Nov. 5, 1957 F. A. SNELL 2,812,185

MAGNETIC CHUCK

Filed April 4, 1956 3 Sheets-Sheet 1

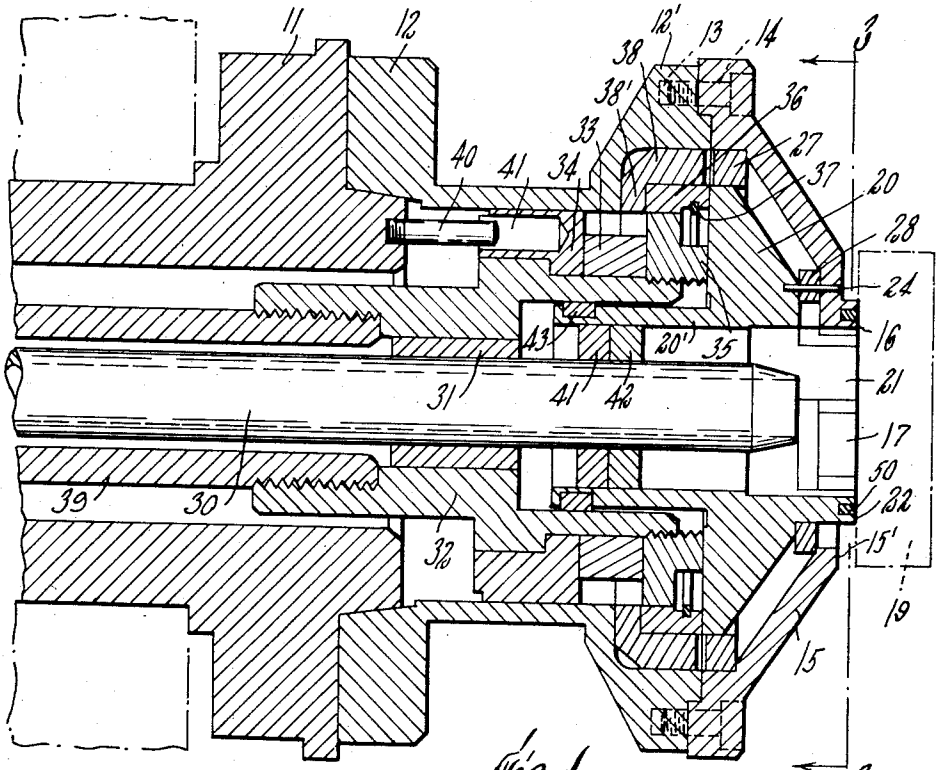

Fig. 1.

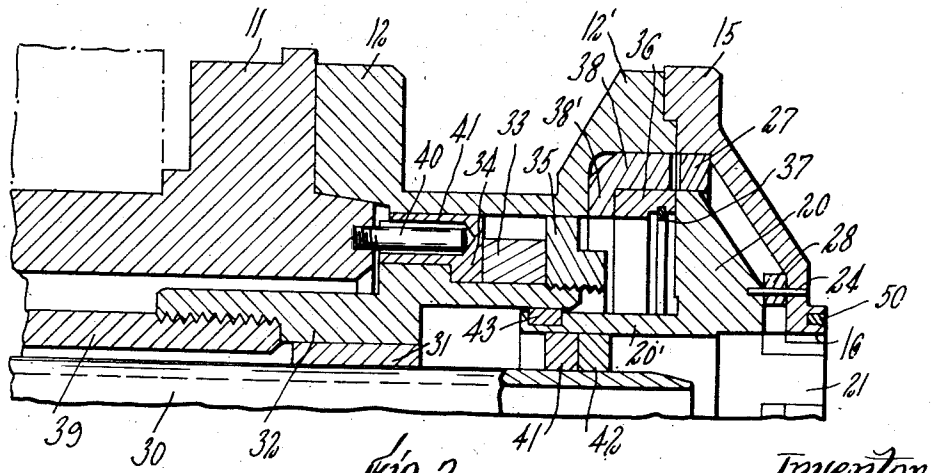

Fig. 2.

