April 11, 1944. F. L. SIMMONS 2,346,193

PERMANENT MAGNET CHUCK

Filed Feb. 5, 1942 4 Sheets-Sheet 1

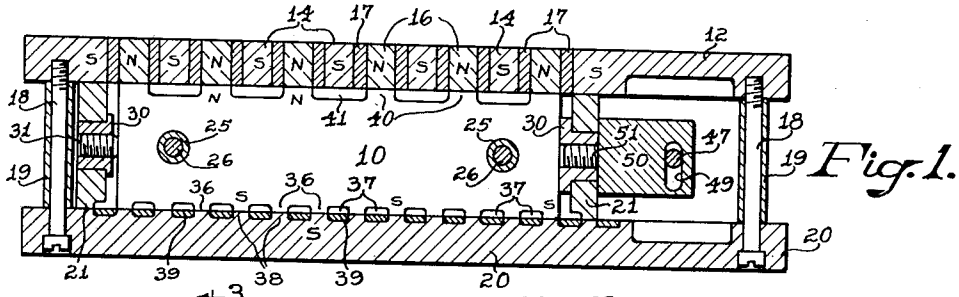


Fig. 1.

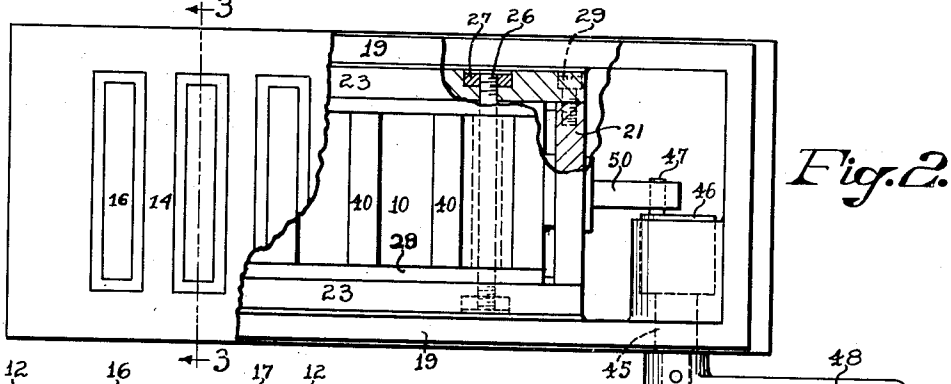


Fig. 2.

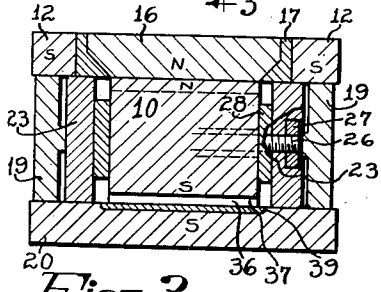


Fig. 3.

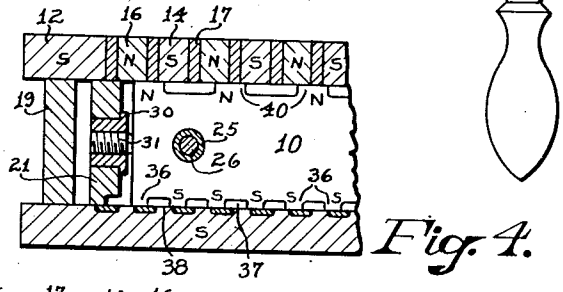


Fig. 4.

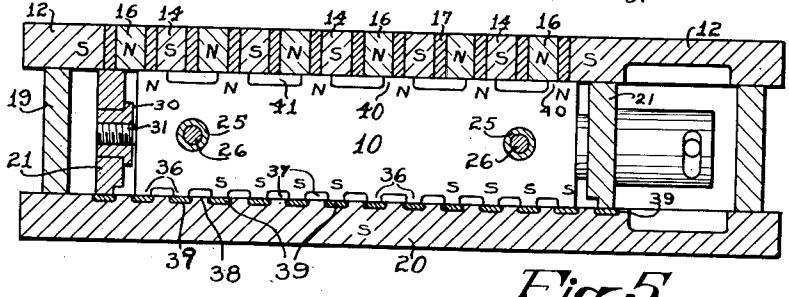


Fig. 5.

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PERMANENT MAGNET CHUCK

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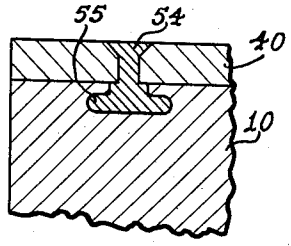


Fig. 6.

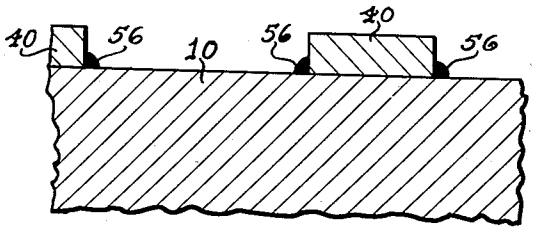


Fig. 7.

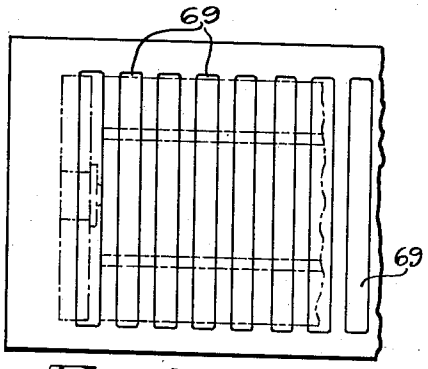


Fig. 12.

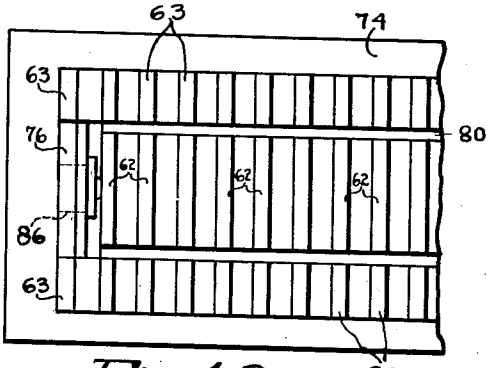


Fig. 13.

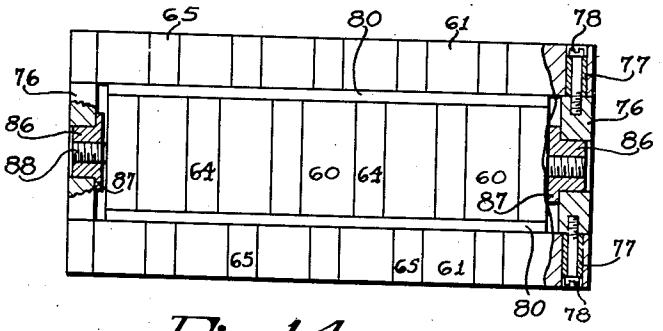


Fig. 14.

