Dec. 15, 1942. C. THUMIM 2,304,865

ELECTRIC CONTROL SYSTEM

Filed Jan. 7, 1941

Fig. 1.

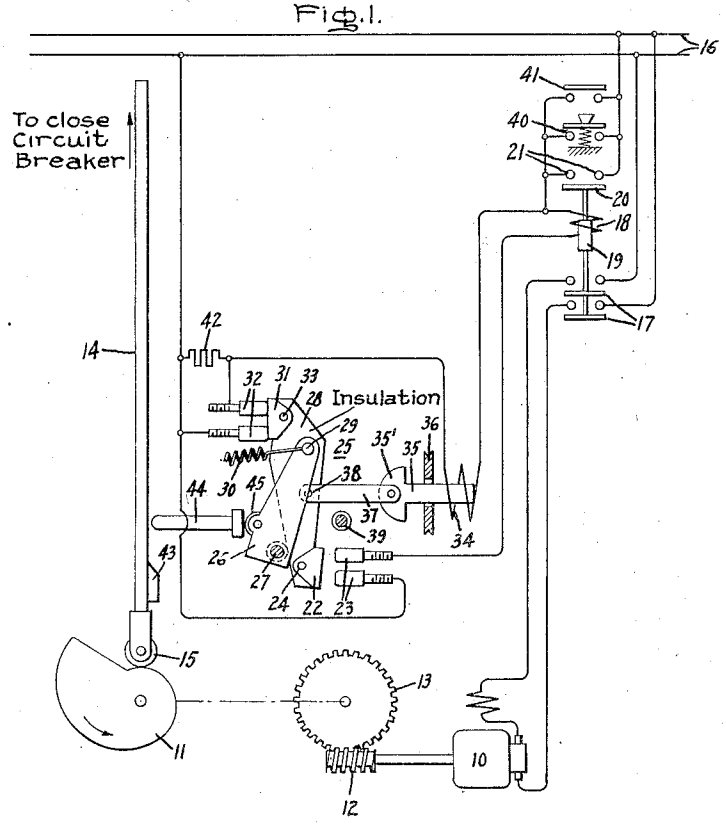


Fig. 2.

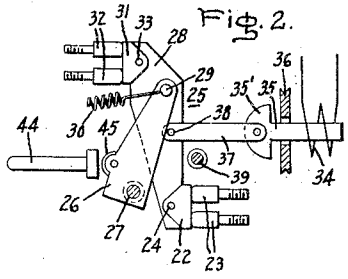


Fig. 3.

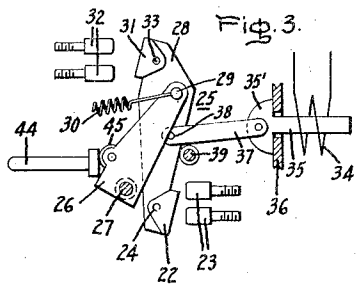
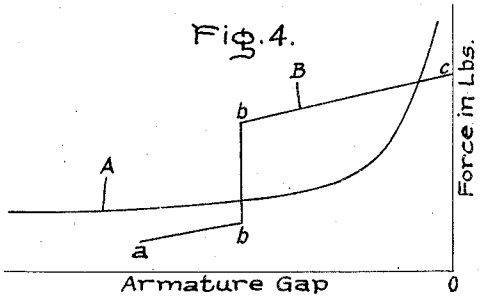


Fig. 4.



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UNITED STATES PATENT OFFICE

2,304,865

ELECTRIC CONTROL SYSTEM

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10 Claims. (Cl. 175—294)

My invention relates to an electric control system for controlling a single predetermined operation, such as a circuit interrupter closing operation so as not only to insure completion thereof but also to prevent recurrent operations when only a single control operation has been initiated by the operator.

It is a common expedient in control systems for circuit interrupters to initiate the closing operation by closing a manual switch of some sort. Generally the closing of this switch initiates the operation of suitable motive means for moving the circuit interrupter to the closed position. If this switch remains in the closed position after the closing operation has been completed and the circuit interrupter immediately opens due to an abnormal condition on the power circuit which it controls, obviously the closing circuit of the circuit interrupter is again completed as soon as it reaches its open position and the closing operation is repeated. Under these conditions, a circuit interrupter or breaker continues to open and close rapidly while the abnormal condition persists and the manual switch remains in its circuit-closing position. This so-called "pumping action" if allowed to continue may result in serious damage to the associated apparatus.

