, center and right hand coils

34, respectively. Valve 39 is similar to valve 36 and controls admission of air from reservoir 12 to a suitable contact actuating means such as an air motor 40 for causing joint opening of the different disconnecting contacts 10 of the circuit breaker. Operation of relay 37 may also be obtained independently of relay 32 by means of a hand switch 41, which closes a circuit from the upper side of battery 33, through switch 41, coil of relay 37, conductor 65 to the lower side of battery 33.

Contacts 10 may be reclosed by suitable closing means such as an air motor 42 which may be supplied with air under pressure from reservoir 12 through a valve 43 similar to valves 36 and 39. Valve 43 may be actuated by a coil 44 connected with battery 33 through a switch 46 and through the contacts of an air relay 47 responsive to the pressure of the air contained within the air motor 40.

Relay 47 serves as an interlock between valves 39 and 43 to prevent operation of motor 42 during operation of motor 40 and to thus render the circuit breaker trip free.

Fig. 1 illustrates the circuit breaker in the normal operating condition thereof, contacts 7, 8, 9, 10 and 17, 18 being closed to complete circuit 11. Since the different pole portions of the circuit breaker are similar to one another and are severally operable, in the following description only the elements associated with a single pole will be referred to unless otherwise specified.

Upon occurrence of an operating condition such as an overload or a short circuit in one of the conductors of circuit 11 resulting in an excessive flow of current therethrough, the current transformer 31 associated with such conductor supplies sufficient current to the coil of the associated relay 32 to cause the relay contacts to close. Operation of relay 32 causes energization of the coil of relay 37 and connects coil 34 with battery 33 to actuate valve 36. The valve admits air from reservoir 12 to motor 30 which opens valve 29 to admit air from reservoir 12 into insulator 13 and through the apertures of flange 22 into insulator 16. The air acts first on the lower faces of piston 21 and of contact 7 to impart thereto an initial acceleration which is also transmitted by contact 7 to contacts 8 and 18. Substantially simultaneously therewith the air contained within insulator 16 exerts an upward thrust on piston 24 to continue the actuation of contacts 8 and 18 independently of contact 7.

During the upward movement of contacts 8 and 18, contact 18 is first separated from contact 17 while contacts 7 and 8 remain in mutual engagement and carry the entire current flowing through the associated conductor 11. When contact 7 reaches the end of its stroke, contacts 8 and 18 continue their upward movement. Contacts 7 and 8 are then separated and an arc is drawn therebetween. At the same time the gap between contacts 7 and 8 forms a path for the flow of air contained in reservoir 12 and in insulators 13, 16 and which issues therefrom as a violent blast. The air blast causes such lengthening of the arc that, at the beginning of the half cycle next following opening of the arcing contacts, the arc path is readily deionized and the current cannot be reestablished between the contacts. The flow of current through the faulty conductor is interrupted and relay 32 returns to the position shown. Coil 34 is deenergized and causes valves 36 and 29 to return to the position shown to discontinue the opening operation of contacts 8, 18, whereupon spring 19 becomes operable to reclose contacts 8, 18.

Contact 8 first reengages contact 7, which is thereby displaced downward against the action of spring 20 and recloses conductor 11. Contact 18 finally reengages contact 17, the segmental portions of which first enter into resilient sliding engagement with the inner side of the groove of contact 18 and thereafter also abut against the bottom of the groove to cause contact 18 to stop. Relay 37 is assumed to be so adjusted as to close the contacts thereof between the return of relay 32 to the position shown and the subsequent reclosure of contacts 7, 8.

The above described operation of the circuit breaker takes place regardless of whether or not the disturbance in circuit 11 has been terminated by opening of contacts 7, 8. If the disturbance is of a transient nature such as a single phase arc to ground from an otherwise sound conductor of a grounded circuit following a stroke of lightning, and if the disturbance is caused to cease upon opening of contacts 7, 8, reclosure of the contacts restores the system to the normal operating condition thereof. Relay 37 returns to the position shown within a limited time without performing any function in the system. It will be observed that the disturbance has been removed and the faulty conductor 11 reclosed without causing any interruption in the continued operation of those conductors of the circuit which were not affected by the disturbance.