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PERMANENT MAGNET CHUCK

Filed Feb. 5, 1942 4 Sheets-Sheet 3

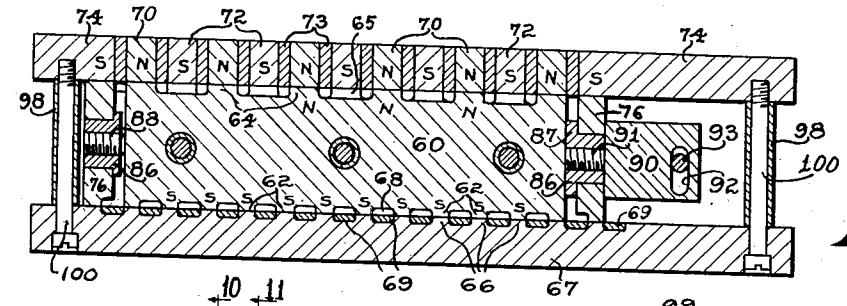


Fig. 8.

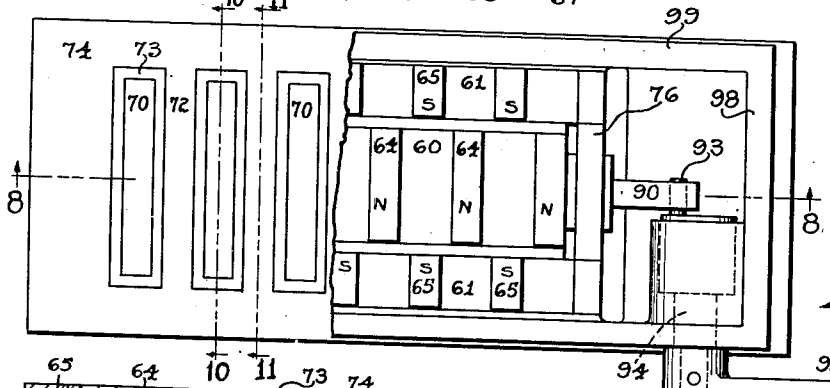


Fig. 9.

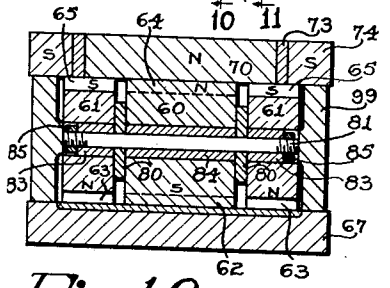


Fig. 10.

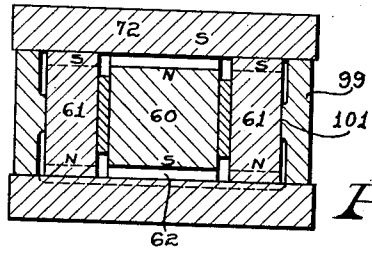


Fig. 11.

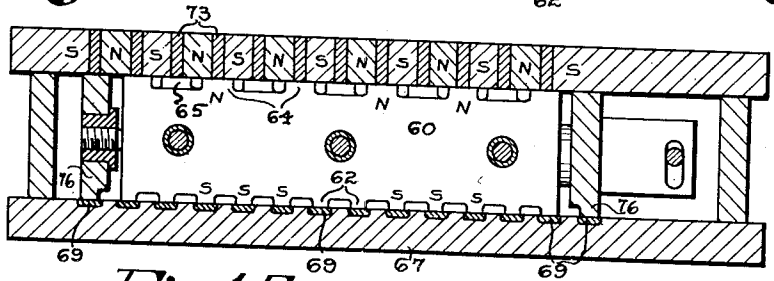


Fig. 15.

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PERMANENT MAGNET CHUCK

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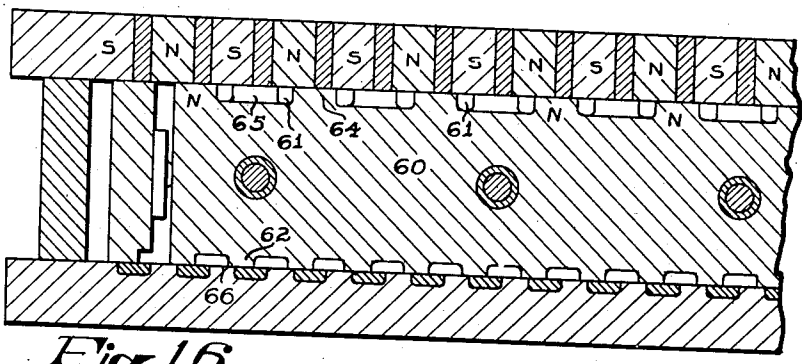


Fig. 16.

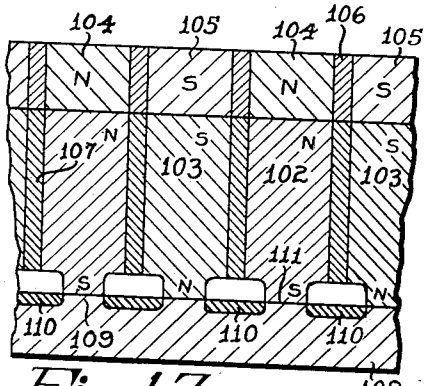


Fig. 17.

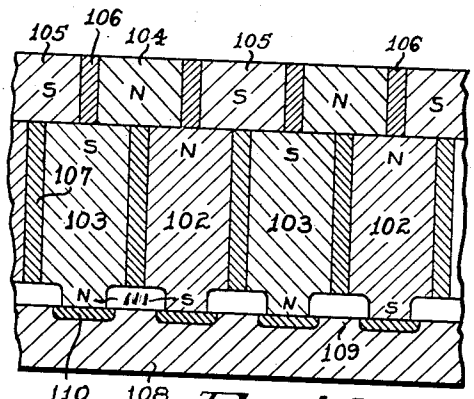


Fig. 18.

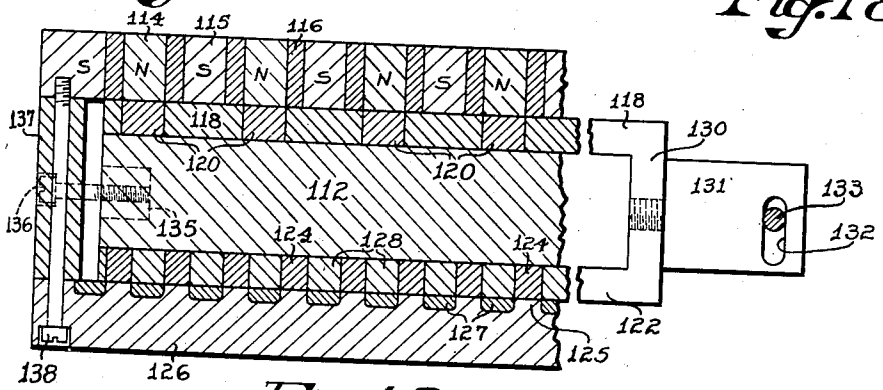


Fig. 19.

