

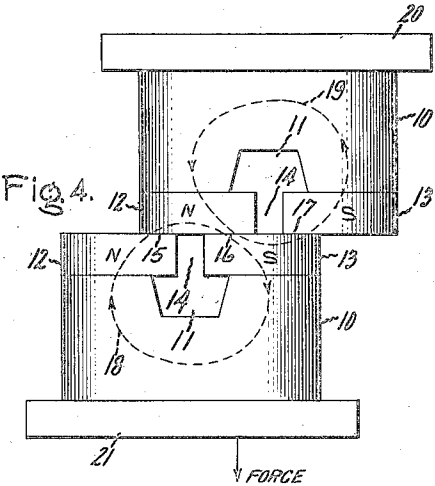
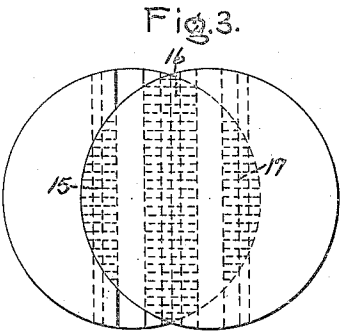
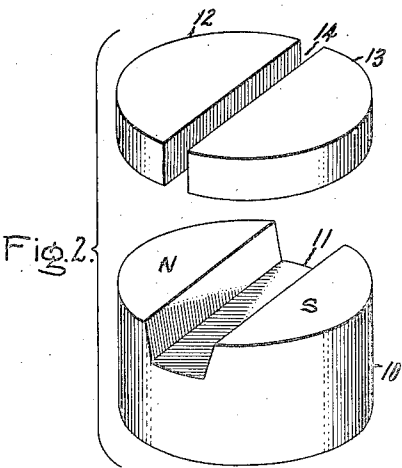
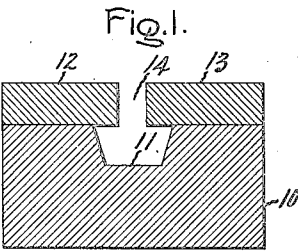
March 10, 1942.

G. H. HOWE

2,275,904

MAGNET STRUCTURE

Filed Dec. 19, 1939



Inventor:
Goodwin H. Howe,

by *Harry E. Duham*
His Attorney.

UNITED STATES PATENT OFFICE

2,275,904

MAGNET STRUCTURE

Goodwin H. Howe, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application December 19, 1939, Serial No. 310,014

4 Claims. (Cl. 175—367)

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

In accordance with my invention in its preferred form I provide a plurality of permanent magnet elements, each magnet being preferably composed of a magnetic material having a high coercive force, and each having pole pieces of comparatively high permeability, high saturation, magnetic material. One of the pole faces of the first magnet is arranged in such a manner that it overlaps the pole faces of the two poles of the second magnet and the other pole face of the first magnet is in contact with the pole face of like polarity of the second magnet. With this arrangement, three working air gaps are formed so that the combined flux from both of the magnets passes through a common working air gap. In this way, a lifting or holding magnet is obtained having a great attractive power.

The novel features which are characteristic of my invention are pointed out in the appended claims. My invention, however, will be understood more readily from reference to the following specification when considered in connection with the accompanying drawing in which Figs. 1 and 2 illustrate respectively vertical section and exploded perspective views of one of the permanent magnet elements employed in illustrating the principles of my invention. Fig. 3 is a plan view illustrating the approximate relative pole face areas in contact between the two magnets when they are arranged in accordance with my invention. Fig. 4 is an elevational view of the holding magnet elements arranged in accordance with my invention.

Referring to Figs. 1 and 2 of the drawing I have illustrated a permanent magnet element 10 of cylindrical construction and having polar portions N and S formed on opposite sides of a transverse groove 11 in one end of the cylindrical member. The magnet thus has a substantially U-shape cross section. I may provide a pair of pole pieces 12 and 13 for engaging the polar portions N and S, respectively of the permanent magnet element 10. In forming these pole pieces I have found it convenient to employ an annular disk and secure it to the polar portions N and S in any convenient manner, such as by a soldering process of the character dis-

closed and claimed in my United States Patent 2,169,098, assigned to the same assignee as the present invention. A slot such as 14 may then be formed in the disk by means of a milling cutter or the like in order to separate the pole pieces 12 and 13.

