Aug. 14, 1928. 1,680,674

A. S. FITZGERALD

ELECTRIC SWITCH

Filed Sept. 8, 1924 2 Sheets-Sheet 1

Fig. 1.

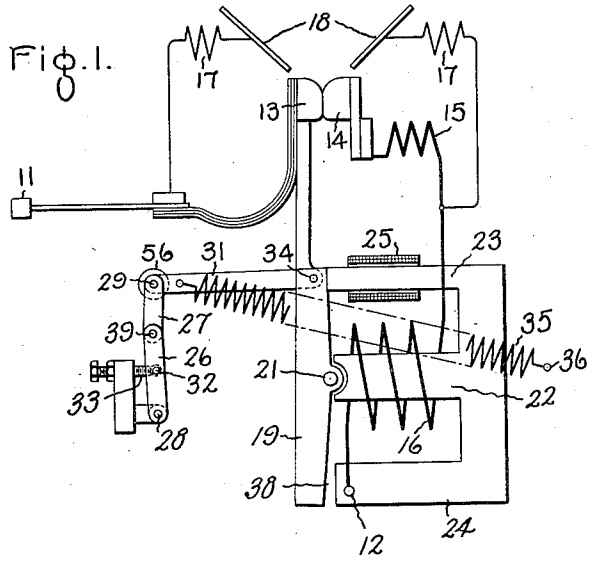


Fig. 2.

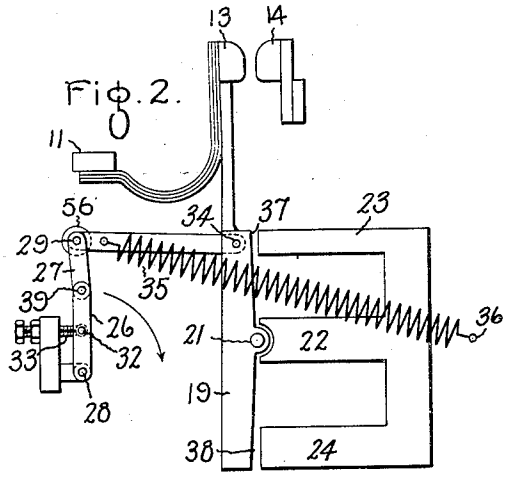
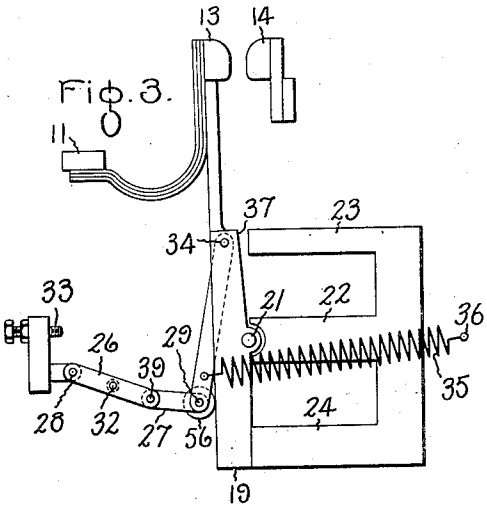


Fig. 3.



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by Alexander S. Lunt
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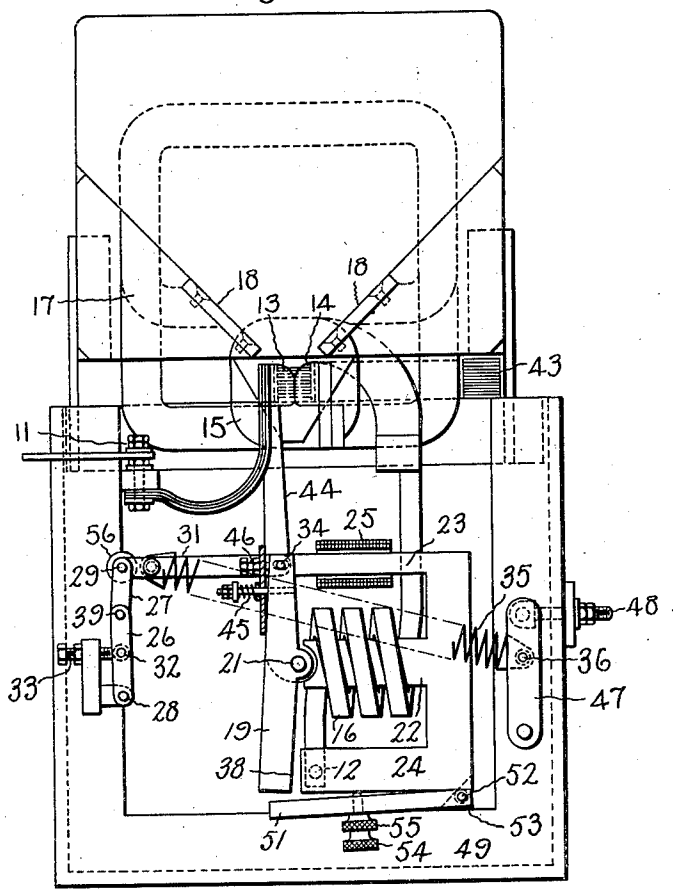
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ELECTRIC SWITCH

