Dec. 22, 1931. J. W. McNAIRY ET AL 1,837,977

ELECTROMAGNETIC DEVICE

Filed Dec. 31, 1923

Fig. 2.

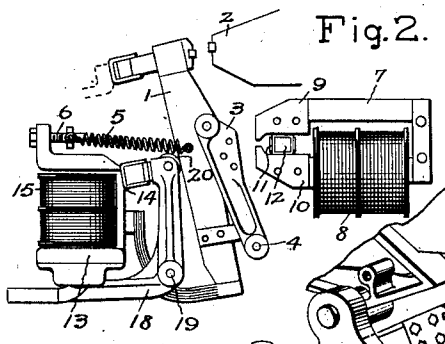


Fig. 1.

Fig. 5.

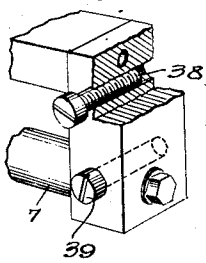


Fig. 4.

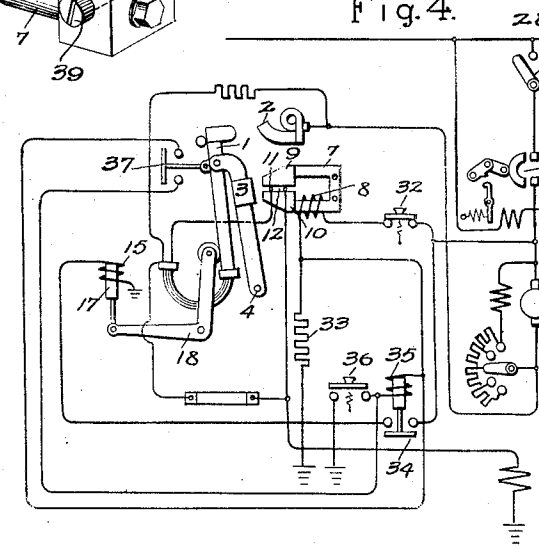
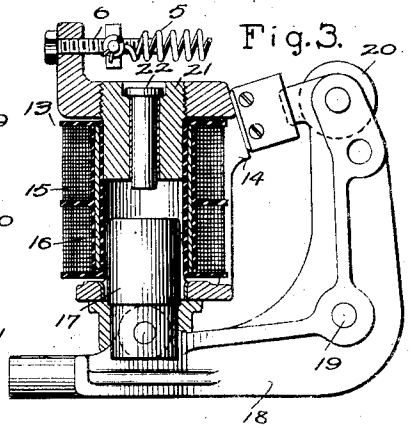


Fig. 3.



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UNITED STATES PATENT OFFICE

JACOB W. McNAIRY AND JOHN F. TRITLE, OF SCHENECTADY, NEW YORK, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

ELECTROMAGNETIC DEVICE

Application filed December 31, 1923. Serial No. 683,533.

Our invention relates to improvements in electromagnetic devices and more particularly to electromagnetic circuit interrupters and the like, and has for its general object the provision of improved systems and apparatus for controlling the operation of such devices.

Ordinarily when a device, such as for example, a circuit breaker, is moved to one position by electromagnetic action and is biased to another position, as by gravity or a spring, an impact or hammer-blow terminates the movement to each position, particularly when the moving parts are of considerable weight. The general undesirability of these impacts or hammer-blows is obvious and various forms of well known cushioning devices as, for instance, buffer springs or air dashpots, have been employed to reduce the shock of the impacts.

One of the specific objects of our invention is to provide an electromagnetically actuated device which is movable from one position to another position with electromagnetic means for automatically retarding the movement of the device at a definite intermediate position to reduce the momentum of the moving parts and thereby prevent undesirable shocks.

Furthermore, in electromagnetic devices, it is often desirable to vary the magnetic influence of an electromagnet upon a movable magnetic member. It is, therefore, a further object of our invention to provide an improved electromagnet having an aperture disposed intermediate the poles thereof, with a plug of magnetic material adjustably secured in the aperture for varying the magnetic influence of the electromagnet on a movable magnetic member.

Although our invention has a wide field of application, it is however, of particular utility when embodied in high speed trip-free circuit interruptors of the type described and claimed in the patent to John Tritle, 1,560,440, November 3, 1925, which is assigned to the same assignee as this invention.

