

June 16, 1942.

F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 1

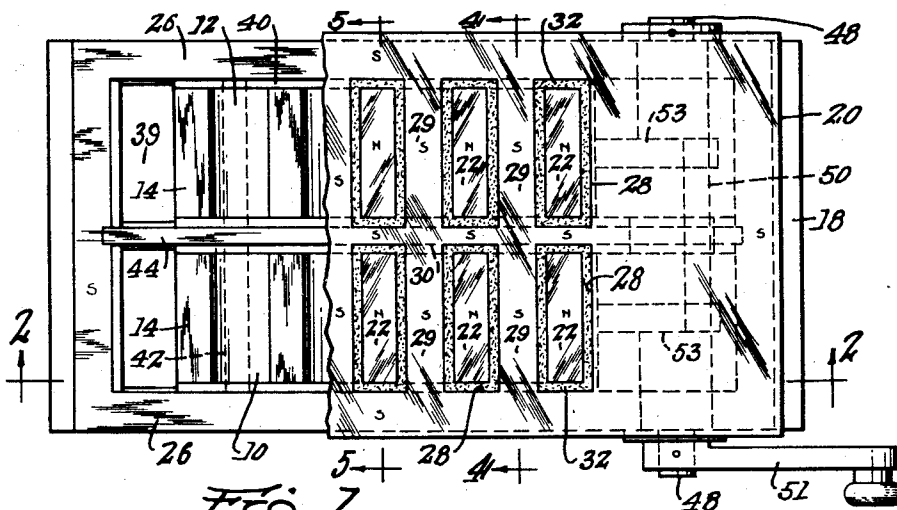


Fig. 1.

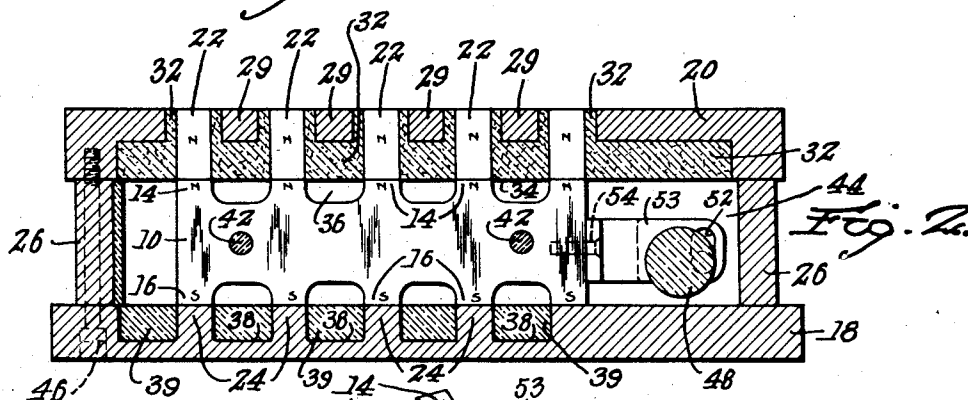


Fig. 2.

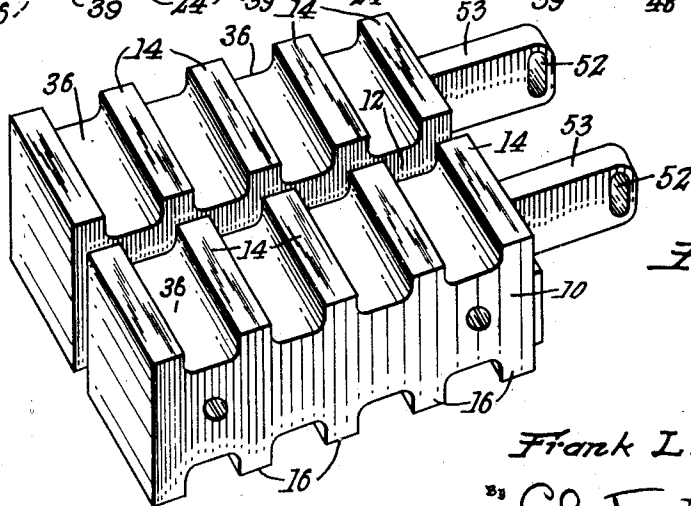


Fig. 3.

Witness
Wm. D. McLeod

Inventor
Frank L. Simmons
by Clayton R. Jenkins
Attorney

June 16, 1942.

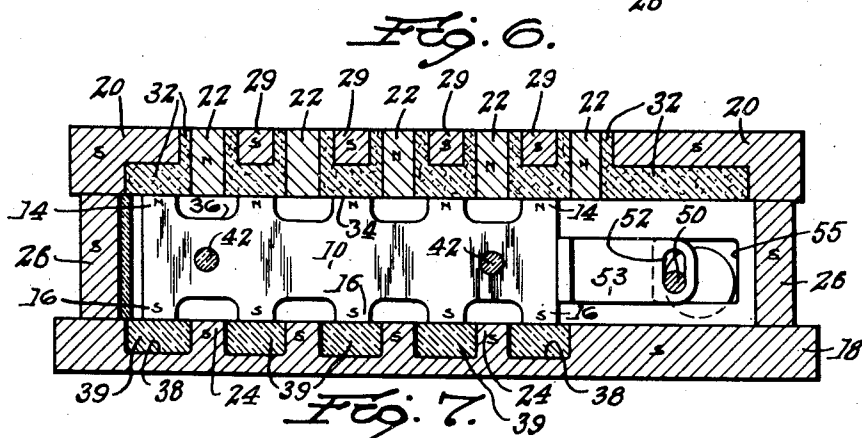
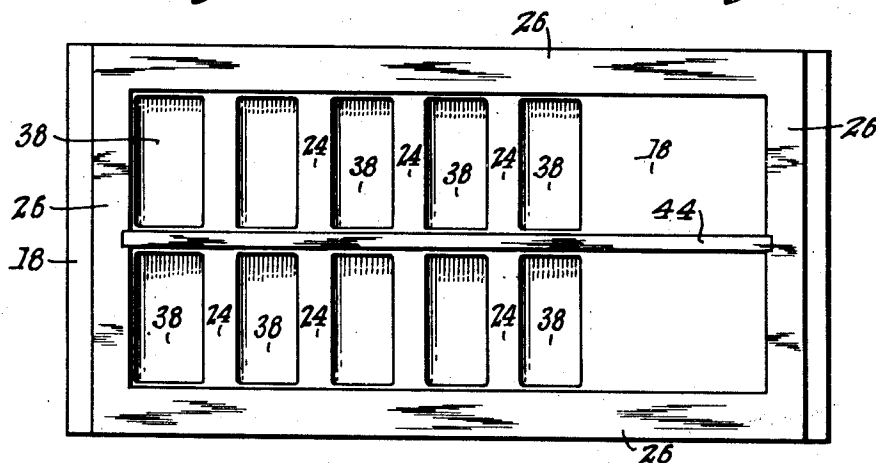
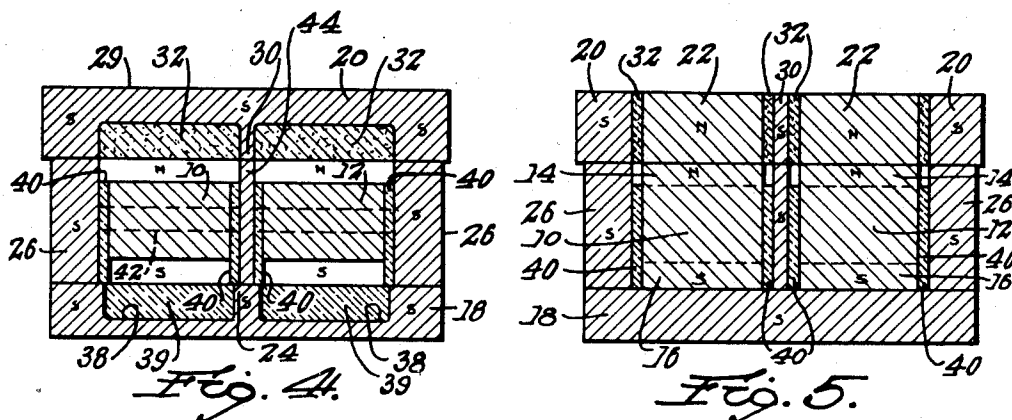
F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 2



June 16, 1942.

