

UNITED STATES PATENT OFFICE

2,269,345

PERMANENT MAGNET

Clifford A. Nickle, Schenectady, and Goodwin H. Howe, Scotia, N. Y., assignors to General Electric Company, a corporation of New York

Application January 12, 1940, Serial No. 313,594

3 Claims. (Cl. 175—367)

This invention relates to improvements in magnetic structures and more particularly to permanent magnets of the lifting or holding type and has for its object the provision of magnets of this character having improved characteristics and which are capable of producing a large attractive force between the magnet poles and a relatively movable armature or keeper element.

In a copending application of Eugene W. Boehne, Serial No. 315,982, filed January 27, 1940, and entitled "Magnetic structure," which application is a continuation in part of Boehne application, Serial No. 248,783, filed December 31, 1938, there is described and broadly claimed a lifting or holding magnet having annular pole pieces with a shunt flux path between the two pole pieces comprising at least one annular member of magnetic material separated from the pole pieces by at least two air gaps. An armature element in multiple with the shunt flux path and comprising at least two annular magnetic members separated from each other by an air gap, cooperates with the shunt flux path and the pole pieces to provide a minimum of four holding surfaces through which passes in series relation the useful magnetic flux. The same flux is used in a plurality of gaps, instead of the usual two, and the holding power is greatly increased.

In accordance with the present invention in its preferred form, we provide a permanent magnet element which is preferably composed of a magnetic material having a high coercive force and which is joined to a pair of pole pieces of comparatively high permeability, high saturation, magnetic material for concentrating the flux of the magnet in the working air gaps. The magnet element and the poles are arranged in a substantially U-shape magnetic circuit. A feature of the invention resides in the employment of a segmented shunt flux path comprising at least one member of high permeability, high saturation, magnetic material which is joined to the pole pieces of the magnet by non-magnetic spacer elements one of which is positioned intermediate each pole piece and the member of magnetic material. Cooperating with the pole pieces and this shunt flux path is a relatively movable multiple armature or keeper element composed of at least two segments of high permeability, high saturation, magnetic material which are separated by an element of similar non-magnetic material. The magnetic segments of the flux producing member including pole pieces and shunt flux path are offset or staggered with respect to

the magnetic segments of the other member or armature, so that each magnetic segment makes contact with or engages the two adjacent magnetic segments of the other member. The magnetic and non-magnetic members are so dimensioned that the magnetic segments overlap at all points and the non-magnetic segments of one of the members are disposed at substantially the median lines of the opposite magnetic segments in order that a continuous magnetic circuit through the magnetic material, as iron, is provided between the pole pieces, except for the working gaps lying in the plane of engagement of the members. Of course, where all of the magnetic segments are of the same size and where the non-magnetic spacing elements are also equal in size with respect to each other, the offset positions of the median lines of all the magnetic elements will be equally spaced. With this arrangement the useful flux in passing from one pole of the magnet to the other pole traverses a minimum of four working gaps or holding surfaces thereby adding greatly to the holding power or attractive force of the magnet.

The novel features which are characteristic of our invention are pointed out in the appended claims. The invention, however, will be understood more readily with reference to the following specification when considered in connection with the accompanying drawing in which Figs. 1 and 2 illustrate respectively perspective and sectional elevation views of a holding magnet constructed in accordance with our invention; Fig. 3 is a perspective view of the permanent magnet element employed in the magnetic structures of Figs. 1 and 2; Figs. 4 and 5 illustrate modifications of holding magnets constructed in accordance with our invention; and Fig. 6 is a perspective view of the permanent magnet element employed in the arrangement of Fig. 5.