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UNITED STATES PATENT OFFICE

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PERMANENT MAGNET CHUCK

Frank L. Simmons, Woonsocket, R. I.

Application February 5, 1942, Serial No. 429,675

13 Claims. (Cl. 175—367)

This invention relates to permanent magnet chucks and more particularly to magnetic chucks in which the magnetism may be controlled to hold a work piece securely in position or to permit ready removal thereof.

A permanent magnet chuck of the type herein described comprises two sets of spaced, alternately arranged pole pieces of opposite polarity, when magnetically energized for holding work on the chuck, and one or more permanent magnets operatively arranged in circuit with the pole pieces and work mounted thereon. In order to permit removal of the work, it has been proposed to so arrange the magnets and associated parts that magnetic flux may be shunted out of the work by connecting the top poles of the magnet with both sets of pole pieces. This provision of a shunt path however permits some of the primary flux to permeate the work and still make its removal difficult. It has also been proposed to break the magnetic circuit between one of the magnet poles and its associated pole pieces, but the direct or primary magnetic effect of the other pole and the secondary leakage flux still maintain such a holding power that removal of the work is likely to scratch its surface or that of the accurately finished work plate.

The primary object of my invention is to overcome such problems and to provide a magnetic chuck of this general type in which the magnetic flux is utilized efficiently for holding the work piece, or alternatively the leakage and primary magnetic flux are removed from the work sufficiently to permit ready release thereof.

It has also been proposed to make a magnetic chuck in which a plurality of the magnets are mounted beneath the work plate with their polar faces in a reverse arrangement so that one magnet forms a return path for the flux of another. The upper polar faces may contact magnetically with associated pole pieces and the lower polar faces of the magnets may be connected to form a circuit with the work on the work plate. If the upper magnet polar faces are moved so that each contacts with pole pieces of opposite polarity and thus forms a shunt circuit for the flux, yet a strong flux goes through the work since the magnetic circuit has not been broken and all of the magnetic flux flows through the two paths. If, moreover, the magnetic circuit should be broken between the upper polar faces of the magnets and their associated pole pieces, nevertheless the magnetic potential difference available for forcing flux through the work is concentrated near the upper terminal polar faces of the magnets, and this concentration of magnetic potential difference results in sufficient leakage flux passing through the work to hold it with considerable force.

A further object of my invention is to make a magnetic chuck of the type having one or more permanent magnets in which the magnetism is so controlled that no magnetic potential difference will concentrate at or polarize the pole pieces when the work is to be removed.

A still further object is to provide a permanent magnet chuck which embodies provisions for removing the magnetic flux from the work when desired and which is so constructed and arranged that a keeper may be applied to the magnet poles when the chuck is not in use. Other objects will be apparent in the following disclosure.

In accordance with my invention, I propose to make a permanent magnet chuck in which the polar faces of one or more magnets and associated parts may be moved to break the magnetic circuit and to cause the magnetic potential difference to concentrate at points remote from the pole pieces. This may comprise a construction in which the two sets of work plate pole pieces of opposite polarity when energized or the upper poles of a plurality of magnets of reverse polarity are magnetically connected together to depolarize the same, while the magnetic circuit is broken at the opposite or lower magnet pole which thus becomes polarized. This is preferably accomplished by having the poles terminate in two sets of upper and lower polar faces which are operatively in magnetic circuit with the associated sets of pole pieces when the chuck is "on," but which are movable to inoperative or "off" positions where each of the upper polar faces may contact with and connect two adjacent work plate pole pieces, which are of opposite polarity when energized for holding the work, while the lower polar faces are isolated from their pole pieces. In a chuck having a single magnet, a magnetic conductor of high permeability provides a return path for the flux and the polarization of the magnet unit at a point remote from the pole pieces. In a chuck having a plurality of magnets mounted in reverse polarity arrangement, the construction is such that the upper spaced polar faces of the magnets may be moved to contact with their associated pole pieces and form a connecting shunt path, while the magnetic circuit is broken at the lower polar faces. In each type of chuck the magnetic potential difference is caused to concentrate at the pole pieces to hold the work

or at points remote from the pole pieces for removal of the work.

Various embodiments of this invention are illustrated in the drawings in which:

Fig. 1 is a vertical longitudinal section through a chuck having a permanent magnet provided with spaced polar faces at its top and bottom and arranged with a conductor for making a magnetic circuit with the work or alternatively for breaking the circuit and concentrating the magnetic potential difference adjacent to the lower magnet pole while all of the work plate pole pieces are connected by the top polar faces of the magnet;

Fig. 2 is a top plan view, partly broken away, to show the magnet and associated structure;

Fig. 3 is a transverse vertical section through the magnet on the line 3—3 of Fig. 2;

Fig. 4 is a fragmentary view similar to Fig. 1 in which the magnet has been moved to a position in which the iron parts form a keeper for the poles of the magnet;

Fig. 5 is a view corresponding with Fig. 1 in which the magnet has been moved to an "off" position;

Fig. 6 is a fragmentary sectional detail showing one manner of securing separate ribs to the magnet body so as to form the desired spaced polar faces;

Fig. 7 is a similar detail showing another way of securing the ribs to a magnet;

Fig. 8 is a longitudinal transverse section on the line 8—8 of Fig. 9 of a chuck embodying a plurality of magnets in reverse polarity arrangement;

Fig. 9 is a top plan view of the work face of the chuck, partly broken away to show the arrangement of the magnets;

Fig. 10 is a transverse section on the line 10—10 of Fig. 9;

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

Fig. 12 is a fragmentary plan view of the bottom plate showing the arrangement of the Babbitt metal strips of the construction of Fig. 8 and showing the magnets thereabove in dotted outlines;

Fig. 13 is a fragmentary under side plan view looking up at the bottoms of the three magnets as if the bottom plate were removed;

Fig. 14 is a top plan view of the assembly of the three magnets as removed from the chuck casing;

Fig. 15 is a view similar to that of Fig. 8 in which the magnets have been moved to the "off" or work removing positions;

Fig. 16 is a fragmentary detail corresponding with Fig. 5 in which the magnets have been moved to a keeper position;

Fig. 17 is a fragmentary sectional detail showing a plurality of separate narrow magnets in a vertical alternate arrangement in the "on" positions;

Fig. 18 is a similar view showing the magnets in the "off" positions; and

Fig. 19 is a fragmentary vertical sectional view of a chuck of the type shown in Fig. 1 in which separate slide plates are utilized to provide the spaced terminal polar faces of the magnet, which is immovably mounted.