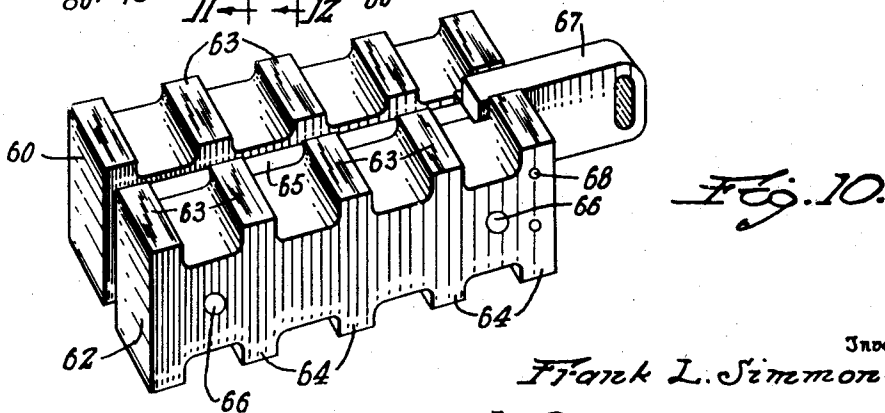
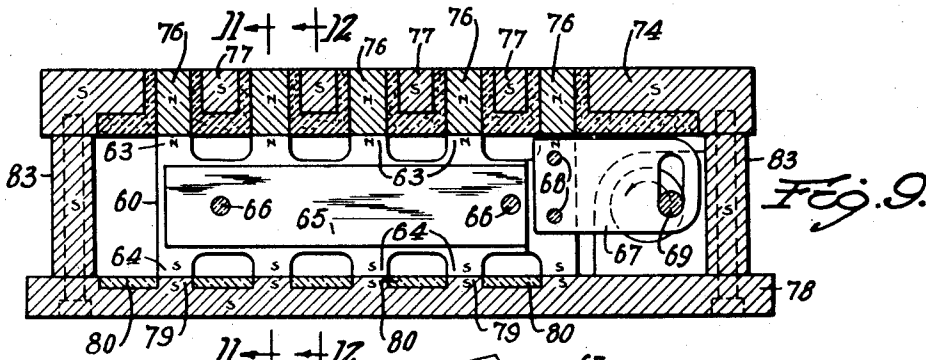
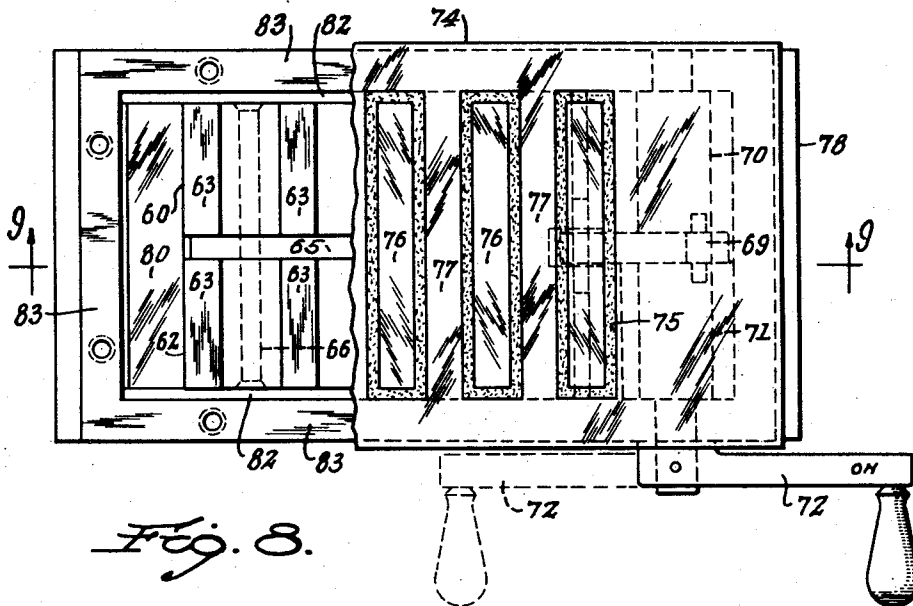
F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 3



Witness
Wm. D. McKee

Inventor
Frank L. Simmons
by Clayton R. Jenks
Attorney

June 16, 1942.

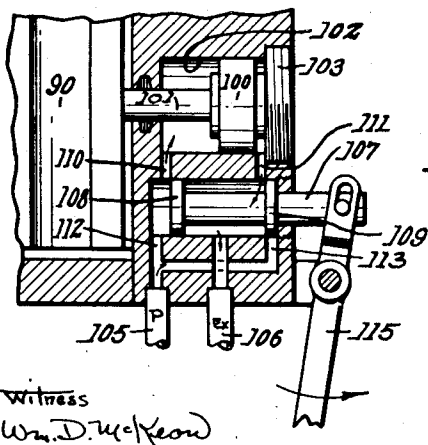
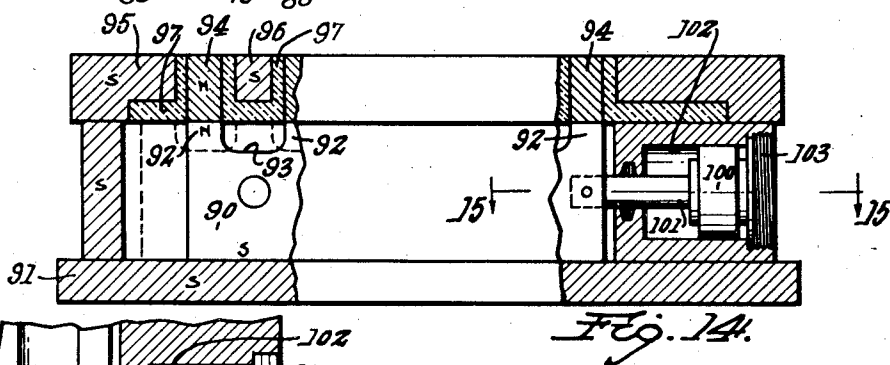
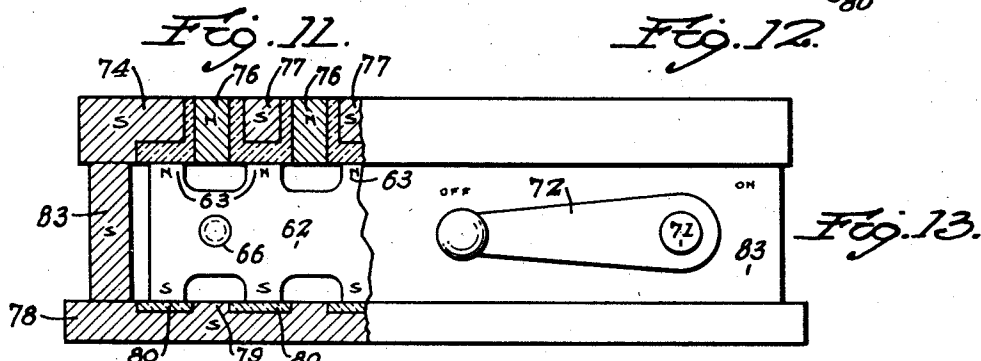
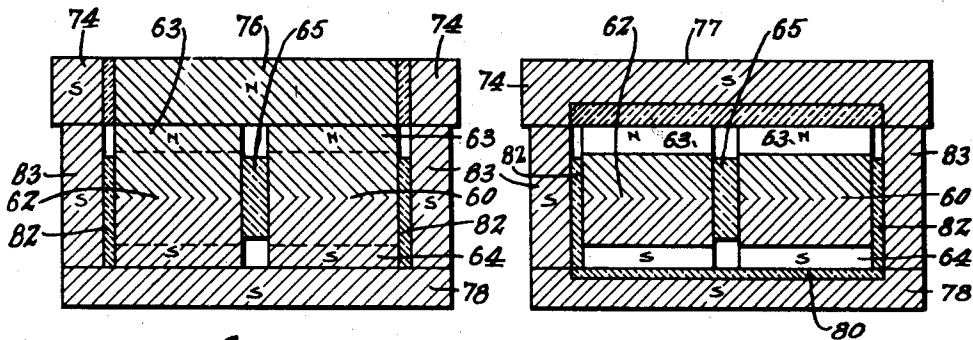
F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 4



Witness
Wm. D. McKeon

Inventor
Frank L. Simmons
By Clayton L. Jenkins
Attorney

June 16, 1942.

