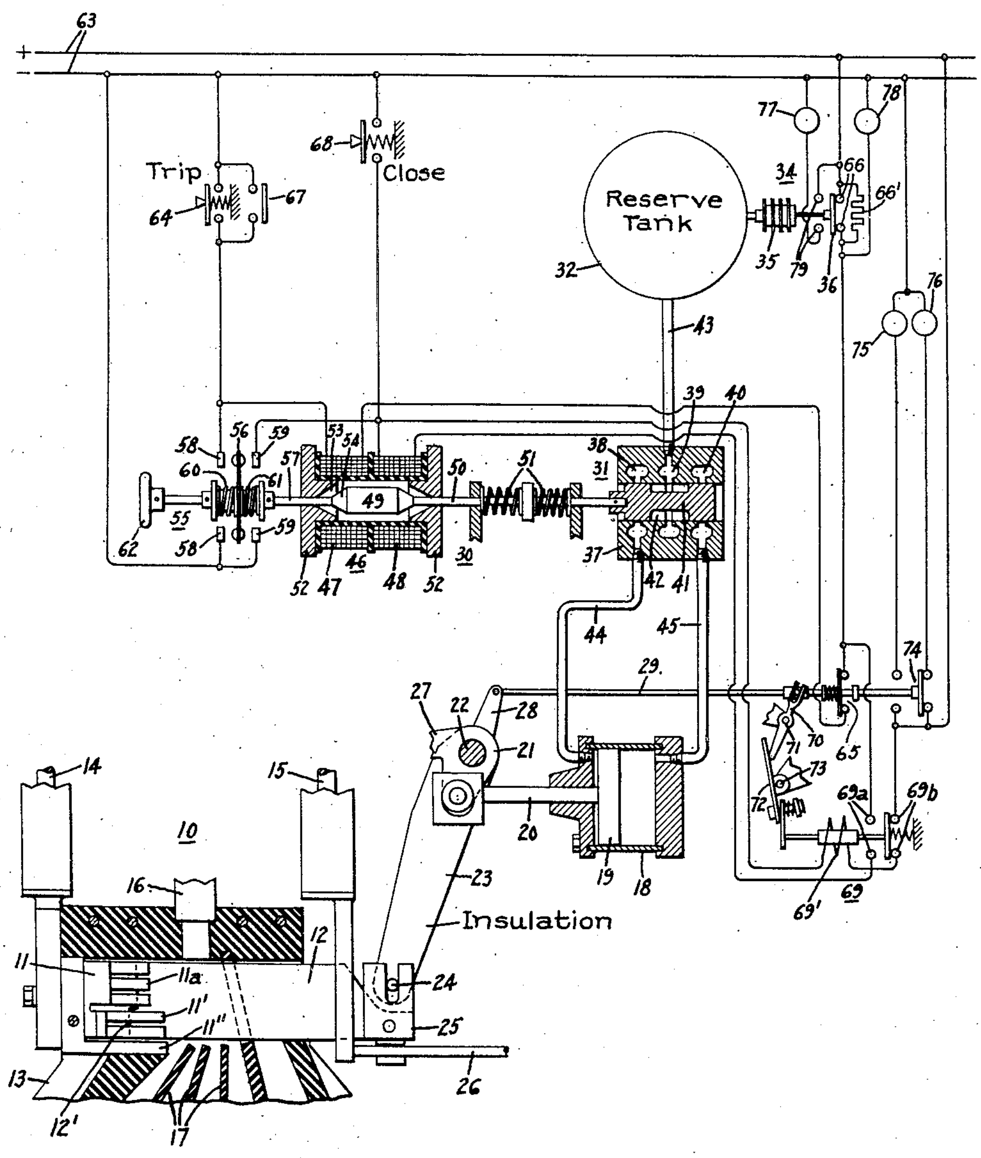
Sept. 9, 1941. B. W. WYMAN 2,255,496

CONTROL SYSTEM FOR CIRCUIT BREAKERS

Filed Dec. 22, 1939



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Patented Sept. 9, 1941

2,255,496

UNITED STATES PATENT OFFICE

2,255,496

CONTROL SYSTEM FOR CIRCUIT BREAKERS

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Application December 22, 1939, Serial No. 310,599

7 Claims. (Cl. 175—375)

My invention relates to a control system for an electric circuit breaker and more specifically to a control system for a fluid-operated circuit breaker.