A chuck embodying my invention may utilize a single large size permanent magnet or a plurality of various shapes of magnets assembled to provide the required flux. The magnet may be made of suitable material, such as a ferrous alloy known as "Alnico" and comprising aluminum, cobalt, iron and nickel. In the chuck shown in Figs. 1 to 5 inclusive, the magnet 10 may be shaped somewhat as a parallellepipedon, but, if desired, two or more of the large magnets or a considerable number of small magnets in parallel or other arrangement may be connected together to act as a unit. Since a plurality of magnets act collectively as a single magnet, only one large magnet is shown in the drawings.

The work plate, which may be constructed as desired, is shown as comprising a soft iron frame 12 having a series of parallel slots cut transversely therethrough and forming the spaced cross bars 14. Soft iron pole pieces 16 are assembled within these slots and held in place by brazing at spaced points. Babbitt metal 17 is filled in the remaining space, and the pole pieces are thus isolated from the cross bars and other parts of the plate 12. The pole pieces 14 and 16 preferably have the same width. These iron inserts 16 form poles of one polarity when energized, herein termed the north pole pieces, and the cross bars and frame have the opposite polarity and are termed the south pole pieces. The work plate 12 may be suitably secured, as by cap screws 18, to end and side walls 19, and the latter are secured to the bottom iron plate 20 by the same members. The end and side walls 19 of the casing may be made of iron or other magnetic metal or of non-magnetic material, such as aluminum or brass, since the casing walls do not form a part of the primary magnetic circuit.

The iron bottom plate 20 is connected magnetically with the frame 12 by means of soft steel or iron conductor plates 21 located at the opposite ends of the magnet together with soft steel or iron side plates 23. These conductor plates 21 and 23 have parallel plane top and bottom surfaces which slidably fit against the under side of the work plate 12 and the top side of the bottom plate 20. The magnet, or a plurality thereof if used, and the conducting members 21 and 23 are assembled as a single rigid unit which is mounted for sliding on the bottom 20 of the casing and in sliding contact with the under face portions of the work plate. Since the magnet alloy is very hard, it cannot be readily machined or drilled. I prefer to make the connections by casting the magnet with cores to form openings therethrough which may be subsequently ground to provide smooth surfaces, after which soft steel plugs are driven into the openings and then drilled out to form the bushings 25. The brass rods 26 are fitted into these bushings, and their outer ends carry nuts 27 located within recesses in the side conductor bars 23 which serve to clamp the side bars tightly against spacer blocks 28 of brass or other non-magnetic material and thus hold the magnet and the plates 23 in a rigid assembly. The end conductor plates 21 are also secured to the side plates 23 by means of cap screws 29. A brass bushing with an enlarged head 30 fits within a hole in each of the end plates and the head 30 separates the end of the magnet from the conductor plates 21. A set screw 31 threaded into the left hand bushing 30 may be used to force the magnet into tight engagement with the bushing 30 at the opposite end, thus making a very strong and rigid structure. It is to be noted that the side members 23 contact only with the side portions of the frame 12 and the cross bars 14, and they do not touch the north

pole inserts 16, as shown particularly in Fig. 3. The north pole pieces 16 flare outwardly beyond the sides of the magnet so as to provide a wide work face, and the Babbitt metal parts 17 between the inserts 16 and the south pole cross ribs 14 are shaped accordingly.

A primary feature of this invention involves breaking the magnetic circuit between the lower south pole and its associated pole pieces. For this purpose, I may utilize a construction in which the lower or south pole portion of the magnet is shaped to provide a plurality of narrow ribs 36 which extend across the magnet and are equally spaced. The ribs have a width somewhat less than that of the cut out portions 37 between them. The lower faces of these ribs, which constitute the south polar faces of the magnet, are flat and lie preferably in the same or parallel planes. The bottom plate 20 of the chuck is also provided with spaced ribs 38, the tops of which form flat plane contact surfaces coextensive in area with the south polar faces of the ribs 36. These ribs 38 may be formed by casting, milling, or otherwise cutting out parallel grooves in a flat plate, and these grooves may serve as air gaps between the ribs, but they are preferably filled with non-magnetic material 39, such as Babbitt metal. These non-magnetic inserts 39 are coextensive in width with the air gaps 37 between the ribs 36 of the magnet, but are longer as shown in Fig. 3. The upper surfaces of the inserts 39 preferably lie in the same plane with the upper contact surfaces of the ribs 38, so that the magnet may slide readily on the lower plate. The ribs and non-magnetic inserts are, therefore, such that the south polar faces of the magnet may contact fully with the contact surfaces of the ribs 38, or they may be moved to contact fully with the non-magnetic material 39 and thus be isolated from the work plate. Hence, by moving the magnet longitudinally from the position of Fig. 1 to the position of Fig. 5, the south polar faces are moved from an operative magnetic circuit to an inoperative position where they are fully isolated from the south pole members of the work plate.

A further primary feature of this invention involves magnetically connecting the pole pieces of the work plate, when the south polar faces are insolated from the work plate and the magnetic circuit is broken as above described, so as to eliminate the magnetic potential difference between the pole pieces of the work plate and to remove the flux from the work. This is accomplished by shaping the upper portion of the magnet, as illustrated in Figs. 1 to 5 inclusive, so as to provide a set of north polar ribs 40, the top surfaces of which lie preferably in the same plane so that they may slidably contact with the exposed under faces or contact surfaces of the plate 12 and the pole pieces 14 and 16 which lie also in that plane. The ribs 40 are arranged like the ribs 36 across the magnet and they are separated by spaces 41 which are coextensive in width with the south pole pieces 14 and the non-magnetic isolating material 17 which separates the two sets of pole pieces. The ribs 40 have the same width and length as the pole pieces 16, but they have double the width of the south polar ribs 36. The two sets of ribs are so arranged that, when the lower ribs 36 make full magnetic contact with the bottom plate 20, the north polar faces of the ribs 40 likewise contact only but fully with the under contact surfaces of the north pole pieces 16. When the ribs 36 are moved to their inoperative positions, as shown in Fig. 5, then each top polar rib 40 will contact with both the south and the north pole pieces 14 and 16 that are adjacent. This serves to connect the pole pieces of the work plate and to remove the magnetic flux from the work at the same time that the magnetic circuit is broken at the lower south polar faces of the magnet. This arrangement makes it possible to remove the work easily.

In this construction, the frame comprising the conducting plates 21 and 23 is rigidly secured to the magnet and slides therewith in contact with both the upper and the lower plates. The side plates 23 are always in contact with the frame 12. The top end of the right hand end plate 21 makes a continued sliding contact with the under side of the south pole work frame 12. The top face of the left hand plate 21 is however arranged to overlap the adjacent Babbitt material 17 when the chuck is in the "off" position and thus aid in connecting the frame with the adjacent north pole piece 16. At the same time, the right hand end rib 40 overlaps the adjacent Babbitt metal 17 and contacts with the plate 12 and the adjacent pole piece 16. The two end plates 21 are cut away at their bottoms, as indicated in Figs. 1 and 5, so that when the magnet and the plates are moved toward the right, these plates will contact only with the Babbitt metal inserts 39. This prevents any magnetic connection from the north pole piece 16 to the bottom plate through those end walls and the flux concentrates on opposite sides of the non-magnetic inserts 39.