F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 5

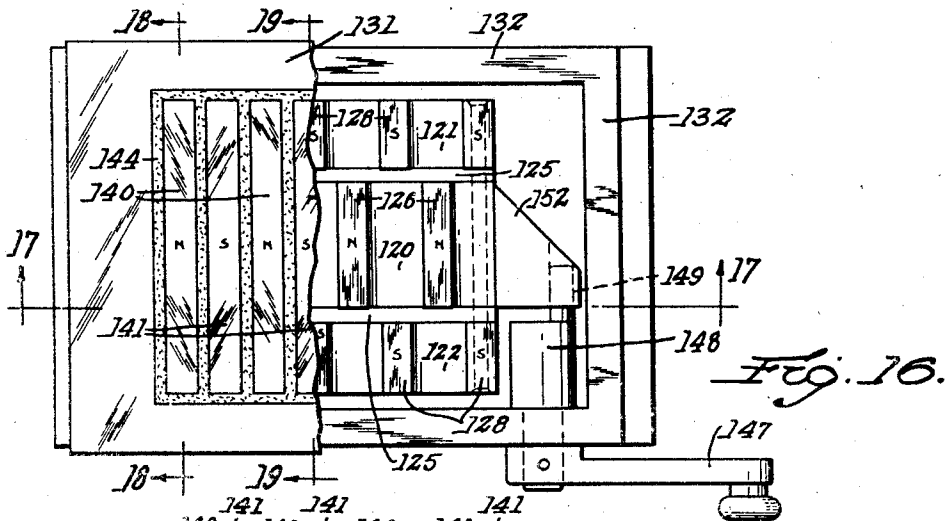


Fig. 16.

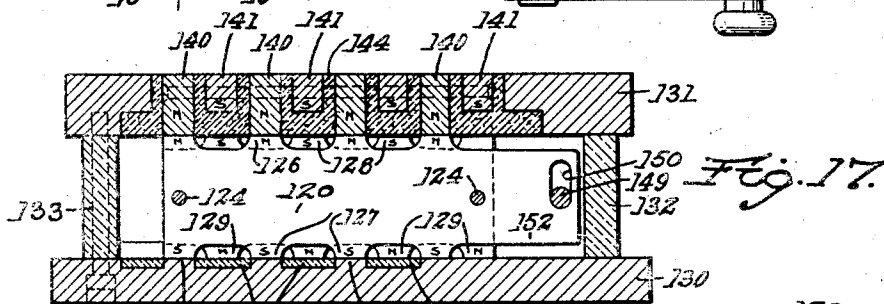


Fig. 17.

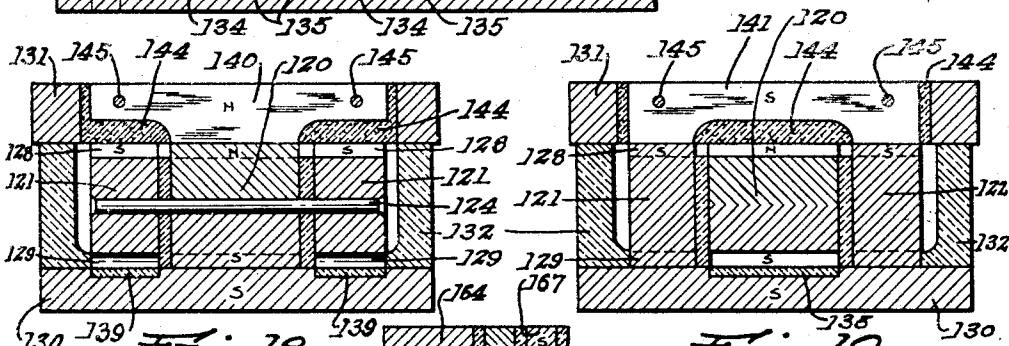


Fig. 18.

Fig. 19.

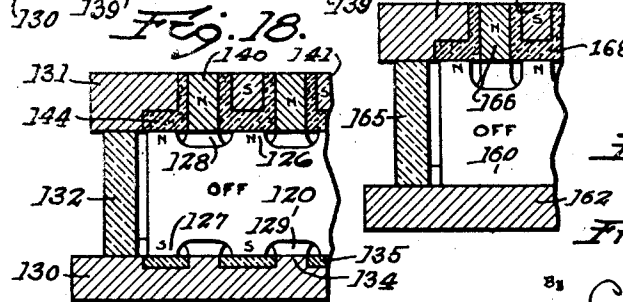


Fig. 20.

Fig. 21.

Witness
Wm. D. McKeon

Inventor
Frank I. Simmons
Clayton L. Jenkins
Attorney

June 16, 1942.

F. L. SIMMONS

2,286,238

MAGNETIC CHUCK

Filed Dec. 10, 1938

6 Sheets-Sheet 6

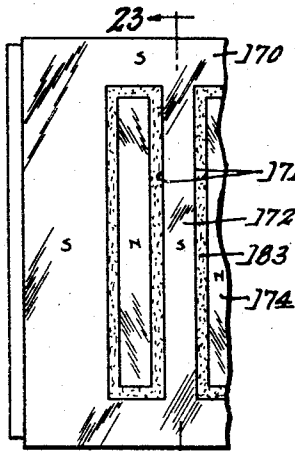


Fig. 22.

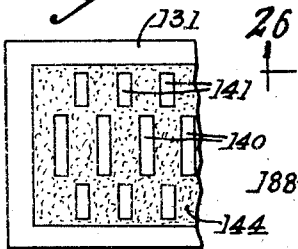


Fig. 24.

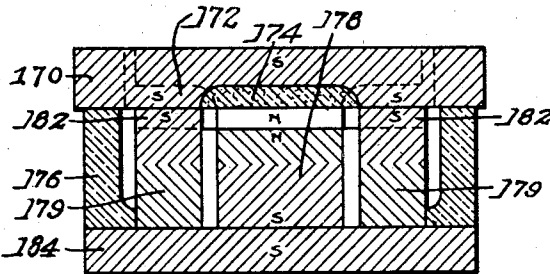


Fig. 23.

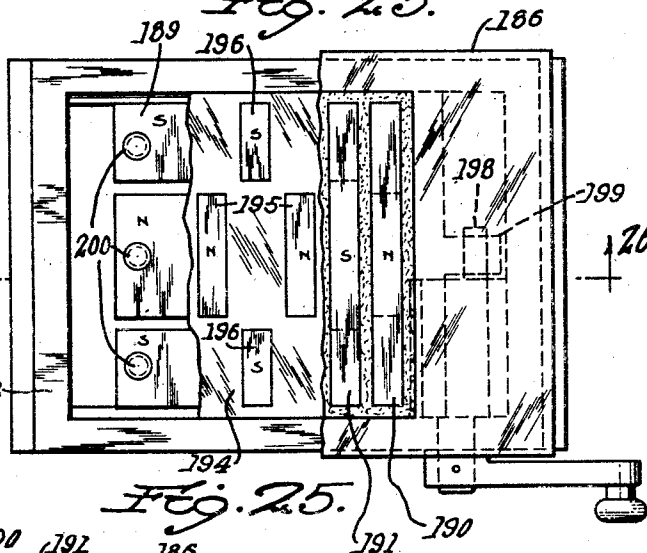


Fig. 25.

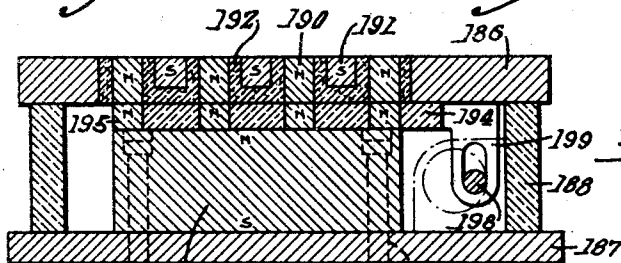


Fig. 26.

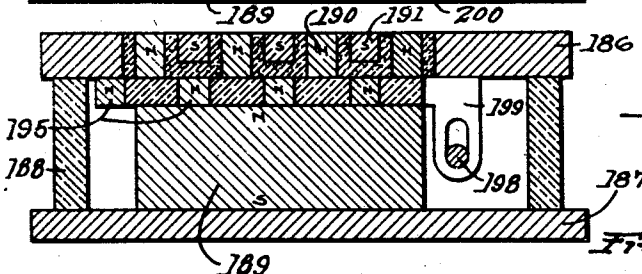


Fig. 27.

Witness
Wm. D. McKeon

81

Inventor
Frank L. Simmons
Clayton R. Jenkins
Attorney

UNITED STATES PATENT OFFICE

2,286,238

MAGNETIC CHUCK

Frank L. Simmons, Woonsocket, R. I.