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MAGNETIC CHUCK

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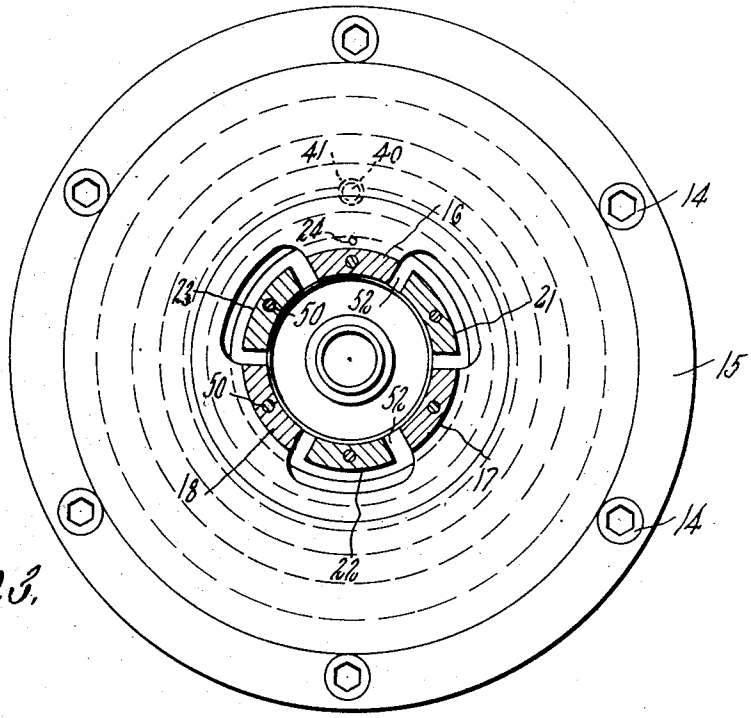

Fig. 3.

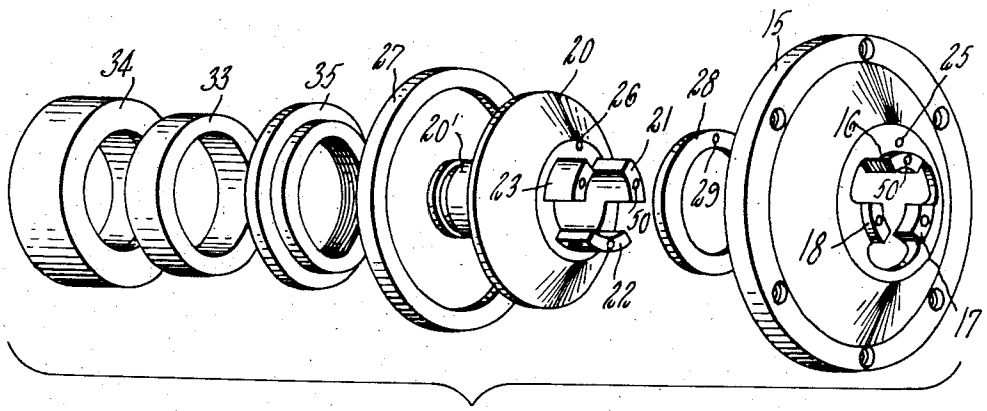

Fig. 4.

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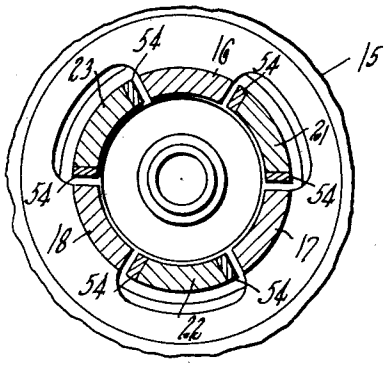

Fig. 5.