If, however, the disturbance is of a permanent nature, such as a short circuit resulting from rupture of a conductor of circuit 11, the excessive flow of current through the faulty conductor is reestablished therethrough immediately upon reclosure of contacts 7, 8, i. e. within a short time following the first occurrence thereof. Relay 32 is actuated a second time in response thereto while the contacts of relay 37 are closed. Battery 33 is then connected through the contacts of the relays with the coils 34 of all the pole portions of the circuit breaker and with coil 38 to initiate opening operation of all the contacts of the circuit breaker.

Coils 34 open valves 36 which admit air from reservoir 12 to motors 30 to cause opening of valves 29. Air is admitted therethrough to the arcing chambers to actuate all pistons 21 and 24 and for momentarily opening all contacts 7, 8 and 17, 18. The flow of current through all conductors 11 is interrupted at the arcing contacts by the air blasts issuing from the arcing chambers. Coil 38 opens valve 39 which admits air to motor 40 for causing joint opening of all disconnecting contacts 10.

The different contact separating means of the circuit breaker are so constructed that the arcing contacts and the disconnecting contacts open sequentially, the disconnecting contacts being opened only after interruption of the flow of current through the circuit and while contacts 7, 8 are still open. Relays 32 and 37 are therefore operable in response to the flow of excessive current through one of conductors 11 within a predetermined time following an occurrence of such flow and within a limited time following a reclosure of contacts 7, 8 of one pole portion for causing opening of all the contacts of the circuit breaker. Relay 37 operates in response to the operation of one of relays 32 for causing the same one of the relays 32 to control motor 40 within a limited time and forms an interlock between

the contact opening means of contacts 7, 8 and motor 40 to render the latter effective only during a limited time following opening operation of contacts 7, 8.

Upon interruption of the flow of current through circuit 11, relay 32 returns to the position shown, thereby deenergizing coils 34 and 38. Valves 29 reclose to enable springs 19 to reclose contacts 7, 8 after opening of contacts 10. Contacts 10, however, remain permanently open after deenergization of coil 38 and may subsequently be reclosed by closing switch 46.

It will be apparent that if a disturbance affects two or more of the conductors of circuit 11, the relays and the pole portions severally associated therewith will function simultaneously and independently of one another in the manner above described, any conductor not affected by the disturbance remaining in normal operation until eventual opening of contacts 10. Relay 37 may also be so adjusted as to close the contacts thereof in the full time necessary for the completion of a predetermined plurality of consecutive openings and reclosures of the arcing contacts, but care must be taken that the contacts of the relay close only while relays 32 are momentarily all in the deenergized position shown.

In the embodiment illustrated in Figs. 3 and 4, motor 40 is not under the control of relays 32 and therefore always tends to maintain contacts 10 in the open position. Motor 42 is of such construction as to be operable upon actuation of valve 43 to the position shown to overcome the action of motor 40 and to close contacts 10. When valve 43 is released by coil 44, motor 42 is rendered ineffective and motor 40 is therefore enabled to open contacts 10. To prevent untimely opening of contacts 10 as a result of a failure of battery 33, the connection of motor 40 with reservoir 12 is again controlled by valve 39 which is normally maintained open by direct connection of coil 38 with battery 33. Upon failure of battery 33 both coils 38 and 44 are deenergized and both motors 40 and 42 are therefore rendered ineffective so that contacts 10 remain in the position previously assumed thereby.

In the present embodiment contacts 8, 18 are provided with means operable by air under pressure below a predetermined value for closing the contacts and with means operable by air under pressure above the same predetermined value for opening the contacts. The selective actuation of the arcing contact opening and closing means is under the control of two pressure responsive valves 48, 49. Valve 48 is a reducing valve admitting air from reservoir 12 into insulator 13 independently of valve 29 under a pressure which is lower than the pressure of reservoir 12 and which is also preferably slightly lower than the lowest pressure under which contacts 8, 18 are able to open and to interrupt current satisfactorily. Flange 22 contains valve 49, which is a slide valve closing the connection between the arcing chamber and insulator 13 when the pressure in the insulator is below a predetermined value. This value is preferably the lowest value which will enable contacts 8, 18 to open and to interrupt current satisfactorily. A passage is provided from insulator 13 through valve 49 and flange 22, through an insulating pipe 50, flange 26 and insulator 16 to the upper face of piston 24 to cause the latter to cooperate with spring 19 in closing contacts 7, 8 and 17, 18.