Electric circuit breakers have gone through much development and improvement. This is especially true of the oil circuit breakers and, more recently, also of the fluid or air-blast circuit breakers. However, the structural and operating advantages of all circuit breakers are limited as far as the system which they are to protect is concerned by the problem of providing suitable control systems or apparatus which often furnish considerable difficulty. The value of any circuit breaker lies in its ability to interrupt a circuit at the proper time and in the proper manner. Similarly, the value of a control apparatus lies in its ability to effect control of the circuit breaker in the manner intended. A great number of undesirable conditions may occur as a consequence of the control system or apparatus not effecting the desired regulation.

My control system will be described hereinafter as applied to a new type of circuit breaker of the cross air-blast type which is disclosed and claimed in the joint application of David C. Prince, William K. Rankin, and Wilfred F. Skeats, Serial No. 303,126, filed November 6, 1939, and assigned to the same assignee as the present application. It will be understood, however, that this control system is also applicable to other types of circuit-interrupting apparatus, for example, circuit breakers in which a blast of fluid, such as oil, is used to extinguish the arc between the contacts, or in which the contacts are merely separated in oil.

Accordingly, it is an object of my invention to provide a new and improved control system for electric circuit breakers of the fluid-operated type.

It is another object of my invention to provide a new and improved combined electric and fluid control system for operating an electric circuit breaker.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing, the single figure of which is a schematic diagram of the control system for an electric circuit breaker embodying my invention.

Referring now to the drawing, I have illustrated my invention as applied to a gas-blast circuit breaker 10 of the cross blast type comprising a stationary contact 11 and a movable contact 12 arranged to be operated so as to draw an arc in an arc chute 13. The fixed contact 11 is connected to the line terminal 14 while the movable contact 12 is connected to the line terminal 15. Fixed contact 11 is provided with spring pressed contact fingers 11a and longer arcing contact fingers 11′ while movable contact 12 is provided with an arcing tip 12′ so that, when the contacts separate, an arc therebetween occurs between arcing tips 11′ and 12′. Immediately after separation of the contacts, one terminal of the arc is transferred by an air blast through conduit 16 from contact fingers 11′ to the contact 11″ which is provided with a tip of arc-resistant metal. The air blast from conduit 16 upon opening of the breaker drives the arc into the arc chute 13 against the edges of a plurality of partitions 17 in the arc chute, which partitions are transverse to the arc gap and the ends of which extend close to the path of movement of the arcing tip 12′ of the movable contact 12. The circuit breaker 10 illustrated by way of example in order to describe my control system is not my invention but is described and claimed in copending application Serial No. 303,126 referred to above.

In order to operate circuit breaker 10 automatically by fluid pressure, I provide a cylinder 18 with a piston 19 connected through a rod 20 to operate a lever 21 secured to the shaft 22. The shaft 22 has attached thereto an arm 23 of insulating material for operating the movable contact 12 of the circuit breaker. Although circuit breaker 10 is described with respect to a single phase, it will, of course, be understood by those skilled in the art that it may just as well comprise a plurality of phases, in which case, a plurality of arms 23 would be provided for operating the movable contacts 12 of the various phases. The arm 23 is shown provided with a pin 24 operating the member 25 secured to the outer end of movable contact 12. Member 25 is arranged to slide on a pair of rods 26, only one of which is shown in the drawing since the other is obscured from view thereby. It will be apparent that, when the shaft 22 is rotated in a counterclockwise direction, the arm 23 will move the contact 12 to the open position of circuit breaker 10 and that, when the shaft 22 is rotated in a clockwise direction, the arm 23 will move the contact 12 to the closed position. The member 25 and the rods 26 constitute a kind of crosshead arrangement by which the movable contact is reciprocated. The lever 21 mounted on shaft 22 has an extension 27 only partially shown which operates the mechanism for controlling the air-blast valve (not shown) so as to supply a blast of air through conduit 16 during the opening and closing operations of the circuit breaker 10. This arrangement is disclosed and claimed in the joint application of Leonard J. Linde and Torild Andersen, Serial No. 310,602, filed December 22, 1939, and assigned to the same assignee as the present application.

In addition to controlling the air-blast valve in response to certain operating positions of the circuit breaker 10, it is usually necessary to control certain other parts of the system or apparatus in accordance with the breaker position, and, therefore, I provide another lever 28 rigidly attached to shaft 22 for operating by means of operating rod 29 a plurality of switches which will be hereinafter described.