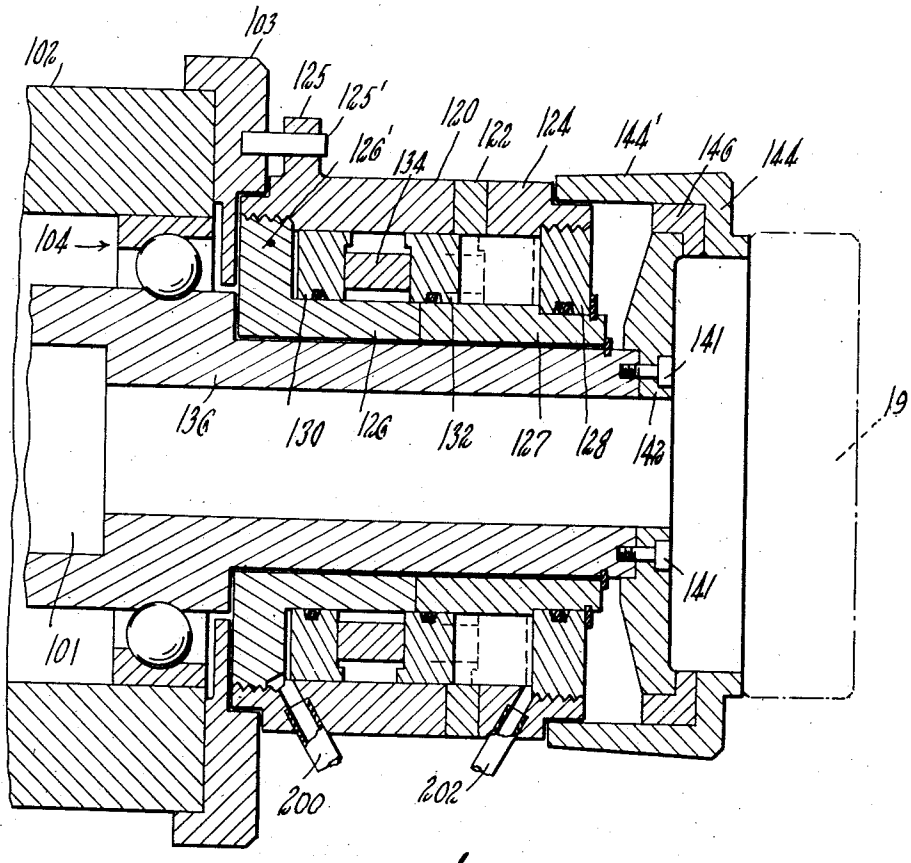

Fig. 6.

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MAGNETIC CHUCK

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Application April 4, 1956, Serial No. 576,008

7 Claims. (Cl. 279—1)

This invention relates generally to work holders for machine tools, and more particularly it relates to a magnetic chuck for centerless grinding machines and the like.

It is an object of the present invention to provide a magnetic chuck of relatively simple construction which is particularly suited to use in centerless grinding operations.

It is another object of the invention to provide a magnetic chuck having a driver face which is formed with a plurality of pole faces energized by a single magnet element.

It is another object to provide a magnetic chuck including means whereby a substantial amount of flux may be diverted from the work piece simply and easily to effectively deenergize the chuck and permit removal of the work piece.

It is a further object to provide a magnetic chuck having a non-rotating magnet assembly so as to permit the same to be actuated more simply and easily and at the same time to materially lessen the inertia load on the driver.

It is a still further object to provide a magnetic chuck which includes wear retarding means in its driver face.

In brief, the magnetic chuck, according to the present invention, makes use of an annular magnet having oppositely poled faces which is rigidly held between a pair of generally cylindrical pole pieces, both the magnet and the pole pieces being adapted for axial movement as a unit with respect to a pair of axially spaced magnetic coupling members. The coupling members in turn are provided with inner cylindrical surfaces of common radius for sliding contact with the pole pieces, and have their end surfaces in engagement with a pair of face pieces, respectively, thereby to provide individual flux paths between the pole pieces and the face pieces. Accordingly, when a work piece is placed on the chuck, or more specifically on certain portions of the face pieces which are arranged as interfitting salient poles having coplanar pole faces, there results a closed flux path or loop of relatively low reluctance from one pole of the magnet through the work piece, and back to the opposite pole of the magnet. This is the normal condition which obtains when the chuck is energized or in other words holding the work piece. When it is desired to release the work piece, however, the magnet and pole pieces are moved together in an axial direction until a condition obtains where both pole pieces are in contact with a single one of the coupling members. As a result, a substantial amount of flux is diverted from the work piece, which of course greatly reduces the magnetic force acting on the work piece and permits it to be removed relatively easily.

The novel features of the invention, together with further objects and advantages thereof, will become more readily apparent from the following description taken in connection with the accompanying drawings wherein:

Fig. 1 is a sectional view of the magnetic chuck according to the present invention illustrating the relative positions of its various parts when the chuck is energized;

Fig. 2 is a cross-sectional view similar to that of Fig. 1 with the chuck in a deenergized condition;

Fig. 3 is a front view in elevation of the chuck;

Fig. 4 is an exploded view in perspective of the various parts in the forward section of the chuck;

Fig. 5 is a front view of the driver face of the chuck; and

Fig. 6 is a sectional view of a modification of the chuck also in accordance with the invention.