Application December 10, 1938, Serial No. 245,047

11 Claims. (Cl. 175—367)

My invention relates to magnetic chucks, and more particularly to a chuck employing a permanent magnet therein.

The recent improvement in permanent magnets has suggested the substitution thereof for the standard electromagnets heretofore used in chucks. It, however, is possible to release the work readily and quickly from an electromagnet by reversing the current and neutralizing the pole pieces supporting the work. But, a permanent magnet tends to hold the work fixed in position and requires a strong force for removing the work therefrom. It has been proposed to overcome this difficulty by providing a shunt circuit for the magnetic flux when it is required to remove the work from the chuck. Such a construction has comprised a set of narrow horseshoe magnets so arranged relatively to a pole piece plate which supports the work that the magnets may be moved bodily to a position where the pole piece forms a shunt circuit for part of the flux and thus decreases the holding force of the chuck. Since part of the lines of force still pass through the work, this requires the use of force for removing the work; and if the undersurface of the work has been finely polished, there is danger of scratching or marring it. To build such a construction, the narrow magnets must be first ground to size and assembled on brass rods with brass spacers and fitted into place in the chuck, then removed for heat treatment and to be magnetized, and thereafter reassembled, with the possibility of poor workmanship making an inferior construction. The new alloy, sold under the trade name of "Alnico," which is now employed for permanent magnets, is extremely hard and cannot be readily machined but must be cast in substantially the desired shape and then have its surfaces ground to the required finish. This makes the use of small magnets a serious expense. If, to save expense, the faces of the magnet are left rough, they do not make proper contact with the other members forming the magnetic circuit and thus cause a loss of power; and it is more difficult to secure them rigidly together, as is necessary to make a strong chuck for holding heavy pieces of work against the pull of a grinding or a machined operation. It moreover has been proposed, in order to get the maximum holding power in such constructions, that two different thicknesses of bar magnets be employed, and that the wide magnets be arranged to magnetize the pole piece frame and the narrow ones the inserts therein. This has made it impossible to obtain the same magnetic contact for each of a plurality of similarly shaped, small work pieces; and such chucks have provided insufficient flux to magnetize a thick work piece, such as a die block.

It is one object of my invention to overcome

such disadvantages and to provide a construction which gives a strong and uniform field capable of holding both large and small objects securely in place.

5 A further object is to provide a chuck having a permanent magnet which is so constructed that a work piece may be readily removed therefrom.

In accordance with my invention, I propose to use in a chuck a single large sized permanent 10 magnet, or a plurality assembled together, and to provide a return path for the lines of force from the magnet through either the framework of the chuck or an adjacent magnet of oppositely arranged polarity. I also propose to neutralize 15 the pole pieces of the chuck, so that the work may be readily removed therefrom, by temporarily isolating one pole of the magnet from the other, and particularly by breaking the magnetic circuit between both poles of the magnet or between one 20 or both poles of the magnet and the associated pole pieces and the work held thereby. This is preferably accomplished by so arranging and shaping the magnet and associated pole pieces that one may be moved relatively to the other to 25 position the parts in either operative or inoperative positions; and power mechanism may be provided for the purpose. A small chuck may comprise one large bar magnet arranged to magnetize spaced pole pieces of one polarity and 30 frame pieces of the opposite polarity. A larger chuck may be formed of substantially a duplication of that construction. Also, I may make a chuck of three, or multiples of three, large bar magnets arranged with alternate north and south 35 poles uppermost and so constructed as to give a satisfactory distribution of the lines of force at the work surface and to provide for breaking the circuit, as required.

It is accordingly a further object of my invention 40 to make a magnetic chuck one or more massive bar magnets therein constructed and arranged to give a strong field which is so distributed as to hold small or large work pieces firmly thereon.

Another object is to provide chucks of the 45 types herein described which permit easy removal of the work pieces without injury thereto and which may be readily operated to magnetize or to neutralize the work supporting pole pieces as desired. Other objects will be apparent in the following disclosure.

Referring to the drawings, which illustrate various embodiments of my invention comprising these different features:

55 Fig. 1 is a plan view, partly broken away, of one form of chuck having two permanent bar magnets therein;

Fig. 2 is a section on the line 2—2 of Fig. 1;

60 Fig. 3 is a perspective view of the two bar magnets of Fig. 1 in their assembled relationship;

Fig. 4 is a section on the line 4—4 of Fig. 1;
 Fig. 5 is a section on the line 5—5 of Fig. 1;
 Fig. 6 is a plan view of the bottom and sides of the chuck with the top work plate, magnets and operating mechanism removed;

Fig. 7 is a view similar to Fig. 2, showing the parts in an inoperative position;

Fig. 8 is a top plan view of a modification showing a different type of work carrying plate, part of the plate being broken away;

Fig. 9 is a section on line 9—9 of Fig. 8, with the plates in their operative work holding positions;

Fig. 10 is a perspective view of the two assembled bar magnets of Fig. 8;

Fig. 11 is a section on the line 11—11 of Fig. 9;

Fig. 12 is a section on the line 12—12 of Fig. 9;

Fig. 13 as a view, partly in section, and partly in elevation, with the parts in inoperative positions as contrasted with the view in Fig. 9;

Fig. 14 is a modification showing in a sectional view, partly in elevation, a different type of bar magnet and embodying a fluid pressure mechanism for moving the magnet;

Fig. 15 is a sectional detail on the line 15—15 of Fig. 14 showing the fluid pressure and valve mechanism;

Fig. 16 is a top plan view of a further modification with the work plate partly broken away, which shows an arrangement embodying three bar magnets;

Fig. 17 is a section on the line 17—17 of Fig. 16;

Figs. 18 and 19 are sections on the lines 18 and 19 of Fig. 16;

Fig. 20 is a fragmentary detail corresponding with Fig. 17 with the magnet in an inoperative position;

Fig. 21 is a view corresponding with Fig. 20, showing a modified type of bar magnet;

Fig. 22 is a fragmentary top plan view of a modification of the work plate of Fig. 16;

Fig. 23 is a section on the line 23—23 of Fig. 22;

Fig. 24 is a plan view of the underside of the work supporting plates of Fig. 16;

Fig. 25 is a top plan view of a modification having a fixed bar magnet and a slide plate for breaking the magnetic circuit, the top plate and the slide plate being broken away;

Fig. 26 is a section on the line 26—26 of Fig. 25; and

Fig. 27 is a similar sectional view with the slide plate in position for breaking the magnetic circuit.

In accordance with this invention, I provide a magnetic chuck which comprises a permanent magnet so constructed and arranged that the magnetic flux may be broken between the two poles of the magnet and particularly between both poles of the magnet and the pole pieces which contact with the work. The magnetic lines may be broken at one pole of the magnet for certain types of magnetic chucks, or they may be broken at both poles so as to isolate the permanent magnet completely from the work which is supported by the chuck.

In the form shown in Figs. 1 to 7 inclusive, I have shown an arrangement in which one or more permanent magnets may be so arranged in the chuck that the magnetic circuit may be broken at both the north and the south poles thereof. These magnets may be constructed of suitable material well known in the industry, such as magnetizable high carbon steel or an alloy comprising aluminum, nickel and cobalt

which is sold under the trade name of "Alnico." As illustrated in Fig. 3, the magnets are shaped as massive solid bars and not as narrow spaced separate magnets, so that each bar acts as a single magnet and the lines of force are distributed accordingly. A narrow chuck may comprise but one bar magnet and a corresponding change in construction; but in the form shown I have illustrated two permanent magnets 10 and 12 which have corrugated surfaces providing spaced ribs or polar pieces 14 and 16 terminating in spaced polar faces at their top and bottom portions respectively, which serve as the north and south poles, or vice versa, of the magnets. As illustrated in Fig. 2, the assembled magnets are slidably mounted between a base plate 18 and a top plate or frame 20 which may form the work support. The frame 20 may be made of Swedish or wrought iron which does not retain residual magnetism; and it is so constructed as to provide openings for a set of spaced pole pieces 22 magnetically isolated from the frame and suitably mounted in the frame. These pole pieces are arranged to contact with or to be in magnetic circuit with the upper spaced polar faces on the ribs of the permanent magnet, and they may be considered as north poles. The lower spaced south polar faces on the ribs 16 are in contact with spaced ribs 24 of the bottom plate 18, which may be made of low carbon steel. The sides 26 which rest on plate 18 and support the top plate are also made of iron, steel or other suitable magnetic material. Hence, the lines of force may traverse from the north pole of the magnet to the pole pieces 22 in the work plate, then through a work piece supported thereon, and thence back into the top frame 20 and through the side walls 26 and the lower plate 18 of the chuck casing to the south pole of the permanent magnet.