In the Tritle type of interruptor, a movable magnetic member of an electromagnet is strongly biased to the unattracted position and carries a relatively movable switch arm which is biased to the closed position when the magnetic member is moved to the attracted position by means of an electromagnetically actuated closing mechanism. The attractive effect of the electromagnet upon the movable magnetic member is under the joint magnetic influence of a shunt holding winding and means responsive to the current through the switch, so arranged as to quickly release the movable magnetic member and thereby open the switch arm upon the occurrence of an overload current. Circuit interruptors constructed and arranged in the manner described in said application are eminently successful in all ordinary service but when applied to heavy duty circuits where large currents are encountered, the necessarily increased weight of the moving parts, the increased accelerating force of the biasing springs, and the correspondingly increased power of the closing mechanism, produce impacting shocks which not only may severely rack the structure of the interruptor but also may cause premature releasing of the magnetic member should a current near the overload value flow in the circuit upon closure of the switch arm.

Hence, a still further object of our invention is the provision of electromagnetic means for operating the magnetic member of such an interruptor for electrical circuits from the unattracted to the attracted position and then releasing the switch arm to close according to its bias after momentarily retarding both the movement of the magnetic member prior to the attraction thereof and the movement of the switch arm prior to closure thereof.

For a better understanding of our invention reference is had to the following description together with the accompanying drawings in which we have shown the invention embodied in an electromagnetically actuated high speed, trip-free type of circuit interruptor for the purpose of explaining the principles thereof and in which Fig. 1 is a perspective view of the circuit interrupter embodying our invention, Fig. 2 shows diagrammatically the relative arrangement of the moving parts of the interrupter, Fig. 3 is

a view, partly in section, of the electromagnetic actuating mechanism of the interrupter shown in Fig. 1, Fig. 4 is a diagram showing the circuit connections of the interruptor, and Fig. 5 is a detailed perspective view, partly in section, of a portion of the magnetic structure of the interruptor.

Referring to Figs. 1 and 2, the principal parts of the circuit interruptor comprise the movable switch arm 1 which cooperates with the stationary contact 2 to open or close an electrical circuit. Switch arm 1 is pivoted intermediate its ends in suitable bearings carried at one end of movable magnetic member 3 which in turn is mounted to rotate about the stationary pin 4. A common biasing spring 5 for both magnetic member 3 and switch arm 1 has one end connected to switch arm 1 on the opposite side of the pivot from the circuit interrupting contact and the other end connected to a stationary adjusting screw 6. The movable magnetic member 3 and the switch arm 1 thus constitute a compound switch element which is biased as a unit to the open position and the switch arm 1 is biased to the closed position when the movable magnetic member 3 is actuated to and held in the attracted position.

In order to retain the compound switch element in the closed position, an electromagnet 7 is provided with a shunt winding 8 for normally exerting sufficient magnetic attraction on the movable magnetic member 3 when the latter is in abutting engagement with the pole pieces 9 and 10 to overcome the opening strain of biasing spring 5. A series winding 11 is disposed on a part of magnetic material 12 which is interposed in the air gap between the pole pieces 9 and 10 as described and broadly claimed in the Reisssue patent to John Tritle, No. 15,441, and as more particularly described and claimed in the patent to Leonard Haag, 1,506,483, September 26, 1924 each of which is assigned to the same assignee as our present invention. The series winding 11 may be connected in the circuit to be protected by the interruptor and effects the release of magnetic member 7 and consequently the opening of switch arm 1 upon the occurrence of an overload current in the circuit.

An electromagnetic closing mechanism 13 is arranged to actuate the magnetic member 3 from the unattracted position in which it is shown in Figs. 1 and 2, to the attracted position and then release the switch arm 1 to allow the same to close according to its bias. As shown more in detail in Fig. 3, this mechanism comprises an electromagnet 14 having an energized winding 15, a short circuited winding 16, and an operating member 17 of magnetic material. Member 17 is pivotally supported at one end of a bell crank 18 which rotates about the stationary pin 19 and carries a roller 20 at its other end for engaging the movable switch arm 1. The magnetic structure of electromagnet 14 includes an adjustable core 21 and a relatively movable magnetic stop 22 of magnetic material which extends through an aperture in core 21 into the path of operating member 17.

It will be observed that the circuit interrupter is provided with the usual type of magnetic blow-out coil 23, arcing contacts 24, and arc chute 25 to adapt it for interrupting high voltage power circuits and that the entire device is supported on insulated rods 26 which form a part of base 27.