Many antipumping arrangements have been proposed which usually depend upon electromagnetic means for rendering the control circuit ineffective at the completion of the closing operation as long as the manual initiating switch remains closed. Cases have been known, however, where such electromagnetic means have become defective, such as when the winding thereof is open circuited or short circuited, so that pumping resulted with serious damage to associated apparatus.

It is an object of my invention, therefore, to provide a new and improved control system which will overcome the disadvantage set forth above.

It is another object of my invention to provide a new and improved arrangement for preventing the repeated opening and closing of a circuit interrupter under the conditions mentioned above.

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 in which Fig. 1 is a partly diagrammatic layout of an electric control system and apparatus illustrating a specific application of my invention, Figs. 2 and 3 illustrate a portion of the apparatus shown in Fig. 1 and represent successive positions assumed by this apparatus during the operation of the electric control system, and Fig. 4 is a graph representing certain operating characteristics of the apparatus and control system of Fig. 1 to aid in the understanding of my invention.

As will be understood by those skilled in the art, any suitable motive means may be utilized for moving to a predetermined position, such as the closed position, the device to be operated, such as a circuit breaker. Such motive means may comprise motors of various sorts, such as pneumatic motors, dynamoelectric machines, solenoid motors, and the like, all of which may be controlled electrically. In order to illustrate my invention, I have chosen in Fig. 1 to illustrate this motive means as comprising an electric motor 10, which rotates an operating cam 11 in a counterclockwise direction through suitable connections, such as a worm and drive gear 12 and 13. Operating cam 11 is illustrated as being connected in any suitable manner to means to be actuated, such as by longitudinally guided operating rod 14 having a roller 15 engaging the cam-actuating face. Preferably rod 14 is connected to an electric circuit breaker through a suitable trip-free mechanism, not shown, so that upward movement thereof upon counterclockwise rotation of operating cam 11 causes closing of the circuit breaker, not shown.

It will be obvious to those skilled in the art that operating rod 14 might be actuated directly by a solenoid having the desired straight-line motion or from a pneumatic or fluid-operated motor connected thereto. In any event, these various motive means could all be controlled electrically from a suitable source of electrical energy. In Fig. 1, I have shown motor 10 as arranged to be energized from an electric supply circuit 16, the energization of the motor circuit being controlled by a motor switch 17.

The motor switch 17 is provided with electromagnetic actuating means including a solenoid 18, the movable element 19 of which is connected to the movable contact structure of switch 17 and is likewise provided with a contact 20 for bridging seal-in contacts 21 when solenoid 18 is energized. Energization of the solenoid 18 from supply circuit 16 and closing of the motor switch

17 is attained upon closing of cutoff switch 22 adapted to bridge contacts 23 associated therewith.

For reasons which will be described hereinafter, cutoff switch 22 is pivotally supported at 24 by a lever mechanism, generally indicated at 25, which comprises member 26 rotatably mounted on fixed support 27 and insulating member 28 which is pivotally connected at an intermediate point 29 thereof to member 26. Suitable means, such as tension spring 30, is provided for normally urging member 26 to rotate in a counterclockwise direction about fixed support 27. The spring force is preferably applied at pivot point 29 of lever mechanism 25 for reasons which will be brought out hereinafter and cutoff switch 22 is supported by the end of member 28 most remote from pivot point 29. A shunting switch 31 adapted to bridge contacts 32 is pivotally supported at 33 by the other end of insulating member 28.

Cutoff switch 22 is normally held in the open position shown in Fig. 1 by spring means 30 which rotates member 26 and insulating member 28 in a counterclockwise direction around fixed support 27 until shunting switch 31 bridges contacts 32. Thereafter, spring means 30, by virtue of being connected at pivot point 29, causes clockwise rotation of insulating member 28 about pivot point 33, until it engages fixed support 27, as shown in Fig. 1, which limits the clockwise rotation thereof.