When the pressure within insulator 13 is raised above the previously considered predetermined value, valve 49 is actuated to release the pressure above piston 24 and to admit air from cylinder 13 to the arcing chamber. Contacts 8, 18 therefore cannot open when the pressure within reservoir 12 falls below the selected predetermined value, and it is accordingly desirable to connect motors 40 and 42 with reservoir 12 through a pressure responsive valve or air relay 51 which completes the connection only when reservoir 12 is under sufficient pressure.

In the present embodiment relays 32 are provided with three sets of contacts. Relay 37 is replaced by a plurality of interlocked counting relays, there being only two relays 52 and 53 if all the contacts of the circuit breaker are to be opened following a single reclosure of the arcing contacts of one pole. Relay 52 is of the instantaneous closing and delayed opening type and cooperates with relay 32 in controlling the energization of the coil of relay 53. Relay 53 cooperates with relay 32 in controlling the energization of the coil of relay 52 and of coils 34 and 44. A self-locking relay 54 maintains coil 44 deenergized after any momentary opening of the circuit thereof.

The operation of the present embodiment is generally similar to that of the embodiment illustrated in Fig. 1 and is therefore described herein only briefly. The circuit breaker being in the closed position shown, valves 48 admit air under reduced pressure into insulators 13 and, through valves 49, into the spaces above pistons 24 to cooperate with springs 19 in maintaining contacts 17, 18 closed under relatively high pressure. Upon occurrence of a fault in one of conductors 11, the corresponding relay 32, through its center set of contacts, energizes the associated coil 34 to cause opening of valve 29 of the same pole portion. Valve 29 admits air under full pressure from reservoir 12 into insulator 13, thereby causing valve 49 to be lifted. The air in the space above piston 24 is discharged through valve 49 and air under pressure is admitted to the arcing chamber to cause opening of contacts 7, 8 and interruption of the flow of current therethrough.

Relay 32 also connects the coil of relay 52 with battery 33 through a circuit extending from the upper side of battery 33, through the upper contacts of any relay 32, coil of relay 52, the lower contacts of relay 53, conductor 65 to the lower side of battery 33. Relay 52 immediately closes the contacts thereof, the lower contacts energizing the coil of relay 52 independently of relay 32, through conductor 69. Upon interruption of the disturbance in circuit 11, relay 32 is deenergized to enable contacts 7, 8 to reclose. Upon return of relay 32 to the position shown, the coil of relay 53 becomes energized through contacts of relay 32 and 52. This circuit extends from the upper side of battery 33, through the lower contacts of all three relays 32, the upper contacts of relay 52, coil of relays 53, conductor 65 to the lower side of battery 33. Relay 53 by opening its lower contacts disconnects the coil of relay 52 from battery 33 but relay 52 remains in the contact closing position for a limited time thereafter. It will be observed that relays 52 and 53 form a counting system in which each relay responds to a movement of relay 32, and it will be apparent that additional relays in any number may be added to respond to a greater number of movements of relay 32. If the disturbance has been permanently removed by opening of contacts 7, 8, circuit 11 is restored to

the normal operating condition thereof by reclosure of the contacts. Relay 52 returns to the position shown after a predetermined time delay and deenergizes the coil of relay 53 which will likewise return to the position shown.

If, however, the disturbance is still present upon reclosure of contacts 7, 8, relay 32 is again actuated while relays 52 and 53 are in the energized position. Relays 32 and 53 jointly connect all coils 34 with battery 33 and cooperate to disconnect coil 44 from the battery. The circuit closed through coils 34 extends from the upper side of battery 33, through conductor 69, center contacts of left hand (for example) relay 32. Here the circuit splits two ways, one through left hand coil 34, conductor 65, to the lower side of battery 33, and the other through conductor 73, upper contacts of relay 52 where the circuit again splits, energizing the center coil 34 through the lower contacts of relay 52 and conductor 65, and energizing the right hand coil 34 through conductors 71 and 65. Coils 34 actuate valves 29 to cause all contacts 7, 8 to open momentarily while coil 44 releases valves 43 to enable motors 40 to open all disconnecting contacts 10 while the arcing contacts are open. The arcing contacts are thereafter reclosed and relays 32, 52 and 53 return to the position shown. Contacts 10 may subsequently be closed by manually resetting relay 54 or by closing switch 55.