The frame plates 21 and 23 give the shortest possible path for the flux to travel from the lower south pole of the magnet to its associated pole pieces, and this materially increases the magnetic force applied to the work over that which would be had if the return path were made through the casing. Although the casing may be made of non-magnetic material, such as aluminum, it is now feasible to make this casing of iron or soft steel and thus provide a path for the leakage flux. As shown in Fig. 3 the side walls 19 contact only at their central portions with the middle parts of the conducting plates 23, and thus form sliding surfaces which guide the magnet and iron frame assembly in its sliding movement. The primary magnetic flux takes the shortest possible path through the conductor frame made of plates 21 and 23 from the associated pole pieces 14 to the lower magnet pole. When the magnet and frame are moved to the "off" position, the magnetic potential difference concentrates beneath the under sides of the Babbitt metal inserts 39 in the bottom plate and on the south polar faces 36 of the magnet and the work plate is devoid of holding power.

The permanent magnet may be moved relatively to the associated pole pieces and the lower contact surfaces by suitable power or manually operated mechanism. A simple construction as shown in Figs. 1 and 2 comprises a short shaft 45 having an enlarged head 46 suitably mounted in a bearing on the side wall 19 of the casing for rotation therein. The enlarged head 46 has a pin 47 arranged eccentric with and axially parallel to the shaft. A handle 48 is connected to the shaft and so arranged that revolving the handle serves to move the pin through an arc. The pin 47 is slidably inserted in an elongated slot 49 in the end of the brass member 50 which has a screw threaded end 51 threaded into the right hand bushing 30, as shown in Fig. 1. Hence, by suitably revolving the handle, the permanent mag-

net may be moved from the operative position of Fig. 1 to the inoperative position of Fig. 5.

The permanent magnet may be shaped by casting or by any other suitable operation to provide the north and south polar ribs. In the form shown in Fig. 1 the ribs are indicated as integral with the body of the magnet, and this structure may be obtained by casting the magnet in the shape indicated and then grinding the outer faces of the ribs. I may also form the polar ribs of soft iron or other suitable magnetic metal which may be readily ground or otherwise machined to provide the required smooth faces. That is, each rib 40 and/or 36 may be initially shaped as a separate bar of soft iron or steel which is later attached to the magnet. For example, it may be made substantially integral with the body 10 of the magnet during the operation of casting the "Alnico" metal. One manner of securing the bar in position is to provide it with one or more pins 54 of suitable shape, such as one having an enlarged head 55 (Fig. 6), which is driven into place in a hole in the rib and there fastened by riveting. The "Alnico" metal may be cast in position around these pins and in contact with the under faces of the suitably supported ribs. In the form shown in Fig. 7, the ribs may be formed of separate soft iron or steel bars which are secured to the top substantially plane face of the magnet 10 by welding metal 56. Various other expedients may be adopted for securing the ribs 36 and 40 in position.

This invention may also be employed in a permanent magnet chuck having a plurality of magnets mounted in a reverse polarity arrangement so that one magnet forms a return path for the flux from another. One construction is shown in Figs. 8 to 16 inclusive. That arrangement comprises at least two and preferably three or more permanent magnets, which may be of the general shape and structure above described. In the form shown, the central magnet 60 is mounted so that its north polar face, for example, is at the top and two outer magnets 61 are arranged in a reverse polarity so that their south polar faces are at the top. The central magnet is shaped to provide the narrow polar ribs 62 at its bottom and the outer magnets have the narrow ribs 63 at their bottoms. The central magnet has the wide polar ribs 64 at its top and the outer magnets have the wide ribs 65 at their tops. The lower ribs 62 and 63 of the magnets are arranged in with contact surfaces on the upper portions of spaced ribs 66 formed by cutting or casting parallel grooves in the bottom plate 67. The ribs 66 are coextensive in width with the lower polar faces of the ribs 62 and 63 of the magnets. The spaces 68 between the ribs 62 and 63 of the magnets are also coextensive in width with the Babbitt metal inserts 69 mounted in the spaces between the lower ribs 66, but these inserts may extend continuously across the bottom plate as shown in Fig. 12. The polar faces of the under ribs 62 and 63 of the magnet sare arranged in aligned sets as shown in Fig. 13, which is a view looking up at the under faces thereof, while the top polar faces of the upper ribs 64 and 65 are out of alignment as shown in Fig. 14. At the tops of the magnets, the ribs 64 and 65 are of the same width and each is coextensive in width with the associated pole piece of the work plate; and the spaces between these ribs are coextensive with the width of the other pole piece and the Babbitt metal 73 that isolates the south pole pieces 72 from the north pole inserts 70. The work plate may be made as above described with reference to Figs. 1 to 5 inclusive in which the south pole frame 74 has parallel slots cut there through and the north polar pieces 70 are brazed therein and isolated from the frame and cross bars 72 by the Babbitt metal 73 and brass brazing.

The top polar faces of the ribs of the outer magnets slidably contact with the under sides of the south pole bars 72 and the frame 74 at the same time that the top polar faces of the central magnet also contact with the pole pieces 70, so that when in the positions of Fig. 8 the chuck is "on" and ready to hold the work piece. In that "on" position the magnetic flux from the central magnet passes upwardly through its polar faces into the associated north pole pieces 70, thence through the work and back through the south pole pieces and top ribs 65 of the outer magnets and then to the lower ribs 63 and bottom plate 67 and back through the lower ribs 62 of the central magnet, thus making a full circuit.

As shown particularly in Figs. 10 and 14, the three magnets are connected together so that they may be moved as a unit. In this arrangement, the central magnet 60 is shorter than the two end magnets 61 and the latter are connected at their ends by two plates 76 of soft wrought iron. The two outer magnets are preferably cast by coring to provide aligned holes which are filled with soft steel plugs and the latter are then bored out to form steel bushings 77. A screw 78 is then fitted into this bushing and threaded into a tapped hole in the plate 76. The central magnet 60 is spaced from the outer magnets by brass spacers 80. The three magnets are held together by means of brass rods 81 suitably secured in steel bushings 83 tightly fitted within the outer magnets and further steel bushings 84 fitted within the central magnet. Adjusting nuts 85 on the brass rods serve to draw the parts together into a rigid structure. Two brass bushings 86 are likewise mounted within central openings in the two end plates 76, and their enlarged heads 87 are located between the steel plates 76 and the end of the central magnet. A set screw 88 in the left hand bushing 86 forces the magnet toward the right into a rigid contact with the flared portion 87 of the bushing 86 and thus holds the parts immovable relatively to each other.