In order to close cutoff switch 22 by bridging contacts 23, I have provided an electromagnet 34 having a suitable magnetic circuit, only the armature 35 and a portion of the pole piece 36 being shown in the drawing. The armature is illustrated as having an enlarged end 35' for limiting its movement upon energization of electromagnet 34 and the space between this enlarged head 35' and pole piece 36 will be hereinafter referred to as the armature gap, the electromagnetic force exerted on the armature 35 upon energization of electromagnet 34 being a minimum when the armature gap is a maximum and a maximum when the armature gap is a minimum. Armature 35 is mechanically connected by means of link 37 to insulating member 28 at 38, which is intermediate pivot points 24 and 29. When electromagnet 34 is energized, a force-opposing spring means 30 is applied to insulating member 28, causing it to rotate about pivot 33 until cutoff switch 22 bridges contacts 23. As may be observed from Fig. 2, such bridging action of cutoff switch 22 occurs before armature 35 has moved sufficiently to reduce the armature gap to a minimum when enlarged end 35' engages pole piece 36. If armature 35 were to continue to move toward pole piece 36 after cutoff switch 22 bridges contacts 23, then insulating member 28 would rotate about pivot 24 and cause shunting switch 31 to move away from contacts 32 until insulating member 28 engages stop 39. This stop 39 would then act as a pivot for insulating member 28, and cutoff switch 22 would also be moved away from contacts 23 so that the lever mechanism 25 would assume the position shown in Fig. 3.

It will be observed from Figs. 1 and 2, however, that, when electromagnet 34 is energized to rotate insulating member 28 about pivot 33 against spring means 30 to cause cutoff switch 22 to bridge contacts 23, it has a considerable mechanical advantage over spring means 30 since the moment arm through which the force provided by electromagnet 34 acts is much greater than that through which the spring force is applied. However, as soon as the contacts 23 are bridged by cutoff switch 22, the point about which insulating member 28 rotates shifts from pivot 33 to pivot 24. The mechanical advantage which solenoil 34 had up to this time now changes to a disadvantage since spring means 30 acts through the long moment arm. Electromagnet 34 is designed when energized to move cutoff switch 22 to the position shown in Fig. 2 but is not capable of assuming the position indicated in Fig. 3 where the armature gap is reduced to zero.

Electromagnet 34 may be energized from supply circuit 16 through shunting switch 31, associated contacts 32, and push-button control switch 40, which may be closed by the operator to initiate the closing operation. This operation may also be initiated by automatic reclosing switch 41 paralleling push-button switch 40, which may be controlled in a manner well known to those skilled in the art. A suitable resistor 42 is provided in parallel with contacts 32 associated with shunting switch 31 so that, if electromagnet 34 tended to move armature 35 beyond the position shown in Fig. 2 to open shunting switch 31, the insertion of this impedance in the energization circuit of electromagnet 34 would reduce the pull on armature 35, causing it to snap back to the position shown in Fig. 2. Furthermore, the provision of resistor 42 maintains electromagnet 34 in an energized condition even after shunting switch 31 no longer bridges contacts 32.

For the purpose of deenergizing motor 10 in accordance with a predetermined operation thereof, I have provided a cam 43 mounted on longitudinally guided operating rod 14 which engages with a horizontally movable member 44 when operating rod 14 reaches a predetermined position so as to force the latter against a projection 45 on member 26, thereby causing clockwise rotation thereof against spring means 30. This action forces the enlarged end 35' of armature 35 against pole piece 36, reducing the armature gap to zero and, as was mentioned heretofore, causing shunting switch 31 and finally cutoff switch 22 to move away from their associated contacts 32 and 23, respectively. As is well known by those skilled in the art, the force exerted by electromagnet 34 on armature 35 greatly increases as the armature gap decreases and, consequently, when the armature 35 attains a position shown in Fig. 3, electromagnet 34 exerts a greater force thereon than does opposing spring means 30 through lever mechanism 25 so as to hold armature 35 in this position of zero armature gap even though electromagnet 34 could not exert a sufficient force on armature 35 to move it from the position shown in Fig. 2 to the position shown in Fig. 3.

The operation of my invention will be briefly described with particular reference to Fig. 4 wherein the curve A represents a typical pull curve for an electromagnet, such as 34, wherein the force exerted on armature 35 increases nonlinearly as the armature gap is reduced to zero. The curve B, on the other hand, represents the opposing force exerted by spring means 30 on armature 35 through lever mechanism 25 and link 37 for various armature gaps. The portion *ao* of curve B represents the force exerted by spring means 30 on armature 35 for armature gaps between the maximum gap shown in Fig. 1 and the intermediate gap shown in Fig. 2. It will be observed that the portion *ab* of curve B falls below the corresponding portion of curve A and,