As diagrammatically shown in Fig. 4, the interrupter is arranged to protect the power circuit from overload current which is completed from high voltage line 28 through disconnecting switch 29, low voltage circuit breaker 30, dynamo electric machine 31, and the trip-free circuit interruptor to ground upon closure of the respective switches. In this arrangement the shunt winding 8 of the holding electromagnet 7 of the circuit interruptor is permanently connected from the high voltage terminal of the dynamo electric machine 31 to ground in series circuit with a manually operable switch 32, which is biased to the closed circuit position and a voltage reducing resistance 33. The circuit of the energizing winding 15 of closing mechanism 13 is controlled by relay 34 which is biased to the open circuit position and has its winding 35 controlled by the manually operable switch 36 which is also biased to the open circuit position.

A short circuit around the operating winding 35 of the relay 34 is established by an auxiliary switch 37 which is mechanically connected to the movable magnetic member 3 so as to be actuated to the closed position when member 3 is moved to the attracted position.

During the operation of the interrupter to the closed position the attractive force of the holding electromagnet 7 is increased automatically so as to insure that the movable switch element is positively held by the electromagnet even though subject to the jar or shock necessarily accompanying the closure of the interrupter. The arrangement whereby this is accomplished is fully described and broadly claimed in our co-penping application, Serial No. 6,204, filed Feb. 2, 1925, which is a division of the present application.

In order to permit the series winding 11 to open the switch arm 1 upon different values of overload current we have provided adjustable magnetic plugs 38 and 39 for varying the holding effect of shunt winding 8 on the movable magnetic member 3. As shown more in detail in Fig. 5, the magnetic structure of electromagnet 7 is provided with two internally threaded apertures disposed intermediate the poles 9 and 10. The plugs 38

and 39 are provided with corresponding screw threads for adjustably securing the plugs in the respective apertures. It will be readily understood that when either of the plugs 38 and 39 is withdrawn from the magnetic structure of electromagnet 7, the reluctance of the path for the flux of winding 8 is increased and the magnetic influence of this winding on the movable magnetic member 3 is correspondingly decreased without varying the magnetic influence of the series winding 11 on the movable magnetic member 3. A lower value of current through the series winding 11 is then required to effect the release of magnetic member 3 and the opening of switch arm 1. Adjustment of the plugs in the opposite direction obviously requires a higher value of current through winding 11 to release the arm 1 since the relative magnetic influences of the holding winding 8 and the tripping winding 11 are varied in the reverse manner from that just described.

Operation

As thus constructed and arranged and with the parts in their respective positions shown in the drawings the operations of our improved circuit interrupter is as follows:

Assume that it is desired to connect the dynamo electric machine 31 to the high voltage line 28. Disconnecting switch 29 and the voltage failure protective circuit breaker 30 first are moved from the open positions shown to their respective closed positions, thereby completing an energizing circuit for winding 8 of holding electromagnet 7 from line 28 through disconnecting switch 29, circuit breaker 30, switch 32, winding 8, resistance 33 to ground. The normally open control switch 36 then is moved to the closed position and connects the relay winding 35 in shunt with resistance 33. Thereupon winding 35 is energized by the voltage drop across the resistance 33 and upon the resulting response of relay 34 an energizing circuit for winding 15 of the closing mechanism 13 is established from supply line 28 through disconnecting switch 29, circuit breaker 30, relay 34 and winding 15 to ground.

It will be observed that operation of control switch 36 to the closed position not only serves to energize closing winding 15 but also to over-excite the holding winding 8 due to the fact that additional current is shunted around resistance 33 through the relay winding 35. This feature of automatically over-exciting the holding magnet 7 during the energization and operation of the closing mechanism 13 is of great practical advantage as it permits the circuit interrupter to successfully close the power circuit when the resulting current through the series winding is only a slight amount below the releasing value.