The top plate is constructed as shown particularly in Fig. 1. It comprises an iron plate or a welded structure having two sets of spaced rectangular openings 28 therein separated by iron cross bars 29 and a single longitudinal bar 30. The pole pieces 22 are located in these rectangular openings and as illustrated are spaced from the walls thereof. The ends of the pole pieces 22 are spot brazed at spaced points across the gap with non-magnetic material to secure them to the adjacent parts of the plate 20 so as to make an integral structure. Babbitt metal 32, or other suitable non-magnetic material, such as a synthetic resin or brass may be molded or cast in position to fill the remainder of the space and hold the metal inserts 22 rigidly in place and isolated magnetically from the cross bars 29 and 30 of the frame. As shown particularly in Fig. 2, the non-magnetic material 32 extends beneath the cross bars 29 and forms a surface which lies in substantially the same plane with the bottoms of the inserts 22. The bottom plate 18 is similarly constructed to provide spaced portions of magnetic and non-magnetic material. That is, the cut out spaces 38 between the ribs 24 are filled with brass, Babbitt metal or the like, and the dimensions of these non-magnetic inserts 39 are such as to substantially prevent the passage of the flux therethrough. The top surfaces of the inserts 39 lie in the same plane with the tops of the ribs, so that the magnet bar may slide thereover, and these surfaces are as wide as the width of the cut away space 36 in the magnet.

The parts are so constructed and located that when the magnet is in the position of Fig. 2, the

flux will pass to the pole pieces 22, then through a work piece to the other set of pole pieces 29, thence through the side walls 26 to the plate 18 and the bottom ribs of the magnet. If the permanent magnet is shifted laterally from the operative position of Fig. 2 to the inoperative position of Fig. 7, the north pole ribs 14 will be moved out of contact with the pole pieces 22 and lie beneath the non-magnetic material 32. Similarly, the lower pole ribs 16 will rest solely on the non-magnetic inserts 39. Hence, the magnetic circuit is broken at both poles of the magnet. The north and south pole pieces in the top work supporting plate are of substantially the same width, and the bottom surfaces 34 of the non-magnetic material 32 are much wider, as shown in Figs. 2 and 7. Also, the cross bars 29 forming the set of south pole pieces in the top plate 20 are only about half as deep as the inserts 22. Hence, the parts are effectively isolated magnetically, and the pole pieces give a uniform distribution of flux. This construction is particularly effective for holding small work pieces in closely spaced arrangement, because of the substantially equal holding areas of opposite polarities. The U-shaped portions 36 between the ribs 14 and 16 of the magnet are wider than the pole pieces, and these spaces are cut deeply enough so as to provide sufficient distance to prevent material leakage of flux from the poles of the magnet. Four side plates of brass 40 fill the spaces between the inside walls of the two part chuck casing and the magnets and form the side walls of two troughs within which the magnets slide. The two magnets may be connected together by a brass pin 42 or other suitable non-magnetic material so that they may be moved together. As shown in Fig. 4, an iron rib 44 is fitted in between the two innermost brass plates 40, and it contacts with the longitudinal rib 30 on the underside of the top plate 20 and thus forms a central partition which serves as a part of the return circuit for the lines of force going from south pole plate 18 to the set of pole pieces 29 in the top plate. The bottom and top plates 18 and 20 and the side plates 26 are suitably secured together, as by long screws 46 located at spaced intervals around the edge of the casing and thereby making a rigid construction. This chuck will, of course, be suitably mounted on the work table of a machine tool, such as a grinding machine, as by means of projecting ears on the chuck and T-bolts fastened to the work table.

The permanent magnets and the associated pole pieces or other suitably related parts, such as the separate polar piece plate shown in Fig. 26, may be moved relatively to each other to make or break the magnetic circuit, either manually or by a power operated mechanism. In the construction shown in Figs. 1 to 7, the magnets are arranged to be moved by means of a manually operated mechanism, which comprises two spaced, axially aligned hubs 48 suitably mounted in bearing holes in the side walls 26 of the frame for rotation therein. A pin 50 connects the two hubs and is arranged eccentric with their axis. A handle 51 is connected to one of the hubs so that rotation thereof serves to move the pin 50 through an arc. This pin 50 is slidably inserted into holes in the two hubs and arranged for removal therefrom. The pin passes through elongated slots 52 in the projecting ends of the T-shaped members 53, made of brass or other non-magnetic material, which are suitably secured as by means of brass rivets 54 to the permanent

magnets. A suitable hole 55 (Fig. 7) is cut through the center plate 44 so as to permit proper movement of the eccentrically mounted pin 50. Hence, by suitably revolving the handle 51, the permanent magnets may be moved from the operative position of Fig. 2 to the inoperative position of Fig. 7. When in this latter position, both the north and the south pole rib faces of the magnets are completely isolated from the spaced pole pieces 22 and 29 in the work plate and the work may be readily removed from the chuck, since there is but little residual magnetism in the pole pieces.

A further modification is shown in Figs. 8 to 13 inclusive. Here again, I employ permanent magnets, as shown in Fig. 10, which are shaped substantially as above described. These comprise two magnet bars 60 and 62 having spaced north pole ribs 63 and bottom south pole ribs 64. The two magnets are spaced apart by a brass plate 65 and are held together by brass rivets 66 so that the two may be moved together as a unit. A brass ear 67, Fig. 10, is located between the two bar magnets and suitably secured thereto as by rivets 68 and this ear is adapted to be reciprocated by an eccentrically mounted pin 69 carried between the two hubs 70 and 71 and rotated by the handle 72, as above described.

In this particular construction, the top work supporting plate or frame 74 is made of Swedish or wrought iron and constitutes one pole, such as the south pole. It has rectangular openings 75 therein within which are secured the north pole pieces 76 of Swedish or wrought iron, which are held in place by means of brass and Babbitt metal as above described. These pole pieces 76 are single members which bridge across the gap between the two magnets and thus contact with both of the north pole ribs 63. The cross ribs 77 between the inserts 76 extend the entire distance between the side portions of the frame. The arrangement of the magnets and pole pieces are otherwise as described above. The bottom plate 78 of low carbon steel is cut away to form spaced ribs 79 which are arranged to contact with the south pole ribs of the bar magnets when the parts are in the position of Fig. 9. These spaced ribs 79 on the bottom plate are separated by strips of non-magnetic material 80, such as brass, aluminum or Babbitt metal welded or brazed into the grooves, which have their top surfaces aligned with the tops of the rib 79 and are so arranged that the bar magnets may slide along the surface of the bottom plate. When in the position of Fig. 13, the south poles of the magnets contact only with non-magnetic material. This construction likewise serves to isolate both the north and the south pole ribs of the bar magnets from the framework of the chuck and the parts forming the work supporting pole pieces. Hence, one may break the magnetic circuit at both the north and the south poles of the magnets and entirely isolate them from the pole pieces and thus permit ready removal of the work from the chuck. Non-magnetic bars 82 separate the permanent magnets from the side walls 83 of the framework of the chuck and form a slideway within which the magnets slide.

The above constructions are particularly applicable for use with pieces of work made of high carbon steel or other metal tending to retain the magnetic lines of force, and particularly work pieces which have finished plane surfaces contacting fully with the pole pieces. In such a case, it is desirable that both sets of pole pieces in the

work plate be cut off from the lines of force, and that neither set remain in magnetic circuit with the magnet when the work is to be removed. If, on the other hand, the work is a rough surfaced casting of low carbon steel or cast iron, or other metal which does not readily hold residual magnetism then it is feasible to cut the lines of force issuing from either set of pole pieces, but leaving the other pole pieces in magnetic circuit with the magnet. A simplified form of chuck in which the permanent magnet has the spaced poles on only one side, such as the top, is shown in Fig. 14. The permanent magnets of hard alloy material are difficult to machine and it is, therefore, desirable to cast the magnet in substantially its final shape and then finish by grinding only the one set of contact surfaces on one side thereof. In such a construction, the top pole piece plate may be made the same as shown in Figs. 1 to 13 inclusive. The bottom of the permanent magnet 90 is not cut away but has a substantially plane face contacting with the south pole base plate 91 to form a permanent magnetic contact therewith irrespective of the position of the magnet. The north pole may be formed as above described to provide ribs or polar pieces 92 spaced by grooves 93. These ribs have plane faces contacting with the pole pieces 94 inserted in the top plate 95. This plate has spaced cross ribs 96 forming the south pole pieces. Non-magnetic material 97, such as Babbitt metal, spaces the inserts 94 from the ribs 96 and lies under the latter to form spaced surfaces of a size to receive the pole faces when the magnets are moved to their inoperative positions. The chuck may be otherwise constructed as above described. When the magnet or magnets 90 are moved laterally, the north pole ribs 92 move into position beneath the Babbitt metal 97 and thus the magnetic circuit is broken between each rib and its pole piece 94 but the lines of force are still able to pass from the south pole of the lower end of the permanent magnet through the iron sides of the framework to the cross ribs 96 of the top plate. Hence, these are never fully neutralized, although the holding power of the chuck is reduced sufficiently for removal of the work.