Control of the operation of circuit breaker 10 by fluid-pressure means operating upon piston 19 is obtained through solenoid-operated valve 30 including a two-way valve 31 adapted to interconnect one or the other end of cylinder 18 with a reserve fluid-pressure tank 32. Reserve tank 32 is connected to a fluid-pressure supply system through a nonreturn valve, not shown, so as to trap sufficient fluid, which, for example, may be air, at a suitable pressure to permit at least one operating cycle independent of the main supply. Therefore, if the main air supply should fail for any reason, one operating cycle of circuit breaker 10 may still be obtained by virtue of the air or other fluid trapped in reserve tank 32. Reserve tank 32 is provided with a pressure relay indicated schematically at 34 as comprising a Sylphon bellows 35 connected to reserve tank 32 and operatively connected to a suitable switch 36 cooperating with a plurality of contacts, which will be hereinafter described in greater detail. Valve 31 is schematically illustrated as comprising a cylinder 37 including a plurality of annular chambers 38, 39, and 40. Movably mounted within cylinder 37 is valve member 41 provided with an annular groove 42 adapted to connect either annular chamber 38 or 40 with annular chamber 39 when moved to either the left or right, respectively. If movable member 41 of valve 31 is moved to the left, a path for the air or fluid from reserve tank 32 to the left side of piston 19 in cylinder 18 is provided through conduit 43, annular chambers 39, 42, and 38, and conduit 44. Such an operating position of the valve would cause piston 19 to move to the right for opening circuit breaker 10. If valve member 41 is moved to the right, air or fluid from reserve tank 32 may pass through conduit 43, annular chambers 39, 42, and 40, and conduit 45 into the right-hand end of cylinder 18 against the right-hand end of piston 19 so as to close circuit breaker 10. Valve 31 is provided with a solenoid 46 having a tripping coil 47, a closing coil 48, and an armature 49. Armature 49 is operatively connected to valve member 41 through rod 50. In order to tend to maintain armature 49 of solenoid 46 and valve member 41 of valve 31 in the intermediate or neutral position, means comprising springs 51 are provided. In order that valve member 41 assumes a proper position so that annular chamber 42 thereof may register properly with annular chambers 38 and 39 or 39 and 40, solenoid 46 is provided with pole pieces 52 having cone-shaped openings 53 therein which cooperate with correspondingly shaped portions 54 formed on the ends of armature 49.

In addition to operating valve 31, solenoid 46 is also arranged to operate seal-in switching means 55 so as to take control away from the operator when the "trip" or "close" buttons are operated. Seal-in switching means 55 comprises a double-throw bridging member 56 operatively connected to the armature 49 of solenoid 46 by means of rod 57, and a plurality of cooperating contacts 58 and 59. In order to obtain proper wiping action of bridging member 56 and cooperating contacts 58 and 59, as well as to cause closure of one of the seal-in switches before operation of valve 31 a pair of springs 60 and 61 are provided. A manual lever or handle 62 is also operatively connected to the armature 49 of solenoid 46 and also to valve member 41 of valve 31 so that manual operation of the circuit breaker may be obtained in an emergency without using the electrical circuit which will be hereinafter described.

In order to electrically operate solenoid controlled valve 31 and also to control certain other features of my control system, I provide a source of direct-current potential 63. This source of potential 63 is connected to the solenoid-tripping coil 47 for tripping circuit breaker 10 through a manually operable "trip" button 64, limit switch 65 operatively connected to the circuit breaker 10 through rod 29, and contacts 66 cooperating with switch member 36 of pressure relay 34. A resistance 66' of such magnitude as to allow sufficient current to flow to enable coils 47 and 48 of solenoid 46 to hold valve 31 in one of its operating positions but not sufficient to operate the valve is connected across contacts 66. Connected in parallel with manually operated "trip" button 64 is a switch 67 adapted to be operated by a protective relay (not shown) so as to trip circuit breaker 10 upon the occurrence of abnormal current conditions on the power line connected to line terminals 14 and 15. Also connected in parallel through another circuit with manually operable "trip" button 64 are seal-in contacts 58 and bridging member 56 by means of which tripping coil 47 of solenoid 46 may remain energized even after the operator releases "trip" button 64. Closing coil 48 of solenoid 46 is connected to the direct-current circuit 63 through manually operable "close" button 68, contacts 69a of relay 69 which will be hereinafter described, and contacts 66 and switch member 36 of pressure-operated relay 34. Seal-in contacts 59 and bridging member 56 maintain closing coil 48 of solenoid 46 energized even after the operator releases "close" button 68 since they are connected in an electrical circuit which parallels "close" button 68.