The assembled magnets may be moved by the same arrangement as above described which comprises a brass plate 90 (Fig. 8) having a threaded end 91 screw threaded into the right hand bushing 86. A vertical elongated slot 92 carries the end of a pin 93 which is eccentrically mounted on the head of a shaft 94 carried by one of the side walls of the casing and operated by the handle 95. The end plates 76 are cut away at their bottoms, as shown in Figs. 8 and 15, and the Babbitt metal inserts 69 are so arranged that when the magnets have been moved through a maximum distance toward the right the bottoms of these iron plates 76 will contact only with non-magnetic material and thus the circuit will be broken through these plates.

The top work plate 74 and the bottom plate 67 may be spaced by means of end and side walls 98 and 99 of iron, aluminum, or other magnetic or non-magnetic material, and the parts are connected by set screws 100 suitably mounted in aligned holes. It will be noted that the casing side walls do not form a part of the magnetic circuit. Hence, as is preferred, the

walls 98 and 99 may be made of soft iron. The side walls 99, are shaped, as shown in Fig. 11, to provide inwardly projecting ribs 101 which contact with the outer magnets only at their central or equatorial portions so that these iron members do not interfere with the magnetic action of the chuck. These inwardly projecting ribs 101 form slideways for guiding the magnets and holding them in correct position. The side wall 99 contacts only with the south pole frame of the work plate as shown clearly in Fig. 10. The walls 98 and 99 serve a very useful purpose by cooperating with the plates 76 to form a shield for stray magnetic flux. The magnetic shield does not carry the primary flux because the magnets themselves form return paths therefor.

Narrow magnets may be substituted for the massive type described above. This is illustrated diagrammatically in Figs. 17 and 18 in which a set of slidably mounted, narrow and vertical magnets 102 and 103 have their north and south poles in alternate arrangement as shown by the letters N and S. The tops of the magnets are coextensive in area with the north and south pole pieces of the work plate, which may be made as above described. The top north polar faces of the magnets 102 contact with the iron inserts 104 of the work plate, and the top south polar faces of the magnets 103 contact with the iron cross bars 105 of the work plate. The pole pieces are separated by the Babbitt metal 106. The magnets are likewise isolated by brass strips 107 suitably secured therebetween, as by means of bolts running through the assembled magnets and strips, so that the parts may be moved as a unit. The iron bottom plate 108 of the chuck is cut away to provide spaced ribs 109 and the spaces therebetween are filled with Babbitt metal 110. If desired, the bottom plate may be suitably isolated from the work plate, as by means of aluminum side walls. The magnets are cut away at their bottoms so that their lower polar faces 111 are coextensive in area with the tops of the ribs 109 of the bottom plate. The Babbitt metal inserts 110 between the ribs 109 are wider than those ribs and coextensive with the spaces between the bottom narrowed poles of the magnets. These dimensions are such that when the magnets have been moved toward the right to the positions indicated in Figure 18, then the bottom polar faces 111 of these magnets will contact wholly with the Babbitt metal and each of the magnets will be fully isolated from the bottom plate, while at the same time the top poles of the magnets will straddle the insulation 106 between the pole pieces and connect the same as above described. Various other modifications and arrangements may be made in the chuck construction, provided the primary features of this invention are incorporated therein so that the top poles of the magnets may be moved to connect adjacent pole pieces of the work plate while the bottom poles of the magnets are fully isolated from each other.

In view of the above explanation of the invention, it will be appreciated that the magnets may terminate in polar faces on members that are not integral with the magnet but are in full magnetic contact therewith. This is simply illustrated in Fig. 19, which represents a modification of the Fig. 1 construction, wherein the spaced polar faces are located on separate iron members that are slidable relatively to a stationary magnet. The magnet 112 may be shaped as a parallelepipedon and it may be provided with either one of the top or bottom sets of ribs illustrated in Fig. 1 while the other set is located in a slide bar as illustrated. In the preferred construction, there are two slide bars which provide all of the terminal polar faces for the magnet or magnets. As shown, the work plate may have the north pole inserts 114 mounted in slots therein and separated from the south pole cross bars 115 by means of Babbitt metal 116. The under faces of the cross ribs 115 and the iron inserts 114 are in the same plane. A brass slide plate 118 is mounted for sliding on the plane top of the magnet in contact with the under face of the work plate. This plate may be made of brass cut out to provide openings within which iron inserts 120 are mounted. The iron inserts have plane top and bottom faces and are shaped to make full magnetic contact with the top of the magnet and with the under contact surfaces of the associated pole pieces. The brass and iron parts are so shaped that the brass portions in the "on" position of the magnet, extend wholly beneath the south pole ribs 115 and the associated Babbitt metal strips 116. The top of the magnet terminates in the polar faces of the tops of the iron inserts 120 which contact fully with the north pole inserts 114. These north pole inserts 120 are coextensive with the areas of the under sides of the north pole pieces 114. Similarly, another brass slide plate 122 is provided beneath the magnet. This plate has slots crosswise thereof within which are secured the iron inserts 124. These inserts are arranged to contact in the "on" position with the top exposed faces of ribs 125 on the bottom plate 126 of the chuck. These ribs 125 are separated by inserts of Babbitt metal 127 which are substantially coextensive with the portions 128 of the brass plate and are materially wider than the iron inserts 124, so that when the slide 122 is moved toward the right the iron inserts may contact wholly with the Babbitt metal 127 and thus fully break the circuit at the bottom of the magnet and cause the lines of force to concentrate there. In the "on" position, the iron inserts providing the polar faces of the magnet make full contact with the magnetic parts of the work plate and the bottom plate, but when the slides 118 and 122 are moved toward the right the top iron inserts 120 will contact with both the north and the south pole pieces while the lower iron inserts 124 will contact only with the non-magnetic Babbitt metal 127. The operation is therefore the same as that of Fig. 1. The two slides 118 and 122 may be moved by a crank mechanism as above described. These slides are connected together by a cross arm 130 having threaded therein the cam part 131 having the slot 132 within which rides the pin 133 that is eccentrically moved by an associated handle. The magnet may be held stationary by suitable means, such as a steel bushing 135 press fitted into the left hand end of the magnet and into which is tapped a screw thread for receiving a brass screw 136 carried in the iron end wall 137. That end wall 137 and side walls may be connected between the work plate and the bottom by means of bolts 138 so that the magnetic circuit may be made through these end walls and side walls.

