April 13, 1937. O. A. MORGENSTERN 2,076,858

ELECTROMAGNET

Filed Feb. 23, 1935

FIG. 1

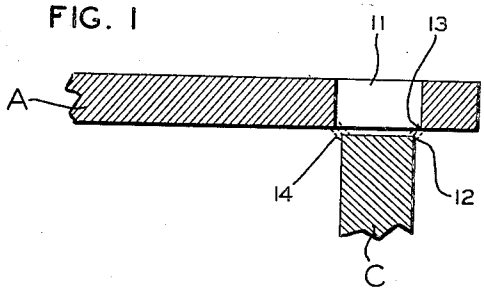


FIG. 2

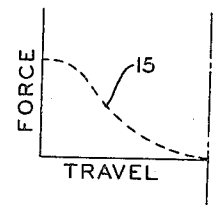


FIG. 3

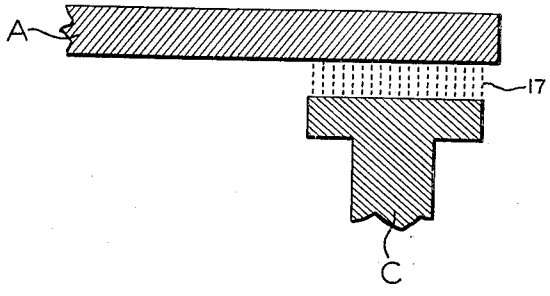


FIG. 4

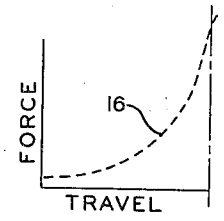


FIG. 5

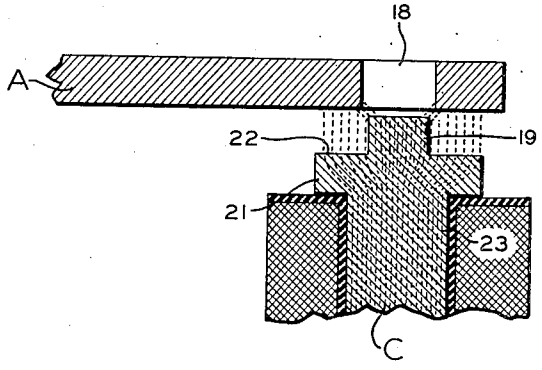
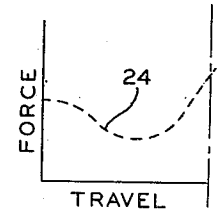


FIG. 6



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2,076,858

ELECTROMAGNET

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Application February 23, 1935, Serial No. 7,823

2 Claims. (Cl. 175—336)

This invention relates to electromagnetic structures and has as its object an electromagnet which is simple and economical to manufacture and wherein the movement of its armature is effected by a magnetic force that is relatively constant.

In conventional magnet design, two known types of magnets, sometimes referred to as the sliding armature or plunger type and the core and abutting armature type, are frequently employed. It has been found that during travel of their armatures, the force characteristics vary; the former case having a marked decline at the conclusion of the travel and the latter case having a correspondingly low initial characteristic.

For certain operating purposes it has been found desirable to obtain an armature movement whose force characteristics do not decline so appreciably but instead are more nearly constant throughout its travel or at least whose initial force and whose holding force are relatively strong. A magnet structure having such characteristics is contemplated by the present invention, featuring an armature having an aperture or transverse opening therethrough into which there protrudes a reduced pole projection of the magnet core. The cross-sectional area of the projection may be of any proportion relative to its adjacent core structure, but should preferably be smaller in order to obtain a saturated condition of magnetic induction therein after a predetermined distance of travel. Due to the saturated condition obtained in the core projection, surplus magnetic lines are diverted through an adjacent pole head which is enlarged and which comes into abutting relation with the armature at the conclusion of its movement. The proportioning of the projection, head, and principal section of the core may be varied in order to obtain corresponding variations in the force characteristics. The general object, however, of increasing the initial pull and the concluding force or holding force is obtained by combining in one proportion or another the features set forth more specifically in the following description and illustrated in the accompanying drawing, wherein similar reference characters are employed to designate corresponding parts throughout.

In the drawing;

Fig. 1 is a transverse sectional view through a conventional type of sliding armature or plunger magnet;

Fig. 2 is a diagrammatic illustration of a curve chart representing the typical force-travel characteristic of a magnet such as that illustrated in Fig. 1;

Fig. 3 is a transverse sectional view through a conventional type of abutting core and armature magnet.

Fig. 4 is a diagrammatic illustration of a travel-force curve chart relating to a magnetic construction such as that illustrated in Fig. 3;

Fig. 5 is a transverse sectional view of a magnet structure embodying the principles of the present invention, and

Fig. 6 is a diagrammatic curve chart illustrating a typical curve based upon the force-travel characteristic obtained in a magnetic structure such as that illustrated in Fig. 5.