Referring now to the drawings wherein like elements have been desginated by the same reference characters, and more specifically to the embodiment of Figs. 1–4, it will be observed that numeral **11** designates a spindle of the type often found on centerless grinding machines, for example, although it should be understood that the invention is by no means limited to use with any particular form of spindle. Adapted to mate with the spindle **11**, and to rotate therewith is a housing member **12** of generally cylindrical configuration, which may be regarded as the body of the chuck, and which has at its end remote from the spindle a flanged portion **12'** provided with a series of equally spaced threaded holes **13**. Fastened to the flanged portion **12'** by means of machine bolts **14** threaded into the holes, is a removable and interchangeable pole face assembly including an outer face piece **15** which is generally disc-shaped and has projecting from its forward end, that is the end remote from spindle **11**, three salient poles **16**, **17** and **18**. These poles are shaped in the form of annular sectors which are angularly spaced from one another by equal amounts (120 degrees on centers), and which present coplanar pole faces to receive a work piece, as is shown in dotted outline and designated by the numeral **19** in Fig. 1. In addition to face piece **15**, the pole face assembly includes an inner face piece **20** which is adapted to interfit with the outer face piece **15** by having its forward portion contoured in a complementary manner. That is to say, inner face piece **20** has a convex forward surface adjacent the rearward surface of face piece **15**, which is essentially concave, and is provided with three angularly spaced salient poles **21**, **22** and **23** of the same general configuration as salient poles **16–18** associated with outer face piece **15**, but of somewhat greater axial dimension. Poles **21–23** project through the outer face piece **15** between the poles **16–18**, and form in combination with the latter a planar driver face of generally annular outline to receive the work piece. Of course, it is essential that each set of poles **16–18** and **21–23** be effectively magnetically isolated from one another, and to this end outer face piece **15** is suitably apertured to receive the poles **21–23**, such that a substantial amount of clearance will be present between the poles **21–23** and the face piece **15**, and likewise the sets of poles themselves are so arranged that a suitable angular spacing exists between adjacent ones thereof. These relations are maintained by a pin **24** which projects through aligned holes **25**, **26** and **29** in the bodies of the face pieces and in a spacer ring **28**, respectively, the latter in conjunction with a spacer ring **27** serving to fix the relative positions of the face pieces axially and radially.

The face pieces themselves are made from magnetically soft material, such as low carbon content steel, so that they will not retain an appreciable amount of residual magnetism. As is well known, this material has comparatively poor wear characteristics, however, which is undesirable in many applications including certain types of centerless grinding, for example, where minute relative sliding movement occurs between the end face of the work piece and the driver face of the chuck. To minimize the wear on the driver face which might otherwise

be intolerable in these applications, poles 16–18 and 21–23 are preferably supplied with inserts 50 of wear resisting material such as tungsten carbide or the like. As best shown in Figs. 3 and 4 these inserts take the form of cylinders of comparatively small diameter, so as not to diminish unduly the respective areas of the pole faces. After being rigidly assembled in the poles as by a shrink fit or brazing, for example, the inserts should then be trued so as to present free end faces flush with the individual pole faces which make up the driver face. It is desirable that the inserts have axial dimensions at least as great as poles 16–18 to permit re-truing as required to maintain the driver face in proper condition, that is to maintain a true driver face surface which extends in a plane perpendicular to the rotative axis of the chuck and spindle. As well known in the art, this may be accomplished by grinding or other means, while the chuck is rotated on its spindle.

Fig. 5 illustrates a modification of this arrangement. In the modification of Fig. 5, inserts 54 comprise small annular sectors interposed between respective pairs of adjacent poles but angularly spaced somewhat from one of them in order to maintain the north poles isolated magnetically from the south poles. Inserts 54 may be held in place in any suitable manner such as by brazing.

Disposed along the axis of the spindle 11 is a stationary coolant pipe 30, as is conventional on many machine tool spindles, the front end of the pipe in the chuck according to the invention being supported by a bearing bushing 31 in a member 32 of non-magnetic material. Member 32 rotates with the spindle 11, and is also adapted for axial sliding movement with respect thereto. There is mounted on the slide member 32 a magnet 33 which is seen to be annular in shape and to have oppositely poled faces, for example, north towards the left and south towards the right, as shown in Fig. 1. Magnet 33 is held between a pair of generally annular pole pieces 34 and 35 of magnetically soft material which abut its north and south faces respectively. To maintain the pole pieces fixed on slide member 32, the latter has a shoulder to abut pole piece 34 and exterior threads at its rightward end onto which pole piece 35 is threaded.