The embodiment partially illustrated in Fig. 5 differs from the embodiment illustrated in Figs. 3 and 4 mainly in that relays 52 and 53 are replaced by a single operation counting relay 56. Relay 56 may be of any known type and may comprise a latch 57 actuable by means of a coil 58 to engage the teeth of a ratchet 59. Ratchet 59 may be instantaneously raised one step by latch 57 but returns towards the position shown with a time delay. After a predetermined number of operations of latch 57 within a limited time, ratchet 59 engages the contacts 60 of the relay. Coil 58 is connected with battery 33 through the upper contacts of one of relays 32 so that operation of any relay 32 causes ratchet 59 to be raised one step. Subsequent deenergization of the same one of relays 32 enables ratchet 59 to gradually return towards the position shown. If a disturbance in circuit 11 having caused operation of a relay 32 is of a permanent nature, reclosure of the arcing contacts causes immediate reactuation of the relay 32 which causes latch 57 to raise ratchet 59 another step. Relay 56 thus counts the number of operations of relay 32 within a limited time and, after a predetermined number of consecutive operations of relay 32, rack 59 engages contacts 60 which cooperate with the contacts of relays 32 in causing opening of all the contacts of the circuit breaker. This is done by energizing coils 34 through a circuit similar to that traced for similar action in the embodiment of Fig. 3, except that the contacts 60 replace those of relay 53. Relays 32 and 56 then return to the position shown.

Although but a few embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various modifications and changes may be made therein without departing from the spirit of the invention or from the scope of the appended claims. Some of the features of the invention disclosed herein are claimed in a copending application of Didier Journeaux, Serial No. 443,259, filed May 16, 1942.

It is claimed and desired to secure by Letters Patent:

1. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, and means responsive to said operating condition within a limited time following a reclosure of said certain arcing contacts for opening all said contacts.

2. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, and means responsive to said operating condition within a limited time following a reclosure of said certain arcing contacts for sequentially opening all said arcing contacts and all said disconnecting contacts.

3. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, and means responsive to said operating condition within a limited time following a reclosure of said certain arcing contacts for sequentially opening all said arcing contacts, opening all said disconnecting contacts, and reclosing all said arcing contacts.

4. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, and means responsive to said operating condition and to occurrence of a plurality of openings of said certain arcing contacts and or reclosures thereof within a limited time for opening all said contacts.

5. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially con-

nected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only the arcing contacts connected in said one of said conductors, and means responsive to continuance or reoccurrence of said operating condition within a predetermined time following initiation of an operation of the first said means for opening the remainder of said contacts.

6. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, means responsive to said operating condition for opening all said contacts, and means operative between the first and second said contact opening means for rendering the second said contact opening means effective only during a limited time following operation of the first said contact opening means.

7. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only certain of said arcing contacts connected in said one of said conductors, means operable upon opening of said certain arcing contacts for causing reclosure thereof, means operable after said reclosure for opening all said contacts, a relay responsive to an operating condition of said one of said conductors for controlling the first said contact opening means, and means responsive to operation of said relay for causing said relay to control the second said contact opening means within a limited time.

8. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means severally associated with each one of said conductors and each responsive to an operating condition of the associated one of said conductors to cause opening of the arcing contacts connected therein, means operable upon opening of any of said arcing contacts for causing reclosure thereof, and means responsive to said operating condition of any one of said conductors within a limited time following a reclosure of any of said arcing contacts for opening all said contacts.

9. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in a different one of said phase conductors, means for opening only the arcing contacts connected in one of said conductors comprising a source of fluid under pressure, contact separating means, and a valve for connecting said source with said contact separating means, means responsive to an operating condition of said one of said conductors for actuating said valve to cause momentary opening of only the second disconnecting contacts comprising a second contact separating means and a second valve for connecting said source with said second contact separating means, and means responsive to said operating condition within a limited time following a predetermined number of openings of the second said arcing contacts for actuating the second said valve to cause opening of said disconnecting contacts.

10. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means for causing opening of said arcing contacts comprising a source of fluid under pressure, contact separating means, and a valve for connecting said source with said contact separating means, means for actuating said valve to cause momentary opening of said arcing contacts, means for opening said disconnecting contacts comprising a second contact separating means and a second valve for connecting said second contact separating means with said source, means for actuating the second said valve to cause opening of said disconnecting contacts while said arcing contacts are open, means for reclosing said disconnecting contacts comprising contact closing means and a third valve for connecting said contact closing means with said source, and an interlock between the said second and third valves for preventing operation of said contact closing means during operation of the second said contact opening means.

11. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means for causing opening of said arcing contacts comprising a source of fluid under pressure, contact separating means, and a valve for connecting said source with said contact separating means, means for actuating said valve to cause momentary opening of said arcing contacts, means for opening said disconnecting contacts comprising a second contact separating means connected with said source, means for reclosing said disconnecting contacts comprising contact closing means and a second valve for connecting said contact closing means with said source to overcome the action of the second contact separating means, and means for actuating the said second valve to render said contact closing means ineffective and to cause the second said contact separating means to open said disconnecting contacts while said arcing contacts are open.

12. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means for causing opening of said arcing contacts comprising a source of fluid under pressure, contact separating means, and a valve for connecting said source with said contact separating means, means for actuating said valve to cause momentary opening of said arcing contacts, means for opening said disconnecting contacts comprising a second contact separating

means connected with said source, means for reclosing said disconnecting contacts comprising contact closing means and a second valve for connecting said contact closing means with said source, and means responsive to the pressure of the fluid of said source below a predetermined value for rendering said contact separating and closing means ineffective.

13. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means for causing opening of said arcing contacts comprising a source of fluid under pressure, contact separating means, and a valve for connecting said source with said contact separating means, means for actuating said valve to cause momentary opening of said arcing contacts, means for opening said disconnecting contacts comprising a second contact separating means connected with said source, means for reclosing said disconnecting contacts comprising contact closing means and a second valve for connecting said contact closing means with said source to overcome the action of the second said contact separating means, means comprising a source of energy for controlling the operation of said second valve, a third valve for controlling the connection of said second contact separating means with said source of fluid, and means connected with said source of energy for maintaining said third valve open, whereby said second contact separating means is rendered ineffective upon failure of said source of energy.

14. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means operable by fluid under pressure below a predetermined value for closing said arcing contacts, means operable by fluid under pressure above said predetermined value for opening said arcing contacts, means operable by fluid under pressure for opening said disconnecting contacts while said arcing contacts are open, and means comprising a source of fluid under pressure for selectively controlling the operation of said contact actuating means.

15. In combination, an electric circuit, a circuit breaker comprising cooperating arcing contacts and cooperating disconnecting contacts serially connected with said arcing contacts in said circuit, means operable by fluid under pressure for closing said arcing contacts, means operable by fluid under pressure for opening said arcing contacts, means comprising a source of fluid under pressure and a pressure responsive valve for causing selective actuation of the said contact closing and opening means, and means operable by fluid under pressure from said source for opening said disconnecting contacts while said arcing contacts are open.

16. In combination, an electric circuit, a circuit breaker having contacts connected in said circuit, a source of fluid under pressure, means operable by fluid under pressure connected with said source for relatively actuating said contacts, means operable by fluid pressure to overcome the action of the first said means, a valve for controlling the connection of the second said means with said source, means comprising a source of energy for controlling the operation of said valve, a second valve for controlling the connection of the first said means with said source of fluid, and means connected with said source of energy for maintaining said second valve open whereby the first said means is rendered ineffective upon failure of said source of energy.

17. In combination, a polyphase electric circuit comprising a plurality of phase conductors, a circuit breaker having a plurality of pole portions each comprising contacts connected in a different one of said phase conductors, means responsive to an operating condition of one of said conductors for opening only contacts connected in said one of said conductors, means operable upon opening of the second said contacts for causing reclosure thereof, and means responsive to said operating condition within a limited time following a reclosure of the second said contacts for opening all said contacts.

18. In combination, an electric circuit, a circuit breaker comprising cooperating contacts connected in said circuit, means operable by fluid under pressure for closing said contacts, means operable by fluid under pressure for opening said contacts, and means comprising a source of fluid under pressure and a valve operatively responsive at a predetermined fluid pressure for causing selective actuation of said contact closing and opening means dependent upon the fluid pressure acting upon said valve being above or below said predetermined value.

DIDIER JOURNEAUX.