Upon the energization of winding 15 of closing mechanism 13, operating member 17 is actuated from the unattracted position in which it is shown in Fig. 3 towards the core 21, thereby rotating the bell crank 18 in a clockwise direction about the pin 19. Roller 20 engages with the switch arm 1 and moves the switch arm 1 and the magnetic member 3 as a unit about the pin 4 against the strain of biasing spring 5. The mechanical arrangement is such that, prior to the magnetic member 3 arriving at the attracted position in which it engages pole pieces 9 and 10 of holding electromagnet 7, the operating member 17 of closing mechanism 13 approaches the magnetic stop 22. This tends to rapidly increase the flux through the magnetic structure of electromagnet 14 and cause a larger accelerating force to be exerted on the operating member 17. But it will be understood that such a change in flux value induces a heavy current in the short circuited winding 16 which limits both the increase of flux and the accelerating force. Upon the engagement of operating member 17 with magnetic stop 22, a closed magnetic circuit is formed for a considerable portion of the flux through armature 17 which causes the magnetic attraction between member 17 and the core 21 to be greatly reduced. The movement of operating member 17 and consequently the movement of switch arm 1 and magnetic member 3 is momentarily retarded at this definite intermediate position while the flux is gradually increasing to the saturation value in stop 22. Then additional attractive force is exerted across the air gap remaining between core 21 and member 17 and the latter continues the closing movement, causing the stop 22 to slide upwardly in the aperture in core 21 and effecting the final engagement of magnetic member 3 with the pole pieces 9 and 10 of the holding magnet 7 without undue impact or shock. The compound switch member composed of movable magnetic member 3 and the switch arm 1 is temporarily held at this intermediate position between the open and the closed position by the operating mechanism 13 until the operating winding 15 is deenergized.

As magnetic member 3 is thus operated to the attracted position in which it is held under the magnetic influence of shunt winding 8, auxiliary switch 37 is actuated from the open position shown to the closed position thereby short circuiting relay winding 35. After a temporary delay while the magnetism of relay 34 is decreasing under the retarding influence of the short circuited winding 35, the relay contact drops to the open position according to its bias and interrupts the energizing circuit of closing winding 15. Upon the short circuiting of relay winding 35 by the auxiliary contact 37, the shunt winding 8 of electromagnet 7 is still further over-

excited due to the fact that the resistance 33 and the operating winding 35 are both short circuited by the contact 37. This heavy over-excitation of the shunt winding 8 continues during the time of deenergization of the closing winding 15 and the resulting movement of switch member 1 to the closed position according to its bias in the manner now to be described.

Upon the deenergization of closing winding 15 by the opening of relay 34 the flux through core 21 and operating member 17 gradually decreases under the retarding influence of the short circuited winding 16. When the flux has decreased to a value which permits biasing spring 5 to rotate switch arm 1 about its pivotal support on member 3 in a clockwise direction, bell crank 18 and member 17 are actuated toward the open position. As operating member 17 is thus returned to open position, magnetic stop 22 slides downwardly in the aperture in core 21 until the collar with which it is provided engages the core 21. Thereupon the movement of operating member 17 and switch arm 1 is momentarily retarded until the flux through the magnetic stop 22 and member 17 is reduced to a value which permits biasing spring 5 to overcome the magnetic attraction existing between stop 22 and member 17. The electromagnetically actuated closing mechanism 13 is so designed that the momentary retardation of operating member 17 and switch arm 1 is produced just prior to the engagement of switch arm 1 with the stationary contact 2 so as to avoid the production of a heavy jar or shock which might cause movable magnetic member 3 to leave pole pieces 9 and 10 in case a current near the releasing value should pass through series winding 11 when the circuit is closed by the switch arm 1. After the flux through magnetic stop 22 and member 17 has decreased to this value, switch arm 1 is permitted to move to the closed position according to its bias and operating member 17 returns to the position shown in Fig. 3, thereby leaving the switch arm 1 held in the closed position against the opening strain of biasing spring 5 by electromagnet 7.

Should the current in the power circuit of the dynamo electric machine 31 now increase beyond a predetermined value, the series winding 11 will effect the release of switch arm 1 in the following manner. As the current increases through series coil 11 the magneto-motive force impressed upon the part of magnetic material 12 quickly increases the flux through this part and proportionally decreases the flux through the movable magnetic member 3 until the biasing spring 5 overcomes the attractive effect of electromagnet 7 and rapidly moves the magnetic member 3 and switch member 1 to the open position. In order to avoid a reversal of the flux through the movable magnetic member 3 when an extremely heavy overload current passes through series coil 11 such as might cause the release of magnetic member 3 to be delayed or even prevented altogether, the tips of poles 9 and 10 are separated by only a small air gap so as to afford a path of relatively low reluctance after the magnetic member 3 has opened a short distance and the part 12 is so designed as to become saturated with the current in coil 11 at a value slightly above the maximum releasing value.