Filed Sept. 8, 1924 2 Sheets-Sheet 2

Fig. 4.



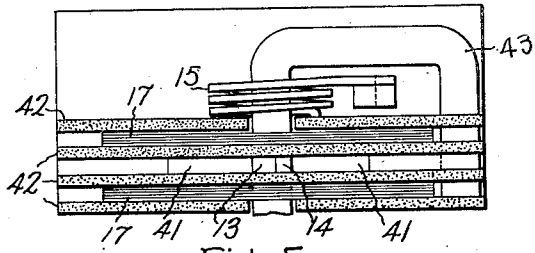


Fig. 5.

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Patented Aug. 14, 1928. 1,680,674

UNITED STATES PATENT OFFICE.

ALAN STEWART FITZGERALD, OF LONDON, ENGLAND, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC SWITCH.

Application filed September 8, 1924, Serial No. 736,390, and in Great Britain September 22, 1923.

This invention relates to electric circuit breakers and particularly to direct current automatic circuit breakers.

Considerable importance is attached to the design of breakers which shall be capable of opening upon a fault in the shortest possible period. In the case of direct current systems this is desirable chiefly with a view to clearing such a fault before the generators or other commutating devices arc over.

The object of the invention is to provide an improved form of what is known as a high speed circuit breaker, and one which can be opened without the necessity of first tripping latches or similar holding devices.

The present invention comprises a contact-operating armature on which are exerted two oppositely-acting magnetic forces; one force predominates at relatively low excitation to bias the breaker to closed position while the other prevails at relatively high excitation and effects the opening of the breaker. The preponderance of one force over the other depends on the interrelation of the reluctance of a substantially closed magnetic circuit and the reluctance of a parallel magnetic circuit comprising an operating air gap.

There are provided, therefore, two parallel magnetic paths, each of different reluctance, the fluxes in which are controlled by a single winding arranged on a common limb. A contact carrying armature forms a part of each magnetic path, and is arranged so as to leave substantially no operating air-gap in the path of greater normal reluctance, but to leave an air gap in the other path, when the breaker is closed. For normal current values in the winding, however, the total reluctance for the former path will be less than that of the latter, due to the air-gap in the latter, and consequently the first circuit carries flux which assists in maintaining the armature in a position in which the breaker is closed. If the current in the winding increases, the flux in the first path and therefore the holding force increases up to a point and finally the time comes at which the first path is saturated to such an extent that the reluctance thereof has become greater than that of the second path, in spite of the air gap in the latter. An increased flux now circulates in the latter path, and, when the current in the winding reaches a predetermined value, the force of attraction upon the armature due to the flux in this latter path exceeds the force of attraction upon the armature due to the flux in the first path, with the result that the armature very rapidly moves over and adopts a position in which there is an air gap in the first path, and not in the second path. In this position of the armature the switch contacts are open.

When current in the winding is above a predetermined value, the force causing the opening of the breaker is approximately proportional to the value of the current.

It is preferable, however, to combine with the breaker a mechanism to assist, by biasing means, in holding the breaker closed, which, when the circuit opens, shall be automatically operated by the movement of the breaker to move into a position to assist in holding it open.

Such a mechanism may be associated with electrical or manual operating means; and a winding or windings may be associated with the breaker for remotely controlling the same.

Means for varying the current value at which the breaker shall open, according as to whether the current rises slowly or rapidly, may comprise a closed coil or short circuiting member arranged to be threaded by the flux in the path of greater normal reluctance.

Additional means may be provided for adjusting the value of current at which the circuit shall be opened, when the current is rising steadily, comprising an adjustable magnetic path in shunt with that path which effects the opening of the breaker.