These permanent magnets may require a very strong force for moving them laterally and especially in a chuck of large size. If desired, I may employ a power mechanism for that purpose and particularly one operated by fluid pressure, such as is shown somewhat diagrammatically in Figs. 14 and 15. As there shown, the magnet or magnets 90 may be attached to a piston 100 by means of a piston rod 101. The piston is slidably mounted within a suitable piston chamber 102 in the right hand end of the framework of the chuck, and a screw threaded head 103 is removably mounted to form a chamber on the outside of the piston. A suitable gland and packing is provided to prevent loss of fluid around the piston and rod. The piston is moved in either direction by fluid pressure from an external source admitted through a pipe 105 and exhausted through a pipe 106. The valve illustrated diagrammatically in Fig. 15 may comprise a slidable piston rod 107 having two valve pistons 108 and 109 suitably mounted thereon in such positions as to admit fluid under pressure through the ports 110 and 111 to the opposite sides of the piston 100. The inlet pipe 105 connects with two passages opening through ports 112 and 113 into opposite ends of the valve chamber. The exhaust pipe connects with the central portion of the chamber.

The ports and the valve pistons are so spaced and arranged that when the handle 115 connected to the valve stem 107 is moved towards the right, the fluid is admitted into the right hand end of the piston chamber 102 and thus causes the permanent magnet 90 to move towards the left or into the inoperative position indicated by the dotted lines in Fig. 14. Movement of the handle towards the left causes the magnet to be moved to the operative position shown in Fig. 15. This power mechanism may be suitably supplied with fluid under pressure, such as compressed air or water or oil under hydraulic pressure. It will also be appreciated that other mechanical equivalents of the hydraulic mechanism may be used, such as an electromagnet or a power operated cam or screw mechanism for traversing the magnet. This aspect of my invention is intended to cover such mechanical equivalents. By such arrangements, I make it possible for one to operate and control the magnets without severe manual exertion and make it easy to remove the work from the chuck.

In the chuck constructions above described, the upper pole of each magnet has been of the same polarity, such as the north pole, and the top frame has been utilized to form the south pole pieces of the work support. In the constructions of Figs. 16 to 20 inclusive, I have shown an arrangement whereby three permanent magnets are arranged with alternately north and south poles uppermost. If desired, the set of three magnets may be duplicated or used in other multiple arrangement. In this construction, the inner magnet has its top of one polarity and the tops of the two outside magnets are of the opposite polarity. Hence, the adjacent magnets form return paths for the flux from each other. This construction is such that the lines of force may permeate the pole pieces readily and with greater uniformity than if only two poles of opposite sign were employed.

As illustrated, there are three bar magnets 120, 121 and 122. These three magnets are attached together by a non-magnetic rod 124 of brass or other suitable material, and they are spaced apart by brass strips 125. Each of these permanent magnets may be cut away, as shown particularly in Figs. 17 and 20, so as to provide spaced ribs 126, 127, 128 and 129 at the tops and bottoms which form spaced polar faces or pieces. The permanent magnet 120 is located in the center and has its spaced ribs 126 at the top and forming the north polar faces thereof. The spaced ribs 127 at its bottom constitute the south polar faces. Similarly, the outer permanent magnets 121 and 122 have spaced ribs 128 at their tops forming the south polar faces and spaced ribs 129 at their bottoms forming the north polar faces. The bottom 130 of the chuck may be made as above described of low carbon steel. The top 131 may be made of Swedish or wrought iron, or it may be made of non-magnetic material, such as aluminum or brass. The top and bottom of the chuck are spaced apart by aluminum or brass sides 132 or other non-magnetic material, and they are suitably bolted together by brass bolts 133 so as to make a rigid construction. The non-magnetic sides are preferably used because of the strong field developed by this construction, and since it is desirable that the pole pieces and associated parts of the work support be entirely cut off from both poles of the magnets when the work is to be removed.

The lower plate 130 is cut away beneath the

middle magnet 120 to provide spaced ribs 134 (Fig. 17). These ribs 134 are separated by non-magnetic inserts 135 brazed or welded into the hollows between the ribs. The ribs 134 are of the same width and length as the bottom south polar surfaces of the magnet 120 and they are so located as to make proper contact with those polar surfaces when the magnetic lines of force are intended to pass to the work. The spaced polar surfaces at the bottom of the central magnet 120 rest on the steel plate 130, when in an operative position, and the return circuit for the flux is through the bottom plate to each of the two outer magnets 121 and 122 which have their spaced north polar faces likewise resting on that plate 130, as shown in Fig. 19. These outside bar magnets 121 and 122 are likewise cut away at their bottoms the same as above described to provide spaced north pole ribs 129. The bottom plate 130 is also provided with a further set of cut out grooves similar to those indicated in Fig. 17 which are located beneath the bottom polar faces of the two outside magnets, and these cut out portions are filled with brass, aluminum or Babbitt metal 139 (Fig. 18) to form non-magnetic shoes between those north polar faces. That is, these non-magnetic inserts in the bottom plate are in such an alternate arrangement that all of the bottom polar faces of the magnets make a full contact with the steel plate 130 when the magnets are in an operative position, and all of these polar faces contact only with the non-magnetic inserts when the magnets are moved to the inoperative position indicated in Fig. 20.

A special feature of this construction lies in the top plate and the arrangement of the pole pieces. As indicated in Fig. 16, this top plate 131 is shaped as a hollow rectangular ring made of either magnetic or non-magnetic material, but preferably Swedish or wrought iron. This plate is not a part of a magnetic circuit since it is isolated magnetically from the pole pieces carried thereby as well as from the iron bottom plate 130. The top plate 131 has inserts 140 and 141 in alternate arrangement constituting the north and south pole pieces respectively of the work support plate. The north pole pieces 140 are substantially T-shaped, as shown in Fig. 18, and their lower faces are plane and in full contact with the spaced north polar faces of the central bar magnet 120 when the parts are in an operative position. Similarly, the south pole pieces 141 are U-shaped, as shown in Fig. 19, and their ends have plane faces contacting with the top south polar faces of the two outer magnets when the parts are in an operative position. The pole pieces 140 and 141 may be suitably spot brazed in position and non-magnetic material 144, such as Babbitt metal, cast into the spaces about the same so as to make a rigid work support. Brass rods 145 may be used to aid in tying the pole pieces together as a rigid structure. The space beneath each end of the north pole pieces 140 (Fig. 18) and the central portion of the south pole pieces (Fig. 19) is filled with non-magnetic material of sufficient thickness to prevent material leakage of flux. The underside of the work plate has its pole pieces and non-magnetic material arranged as shown in Fig. 24. In this arrangement, the lines of force emanating from the central bar magnet 120 will pass upwardly into the pole pieces 140 (Fig. 18) thence through the work and back to the pole piece of opposite polarity 141 (Fig. 19) and into the top south pole of each of the outer magnets 121 and 122 and

thence to the bottom plate 139 and back to the north pole (Fig. 18) of the central bar magnet.

It will also be observed that the central bar magnet is substantially twice as wide as each of the outer magnets, so that the number of lines of force issuing from the north pole of the central magnet will be approximately the same as the number of lines received by the adjacent south poles, thus providing an even distribution of the flux and providing a path of uniform area through the magnets. In this arrangement of pole pieces, the flux will travel to both ends of the T-shaped north pole pieces and be distributed over the entire surface of the pole piece, just the same as in the flux coming from the two south poles of the outside magnets, thus providing a satisfactory distribution of flux, as compared with the uneven distribution that would be had if only two magnets and L-shaped pole pieces were used.

