Jan. 10, 1928. 1,655,453

H. W. BROWN

ELECTROMAGNET

Filed May 15, 1923

Fig. 1.

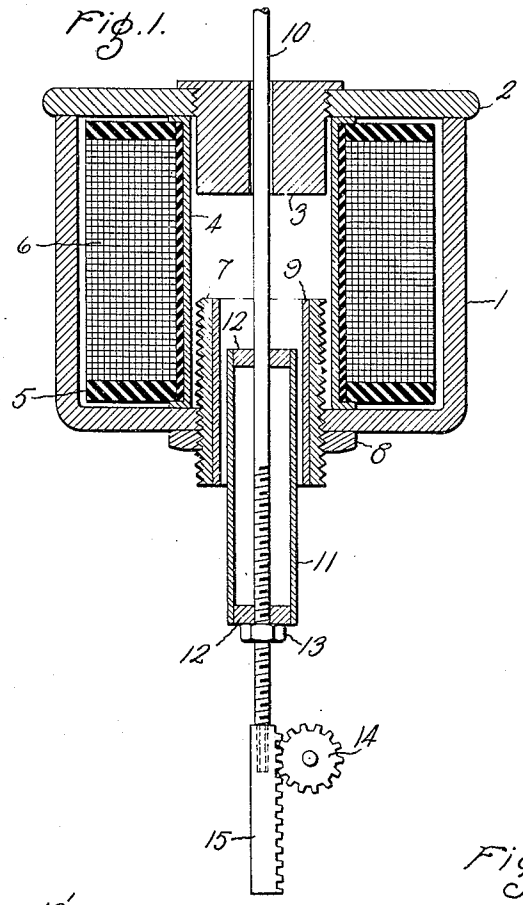


Fig. 2.

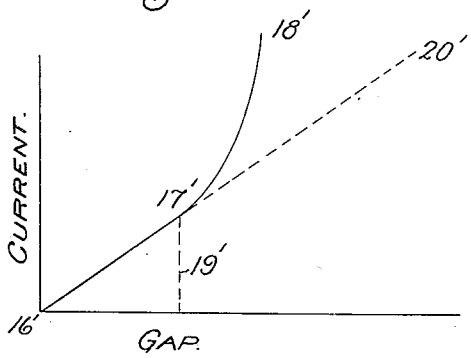
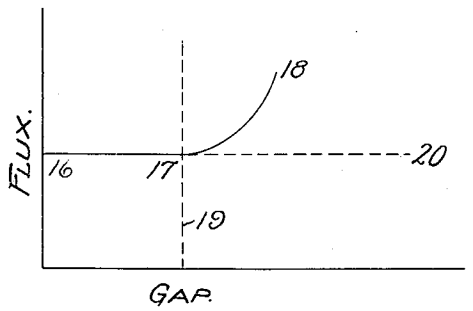


Fig. 3.



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Patented Jan. 10, 1928. 1,655,453

UNITED STATES PATENT OFFICE.

HAROLD W. BROWN, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTROMAGNET.

Application filed May 15, 1923. Serial No. 639,194.

My invention relates to improvements in electromagnets and more particularly to electromagnets for electro-responsive protective devices or relays operative in response to predetermined abnormal circuit conditions and has for an object to provide an improved electromagnetic structure such that relays embodying my invention may have a broad range of operating values.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Fig. 1 illustrates in section an electromagnet embodying my invention and Figs. 2 and 3 are typical characteristic curves illustrating the relation between current and gap and between flux and gap in electromagnets embodying my invention.

In Fig. 1 my invention is illustrated as applied to an electromagnet of the solenoid and plunger type comprising a magnetic structure such as a housing or frame 1 and a cover or top portion 2 provided with a pole piece or polar extension 3 which may be fixed. In the magnetic structure, there is mounted on a liner or spacer 4 of non-magnetic material an insulating spool 5 on which is wound an energizing winding such as a solenoid 6. Mounted in the frame 1 is a magnetic shield such as a tubular magnetic member or hollow pole piece 7 which is spaced from the pole piece 3 to form a predetermined air gap and is preferably adjustably positioned in the frame 1 so that this air gap may be varied to provide different operating characteristics. The tubular member 7 may be positively secured in a given position by any suitable means such as a lock nut 8 and is preferably provided with a liner 9 of non-magnetic material. Mounted on a movable member such as a rod 10 for movement through the tubular member 7 is an armature or plunger 11 of magnetic material. The plunger 11 is preferably tubular and may be provided with heads 12 of non-magnetic material. In case a greater pull is desired with the shielding effect of the tubular member 7 less pronounced, the upper head 12 may be of magnetic material or the plunger 11 may be made solid with the upper end hollow. The plunger 11 forms with the pole piece 3 an air gap which varies according to the position of the plunger, which is adjustably mounted on the rod 10 and positively secured thereon in a given position by any suitable means such as a lock nut 13. The rod 10 may be arranged to control by its movement suitable contact controlling means as is well known to the art.