So as to prevent "pumping" or repeated reclosing operations of circuit breaker 10 when it is closed on a short circuit or other abnormal current condition in the power line and the operator fails to release "close" button 68, relay 69 is provided, as mentioned above, including contacts 69a and 69b and winding 69'. Contacts 69a are normally closed when circuit breaker 10 is in the open position. However, when circuit breaker 10 has reached a predetermined position in the latter part of the closing stroke at which opening of the breaker may be effectively made, that is, when the blast valve control mechanism disclosed in copending application, Serial No. 310,602, referred to above is ready for providing an opening blast of air, its lever 28 and operating arm 29 move lever 70 pivoted at 71 which strikes articulated lever 72 pivoted at 73 which, in turn, mechanically causes relay 69 to operate so as to open contacts 69*a* and close contacts 69*b*. Lever 72 is articulated in order to compensate for any overtravel of rod 29. If now circuit breaker 10 should suddenly be reopened by operation of protective relay switch 67 before the operator has released "close" button 68, a circuit has been established across direct-current circuit 63 through "close" button 68, the winding of relay 69, and contacts 69*b*, whereby contacts 69*a* remain in their open position even though levers 70 and 72 would allow relay 69 under the influence of its biasing spring to assume the position which it would normally take when circuit breaker 10 is in the open position.

It is desirable that the operator may see at a glance the condition of the circuit breaker 10 and associated control system. Accordingly, I provide limit switch 74 of the double-throw type which is adapted to close the circuit through signal means 75 or 76, depending upon the operating position of circuit breaker 10. For example, signal means 75 may be a green light for indicating that the circuit breaker 10 is in the open position while signal means 76 may be a red light for indicating that the circuit breaker is in the closed position. Single-pole single-throw limit switch 65 is provided in order to effect a positive cut off of the tripping circuit at a predetermined point in the opening stroke of circuit breaker 10. A plurality of signal means 77 and 78 may also be provided to indicate the pressure conditions in reserve tank 32 and one or the other of these signal means may be energized by switch 36 operated through pressure relay 34 and cooperating with contacts 66 or 79. For example, when the pressure in reserve tank 32 is sufficiently high, Sylphon bellows 35 will cause switch 36 to bridge contacts 66, thereby energizing signal 78 which may, for example, be a green light. Resistance 66' will not allow sufficient current to flow through signal means 78 when contacts 66 are opened to operate the signal. If, however, the pressure in tank 32 falls below a predetermined minimum, Sylphon bellows 35 will contract, allowing switch 36 to bridge contacts 79, thereby closing an electrical circuit through signal means 77 which may, for example, take the form of a red light.

The operation of my control system for a fluid-pressure operated circuit breaker will be described first with reference to the closed position of circuit breaker 10 as shown in the drawing and also with the "trip" and "close" buttons 64 and 68, respectively, in the released positions and with the pressure in reserve tank 32 sufficiently high so that switch 36 associated with pressure relay 34 bridges contacts 66, thereby energizing green light 78 which informs the operator that the fluid-pressure is adequate. Since the breaker is in the closed position, limit switch 74 is moved to the right so as to energize red light 76 and so informing the operator. Valve 31 and solenoid 46 have their respective parts, namely valve member 41 and armature 49, in their intermediate or neutral positions by virtue of spring means 51. Hence, the fluid under pressure in tank 32 is not in communication with cylinder 18. If it should be desired to trip breaker 10 to the open position, the operator merely presses "trip" button 64 which closes the circuit through tripping coil 47 of solenoid 46, limit switch 65, and relay pressure switch 34—36, whereupon the armature 49 of solenoid 46 moves to the left. This movement causes seal-in contacts 58 to be engaged by switch 56 prior to the opening of valve 31 to transfer control away from the operator. Valve member 41 moves to the left and, by virtue of the valve-positioning function of cone-shaped cooperating members 53 and 54 of solenoid 46, annular chamber 39 is connected with annular chamber 38 by means of annular chamber 42 provided in valve member 41. This connects the fluid or air in reserve tank 32 with the left-hand end of cylinder 18 through conduits 43 and 44, respectively, causing piston 19 to move circuit breaker 10 to the open position. Fluid or air in the right-hand end of cylinder 18 is exhausted to atmosphere through conduit 45 via the exposed bore in valve cylinder 37. During this movement, lever 27, only partially shown, causes operation of an air-blast valve, not shown, so as to supply a blast of air through conduit 16 transversally of the arc drawn between movable contact 12 and stationary contact 11 for extinguishing such arc. At the same time, lever 28 causes limit switch 65 to be opened, effecting a positive cut off of the tripping circuit through tripping coil 47. Limit switch 74 also moves to the left, deenergizing red light 76 and energizing green light 75. Operating levers 70 and 72 are moved by rod 29 so as to allow relay 69 to move to the left, under the influence of a suitable biasing spring, opening contacts 69*b* and closing contacts 69*a*. As soon as limit switch 65 has opened deenergizing the tripping circuit, spring means 51 will cause valve member 41 of valve 31, armature 39 of solenoid 46, and switch member 56 of seal-in switch 55 to assume their intermediate or neutral positions. The same operating cycle described above would occur if protective relay switch 67 had been operated to the closed position because of an abnormal current condition in the power lines interconnected by circuit breaker 10. Similarly, the same operating cycle could be obtained if the operator had manually grasped handle 62 and pulled it to the left, in which case, the electrical circuit would not be used.