Referring to Figs. 1, 2 and 3 of the drawing, we have illustrated a magnetic structure including a holding magnet assembly 10 positioned between a supporting member 11 of non-magnetic material and a supported member 12 of non-magnetic material for supporting a weight W. A short bar type magnet element 13 of substantially cubical form is mounted in a magnetic circuit including a pair of pole pieces 14 and 15 and a shunt flux carrying path comprising a plurality of segments 16 separated from the poles of the magnet and from each other by a series of gaps or segments 17. The supporting member is provided with a transverse groove 18 within which are positioned the magnet element 13 and

should be made quite smooth and all of approximately the same area so that they produce the same attractive force on the armature. Inasmuch as the attractive force between two surfaces in contact or separated by a small air gap is proportional to the product of the square of the flux density times the area of the air gap, it is obviously advantageous to employ as many working air gaps as possible and at the same time operate the permanent magnet at its highest magnetic efficiency from the standpoint of working the magnet at that value of flux density which gives maximum energy. In general, with regard to the optimum number of holding surfaces or working air gaps which should be employed with a given magnet, it may be stated that the number of gaps may be increased to advantage until the attendant increase in reluctance due to the addition of another gap produces a drop in the flux density in the working air gaps without an increase in the total attractive force.

It should also be pointed out that the arrangement of the shunt flux path furnishes a relatively low reluctance leakage path for the flux produced by the magnet element 13 when the armature 22 is drawn away, thereby preventing the flux density of the magnet from dropping to as low a value as it otherwise would. Consequently, the flux density rises to a higher value when the armature is again brought in contact with the poles and the segments 16, and the pull is thus increased.

In Fig. 4 we have shown a modification of the arrangements of Figs. 1 and 2 in which an additional path is provided for the magnetic flux when the armature is pulled away from the poles. In the illustrated embodiment a holding magnet assembly 27 is positioned between a non-magnetic supporting member 28 and a non-magnetic supported member 29. A short bar shaped permanent magnet element 30 of high coercive force material is positioned between a pair of high permeability, high saturation, pole pieces 31 and 32 which are arranged in a magnetic circuit including a shunt flux-carrying path 33 having a plurality of magnetic segments 34 separated by non-magnetic spacer elements 35. As in Figs. 1 and 2 the assembly also includes an armature element 36 comprising magnetic segments 37 separated by non-magnetic spacer elements 38.

The pole pieces 31 and 32 extend beyond the magnet 30 and extend toward each other in the same plane to form a fixed air gap 39. This air gap is so designed with respect to the rest of the circuit that its reluctance is several times greater than that of the useful flux path when the armature is in the attracted position, but it aids in maintaining the flux density of the magnet at a relatively high value when the armature element is moved away from the poles.

The various parts of Fig. 4 may be composed of the same material as the corresponding parts described in connection with the arrangements of Figs. 1 to 3 and they may be secured together in a like manner.

In Fig. 5 we have illustrated a further modification of a permanent magnet assembly 39 which is mounted between a non-magnetic supporting member 40 and a non-magnetic supported member 41. The permanent magnet element 42 is in this case made substantially U-shape, as indicated clearly in Fig. 6, and is provided with short pole pieces 43 and 44. While a permanent magnet arranged in this manner may be

used in some instances, in general we prefer to employ magnets of the type shown in 13 and 30 of Figs. 2 and 4, respectively, since the permanent magnet material is utilized most efficiently in these arrangements because a shorter path is taken through the permanent magnet material thereby avoiding to such extent the adverse effect of high reluctance. Furthermore, the flux lines go directly through the magnet and into the high permeability pole pieces so that there is no energy consuming redistribution in the permanent magnet element when the armature is replaced.

We have found that holding or lifting magnets built in accordance with the principles of our invention will lift a weight or overcome a force as high as approximately 4500 times the weight of the permanent magnet element. Hitherto, in the construction of magnets the holding power has not increased directly in proportion to the magnet size due principally to metallurgical non-homogeneity and the greater internal reluctance with increasing size. These difficulties are largely overcome in the magnetic structure of the present invention which includes a segmented shunt flux path and a multiple armature together with the employment of a novel mounting and an improved method of securing the magnet in close engagement with the pole pieces. In accordance with the illustrated arrangement, the useful magnetic flux is concentrated in a plurality of working air gaps and, further, because of the improved structural arrangement of the parts, the leakage is maintained at a low value and the magnetomotive force is utilized so efficiently that the holding power may be increased for supporting heavier loads with substantially the same efficiency by increasing the amount of the permanent magnet material employed.