In constructing the permanent magnet element 10 I prefer to employ magnetic materials which are characterized by a high coercive force in order that the magnet may be made highly resistant to various demagnetizing influences. I do not intend, however, that my invention shall be limited to the employment of a particular magnetic material, but I have found that highly satisfactory results may be obtained by the employment of permanent magnet alloys containing iron, nickel, and aluminum as the basic or essential ingredients. These magnets may be prepared in accordance with the teachings of United States Patents Nos. 1,947,274 and 1,968,569, to Wm. E. Ruder, and 2,027,994 to 2,028,000, inclusive, to Tokushichi Mishima or, if desired, the magnet may be formed by a sintering process, as disclosed in my copending application Serial No. 196,691, filed March 18, 1938, U. S. Patent No. 2,192,743, entitled, "Sintered permanent magnet," and assigned to the same assignee as the present invention. Magnets composed of such alloys not only have a high coercive force but they also exhibit a fairly high residual induction so that by their use a maximum amount of magnetic energy is made available with a minimum volume of magnetic material, and a permanent magnet of long life is obtained.

The magnets 10 are illustrated for use in connection with pole pieces of different magnetic material from that of the magnets and I prefer to employ pole pieces which are composed of a high permeability, high saturation, magnetic material such as, for example, annealed cold rolled iron or an alloy of 35 to 50 per cent cobalt-iron. In the design of magnets for lifting or holding purposes it is desired to obtain maximum attractive force between the magnet poles and a relatively movable armature or keeper element. Magnets of this character are provided with small working air gaps and since 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 maintain a high flux density at the working air gap. By employing high permeability, high saturation, magnetic material for the pole pieces, I thereby obtain a high flux density at the working air gap

and at the same time the permanent magnet is operated at its most efficient flux density. In other words, the flux may be concentrated in the working air gap without affecting the flux density in the magnet. Whereas, if the pole pieces were constructed of the same material as the permanent magnet element, the concentration of flux would result in a loss of magnetomotive force in the magnet poles. Thus, if the same high density is to be maintained at the working surface considerably more magnetomotive force would be required.

Referring to Figs. 3 and 4, I have illustrated a pair of identical permanent magnet elements 10 of the type illustrated in Figs. 1 and 2 and having high permeability, high saturation, pole pieces 12 and 13 positioned with their polar faces in abutting or opposed relation to form contact surfaces 15, 16 and 17, respectively. The pole pieces are of substantial thickness and have relatively large face or contact areas. It will be observed that the contact surfaces 15 and 16 are formed between the pole face of the pole piece 12 of the upper magnet and the pole faces of both pole pieces of the lower magnet while the contact surface 17 is formed between the pole face area of the pole piece 13 of the upper magnet and the pole face area of the pole piece 13 of like polarity of the lower magnet. The relative contact areas are clearly shown in Fig. 3 by the cross-hatched portions. Thus, the flux from the lower magnet, as indicated by the dotted line 18, passes between the pole piece contact surfaces at 15 and between the pole piece contact surfaces at 16. Likewise, the flux produced by the upper magnet, as indicated by the dotted line 19, passes between the pole piece contact surfaces at 16 and between the pole piece contact surfaces at 17. It will thus be seen that the sum of the fluxes of the two magnets is forced through the common air gap formed between the pole piece contact surfaces at 16.

To obtain a better understanding of the principles of my invention, assume that the two magnets are positioned with their pole faces in abutting relation and so arranged that each pole of one magnet makes contact respectively with a pole of unlike polarity of the other magnet. A series closed circuit magnetic path including the two magnets and two working air gaps is thereby formed. The total flux in each magnet is thus the same and this same flux, neglecting leakage, crosses the two working air gaps. By arranging the parts in accordance with my invention, three working air gaps are provided two of which carry the flux of one magnet and one of which carries the combined flux of both magnets. Since the area of each working gap in this arrangement is greatly reduced, other factors remaining the same, the flux density in each gap will be correspondingly increased. The flux density in the gap 16 is quite high as compared to the series arrangement just described, since the area of the working gap is now much smaller and this gap now carries the sum of the fluxes produced by the two magnets. The result is a greatly increased attractive force.

The flux lines 19 in the upper magnet find a path of lower reluctance through the gap 16 than through the path including the gap 15. The same holds true for the flux emanating from the other magnet as regards the gap 17. Consequently, no appreciable repulsion force exists between the magnets even though they are ar-

ranged with their poles of like polarity in abutting relation.

The permanent magnets of Fig. 4 are shown mounted between an upper member 20 and a lower member 21. The upper member 20, to which the upper magnet is secured, may serve as a support, for example, while the lower member 21 which is secured to the lower magnet may be any member to which a force is applied tending to separate the permanent magnet elements, such for example as a weight or spring.