Assuming now that the circuit breaker is in the open position after the tripping cycle just described, closing operation of the breaker may be obtained if the operator depresses "close" button 68, whereby closing coil 48 of solenoid 46 is energized through contacts 69*a* of relay 69 and pressure relay switch 34—36. This causes armature 49 of solenoid 46 to move to the right carrying with it bridging member 56 which cooperates with seal-in contacts 59, taking control away from the operator. Further movement of armature 49 to the right so that cone-shaped member 54 engages with cooperating member 53 of pole piece 52 causes valve member 41 to assume a position interconnecting conduits 43 and 45, whereby piston 19 is moved to the left forcing movable member 12 to the closed circuit position. Levers 70 and 72 are rotated so as to mechanically move relay 69 to the right, opening contacts 69*a* and closing contacts 69*b*. The opening of contacts 69*a* breaks the circuit through closing coil 48. However, in the event the operator fails to release "close" button 68, relay 69 is sealed in through contacts 69*b* by virtue of winding 69' so as to prevent pumping or reclosure of the circuit breaker in the event that the switch 67 of the protective relay should cause it to trip. Deenergization of closing coil 48 of solenoid 46 allows spring 51 to cause armature 49 and valve member 41 to assume an intermediate or neutral position. The closing movement of circuit breaker 10 closes switch 65 relatively early during the stroke of movable contact 12 so that the control circuit is completed for a tripping operation. It will be understood that, if the pressure in reverse tank 32 should drop so that the circuit through contacts 66 is opened, the "trip" and "close" circuits for the breaker are broken. However, at the discretion of the operator, the breaker may still be operated if sufficient pressure remains by moving operating handle 62 to the right or to the left, depending upon the particular operation desired. Since the reserve air tank 32 is relatively small, a pressure drop occurs during each operation of the circuit breaker 10. In order to be sure that pressure relay 34 will not, during the operating cycle of the circuit breaker, open the circuit to solenoid coils 47 and 48, resistance 66′ is provided. If either coil 47 or 48 has been energized to move member 41 to the left or right, respectively, resistance 66′ will allow sufficient current to flow to hold the valve member 41 in position even though contacts 66 open. However, resistance 66′ will not allow sufficient current to flow to operate valve member 41 initially.

Trip-free response of the circuit breaker in my control system is rendered safe in being accompanied by an effective air blast through the instantaneous functioning at the proper moment of mechanically opened contacts 69*a* of relay 69. As has been set forth above, contacts 69*a* are not opened until a predetermined position in the latter part of the closing stroke of circuit breaker 10 is reached, at which time, the blast valve control mechanism is ready to provide an opening blast of air. At this instant, switch 65 has already closed to complete a tripping circuit. In the event that contacts 67 of abnormal current relay, not shown, are closed, tripping coil 47 of solenoid 46 is energized even though closed coil 48 is still energized, contacts 69*a* having not yet opened. Nevertheless, the lowered reluctance of closing coil 48 of solenoid 46, in view of the energization of tripping coil 47, enables it to resist the counter-attraction of tripping coil 47 until cut-off of closing coil 48 occurs through relay contact 69*a*, deenergizing closing coil 48. Thus, all the elements for trip-free operation are prepared in advance so that the opening of contact 69*a* alone governs the earliest safe instant at which the movable contact 12 may reverse itself to open the circuit breaker during a trip-free operation.