The arrangement of the present invention demonstrates that the relatively high available magnetic energy of high coercive force magnetic materials such as those described can be employed very effectively. Magnets of the character described in this specification may be found particularly useful in those applications where a tenacious attractive force is required between two relatively movable magnetic surfaces.

In accordance with the provisions of the Patent Statutes, we have described the principle of operation of our invention together with the apparatus which we now consider 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:

1. In a magnet assembly of the lifting or holding type, a magnetic circuit including a flux producing member, said member including a flux producing element and a pair of pole pieces of high permeability, high saturation magnetic material, a segmented shunt member extending between said pole pieces and comprising at least one segment of magnetic material separated from and joined to said pole pieces by segments of non-magnetic material, said shunt segments and said pole pieces forming a single plane surface, a segmented armature element comprising at least two segments of magnetic material separated by and attached to a non-magnetic spacing segment, said armature segments forming a second single plane surface, said plane surfaces completely and intimately engaging each other

when the armature is held against the flux producing member, the magnetic segments of each of said members being offset with respect to the magnetic segments of the other of said members in the working positions thereof so that each magnetic segment makes contact with two adjacent magnetic segments of the other of said members, said magnetic and non-magnetic segments being so dimensioned that the magnetic segments overlap at all points, the non-magnetic segments of each member being disposed at substantially the median lines of the opposite magnetic segments in order that a continuous magnetic circuit through the magnetic material is provided between said pole pieces except for a plurality of working air gaps between the magnetic segments lying in the plane of engagement of said members.

2. In a magnetic assembly of the lifting or holding type, a magnetic circuit including a flux producing member and an armature member, said flux producing member comprising a flux producing element and a pair of pole pieces of high permeability, high saturation magnetic material, a segmented member shunting said pole pieces and comprising a plurality of segments of magnetic material separated by spacer segments of non-magnetic material, non-magnetic spacer segments also being disposed between the end-most magnetic segments and the pole pieces, said shunt segments and said pole pieces forming a single plane surface, said armature element comprising a plurality of magnetic segments separated by non-magnetic spacing segments, said armature segments forming a second single plane surface, said plane surfaces completely and intimately engaging each other when the armature is held against the flux producing member, the magnetic segments of each of said members being staggered with respect to the magnetic segments of the other of said members in the working positions thereof so that each magnetic segment makes contact with two adjacent magnetic segments of the other member, said magnetic and non-magnetic segments being so dimensioned that the magnetic segments overlap at all points, the non-magnetic segments of each of said members being disposed at sub-

stantially the median lines of the opposite magnetic segments in order that a continuous magnetic circuit through the magnetic material is provided between said pole pieces except for a plurality of working air gaps between magnetic segments lying in the plane of engagement of said members.

3. In combination in a magnetic structure, a magnetic circuit including a flux producing member and an armature member, said flux producing member comprising a substantially U-shaped device including a permanent magnet element and a pair of pole pieces of relatively high permeability, high saturation magnetic material, a segmented member shunting said pole pieces and comprising a plurality of segments of magnetic material separated by spacer segments of non-magnetic material, non-magnetic spacer segments also being disposed between the end-most magnetic segments and the pole pieces, said shunt segments and said pole pieces forming a single plane surface, said armature element comprising a plurality of magnetic segments separated by non-magnetic spacing segments, said armature segments forming a second single plane surface, said plane surfaces completely and intimately engaging each other when the armature is held against the flux producing member, the magnetic segments of each of said members being staggered with respect to the magnetic segments of the other of said members in the working positions thereof so that each magnetic segment makes contact with two adjacent magnetic segments of the other member, said magnetic and non-magnetic segments being so dimensioned that the magnetic segments overlap at all points, the non-magnetic segments of each of said members being disposed at substantially the median lines of the opposite magnetic segments in order that a continuous magnetic circuit through the magnetic material is provided between said pole pieces except for a plurality of working air gaps between magnetic segments lying in the plane of engagement of said members.

CLIFFORD A. NICKLE.
GOODWIN H. HOWE.

Jan. 6, 1942.