In the accompanying drawing the reference character A in each of Figs. 1, 3, and 5 indicates an armature element and the reference C a core element of a magnet structure illustrated in each of the respective views. In Fig. 1, the armature A is provided with a transverse opening 11 of somewhat larger diameter than that of its cooperating core C. During the initial portion of the operation of this type of magnet, the close proximity of the forward edge 12 of the core C to the adjacent edge 13 of the internal wall surface of the armature opening 11 permits of a minimum reluctance of the magnetic path. In the illustration, the magnetic lines have been represented by the minute vectors 14, whose inclination with respect to the direction of movement of the armature A is inversely proportional to the magnitude of the force which attracts the armature. The illustrated condition prevails during the time in which the armature is withheld and continues, in the main, until the core has entered the aperture 11. Thereafter the direction changes progressively until a zero position is reached, whereat the major portion of the lines is representable perpendicularly to the core C. When the armature has been moved to such a position that the magnetic lines of force are substantially normal to the above mentioned direction of movement of the armature, which conditions obtain when the core C has entered the opening 11 in the armature A, the force with which the core attracts the armature approaches zero, as indicated by the curve 15, Fig. 2. If, by means of a stop member the movement of the armature should be arrested in advance of the point at which the attracting force becomes zero, a minute holding force may be obtained, but as may be seen from the curve 15, the magnitude of this force becomes rapidly diminished as the distance of travel increases, so that an appreciable

proportion of the travel of the armature is executed under very low force characteristics.

In the structure illustrated in Fig. 3, the armature A is normally separated from its core C by a space equal to or exceeding the distance of travel. The spacing of the elements A and C introduces a relatively large value of reluctance in the path of the magnetic circuit, so that at the beginning of the travel of the armature the induction is small, resulting in a very low force of magnetic attraction, as illustrated by the curve 16, Fig. 4. Toward the conclusion of the travel, however, the space 17 becoming a minimum, the reluctance in the magnetic path is diminished correspondingly, causing the curve 16 to turn sharply upward, indicating that there is obtained a relatively strong holding force.

In each of the foregoing embodiments, it will be noted that momentarily during some interval of the travel of the armature A there appears to be an inherently minute force characteristic. This is sometimes objectionable and in certain instances it is especially desired that the minimum force characteristic be maintained at a degree comparatively higher than that permitted by either of the aforedescribed conventional magnet structures. For the attainment of this object, the present invention is proposed embodying an armature A of the general class in shape and performance illustrated in Figs. 1 and 3, having an opening or aperture 18 of somewhat larger diameter than the diameter of a projection 19 formed upon the extremity of a magnet core C. Contiguous with the projection 19 there is an enlarged head 21 affording a circular pole face 22 extending laterally from the projecting portion 19 and forming with said projecting portion a shoulder. The pole face 22 may be concentric with the projecting portion 19, or a similar effect may also be obtained where the shouldered effect of the portions 19 and 21 are not concentric or even circumferentially coextensive. The main body portion 23 of the core C is indicated as having a diameter larger than that of projection 19 and smaller than that of the enlarged head portion 21.

In accordance with the accepted theory of magnetic lines of force, given a suitable induced current, magnetic lines coursing through the main body portion 23 may not all continue through the projection 19 in their circuit longitudinally of the core C, but instead, a certain portion of them, as illustrated in Fig. 5, will be diverted sidewardly and will pass out of the pole face at 22, the circumferential face area.

In the operation of the armature as influenced by the magnetic lines, it will be noted that the initial force is comparable to that illustrated in Fig. 1, so that accordingly, the force curve 24 of Fig. 6 is shown as starting strong and continuing for a short period at a more or less constant strength in accordance with the increase of magnetic lines flowing into the armature A. When a maximum number of lines travelling through the projection 19 enter the armature A so that the portion 19, being saturated, comes fully within the compass of the armature A, the force curve 24 thereafter falls off slightly and continues lower for a short distance. Following such condition, as the armature A approaches the face 22, the intervening space therebetween is diminished, accordingly reducing the reluctance to the lines which diverge and cross through the enlarged pole head 21. This results in a relatively sharp rise of the curve 24 near the conclusion of the movement of the armature.

To vary curve 24 relative to its several portions, the diameter of projection 19 may be varied accordingly with respect to that of the enlarged head 21. In this way, a variety of specific effects may be obtained where, due to a special requirement, the force curve might be preferred to follow courses different from that shown in Fig. 6. By providing the opening 18 in the armature A and having the projection 19 on the core C, there is permitted an economical arrangement whereby the material from which the core C is turned may be obtained in several stock dimensions and turned down to the proper relationship between its pole portions 19 and 21; also, the armature A may be drilled to afford the hole or aperture 18. This economy of construction lends itself particularly to shop practices employed where magnets and special magnetic operating devices are designed to serve individual specifications. By way of summary, it will be noted that the present invention provides a structure lending itself to efficient design and manufacturing practice while affording an armature construction that may be proportioned to operate under any of several varying force conditions having application to peculiar adaptations.

While the present invention has been explained and described with reference to a particular design, it will be obvious that numerous variations and modifications may be made in accordance with the spirit and scope thereof. For this reason it is not intended to be limited by the specific embodiments of the accompanying illustration nor by the language of the foregoing specification except as qualified by the hereinafter appended claims.

What is claimed is:

1. In an electromagnet, a core member having a cylindrical body portion, a pole head integrally formed with said body portion and having a cross-sectional area larger than that of said body portion, and a projection having a cross-sectional area smaller than that of said body portion in combination with an armature having an aperture having a cross-sectional area for receiving said projection and a surface surrounding said aperture receivable in abutting relation to said pole head.

2. An electromagnet comprising a core having a uniform cross-sectional area, a winding surrounding said core, a pole head integrally formed with said core terminating one end thereof and having a cross-sectional area greater than that of said core so as to provide for a diminution of magnetic lines passing therethrough from said core, a projecting pole piece extending centrally from the outer face of said pole head, said pole piece having a cross-sectional area smaller than that of said core, and an armature having sliding cooperation with said pole piece and abutting cooperation with said pole head.

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