For a quick understanding of the invention reference is directed to Figs. 1 to 3 of the accompanying drawings wherein Fig. 1 is a diagrammatic sketch of a circuit breaker according to the invention in closed position; Fig. 2 is a similar sketch with certain windings and parts omitted in which the circuit breaker is beginning to open, and Fig. 3 is a sketch similar to Fig. 2 except that the circuit breaker is shown fully open; Fig. 4 is a more complete view in elevation of the circuit breaker shown in the previous figures and Fig. 5 is a part sectional plan thereof. Like reference numerals are used whenever possible to denote similar parts.

With reference first to Figs. 1, 2, and 3, the main circuit comprises terminals 11, 12, a moving contact 13, fixed contact 14, a series blow-out coil 15 and the actuating coil 16. A pair of shunt connected blow-out coils 17 are connected to arcing horns 18 as shown. The movable contact 13 is carried by a magnetic armature 19 pivoted at 21 adjacent the end of the middle limb 22 of an E-shaped magnetic circuit, the upper limb 23 of which is of greater reluctance or of less cross-sectional area than the lower limb 24. A short-circuited winding of high conductivity 25 is provided on the upper limb. The latching mechanism comprises a toggle mechanism, links 26 and 27, pivoted to the fixed pivot 28 and the floating pivot 29 on the lever 31, respectively. A boss 32 on the limb 26 is adapted to be engaged by the adjustably fixed stop 33 to limit the amount by which the toggle shall be overset. The link 31 is pivoted to the armature at 34 and connected to one end of the spring 35, the other end 36 of which is fixed to the framework.

The operation of this device is as follows: When the circuit breaker is closed the toggle comprising links 26 and 27 is fully extended and preferably slightly overset, and it is retained in this position by the link 31 through the agency of the spring 35. The operating air gap 37 at the end of the upper limb is closed by the armature, but there is an operating air gap 38, at the end of the lower limb when the armature is in this position. When the current in the main circuit, and consequently in winding 16, is below a predetermined value, the reluctance of the upper magnetic circuit (comprising the middle limb 22, the upper limb 23 and the upper portion of the armature) is less than that of the lower circuit (comprising the middle limb 22, the lower limb 24, the lower portion of the armature and the operating air gap 38), in spite of the fact that the reluctance of the limb 23 is greater than that of the limb 24. In these circumstances flux circulates in the upper magnetic circuit in greater proportion than in the lower magnetic circuit, and assists in holding the contacts closed. When current in the winding 16 increases, the upper limb 23 becomes more saturated, and a greater proportion of flux is shunted through the lower limb. As soon as the force pulling the armature towards the lower limb exceeds by the smallest amount that pulling the armature towards the upper limb, the armature is moved away from the upper limb towards the lower limb. This condition is shown in Fig. 2. As soon as the smallest air gap obtains at 37 in the upper magnetic circuit, the force on the upper portion of the armature is greatly diminished and the force on the lower portion of the armature is greatly increased and considerably preponderates. In the position shown in Fig. 2, therefore, the device is definitely unstable and must immediately change over to the position in which the switch contacts are open, as shown in Fig. 3. The stop 33 and boss 32 are arranged so that when the breaker is closed, the toggle is fully extended or slightly overset. But the initial opening movement of the armature rotates the link 27 anti-clockwise about pivot 39 permitting the latching mechanism immediately to collapse under the influence of the spring 35 into the position shown in Fig. 3, in which position the spring is biasing the armature against the lower limb and is therefore biasing the switch to open position. It should be noticed that, although the switch intially opens against the spring bias, yet the final opening movement is completed while the spring bias is ineffective to hinder it. The short circuited winding 25 acts in a manner well understood by those skilled in the art to choke back a large percentage of the increasing flux, when the current in winding 16 rises rapidly, into the lower magnetic circuit. Consequently when the rate of change of current is extremely rapid the circuit breaker will open at a lower value of current than in the case when the current is rising slowly and the short circuiting device is relatively ineffective.