consequently, the force exerted by electromagnet 34 would predominate over that of spring means 30. As was mentioned above, when the position shown in Fig. 2 is attained by leved mechanism 25, the pivot about which member 28 rotates shifts from pivot point 33 to pivot point 24 and the mechanical advantage which electromagnet 34 had up to this time changes to a mechanical disadvantage with reference to the forces acting on armature 35. The portion *bc* of curve B represents the force exerted by spring means 30 on armature 35 for armature gaps equal to and less than that shown in Fig. 2. It will be observed that the opposing spring force is now predominant until the armature gap is almost reduced to zero and, consequently, electromagnet 34 is unable to reduce the armature gap below that shown in Fig. 2. When, however, the armature gap is reduced to zero as in Fig. 3, the force exerted on armature 35 by electromagnet 34 again predominates over spring means 30 so that, if armature 34 were moved to the position shown in Fig. 3 by cam 43 and member 44, it would be held in this position as long as electromagnet 34 is energized. In fact, electromagnet 34 is so designed that, even with the insertion of resistor 41 into its energizing circuit to reduce the effective ampere turns thereof, the force exerted on armature 35 by electromagnet 34 is still predominant over the force exerted by spring means 30 in the position shown in Fig. 3.

Assuming the apparatus in the position shown in Fig. 1, closing operation of the circuit breaker, not shown, may be initiated manually by depressing closing push button 40 or automatically when reclosing switch 41 is closed. Since shunting switch 31 bridges contacts 32, electromagnet 34 is energized from electric supply circuit 16 and lever mechanism 25 is moved from the position shown in Fig. 1 to the position shown in Fig. 2, thereby causing cutoff switch 22 to bridge contacts 23 and complete the energization circuit for electromagnetic actuating means 18. This action results in the closing of motor switch 17 and the bridging of seal-in contacts 21 by member 20. Motor 10 is thereby energized and causes cam 11 to rotate in the counterclockwise direction, moving rod 14 upwardly. As soon as cam 43 moves member 44 against projection 45 of member 26, the lever mechanism 25 would be moved about fixed support 27 until the position illustrated in Fig. 3 is assumed by the apparatus, whereupon electromagnet 34 exerts sufficient force to hold the enlarged end 35' of armature 35 against pole piece 36 even though the effective ampere turns have been considerably reduced by the insertion of resistor 42 into the energization circuit of electromagnet 34.

It will be observed from the above discussion that, as soon as the closing operation of the circuit breaker has been completed, cut-off switch 22 no longer bridges the contacts 23 and electromagnetic actuating means 18 and, consequently, motor 10 are deenergized. Furthermore, as long as the operator holds push button 40 in the closed position, electromagnet 34 will hold the cutoff switch 22 and shunting switch 31 in the open positions shown in Fig. 3 with the result that motor 10 cannot again be energized after a single closing operation until the operator releases the push button 40 and subseqently closes it again. Upon opening push button 40, electromagnet 34 is deenergized and the lever mechanism 25 assumes the position shown in Fig. 1 with the cutoff switch 22 in the open position, so that a new closing operation may be initiated. It will be observed that, if solenoid 34 became defective while the operator held push button 40 in the depressed position, lever mechanism 25 would assume the position shown in Fig. 1, rendering the closing circuit ineffective so that there would be no danger of pumping of the apparatus when the circuit breaker is closed on an abnormal current condition existing on the circuit which it controls. Thus, the disadvantage of the prior-art arrangements is completely eliminated.

It should be understood that my invention is not limited to the specific details of construction and arrangement here illustrated and that changes and modifications may occur to one skilled in the art without departing from my invention 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 circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, means including a cutoff switch supported by a lever mechanism for rendering said electric control circuit effective or ineffective, a solenoid having an armature for operating said cutoff switch, said lever mechanism being so constructed and arranged that closure of said cutoff switch occurs after a predetermined movement of said armature upon energization of said solenoid and opening of said cut off switch occurs upon a further movement of said armature, means including an operator's switch for energizing said solenoid to close said cutoff switch, and means responsive to a predetermined operation of said motive means for further moving said armature to open said cutoff switch and deenergize said motive means.

2. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including electromagnetic actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, and means including a movable member for moving said cutoff switch to the closed position, said last-mentioned means being so constructed and arranged with respect to said lever mechanism that further movement of said movable member causes opening of said cutoff switch.

3. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including electromagnetic actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, electromagnetic means including an armature for operating said cutoff switch to the closed position against the force of said last-mentioned means upon a predetermined movement of said armature, additional means for producing further movement

of said armature to open said cutoff switch, means including an operator's switch for energizing said last-mentioned electromagnetic means to close said cutoff switch, said last-mentioned electromagnetic means being arranged to hold said cutoff switch in the open position during a continued closure of said operator's switch after said additional means has caused opening thereof.

4. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including electromagnetic actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, electromagnetic means including an armature for operating said cutoff switch to the closed position against the force of said last-mentioned means upon a predetermined movement of said armature, means responsive to a predetermined closing movement of said circuit interrupter for producing further movement of said armature to open said cutoff switch, means including an operator's switch for energizing said last-mentioned electromagnetic means to close said cutoff switch, said last-mentioned electromagnetic means being arranged to hold said cutoff switch in the open position during a continued closure of said operator's switch after said means responsive to a predetermined closing movement of said circuit interrupter has caused opening thereof.

5. In a circuit interrupter controlling system comprising cam-operated means for moving said circuit interrupter to the closed position, an electric motor for actuating said cam, an electric control circuit for effecting the operation of said electric motor, a switch including electromagnetic actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, and means including a movable member for moving said cutoff switch to the closed position, said last-mentioned means being so constructed and arranged with respect to said lever mechanism that further movement of said movable member causes opening of said cutoff switch.

6. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including electromagnetic actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, electromagnetic means including an armature for operating said cutoff switch to the closed position against the force of said last-mentioned means upon a predetermined movement of said armature, additional means for producing further movement of said armature to open said cutoff switch, means including an operator's switch for energizing said last-mentioned electromagnetic means to close said cutoff switch, a seal-in switch for said operator's switch, said last-mentioned electromagnetic means being arranged to hold said cutoff switch in the open position during a continued closure of said operator's switch after said additional means has caused opening thereof.

7. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, means normally urging said cutoff switch to the open position, said lever mechanism being so constructed and arranged that closure of said cutoff switch occurs after a predetermined movement of said lever mechanism against the force of said last-mentioned means and opening of said cutoff switch occurs upon a further movement of said lever mechanism against the force of said last-mentioned means, electromagnetic means capable of producing sufficient movement of said lever mechanism to close said cutoff switch against the force exerted by said last-mentioned means but incapable of producing the necessary further movement of said lever mechanism to open said cutoff switch, means including an operator's switch for energizing said electromagnetic means to close said cutoff switch, and means responsive to a predetermined operation of said motive means for further moving said lever mechanism to open said cutoff switch and deenergize said actuating means.

8. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, a switch including actuating means for rendering said electric control circuit effective or ineffective, means including a cutoff switch supported by a lever mechanism for controlling the operation of said actuating means, spring means associated with said lever mechanism for urging said cutoff switch to the open position, electromagnetic means including an armature connected to said lever mechanism for closing said cutoff switch, said lever mechanism being so constructed and arranged that the force applied thereto by said armature predominates over the force applied by said spring means while said cutoff switch moves from the open to the closed position after which the spring means predominates to prevent further movement of said lever mechanism by said armature, said lever mechanism being further constructed and arranged that further movement of said armature by means supplementing said electromagetic means causes subsequent opening of said cutoff switch and allows said electromagnetic means to produce a force predominating over said force produced by said spring means to hold said cutoff switch in the open position until deenergization of said electromagnetic means, means including an operator's switch for energizing said electromagnetic means to close said cutoff switch, and means responsive to a predetermined operation of said motive means for supplying a supplementary force to produce further movement of said lever mechanism to open said cutoff switch and deenergize said actuating means.

9. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric

control circuit for effecting the operation of said motive means, means including a first switch for rendering said electric control circuit effective to initiate operation of said motive means to move said circuit interrupter to the closed position, electromagnetic means having an armature for operating said first switch, means including an operator's switch for energizing said electromagnetic means to operate said first switch and initiate closing of said circuit interrupter, and means operated directly by a predetermined operation of said motive means for causing deenergization of said control circuit, said electromagnetic means being so constructed and arranged to maintain said control circuit in the deenergized condition as long as said operator's switch is closed, regardless of the position of said circuit interrupter.

10. In a circuit interrupter controlling system comprising motive means for moving said circuit interrupter to the closed position, an electric control circuit for effecting the operation of said motive means, electromagnetic means for causing energization and deenergization of said control circuit to render said motive means effective and ineffective to close said circuit interrupter, means including an operator's switch for controlling the energization of said electromagnetic means to initiate the closing operation of said circuit interrupter, means operated by a predetermined closing movement of said circuit interrupter for deenergizing said control circuit, and means responsive to the continued energization of said electromagnetic means for maintaining said control circuit in a deenergized condition as long as said operator's switch remains closed regardless of the position of said circuit interrupter.

CARL THUMIM.