The three bar magnets may be moved endwise from their operative to inoperative positions by a suitable construction, such as is shown in Figs. 16 and 17. This comprises a handle 147 on the end of a hub 148 suitably mounted in a bearing in the aluminum side wall 132. This hub carries an eccentric pin 149 riding in an elongated slot 150 in a lug 152 forming a part of or suitably connected to the central magnet. The other two magnets are connected to the central magnet by the brass rods 124 and so will move therewith as the eccentric pin 149 is revolved. This serves to move the magnets so that their polar faces contact only with non-magnetic material and thus isolates both poles of each magnet from all magnetic metal in the chuck and so cuts off the flux from the work.

For certain purposes, the construction may be as indicated diagrammatically in Fig. 21, wherein the magnetic circuit is broken only at one end of each of the bar magnets, although broken at both pole pieces. That is, each of the three magnets 160 has its bottom formed as a substantially plane surface contacting fully with the lower plate 162 of the chuck. The top plate 164 is supported on the lower plate by aluminum or brass walls 165, as above described. The north pole pieces 166 and the south pole pieces 167 are separated by non-magnetic material 168, the same as shown in Fig. 17, and the construction may be otherwise as above described with reference to the construction shown in Figs. 16 to 20 inclusive.

In Figs. 22 and 23, I have shown a further modification in which the top plate 170 has cross ribs forming one set of pole pieces. The plate has cut out portions 171 separated by cross ribs of iron 172. The north pole inserts 174 are suitably mounted in these cut out portions and the parts otherwise constructed as above set forth. As indicated in the dotted outline in Fig. 23, the north pole inserts 174 correspond in shape with the parts 140 in Fig. 18, while the ribs 172 are U-shaped like the ribs 141 of Fig. 19 and make proper contact with their associated spaced polar faces 182 of the magnets 179. Non-magnetic material is located in the under face of the top plate as above described to separate the pole pieces and to provide for cutting off the flux.

The central magnet 178 and the two outside magnets 179 may be shaped as shown in either Fig. 20 or Fig. 21 to provide for the return magnetic circuit and for breaking the circuit at either the top or the bottom or at both poles of the magnets. As shown in Fig. 23, the bottom plate 184 may remain in contact with all magnets, but the plate and magnets are preferably constructed as

shown in Fig. 20. It will be appreciated that a reverse arrangement may be made whereby the top poles of the magnet or magnets in any of the constructions above described may remain always in magnetic circuit with the associated pole pieces in the work plate, and the flux broken only at the bottom polar faces of the magnet.

In Figs. 25, 26 and 27 I have shown an arrangement which provides for breaking the magnetic lines of force without moving the magnet or magnets. In this case a polar piece plate is arranged between the permanent magnet and the top pole piece plate which supports the work, and the parts are so constructed that the movable plate may be moved to make or break the magnetic circuit. In this construction, the top plate 186 is spaced from the bottom plate 187 by side walls 188 of aluminum, brass or other non-magnetic material. The permanent magnets 189 are massive bars having flat top and bottom faces and are, therefore, easy to construct as by casting the same and then grinding the opposite polar faces. Three of these magnets are employed and they are arranged the same as above described with reference to Figs. 16 to 20 inclusive. The top plate 186 corresponds with the top plate in Fig. 16 and comprises a rectangular ring having the north pole pieces 190 and the south pole pieces 191 alternately arranged therein and separated by Babbitt metal 192 or other suitable material. The north pole pieces are constructed the same as the parts 140 in Fig. 18 and the south pole pieces the same as the parts 141 in Fig. 19.

The magnetic circuit is made through a separate slidable polar piece plate 194 interposed between the permanent magnets and the top work plate 186. This slide plate 194 is a rectangular member made of non-magnetic material, such as aluminum, brass or a Bakelite resinoid. The plate 194 is cut away to form openings within which are mounted the spaced inserts or polar pieces 195 of magnetic metal, which are located and arranged to contact respectively with the north pole pieces 190 and the south pole pieces 191 of the work plate or to contact only with the non-magnetic material on the underside of the work plate. The inserts or polar pieces 195 remain in contact with their associated magnets and thus form spaced terminals for the magnets similar to the ribs of the magnets shown in Figs. 3 and 10. In operation, the flux passes from the top of the central magnet and the associated north polar pieces 195 of the slide plate to the lower faces of the T-shaped north pole pieces of the work plate (which are shaped like part 140 shown in Fig. 18) and then through the work piece to the U-shaped south pole pieces (see part 141 of Fig. 19) of the work plate to the two south pole inserts or polar pieces 195 of the slide plate which contact always with the two magnets on the opposite sides of the central magnet and form their terminal poles. The return circuit is made from one magnet to another through the steel base plate 187 which makes a full contact with all magnets at all times. The sliding plate 194 may be moved by any of the mechanisms above described to neutralize the work plate. As illustrated, this may comprise an eccentrically mounted pin 198 suitably operated by a handle and riding in an elongated slot in an extension 199 connected to the plate 194. The various parts of the chuck are suitably secured together by bolts and screws, such as the bolts 200 which serve to secure the permanent magnets to the base plate. In this

arrangement, the non-magnetic portions and the pole and polar pieces are of such dimensions and arrangement as above indicated that the magnetic flux will not leak to the top plate to a material extent, and it may therefore be substantially completely cut off from both the north and the south pole pieces of the work plate. This construction makes it possible to leave the permanent magnets always in magnetic contact with the bottom plate of the chuck. The lines of force are cut between the north and south pole pieces wholly at the top of the magnets and beneath the work plate.

In this arrangement, the top poles of the magnets terminate in the polar faces at the tops of the magnetic inserts 195. The spaced insert blocks may be considered as movable spaced polar pieces forming a continuation of the associated magnet, so that in this construction the polar pieces are separate from the magnet and alone slide relatively to the pole pieces of the work plate, whereas in the previously described constructions the polar pieces are formed as integral ribs on the magnets and slide therewith.

The operation of each of the above described devices has been fully set forth. In those chucks which have a single bar magnet or a duplication of that structure, the upper pole is in contact, or in direct magnetic circuit, with one set of pole pieces while the flux from the lower pole traverses through the side walls of the chuck to the other set of pole pieces. That structure which comprises three permanent bar magnets or multiples thereof has poles arranged alternately so that the flux need not traverse through the side walls of the chuck. This construction is particularly effective in its concentration of the lines of force where needed and gives a strong magnetic field for holding the work firmly in position. In those chucks which have ribs or spaced polar faces at both the top and the bottom of each magnet, complete isolation of both poles of the magnet from other magnetic material of the chuck is insured so that neither the work supporting plate nor either of its sets of pole pieces is in magnetic circuit therewith. If the spaced polar faces are employed at only one end of the bar magnet then the other pole thereof remains in circuit with one set of pole pieces and with a corresponding effect on the work. Each of these chucks has its advantages and fields of utility. A primary feature lies in the use of a massive permanent bar magnet which has spaced polar faces for magnetizing a set of pole pieces. Another important feature of this invention resides in the complete isolation of one pole of the bar magnet from the other when the work is to be removed. This cuts off the lines of force from one or both of the sets of pole pieces, and since the work supporting surface is ordinarily made of metal that does not readily hold residual magnetism, then the work may be readily removed without injury to its supporting surface or without detrimental effect on the chuck. Many other advantages will be inherent in these constructions as will be understood by one skilled in the art.

It is also to be understood that the drawings and the above description are to be interpreted as illustrative of the principles of the invention and not as limitations thereon except as defined by the scope of the claims appended hereto. Many equivalent structures may be employed and various modifications made in the chuck construction without departing from the scope of this

invention. The pole and polar pieces may be arranged beneath or above the magnet or in any other suitable position, and either the magnet or the polar pieces may be moved so as to break the magnetic circuit and isolate one pole of the magnet from the other or from a set of the pole pieces. It will also be understood that the elements of non-magnetic material form non-magnetic gaps which may be replaced by air gaps and that the claims are to be interpreted as covering such equivalent constructions. Numerous other modifications will be readily apparent in view of the above disclosure.

I claim:

1. A magnetic chuck comprising a support having a set of magnetically connected contact surfaces lying in a lower plane and separated by non-magnetic gaps, a work plate opposed thereto having two sets of alternately arranged, spaced, work supporting magnetic pole pieces, one set having spaced contact surfaces in an upper plane separated by non-magnetic gaps, a permanent bar magnet in a magnetic circuit with said pole pieces and having its poles at its top and bottom respectively which terminate in parts forming sets of upper and lower spaced polar faces lying in said two planes, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, said parts being arranged for sliding the polar faces from engagement with said contact surfaces to positions adjacent to said gaps where all of the polar faces of the magnet are isolated from the pole pieces and each other, and means for sliding said parts and their polar faces relative to said contact surfaces.