While I have shown and described a particular embodiment of my invention as applied to a control system for an electric circuit breaker schematically shown, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In a control system for a fluid-operated circuit breaker, operating means for said circuit breaker including a valve arranged to be supplied with fluid under pressure for controlling the opening and closing movements of said circuit breaker, a solenoid having its armature connected to operate said valve, means normally tending to hold said valve and armature in a neutral or intermediate position, an electric circuit for selectively energizing said solenoid to operate said valve including a "trip" and "close" button, and means mechanically operated by closure of said circuit breaker for preventing repeated closing operations of said circuit breaker when the operator does not release the "close" button in the event that said circuit breaker fails to remain closed.

2. In an electropneumatic control system for a circuit breaker, the combination of pneumatic means for operating said circuit breaker including an air storage tank for trapping sufficient air for one operating cycle of said breaker, a valve arranged to interconnect said pneumatic means and said storage tank to obtain closing and tripping operations of said circuit breaker, solenoid means including closing and tripping coils and an armature operatively connected to said valve, an electric circuit for selectively energizing said closing and tripping coils, spring means normally tending to hold said valve and solenoid in the neutral position, and a relay mechanically operated in one direction by said breaker including a winding associated with said electric circuit for preventing repeated closure operations of said breaker in the event the circuit breaker is closed on a short-circuit current condition.

3. A control system including a circuit breaker, a valve arranged to be supplied with gas under pressure for operating said circuit breaker, an actuating means associated with said valve including a solenoid having its armature connected to said valve, said solenoid including tripping and closing coils, an electric circuit including manually operable means associated with said tripping and closing coils for remotely controlling said valve to control said circuit breaker, means responsive to the pressure of the gas supply determining the control of said manually operable means over said actuating means, a seal-in switch operatively connected to said solenoid armature for taking control away from said manually operable means, and a switch mechanically operated by movement of said circuit breaker including a winding connected in said electric circuit for preventing pumping of said circuit breaker when closed on an abnormal current condition.

4. A control system including a circuit breaker, a valve arranged to be supplied with gas under pressure for controlling said circuit breaker, an actuating means associated with said valve including a solenoid having its armature connected to said valve, said solenoid including tripping and closing coils, an electric circuit including manually operable means associated with said tripping and closing coils for remotely controlling said valve to control said circuit breaker, means responsive to the pressure of the gas supply determining the control of said manually operable means over said actuating means, and means for preventing said means responsive to the pressure of the gas supply from interfering after an operation of said circuit breaker has begun.

5. In a control system for a circuit breaker of the fluid-operated type, a valve arranged to be supplied with fluid under pressure for controlling said circuit breaker, an actuating means associated with said valve including a solenoid

having its armature connected to said valve, said solenoid including tripping and closing coils, an electric circuit including manually operable means associated with said tripping and closing coils for controlling said valve, means responsive to the fluid pressure supply for maintaining said manually operable means ineffective in the event said fluid pressure falls below a predetermined value, and means for maintaining said means responsive to said fluid pressure supply ineffective after an operation of said circuit breaker has begun.

6. In a control system for a circuit breaker of the fluid-operated type, a valve arranged to be supplied with gas under pressure for controlling said circuit breaker, an actuating means associated with said valve including a solenoid having its armature connected to said valve, said solenoid including tripping and closing coils, an electric circuit including manually operable means associated with said tripping and closing coils for controlling said valve, a pressure relay including a plurality of contacts for preventing the operation of said circuit breaker when said gas under pressure for operating said circuit breaker falls below a predetermined value, and a resistance connected across said contacts so that the operation of said circuit breaker may be completed once it has started even through the pressure of said gas falls below said predetermined value during said operation.

7. In a control system for a fluid-operated circuit breaker, fluid-operated means for causing opening and closing movements of said circuit breaker, a solenoid operatively connected to a valve for controlling said last-mentioned means, an electric circuit for selectively energizing said solenoid including manually operable tripping and closing means, and means mechanically operated by closure of said circuit breaker for preventing pumping thereof when said manually operable closing means is held in its controlling position after closure of said circuit breaker which fails to remain closed.

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