In the circuit breaker shown in Figs. 4 and 5, the arcing horns 18 comprise copper members 41 arranged between slabs of refractory material 42. The windings 15 and 17 are arranged on the laminated yoke 43 to assist in blowing out the arc in a well understood manner. In order to provide a wiping motion between the movable contact 13 and the fixed contact 14, the movable contact is carried by a switch arm 44 pivoted on the armature pivot 21 and yieldingly pressed towards the upper portion of the armature by a spring 45. A stop member 46 adapted to screw into the switch member 44 is provided for adjusting the position of the switch member with respect to the armature. Means for varying the tension of the spring 35 comprise a pivoted link 47 adjustably held by the clamped screw 48. A device for adjusting the value of the current at which the circuit breaker shall open, when the current is rising steadily, is shown at 49, and comprises a member of magnetic material 51 pivoted at 52 and yieldingly pressed by the spring 53 towards the lower limb 24. The position of the magnetic member 51 with respect to the lower limb 24 is determined by the stop screw 54 and the locking nut 55. As will readily be understood, when the member 51 is in a position in which it is nearest to the lower limb 24, it shunts a portion of the flux in the lower magnetic circuit away from the operating air gap 38, and the

tendency of the flux to open the breaker for a given value of current is reduced. When the member 51 is in a position further away from the lower limb 24 the breaker will open at a lower predetermined value of current, when the same is rising slowly.

In the previous description in connection with the drawings, no method of closing the breaker and/or resetting the latching mechanism has been given. This may be carried out in any suitable way, for instance, by means of a resetting lever pivoted near the end of the upper limb 23 and adapted to engage, by means of a latch or the like, with the link 31 and/or the link 27 and/or the roller 56. In order to provide "free trip" during the closing of the breaker (i. e. if the breaker should be closed on an overload) a cam or other device, operable by the opening movement of the armature, may be arranged to disengage the latch of the resetting lever, thereby permitting the breaker to open under its bias.

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

1. In an overload circuit breaker, the combination of cooperating circuit controlling contacts, means for holding the contacts in circuit closing engagement, means comprising a winding connected to be energized in accordance with the current in the circuit controlled by said contacts and a magnetic structure therefor including a movable magnetic member arranged to assist said first means for holding said contacts in circuit closing position when the current in the circuit is below a predetermined value and operable to oppose said first means to effect the opening of said contacts when the current in the circuit is above said value, and means responsive to the rate of change of current in the circuit for determining the value of current at which said movable magnetic member is operated to open said contacts.

2. In an overload circuit breaker, the combination of cooperating circuit controlling contacts, means for biasing the contacts into circuit closing engagement, means comprising a single winding energized in accordance with the current in the circuit controlled by the circuit breaker and a magnetic structure therefor including a movable magnetic member arranged to assist said biasing means for holding said contacts in circuit closing position when the current in the circuit is below a predetermined value and to oppose said biasing means to effect the opening of said contacts when the current in the circuit is above said value, and means responsive to the rate of change of flux in said structure for determining the value of current in the circuit at which said movable magnetic member is operated to open said contacts.

3. In an overload circuit breaker, the combination of cooperating circuit controlling contacts, means for biasing the contacts into circuit closing engagement, means comprising an electromagnet having a winding energized in accordance with the current in the circuit controlled by the circuit breaker and a magnetic structure including a movable magnetic member providing parallel paths for the flux of said winding, one path for operating said member to assist said biasing means in holding said contacts in circuit closing position when the current in the circuit is below a predetermined value, and the other path for operating said member to oppose said biasing means to effect the opening of said contacts when the current in the circuit is above said value, and a short circuited winding disposed on said structure to be threaded solely by the flux in said one path.

4. In an overload circuit breaker, the combination of a movable contact operable between a circuit closing and a circuit opening position, means for holding said contact in the circuit closing position, an electromagnet comprising a winding energized in accordance with the current in the circuit controlled by the circuit breaker and a magnetic structure providing parallel paths of different reluctance for the flux of said winding, a magnetic member connected to control the operation of said contact and pivotally supported intermediate its end with different portions thereof in each of said paths, the relation of said member and said magnetic structure being such that the magnetic pull on one portion of the member predominates to hold the contact in the circuit closing position when the current in the circuit is below a predetermined value and the magnetic pull on another portion of the member predominates to operate the contact against the force of said holding means to the circuit opening position when the current in the circuit is above said value.

5. In an electric circuit controlling device, the combination of a movable circuit controlling contact, electromagnetic means for operating the same to circuit opening position, means comprising a toggle mechanism for biasing the contact to the circuit closing position when the toggle is set and to the circuit opening position when the toggle is tripped, and means for tripping the toggle upon the initial opening movement of the contact.