The operations of the chucks will be apparent in view of the above description. If the chuck has one or a plurality of magnets arranged as shown in Figs. 1 to 5 inclusive, then when the

magnet 10 is in the position of Fig. 1 the flux traverses from the north polar faces through the ribs 16 and a work piece carried on the work plate and returns through the cross ribs 14 and the work plate frame 12, the conductor plates 21 and 23 and the bottom plate 20. When the work is to be removed, the magnet is slid to the position shown in Fig. 5 where the south polar faces of the lower ribs 36 of the magnet are isolated from the associated south pole pieces 14. At the same time, the north polar faces of the ribs 40 are brought into contact with the under surfaces of both sets of pole pieces 14 and 16 which lie in one plane, and thus eliminates the magnetic potential difference between the pole pieces and sets up a potential difference between the bottom plate 20 and the south polar faces on the ribs 36 of the magnet. Thus the work plate is deprived of holding power by moving the effective polar faces of the magnet system to the bottom of the chuck and by interposing the reluctance of a gap in the circuit. The work may be readily removed because of of the resultant reduction in flux and because the flux does not enter the work to any material extent. When the chuck is not to be used, then the magnet may be moved part way so that the south polar ribs 36 contact partially with the bottom plate 20 and the north polar faces of the ribs 40 contact partially with the south pole ribs 14 and north poles 16. This provides a return path so that the parts form a keeper for the poles of the magnet, as shown in Fig. 4.

The operation of the triple magnet construction is substantially the same as that above indicated with reference to the Fig. 1 construction, since the magnets may be moved by means of the handle 95 to a position where all of the top and bottom polar ribs make full contact with the associated pole pieces and the spaced ribs of the bottom plate so that the magnetic lines of force pass through the work piece and the return path is formed by the magnets and bottom plate as indicated in Fig. 8. When the work is to be removed, the magnets are moved to the right as shown in Fig. 15 where the upper ribs 64 and 65 bridge the Babbitt metal spacers 73 and connect the adjacent north and south pole pieces and thus connect the magnets to each other. At the bottoms of the magnets the ribs 62 and 63 contact only with the Babbitt metal inserts 69 and thus the circuit is fully broken there. When the chuck is to be put away and not used, then the magnets may be moved to an intermediate position as shown in Fig. 16 in which the lower ribs 62 and 63 of the magnet contact partially with the cross ribs 66 of the bottom plate, while the upper ribs 64 and 65 contact with both north and south pole pieces thus forming a return circuit so that the magnets have keepers applied thereto.

The primary feature of each type of chuck, whether having one magnet, as in Fig. 1, or a plurality of magnets in a reverse polarity arrangement, as in Fig. 9, may be viewed as involving a magnet system so constructed and arranged relative to the two sets of pole pieces in the work plate that the magnetic potential difference may be concentrated in the pole pieces for holding the work in position while a circuit of low reluctance is provided from the magnet poles to the pole pieces; and then, when the work is to be removed, a gap of high reluctance is interposed in the circuit at a point remote from the work plate and the pole pieces are connected together magnetically, whereby the energized polar faces of the magnet system are re-located on the opposite sides of the gap and the leakage flux does not enter the work. If the magnetic circuit were not broken, there would be a strong field and some flux would enter and hold the work. Also, if the circuit were broken only between the top of the magnet and its associated pole pieces, then the magnetic potential difference would concentrate near the pole pieces and the leakage flux would tend to hold the work.

This is exemplified in a two magnet system of reverse polarity arrangement. When the work is to be held in place, an armature is placed across the bottoms of the magnets and the magnet tops are polarized, and when the work is to be removed the circuit is opened at the bottoms of the magnets and an armature connects their tops, so that the polarized polar faces are re-located at the bottom of the chuck away from the work.

It may also be observed that, in the construction of Fig. 1, the magnet is surrounded at its sides and ends by a frame of wrought iron or soft Swedish steel or other material that has a much higher permeability and lower reluctance than has the magnet, so that the frame may be made of thin material and leave ample space for the magnet. This frame of high permeability formed of the plates 21 and 23 remains in magnetic contact with the south pole frame of the work plate for the different positions of the magnet. When the magnet is in the "on" position, this frame forms the primary return circuit for the flux. When the magnet is in the "off" position, the side and end plates 21 and 23 form a shield for leakage flux, and particularly if the stationary side walls of the casing are made of non-magnetic material. It will also be noted that the end walls 21 touch only babbitt at their bottom faces when the chuck is in the "off" position and so do not form a direct shunt circuit for the flux. Similarly, in the Fig. 8 construction, the central magnet is surrounded by the two outer magnets and the end walls 76. This outer unit contacts only with the work plate frame 74 that surrounds the north pole pieces 70. Since the frame 74 of the work plate surrounds the north pole inserts, the center magnet needs to be only large enough to contact with its associated north pole inserts, while the two outer magnets are made longer so that these outer magnets with their connecting cross plates 76 will contact with the marginal portion of the south pole frame as well as the crossbars thereof thus distributing the magnetism quite uniformly to all of the parts.

In view of the above disclosure, it will be appreciated that various other modifications may be made within the scope of this invention and that the above description is to be interpreted as illustrating the general principles of the invention and the preferred embodiments thereof and not as limitations on the claims appended hereto.

I claim:

1. A magnetic chuck comprising a work supporting plate having two sets of alternately arranged, spaced pole pieces having lower contact surfaces separated by narrower gaps, a permanent magnet having upper and lower poles terminating each in a set of spaced polar faces, the upper polar faces slidably contacting with the undersurfaces of all of the pole pieces, a bottom plate having magnetically interconnected, spaced contact surfaces separated by wider non-magnetic gaps, a conductor connecting the bottom plate with one set of pole pieces, and means for slid-

ably moving the polar faces in contact with the contact surfaces of the pole pieces and the bottom plate, said contact surfaces and faces being so arranged that each of the upper polar faces of the magnet may contact solely with a single pole piece while each of the lower polar faces is magnetically connected with the other set of pole pieces, or alternatively each of the upper polar faces may contact with two adjacent pole pieces while each lower polar face is isolated from its associated pole piece or alternatively is connected thereto.

2. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces providing lower contact surfaces of the same width which lie in an upper plane and are separated by narrower non-magnetic gaps, a bottom plate having magnetically connected contact surfaces in a lower plane which are separated by wider non-magnetic gaps, a plurality of slidably mounted permanent magnets having upper and lower polar faces in an alternate reverse polarity arrangement which slide in said planes, each of the polar faces having a width corresponding substantially with that of its associated contact surface, the widths and spacings of said faces and surfaces being such that the lower polar faces may contact fully with magnetic material when each of the upper polar faces contacts solely with a single pole piece, and when each of the upper polar faces engages two adjacent pole pieces then each lower polar face may be isolated by the adjacent non-magnetic gap or alternatively engage a contact surface of the bottom plate, and means for slidably moving the magnets as a unit to said positions.