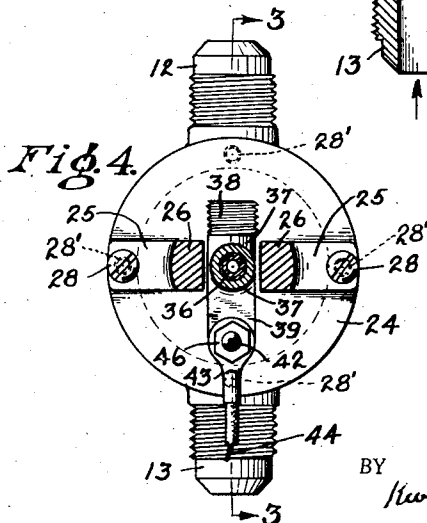
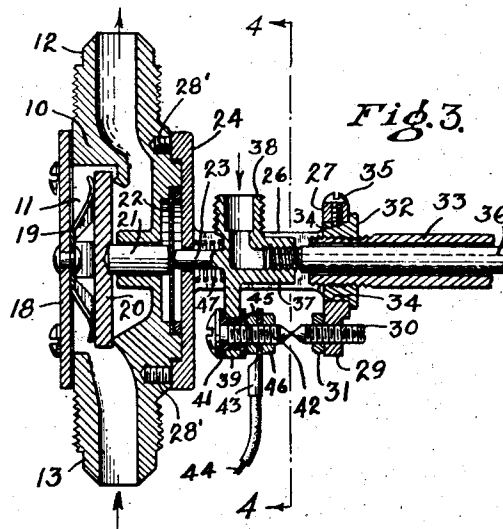
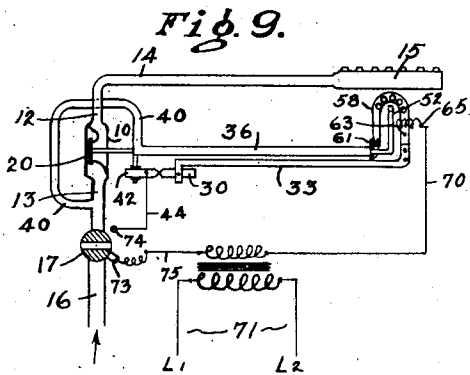
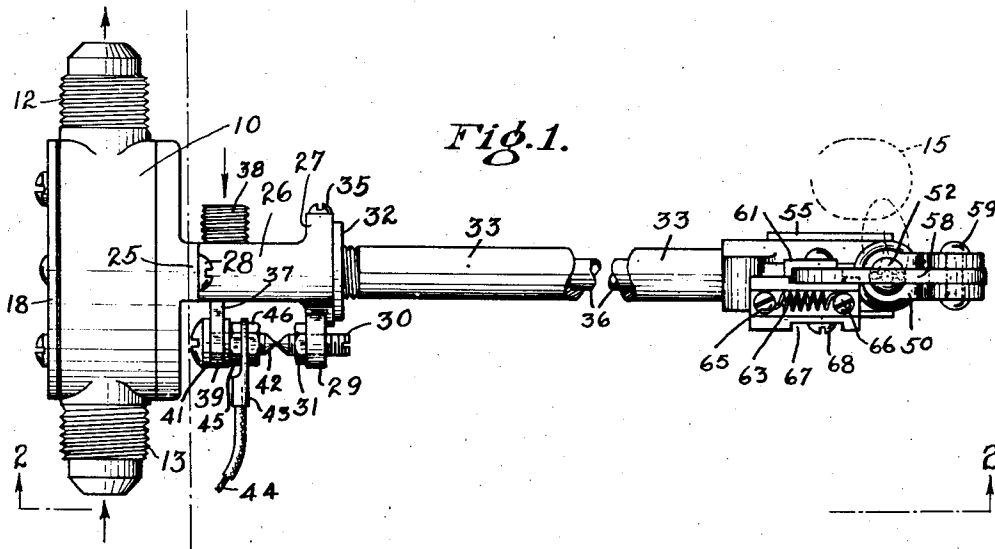
V. O. BEAM ET AL

2,269,356

AUTOMATIC LIGHTER

Filed March 6, 1939

2 Sheets-Sheet 1



INVENTORS
BY *Yilynn O. Beam.*
Julius Converse.
Hewes, Hudson & Kent
Their ATTORNEYS