In arranging the permanent magnet elements it is, of course, desirable that the contact surfaces at 15, 16 and 17 be properly prepared with regard to smoothness, surface contact, and the like in order to obtain the maximum pull under a given set of conditions. Also, referring to Fig. 3, the areas of the pole faces at their contact portions 15, 16 and 17 should be proportioned to obtain a uniform flux density at each contact, and in the embodiment disclosed, the contact area at 16 is made approximately twice that of either 15 or 17 since the combined flux of both of the magnets passes through the contact surface at 16, whereas each of the other contact areas is required to carry the flux from only one magnet.

I have thus provided an improved permanent magnet for producing a large magnetic attractive force. Magnetic devices of this character may be found particularly useful in those cases where it is desired to produce a force having a steep gradient, as in certain circuit breaker and switch operations. Also, it may be found useful in numerous other applications where a tenacious attraction is required between two surfaces.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention in connection with the use of permanently magnetized elements which I now consider to represent the best embodiment thereof but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means, such for example as electromagnetic devices.

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

1. In combination, a first permanent magnet structure of substantially U-shape cross section having a magnet body of relatively high coercive force material and pole pieces composed of relatively low coercive force material having a permeability substantially greater than that of the magnet body, said pole pieces forming pole faces of opposite polarity, and a second permanent magnet structure of substantially U-shape cross section having a magnet body of relatively high coercive force material and pole pieces composed of relatively low coercive force material having a permeability substantially greater than that of the magnet body, said pole pieces forming pole faces of opposite polarity, said magnet structures being arranged with their pole faces in opposed relation in such a manner that a pole face of one polarity of said first permanent magnet is in contact with both of the pole faces of said second permanent magnet and the pole face of opposite polarity of said first permanent magnet is in contact with the pole face of like polarity of said second permanent magnet, the aforesaid pole pieces being of substantial thickness.

2. In combination, a first permanent magnet element in the form of a cylinder having a transverse groove in one end thereof, said element being formed from a high coercive force material and having polar portions of substantial thick-

ness, said portions being formed from a relatively low coercive force material having a permeability substantially greater than that of the magnet element, the pole faces of said magnet being arranged on opposite sides of said groove, and a second permanent magnet element in the form of a cylinder having a transverse groove in one end thereof, said second magnet element being formed from a high coercive force material and having polar portions formed from a relatively low coercive force material having a permeability substantially greater than that of the second magnet element, said polar portions having substantial thickness, the pole faces of said second magnet being arranged on opposite sides of said groove, said second magnet being arranged with its pole faces in opposed relation to the pole faces of said first permanent magnet in such a manner that a pole face of one of said magnets is in contact with both of the pole faces of the other of said magnets and the other pole face of said one magnet is in contact with the pole face of like polarity of said other magnet.

3. In a magnetic device of the lifting or holding type, first and second magnet structures, each of which comprises a permanent magnet of high coercive force material and pole pieces of substantial thickness formed from a relatively low coercive force material having a permeability substantially greater than that of the magnet body and having pole faces of opposite polarity, said magnets being arranged with the pole faces of one magnet in abutting relation with the pole faces of the other magnet to form three working contact areas, the first and second of said contact areas being formed respectively by positioning one of the pole faces of said first mag-

net to have a portion thereof in contact with the pole face of like polarity of said second magnet and another portion thereof in contact with the pole face of unlike polarity of said second magnet, and the third contact area being formed by positioning the other pole face of said first magnet in contact with the pole face of like polarity of said second magnet, said first and third contact areas being substantially equal in magnitude and the sum of said areas being substantially equal to said second contact area.

4. In a holding magnet, a first permanent magnet comprising a magnet body of high coercive force material and pole pieces composed of relatively low coercive force material having a permeability substantially greater than that of the magnet body and a second permanent magnet comprising a magnet body of high coercive force material and pole pieces composed of relatively low coercive force material having a permeability substantially greater than that of the magnet body, the said pole pieces being of substantial thickness and also having relatively large face areas, a pole piece of one polarity of said first magnet being arranged in contact with and in overlapping relationship with both of the pole pieces of said second permanent magnet and the pole piece of opposite polarity of said first permanent magnet being arranged in contact with the pole piece of like polarity of said second magnet, thereby providing three areas of contact between the pole pieces and two complete flux paths, each path crossing two air gaps and all of the flux crossing the air gaps passing through the common area between the pole pieces of opposite polarity.

GOODWIN H. HOWE.