3. A magnetic chuck comprising a work plate provided with two sets of alternately arranged, spaced pole pieces having lower exposed contact surfaces separated by narrower non-magnetic gaps, a slidably mounted permanent magnet having as its upper pole a set of ribs providing spaced polar faces in slidable contact with said surfaces and having as its lower pole another set of ribs providing spaced polar faces, a bottom plate having a set of magnetically connected contact surfaces contactable with the lower polar faces and which are separated by wider non-magnetic gaps, a conductor magnetically connecting the bottom plate with one set of pole pieces, each of the upper polar faces being substantially coextensive in width with an adjacent pole piece of the other set and being slidable to contact either with said pole piece alone or alternatively with two adjacent pole pieces, each of the lower polar faces being contactable with a contact surface of the bottom plate when an upper polar face contacts solely with one pole piece or alternatively slidable to be isolated by a non-magnetic gap when an upper polar face contacts with two adjacent pole pieces, and means associated therewith for moving the magnet to form a magnetic circuit with a work piece or alternatively to interconnect the pole pieces and break the magnetic circuit.

4. A magnetic chuck comprising a work plate having a frame and cross ribs and a set of iron inserts between and spaced from the ribs, said ribs and inserts forming two sets of pole pieces, and each having a lower exposed contact surface, a vertically arranged movable permanent magnet having upper and lower polar ribs, the upper ribs being arranged to contact solely with said surfaces of the inserts or alternatively to be moved into simultaneous contact with both sets of pole pieces, a bottom plate having magnetically connected, spaced contact surfaces substantially coextensive and contactable with said lower polar ribs and which are separated by wider non-magnetic gaps, a frame of high magnetic permeability surrounding and movable with the magnet which connects the bottom plate with the work plate frame and ribs, and means associated with said parts whereby the magnet and frame may be moved so that the lower polar ribs engage said magnetic contact surfaces of the bottom plate when the upper polar ribs contact solely with the inserts or alternatively may be moved to a position where the lower ribs are isolated from the bottom plate when the two sets of pole pieces are interconnected by said upper ribs.

5. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces, a bottom plate having spaced contact surfaces separated by wider non-magnetic gaps, a central permanent magnet, two outer permanent magnets spaced therefrom at its opposite sides in a reverse polarity arrangement relative to the central magnet, conductor plates magnetically connecting the ends of the outer magnets and contacting with said plates to transmit leakage flux, means securing the magnets and conductor plates as a rigid movable unit, said magnets terminating in upper and lower spaced polar faces magnetically contactable with said work pieces and bottom plate, and associated means for moving the magnets relative to said contact surfaces to positions where the upper polar faces interconnect pole pieces of opposite polarity and the lower polar faces are isolated from the opposite magnet pole by said non-magnetic gaps.

6. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces provided with lower contact surfaces, a permanent magnet having upper and lower poles, the upper pole terminating in movable, spaced polar faces which contact solely with the lower surfaces of one set of pole pieces or alternatively are movable to interconnect the two sets, and a magnetic conductor having a contact surface arranged to contact magnetically with the lower magnet pole and complete a circuit with a work piece on the plate, said lower pole being movable relative to the conductor so that it may alternatively be isolated when the pole pieces are interconnected and the magnetic potential difference may be concentrated adjacent to said lower pole when the work is to be released.

7. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces provided with lower contact surfaces, a bottom plate having a magnetic contact surface connected with one set of pole pieces, and a movable permanent magnet unit having spaced, upper, terminal polar faces arranged to contact solely with one set of pole pieces and a lower polar face contactable with said surface on the bottom plate to form a circuit with a work piece, or alternatively the polar faces being movable to interconnect said pole pieces and to isolate the lower polar face from the bottom plate so that the magnetic potential difference concentrates adjacent to said lower polar face when the work is to be released.

8. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces provided with lower contact surfaces, a bottom plate having magnetically connected

contact surfaces separated by non-magnetic gaps, a plurality of magnets in a reverse polarity arrangement whose poles terminate in upper and lower polar faces contacting magnetically with both sets of contact surfaces and forming a circuit with a work piece, and means for moving the polar faces of the magnets relative to said surfaces to an alternative, work releasing position, said upper polar faces interconnecting the pole pieces in the alternative position while the lower polar faces are isolated by said gaps.

9. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces separated by narrower non-magnetic gaps, a bottom plate having magnetically connected contact surfaces separated by wider non-magnetic gaps, a permanent magnet whose poles terminate in upper and lower spaced polar faces contacting operatively with one set of pole pieces and said contact surfaces, means providing a magnetic path from the bottom plate to the other set of pole pieces and means for moving the polar faces to alternative positions for releasing the work, said faces and surfaces being so arranged that the upper polar faces contact with and interconnect both sets of pole pieces and the lower polar faces are isolated by the non-magnetic gaps when in the alternative work releasing positions.

10. A magnetic chuck comprising a work supporting plate having two sets of alternately arranged, spaced pole pieces having lower contact surfaces separated by narrower non-magnetic gaps, a bottom plate having magnetically connected but spaced contact surfaces separated by wider non-magnetic gaps, a plurality of permanent magnets whose poles terminate in upper and lower polar faces operatively contacting with said surfaces and forming a magnetic circuit with a work piece on the work plate, and means for moving the polar faces relative to said surfaces to an alternative work releasing position, said contact surfaces and polar faces being arranged so that the upper polar faces may be moved to interconnect the two sets of pole pieces and the lower polar faces may be simultaneously isolated by said gaps.

11. A magnetic chuck comprising a work plate having two sets of alternately arranged, spaced pole pieces provided with lower contact surfaces separated by narrower non-magnetic gaps, a bottom plate having magnetically connected contact surfaces separated by wider non-magnetic gaps, a movable permanent magnet having its poles terminating in upper and lower spaced ribs, the upper ribs being substantially coextensive with and slidably contacting with only one set of pole pieces or alternatively engaging and interconnecting both sets, and the lower ribs being substantially coextensive with and engaging the contact surfaces of the bottom plate when a work piece is to be held or alternatively being isolated by said non-magnetic gaps when the pole pieces are interconnected, and means for moving the magnet.

12. A magnetic chuck comprising a magnetic bottom support, side walls, a work plate on the side walls having two sets of alternately arranged, spaced pole pieces, a permanent magnet movably mounted on said support and having upper and lower poles, the upper poles terminating in spaced polar faces slidably contacting with one set of pole pieces and the lower pole operatively contacting with the support, a separate conductor plate of high permeability connected closely to and movable with the magnet and slidably contacting with the bottom support and that part of the work plate which has a like polarity when energized and means to move the magnet and conductor plate, said magnet being movable to an alternative position where one pole is isolated from its associated pole pieces.

13. A magnetic chuck comprising a casing having a bottom plate provided with interconnected magnetic surfaces separated by non-magnetic gaps, a work plate and side walls therebetween, said work plate having two sets of alternately arranged, spaced pole pieces, a plurality of slidable magnets in a reverse polarity arrangement whose poles terminate in upper and lower spaced polar faces operatively contacting respectively with said pole pieces and said surfaces of the bottom plate and alternatively movable to be isolated by said gaps, a conductor plate of high magnetic permeability interconnecting magnets of the same polarity arrangement and contacting with the bottom plate and that portion of the work plate which has the same polarity when energized and means for moving the magnets.

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