In accordance with the provision of the patent statutes we have described the principle of operation of our invention, together with the apparatus, which we now consider to represent the best embodiment thereof, but we desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. The combination with a device movable to one position and biased from said position to another position, of electromagnetic means for moving the said device to the one position and then releasing the device to move to the other position in accordance with its bias, and electroresponsive means including a movable magnetic member and cooperating short circuited winding for automatically retarding the movement of said device at a definite position intermediate the said one and the other positions.

2. The combination with a movable device, of an electromagnet for moving the said device to one position and then releasing the device to move to another position, and means including a movable magnetic member and cooperating short circuited winding responsive to the flux of said electromagnet for automatically retarding the movement of said device at a definite position intermediate the said one and the other positions.

3. The combination with a device movable to one position and biased to another position, of an electromagnet having an operating member of magnetic material operable to and from a pole of the said electromagnet for respectively moving the said device to the one position and permitting movement of said device to the other position in accordance with its bias, and a short-circuited winding and a relatively movable stop of magnetic material cooperating with the said member to momentarily retard the movement of said device prior to the final movements thereof to both the said one and the other positions.

4. The combination with a device movable from one position to another position, of electromagnetic means including an energizing winding, a short circuited winding, and an operating member of magnetic material operable under the magnetic influence of said windings for moving the said device,

and a relatively movable stop of magnetic material cooperating with the said member and the said short circuited winding to momentarily retard the movement of said device at a predetermined intermediate position.

5. The combination with a device movable from one position to another position, of an electromagnet having an energizing winding, a short circuited winding, an operating member of magnetic material operable to and from a pole of the said electromagnet under the magnetic influence of said windings for moving the said device, and a relatively movable stop of magnetic material extending from the said pole into the path of the said operating member and cooperating with said short circuited winding to momentarily retard the movement of said device when the said member engages and disengages the said stop.

6. The combination with a device movable from one position to another position and being thereby biased to a third position, of electromagnetic means for moving the said device from the one position to the other position and permitting movement of the said device from the other position to the third position in accordance with its bias, and means including a movable magnetic member and short circuited winding cooperating with the said electromagnetic means for momentarily retarding the movement of said device at predetermined intermediate positions.

7. The combination with a device movable from one position to another position and thereby being biased to a third position, of electromagnetic means for moving the said device from the one position to the other position and permitting movement of said device from the other position to the third position in accordance with its bias, and means including a movable magnetic member and short circuited winding responsive to the flux of said electromagnetic means for momentarily retarding the movement of said device at predetermined intermediate positions.

8. In an interrupter for electrical circuits, the combination with a switch arm biased to the open position and movable from the open position to an intermediate position and thereby being biased to the closed position, of a mechanism for operating the said member from the open to the said intermediate position and then releasing the said switch arm to close according to its bias, and automatic means cooperating with the said mechanism for retarding the movement of said arm prior to the closure thereof.

9. In an interrupter for electrical circuits, the combination with a switch arm biased to the open position and movable from the open position to an intermediate position and thereby being biased to the closed position, of electromagnetic means for operating said member from the open to the said intermediate position and then releasing the said switch arm to close, and means including a movable magnetic member and short circuited winding responsive to the flux of said electromagnetic means for automatically retarding the movement of said arm prior to closure thereof.

10. In an interrupter for electrical circuits, the combination of a switch arm biased to the open position and movable from the open position to an intermediate position and thereby being biased to the closed position, of an electromagnet having an energizing winding, a short circuited winding, and an operating member of magnetic material operable to and from a pole of the said electromagnet under the magnetic influence of said winding for respectively moving the said switch arm from the open position and then permitting movement of said switch arm to the closed position in accordance with its bias, and a relatively movable stop of magnetic material extending from the said pole into the path of the said operating member and cooperating with the said short circuited winding to automatically retard the movement of said operating member prior to both the movement of the said switch arm to the said intermediate position and to the closure thereof.

11. In an interrupter for electrical circuits, the combination with a compound switch element biased to the open position and movable from the open position to an intermediate position and having a relatively movable switch arm thereby biased to the closed position, of electromagnetic means for operating the said switch element from the open position to the said intermediate position, then holding the said element and releasing the said switch arm to close according to its bias, and means including a movable magnetic member and cooperating short circuited winding cooperating with the said electromagnetic means for automatically retarding the movement of said arm prior to closure thereof.

12. In an interrupter for electrical circuits, the combination with an electromagnet having a movable magnetic member biased to the unattracted position and provided with a relatively movable switch arm biased to the closed position when said magnetic member is in the attracted position, of a device for operating the said member from the unattracted to the attracted position and then releasing the said switch arm to close according to its bias, and means cooperating with the said device for automatically retarding both the movement of said movable magnetic member prior to the attraction thereof and

the movement of said switch arm prior to closure thereof.