6. An electric circuit breaker comprising, a movable circuit controlling contact, a stationary contact cooperating therewith, means for biasing the said contacts into circuit closing engagement, a movable magnetic member pivotally supported intermediate its end and mechanically connected to said movable contact, an electromagnet

having an energizing winding connected to be energized in accordance with the current in the circuit controlled by the said cooperating contacts and a magnetic structure cooperating with said magnetic member to provide parallel paths of different reluctances for the flux of said winding with an air gap in the path of lesser magnetic reluctance when the said contacts are in circuit closing engagement whereby the said movable contact is magnetically held in the circuit closing position by the pull through the magnetic path of greater magnetic reluctance when the current in said winding is below a predetermined value and is operated to the circuit opening position by the pull through the path of lesser magnetic reluctance when the current in said winding exceeds said predetermined value.

7. An electric circuit breaker comprising a movable circuit controlling contact, a stationary contact cooperating therewith, means comprising a toggle mechanism for biasing the said movable circuit controlling member to the closed and the open positions respectively when operated thereto, and means comprising an electromagnet having a substantially E-shaped magnetic structure and a movable magnetic member cooperating therewith to provide parallel paths of different reluctance for the flux of said electro-magnet, one path for reinforcing the bias of said toggle mechanism to hold said movable contact in circuit closing position when operated thereto and the current in said electromagnet is below a predetermined value and the other path for tripping said toggle and magnetically operating said movable contact to the open position when the current in said electromagnet is above said value.

8. An overload circuit breaker comprising cooperating circuit controlling contacts operable into and out of circuit closing engagement, mechanical means for holding the contacts in circuit closing engagement, an electromagnet energized in accordance with the current in the circuit controlled by said contacts and having a movable magnetic member for rendering said holding means ineffective, the magnetic structure of said electromagnet being arranged to effect operation of the movable magnetic member to render said holding means ineffective at a value of energizing current dependent upon the rate of change of the current.

9. An overload circuit breaker comprising cooperating circuit controlling contacts operable into and out of circuit closing engagement, mechanical means for holding said contacts in circuit closing engagement, an electromagnet having an operating winding energized in accordance with the current in the circuit controlled by the said contacts and a magnetic structure providing two multiple paths for the flux of said operating winding, means responsive to the flux in one of said paths for rendering said holding means ineffective, and a short circuited winding associated with the other of said flux paths for varying the flux in said one flux path in accordance with the rate of change of current in the operating winding.

10. An overload circuit breaker comprising cooperating circuit controlling contacts operable into and out of circuit closing engagement, mechanical means for holding said contacts in circuit closing engagement, an electromagnet having an operating winding connected to be energized in accordance with the current in the circuit controlled by the said contacts and a movable magnetic member operable from one position to another position to render said holding means ineffective and having a magnetic structure cooperating with said movable magnetic member to provide two paths for the flux of said operating winding, one of said paths for maintaining said magnetic member in said one position when the current in the circuit is below a certain value and the other of said paths for operating the movable magnetic member to render said holding means ineffective, and a short-circuited winding encircling said one magnetic path to effect operation of the magnetic member by the flux in the other path in accordance with the rate of change of current in the circuit.

11. An overload circuit breaker comprising cooperating circuit controlling contacts operable into and out of circuit closing engagement, mechanical means for holding the contacts in circuit closing engagement, and electroresponsive means for controlling said holding means including a winding energized in accordance with the current in the circuit controlled by the said contacts and a movable magnetic member operable under the magnetic influence of said winding to render said holding means ineffective when the current in the circuit is above a certain value, and a short circuited winding in inductive relation with said first winding for controlling the value of current at which said magnetic member is operated to render said holding means ineffective.

12. An overload circuit breaker comprising cooperating circuit controlling contacts operable into and out of circuit closing engagement, mechanical means for holding the contacts in circuit closing engagement, an electromagnet having an operating winding connected to be energized in accordance with the current in the circuit controlled by the contacts and a movable magnetic member operable from one position to another position to render said holding means ineffective and having a magnetic structure cooperating with said movable magnetic member to

maintain the same in said one position when the current in the circuit is below a predetermined value and for operating the magnetic member to said other position when the current in the circuit is above said value, and a short circuited winding associated with said magnetic structure for varying the value of current required to effect operation of said movable magnetic member from said one position to said other position in accordance with the rate of change of current in the circuit.

In witness whereof, I have hereunto set my hand this 6th day of September, 1924.

ALAN STEWART FITZGERALD.