2. A magnetic chuck comprising a support provided with spaced magnetically connected contact surfaces lying in a lower plane which are separated by non-magnetic gaps, a work plate opposed thereto which has two sets of alternately arranged, spaced, work supporting magnetic pole pieces, one set of the pole pieces having lower contact surfaces lying in an upper plane which are separated by non-magnetic gaps, means providing a magnetic circuit between the contact surfaces of the support and the other set of pole pieces, a permanent bar magnet having its poles on its opposite upper and lower sides, the top of the magnet having spaced polar faces lying in said upper plane in engagement with said contact surfaces of the pole pieces, the bottom of the magnet having spaced polar faces lying in said lower plane, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, said magnet being slidably mounted on the contact surfaces of the support to move its polar faces from engagement with said contact surfaces to positions adjacent to the non-magnetic gaps where they are isolated from the pole pieces, and means for slidably moving the magnet.

3. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced, work supporting magnetic pole pieces, one set of which has lower, spaced contact surfaces lying in an upper plane and separated by non-magnetic gaps, a lower supporting plate having spaced magnetically connected contact surfaces lying in a plane parallel with the upper plane and separated by non-magnetic gaps, means providing a magnetic circuit between the contact surfaces of the lower plate and the other set of pole pieces, a permanent bar magnet having

spaced, parallel ribs providing spaced polar faces on its upper and lower sides which lie in said planes and are arranged to contact with the adjacent contact surfaces, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, said magnet being slidably mounted on said supporting plate for sliding said polar faces in said planes from engagement with said contact surfaces to positions adjacent to said gaps and means for slidably moving the magnet.

4. A magnetic chuck comprising a casing, a magnetic bottom plate provided with spaced, magnetically connected contact surfaces separated by non-magnetic material and forming a slide surface lying in a lower plane, a work plate having two sets of alternately arranged, spaced magnetic pole pieces, the pieces of one set having lower contact surfaces in an upper plane parallel with the lower plane, non-magnetic material underlying the remaining set of pole pieces and providing a slide surface in said plane of the lower contact surfaces of said pole pieces, a member of magnetic material connecting the bottom plate with said remaining set of pole pieces, a permanent bar magnet slidably mounted within the casing and having spaced polar faces on its opposite top and bottom sides lying in said planes, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, said polar faces being slidable from engagement with said contact surfaces into contact with the non-magnetic material of the two plates and means for sliding the magnet to said positions to make or break the magnetic circuit between the pole pieces and both poles of the magnet.

5. A magnetic chuck comprising a work plate providing two sets of alternately arranged, spaced, work supporting magnetic pole pieces, the pieces of one set having spaced contact surfaces on their under sides lying in a single upper plane and separated by non-magnetic gaps, a support having a set of spaced magnetically connected contact surfaces lying in a single lower plane and separated by non-magnetic gaps, a plurality of separated, permanent bar magnets in magnetic circuit with said pole pieces which have their poles at their tops and bottoms respectively terminating in parts forming upper and lower spaced polar faces lying in said planes and slidably contacting magnetically with said contact surfaces, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, the parts forming said polar faces being slidable as a unit to move said polar faces in said planes and position them in contact with said contact surfaces or alternatively adjacent to said gaps where they are isolated from the work plate and support, and means for causing such sliding movement.

6. A magnetic chuck comprising a lower magnetic plate having contact surfaces lying in a single lower plane which are separated by non-magnetic gaps, a work plate having alternately arranged, spaced, work supporting magnetic pole pieces providing lower contact surfaces in a single upper plane and separated by non-magnetic gaps, a plurality of permanent bar magnets which have their poles on their upper and lower sides shaped to form spaced upper and lower polar faces lying in said planes in engagement with the contact surfaces of said plates, the distance between each two adjacent contact sur-

faces in each plane being greater than the width of each adjacent polar face, said magnets being fixed together and mounted to slide as a unit on the contact surfaces of the lower plate so that the polar faces may be moved from engagement with the contact surfaces to positions adjacent to said non-magnetic gaps where the magnets are isolated from each other and all of said pole pieces, and means for thus sliding the magnets.

7. A magnetic chuck comprising a bottom plate having spaced but magnetically connected contact surfaces in a lower plane alternating with spaced non-magnetic surface portions, a work plate having two sets of alternately arranged, spaced magnetic pole pieces, spaced non-magnetic material underlying one set of pole pieces, the other set of pole pieces providing lower contact surfaces in an upper plane parallel with the lower plane, a plurality of movable permanent bar magnets, each having a set of ribs on the upper and lower sides providing spaced polar faces at each of its opposite poles, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, the sets of polar faces being respectively arranged in said planes to contact magnetically with said lower contact surfaces of the pole pieces and the magnetic portions of the bottom plate in a first position or alternatively in a second position to contact with said non-magnetic portions and material, and means for moving said magnets from the first to the second position to locate their polar faces adjacent to the non-magnetic portions and material and thereby isolate all of the magnet poles from all of the pole pieces of the work plate.

8. A magnetic chuck comprising a casing having a lower magnetic supporting member, a work plate having two sets of alternately arranged, spaced magnetic pole pieces, each set having lower contact surfaces in a single plane which are separated by non-magnetic gaps, non-magnetic material which isolates said member from the work plate, a plurality of permanent bar magnets in the casing mounted on said member and having their poles at their tops and bottoms in an alternating reverse polar arrangement, the upper poles terminating in parts forming sets of spaced flat polar faces of opposite polarity which are slidable in said plane and operatively contact magnetically with the contact surfaces of both sets of said pole pieces, the distance between each two adjacent contact surfaces being greater than the width of each adjacent polar face, the lower poles of the magnets contacting magnetically with said member, and means whereby said parts may be moved to slide the polar faces in said plane from engagement with said contact surfaces to positions adjacent to said gaps so as to break the magnetic circuit between said magnets and both sets of pole pieces.

9. A magnetic chuck comprising a casing, a work plate thereon having two sets of alternately arranged, spaced magnetic pole pieces, each set having lower contact surfaces lying in a single upper plane and separated by non-magnetic gaps, a supporting plate having magnetically connected portions providing contact surfaces in a lower plane which are separated by

non-magnetic gaps, a plurality of permanent bar magnets having upper and lower poles in an alternate reverse polar arrangement, each magnet having parts forming spaced polar faces at each of its poles which lie in said planes, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, means which magnetically isolates the two plates so that one magnet forms a return path for the flux of another, said magnets being slidably mounted on the contact surfaces of the supporting plate, and means whereby the magnets may be moved to move said polar faces from engagement with the contact surfaces to positions adjacent to the non-magnetic gaps and so isolate the magnets from the pole pieces and from each other.

10. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced magnetic pole pieces having exposed lower contact surfaces in a single upper plane which are separated by non-magnetic material, a bottom plate having magnetically connected material providing spaced contact surfaces in a lower plane which are separated by non-magnetic material, a plurality of slidable permanent magnets having upper and lower poles in an alternate reverse polarity arrangement, each magnet having upper and lower ribs providing spaced polar faces lying in said two planes and contacting magnetically with said contact surfaces, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, the polar faces, contact surfaces and non-magnetic material being arranged so that the polar faces may be moved in parallel planes to contact solely with said magnetic material or alternatively to be isolated from each other and the pole pieces by contacting only with said non-magnetic material, and means for sliding the magnets to form a magnetic circuit with a work piece or to break the circuit.

11. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced magnetic pole pieces, each piece of one set being T-shaped and having a depending contact arm, each piece of the other set being U-shaped and having two spaced depending contact arms, the arms of each set having lower contact faces in a plane, means providing non-magnetic gaps between said contact arms, three movable permanent bar magnets of reverse polarity arrangement, each having parts forming top and bottom spaced polar faces in upper and lower parallel planes, the upper polar faces of one magnet contacting operatively with the contact surfaces of the arms of the T-shaped pole pieces, and the upper polar faces of the other two magnets contacting operatively with the contact surfaces of the arms of the U-shaped pole pieces, a bottom plate having spaced contact surfaces lying in said lower plane and separated by non-magnetic gaps, the distance between each two adjacent contact surfaces in each plane being greater than the width of each adjacent polar face, the magnets being slidably mounted so that the polar faces may be moved from engagement with said surfaces and be isolated by said gaps, and means for slidably moving the magnets.

FRANK L. SIMMONS.