13. In an interrupter for electrical circuits, the combination with an electromagnet having a movable magnetic member biased to the unattracted position and provided with a relatively movable switch arm biased to the closed position when said magnetic member is in the attracted position, of electromagnetic means for operating the said magnetic member from the unattracted to the attracted position and then releasing the said switch arm to close according to its bias, and means responsive to the flux of said electromagnetic means for automatically retarding both the movement of said movable magnetic member prior to the attraction thereof and the movement of said switch arm prior to closure thereof.

14. In an interrupter for electrical circuits the combination with an electromagnet having a magnetic member movable between the unattracted and the attracted positions and a switch arm mechanically connected to the said magnetic member and movable to the closed position when said member is in the attracted position, of electromagnetically actuated mechanism including an energizing winding, a short circuited winding and an operating member of magnetic material movable under the magnetic influence of said windings for operating the said first movable magnetic member from the unattracted to the attracted position and then permitting movement of the said switch arm to the closed position, the said mechanism being provided with a movable stop of magnetic material extending into the path of the said operating member and cooperating with the said short circuited winding to automatically retard the movement of said operating member prior to both the attraction of said first movable magnetic member by the said electromagnet and the closure of said switch arm.

15. In an interrupter for electrical circuits, the combination with an electromagnet having a movable magnetic member biased to the unattracted position, a relatively movable switch arm carried by said member and biased to the closed position when said magnetic member is in the attracted position, of an electromagnet having an energizing winding, a short circuited winding, and an operating member of magnetic material movable under the magnetic influence of said windings to and from a pole of said electromagnet for operating the said magnetic member from the unattracted to the attracted position and thereupon releasing the said switch arm to close according to its bias, a relatively movable stop of magnetic material extending from the said pole into the path of said operating member and cooperating with the said short circuited winding to momentarily retard the movement of said operating member prior to both the attraction of said magnetic member and the closure of said switch arm.

16. In an interrupter for electrical circuits, the combination with an electromagnet having a movable magnetic member biased to the unattracted position, a relatively movable switch arm carried by said member and biased to the closed position when said magnetic member is in the attracted position, of an electromagnetically actuated mechanism having an energizing winding, a short circuited winding, and an operating member of magnetic material movable under the magnetic influence of said energizing winding to mechanically operate the said magnetic member from the unattracted to the attracted position and movable under the magnetic influence of said short circuited winding to thereupon release the said switch arm to close according to its bias, the said mechanism being provided with a movable stop of magnetic material extending into the path of the said operating member and cooperating with the said energizing winding and the said short circuited winding to momentarily retard the movement of said operating member prior to both the attraction of said magnetic member and the closure of said switch arm.

17. An electromagnet comprising a pair of windings, a magnetic structure therefor including a magnetic member movable under the joint magnetic influences of said windings, the said structure having an aperture therein disposed intermediate the poles thereof, and a plug of magnetic material adjustably secured in the said aperture for varying the relative magnetic influences of said windings on said member.

18. An electromagnet comprising a holding winding, a magnetic structure therefor having poles and provided with an aperture therein disposed remotely from said poles, a tripping winding disposed between the poles of said magnetic structure, a movable magnetic member held in abutting engagement with the said poles under the magnetic influence of said holding winding, and a plug of magnetic material adjustably secured in the said aperture for varying the relative magnetic influences of said holding and tripping windings on said member.

19. An electromagnet comprising a substantially U shaped magnetic member with poles at the ends thereof and having an aperture disposed remotely from the poles thereof, a magnetizing winding for said member, a movable magnetic member biased to unattracted position and held in engagement with said poles under the magnetic influence of said magnetizing winding, a releasing winding disposed between the poles of said member for releasing said movable magnetic member, and a plug of magnetic material adjustably secured in the said aperture for varying the relative magnetic influences of said

magnetizing and releasing windings on said movable magnetic member.

20. An electromagnet comprising a plurality of windings, a magnetic structure therefor including a movable magnetic member forming a common path for the flux of said windings and means for varying the reluctance of the path of the flux of one of said windings through said member without varying the reluctance of the path of the flux of the other of said windings through said member.

In witness whereof, we have hereunto set our hands this 29th day of December, 1923.

JACOB W. McNAIRY.
JOHN F. TRITLE.