With this construction, it is obvious that the tubular member 7 and the plunger 11 form parallel paths for the flux of the electromagnet from the tubular member and armature across their respective air gaps to the pole piece 3. Consequently the distribution of the total flux in these parallel paths depends upon the relative values of the air gaps, that is to say the position of the plunger 11 relatively to the tubular member 7. The position of the plunger 11 may be varied by adjusting the plunger relatively to the rod 10 thereby varying the air gap between the pole piece 3 and the plunger 11 or the plunger may be moved through the tubular member 7 by any suitable actuating means such as a pinion 14 arranged to engage a rack 15 on the rod 10, the plunger being free to move independently of the rack 15 so that, when the current attains a pick up value corresponding to the gap between the plunger 11 and the pole piece 3, the plunger will be moved to attractive posion. Any suitable actuating means may be employed operative preferably automatically in response to the conditions on an electric circuit by a motor mechanism such, for example, as that disclosed in United States Letters Patent 1,240,723 issued to E. H. Jacobs, September 18, 1917 and assigned to the same assignee as this invention, or the mechanism, disclosed in United States Letters Patent 1,481,938 issued to O. C. Traver January 29, 1924, and assigned to the same assignee as this invention, may be employed but as such mechanism forms no part of the present invention, it is not illustrated in this application. While electromagnets embodying my invention are particularly well adapted to electroresponsive protective devices in which a wide range of operating values is desired and to electroresponsive devices of the type disclosed

in the aforesaid patents, it is to be understood that my invention is not limited in its application to such devices.

In the following discussion of the operation of electromagnets embodying my invention, it will be assumed that the load to be overcome by the electromagnet in picking up and moving the plunger 11 to attracted position is substantially constant, this being the case generally.

With the plunger 11 in the position shown in Fig. 1, more or less of the total flux will go through the tubular member 7, the amount depending upon the depth or submergence of the plunger 11 in the tubular member 7, that is to say the shielding effect of the member 7, while the balance of the flux, excluding leakage flux, will go through the plunger 11. The characteristic of the total flux necessary before the plunger 11 will be picked up and moved to attracted position for a given air gap between the plunger 11 and the pole piece 3 when the plunger is below the top of the tubular member 7 is represented by the full line portion 17—18 of the curve 16—17—18 of Fig. 3. The curve 16—17—18 represents the total flux in the electromagnet as plotted against the air gap between the plunger 11 and the pole piece 3, the solid line portion 17—18 to the right of the vertical broken line 19 representing conditions when the plunger 11 is below the top of the tubular member 7. It will be observed from the portion 17—18 of Fig. 3, that the total flux required before the plunger 11 will be picked up increases very rapidly with an increase in the air gap between the plunger and the pole piece 3, that is to say with the plunger lower in the tubular member 7. As the plunger 11, however, moves up through the tubular member 7, thereby decreasing the air gap between itself and the pole piece 3, the total flux necessary to pick up the plunger rapidly decreases and becomes substantially constant as indicated by the full line portion 16—17 of the curve 16—17—18. This occurs when the top of the plunger 11 is about even with the top of the tubular member 7, that is, when the end of the plunger 11 adjacent the pole piece 3 begins to emerge from the magnetic shield 7. Without the tubular member 7, the flux characteristic would be as indicated by the curve 16—17—20, which is substantially a straight line.

The characteristic of the current necessary to pick up the plunger 11 and move it to attracted position for a given air gap between the plunger and the pole piece 3 is represented by the full line portion 17′—18′ of the curve 16′—17′—18′ in Fig. 2, which represents the pick up or operating current as plotted against the air gap between the plunger and the pole piece 3. It will be observed from the portion 17′—18′ of the curve 16′—17′—18′ of Fig. 2 that the operating current required increases very rapidly with an increase in the air gap between the plunger 11 and the pole piece 3, that is to say with the plunger lower in the tubular member 7. As the plunger 11 is raised either by adjustment or moved upward by actuation of the pinion 14, the current necessary to pick up the plunger rapidly decreases at a rate which is greater than the rate of decrease of the air gap, that is to say a small change in the air gap produces a relatively large change in the pick up current required, the rate of change of current being greater the farther down the plunger is in the tubular member 7. As the plunger 11 moves up through the tubular member 7, the pick up current required rapidly decreases both in value and rate of change until the rate of change becomes substantially constant as indicated by the full line portion 16′—17′ of the curve to the left of the vertical broken line 19′. This occurs when the top of the plunger is about even with the top of the tubular member 7. Without the shielding effect of the tubular member 7, the current characteristic would be substantially as indicated by the curve 16′—17′—20′ which is substantially a straight line and the rate of change of pick up current with respect to air gap would be substantially constant so that an excessively long air gap, from a practical standpoint, would be required to obtain such a wide range of operating values as is provided by electromagnets embodying my invention.

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

1. An electromagnet comprising an energizing winding, a magnetic structure associated therewith and comprising a pole piece, a magnetic shield mounted in said structure and spaced from said pole piece to form an air gap and an armature extending into said shield and mounted for movement therethrough relatively to said pole piece to form therewith a variable air gap greater than the gap between said shield and said pole piece throughout a part of the movement of the armature whereby parallel paths are provided for the flux from said armature and said shield across said air gaps to said pole piece such that the distribution of the flux is dependent on the relative values of said air gaps.

2. An electromagnet comprising an energizing winding, a magnetic structure associated therewith and comprising a fixed pole piece, a magnetic shield adjustably positioned in said magnetic structure and spaced from said pole piece to form an air gasp, and an armature mounted for movement through said shield toward and from said pole piece to provide a variable air gap between the armature and the pole piece, said

armature and said shield forming parallel paths for flux therefrom to said pole piece whereby the distribution of the flux in said paths is dependent upon the position of the armature in said shield.

3. An electromagnet comprising a solenoid, a magnetic structure associated therewith and comprising a pole piece, a tubular magnetic member adjustably mounted on said magnetic structure, said tubular member being spaced from said pole piece to form an air gap, a member movable through said tubular member, and an armature mounted on said movable member and extending into said tubular member to provide upon actuation of the movable member a change in the relative values of the air gaps between the pole piece and the end of the armature adjacent thereto and between the pole piece and the tubular member, said armature and said tubular member forming parallel paths for flux therefrom to said pole piece whereby the distribution of the flux in said paths is dependent upon the position of said armature relatively to said tubular member.

4. An electromagnet comprising a solenoid, a magnetic structure associated therewith and comprising a pole piece, a tubuular magnetic member mounted on said magnetic structure and extending into said solenoid, said tubular member being spaced from said pole piece to form a predetermined air gap, an armature extending into said tubular member and mounted for movement therethrough relatively to said pole piece to form therewith a variable air gap greater than the gap between said tubular member and said pole piece throughout a predetermined range of movement of the armature, whereby parallel paths are provided for the flux from said armature and said tubular member across said air gaps to said pole piece such that the distribution of the flux is dependent upon the relative values of said air gaps.

5. An electromagnet comprising a solenoid, a magnetic structure associated therewith and comprising a pole piece, a tubular magnetic member adjustably positioned in said magnetic structure and extending into said solenoid, said tubular member being spaced from said pole piece to form a predetermined air gap for any given position of adjustment, a movable member, an armature adjustably positioned on said movable member and mounted for movement through said tubular member, said armature extending into said tubular member and forming with said pole piece a variable air gap greater than the gap between said tubular member and said pole piece throughout a predetermined range of movement of the armature, whereby parallel paths are provided for the flux from said armature and said tubular member across said air gap to said pole piece such that the distribution of the flux across said air gaps is dependent upon the position of said armature relatively to said tubular member.

6. An electromagnet comprising an energizing winding, a magnetic structure associated therewith and comprising a pole piece, a magnetic shield mounted in said structure and spaced from said pole piece to form an air gap, and an armature having one end normally submerged in said shield arranged for movement therethrough and to emerge therefrom to form a variable air gap between said end and said pole piece.

7. An electromagnet comprising an energizing winding, a magnetic structure associated therewith and comprising a pole piece, a magnetic shield mounted in said structure and spaced from said pole piece to form an air gap, and an armature having the end thereof adjacent said pole piece normally submerged in said shield and arranged for movement therethrough and to emerge therefrom to form a variable air gap with said pole piece.

8. An electromagnet comprising an energizing winding, a magnetic structure associated therewith and comprising a pole piece, a magnetic shield mounted in said structure and spaced from said pole piece to form an air gap, and an armature having one end normally submerged in said shield and arranged for movement therethrough and to emerge therefrom to form a decreasing air gap with said pole piece.

In witness whereof, I have hereunto set my hand this 10th day of May, 1923.

HAROLD W. BROWN.