Pole piece 34 is supported in housing member 12, which at this point is seen to be generally cylindrical, and disposed about pole piece 35, as shown in Fig. 1, is an annular coupling member 36, one end of which abuts the rearward end of face piece 20. Coupling member 36 is provided with an interior groove to receive a snap ring 37 which prevents the inner assembly comprising pole pieces 34 and 35, magnet 33, and slide member 32 from accidentally falling out when the outer assembly of the face pieces is removed. To maintain coupling member 36 fixed axially and radially with respect to housing member 12, which also serves in effect as a coupling member, there is provided between housing member 12 and coupling member 36 a spacer ring 38 having a flanged portion 38' which extends radially inwardly with its inner peripheral surface coextensive with the inner surfaces of housing member 12 and coupling member 36, the latter being coaxially aligned as clearly shown in Fig. 1. Spacer ring 38 is formed of non-magnetic material as are spacer rings 27 and 28.

Towards the left of Figs. 1 and 2, it will be observed that slide member 32 is provided with internal threads by means of which a draw bar 39 is attached thereto. Those skilled in the art will recognize draw bar 39 as a conventional attachment for the spindle, and in this case, it serves to actuate the inner magnetic assembly by moving it axially as will be described hereinafter. Any relative angular movement between this assembly and the body of the chuck is prevented, however, by a guide pin 40 projecting from the spindle 11 into a bore 41 provided in the pole piece 34.

Finally there are provided a pair of sealing rings 41 and 42 to prevent dust and dirt from entering the interior

of the chuck. Rings 41 and 42 are mounted at the front end of pipe 30 and are retained within a rearwardly projecting hub 20' formed as a part of face piece 20. For like purposes it has also been found advantageous to provide a seal-ring 43 between the aforementioned hub portion and slide member 32, as shown.

In operation, as the spindle and its associated draw bar are caused to rotate, it is apparent that by virtue of housing member 12 being fixedly fitted to the spindle, and slide member 32 being threaded onto the draw bar 39, all of the parts of the chuck are caused to rotate with the spindle, except coolant pipe 30 which remains stationary. Consequently, the work piece will be rotatably driven by the chuck when there is a sufficient magnetic holding force present to maintain the work firmly against the annular driver face formed by the poles 16—18 and 21—23. To place the chuck in condition to exert such a force on the work piece preparatory to its being operated on by some form of machine tool, draw bar 39 is moved forward (towards the right) until the pole pieces 34 and 35 are in the position shown in Fig. 1. With the pole pieces in this position, it will be observed that members 12 and 36 serve to provide individual flux paths between the pole pieces and the face pieces 15 and 20, respectively, which paths are joined by the work piece, provided of course that it is of size and shape to bridge the gaps between the poles whereat the paths effectively terminate. More specifically, proceeding from the left or north pole of the magnet, a complete flux loop or path including the work piece will be present under these conditions, the path traversing the pole piece 34, the housing member 12, the face piece 15 and the work piece 19, and returning to the south pole of the magnet through the face piece 20, the coupling member 36 and the pole piece 35. As is well known to those skilled in the art, by virtue of the face pieces terminating in a plurality of interfitting poles with short air gaps therebetween, a considerably greater holding force may be exerted on the work piece than would be the case otherwise, were a driver plate provided which had only a single pair of spaced poles.

In order to make the chuck most useful, particularly where it is necessary to operate on a number of work pieces, one after another in rapid succession, pole pieces 34 and 35 have been arranged in combination with members 12 and 36 so that only a small amount of rearward movement of the draw bar is required to effectively deenergize the chuck and permit the work piece to be removed therefrom quickly and easily. With reference to Fig. 2, it will be observed that when the draw bar is thus moved, pole pieces 34, 35 and the magnet 33 are displaced axially, and though the pole piece 34 remains in contact with housing member 12, pole piece 35 is moved out of contact with coupling member 36 and into contact with the housing member. In this way, a relatively low reluctance path is established between the pole pieces, that is the path of much lower reluctance than the aforementioned path which included the work piece, serving to divert the flux from the work piece and at the same time provide a keeper for the magnet. In fact, when the chuck is deenergized, as shown in Fig. 2, coupling member 36 and face piece 20 are both effectively magnetically isolated from pole piece 35 so that the path including the work piece no longer exists.

Alternatively, the force on the work piece may be decreased a lesser amount if the slidable inner assembly is not moved so far as Fig. 2 indicates. This follows from the fact that as the pole piece 35 is moved from right to left, it will come into contact with housing member 12 before it is completely disengaged from coupling member 36. Two closed flux paths will be present simultaneously under these circumstances, one through the work piece and the other directly through the housing member. The relative reluctances of these two paths will be determined by the amount of surface contact which exists between the pole piece and the coupling member on the one hand,

as compared with that between the pole piece and the housing member on the other. Since this in turn is dependent on the extent to which the pole piece is moved axially, the amount of flux diverted from the work piece and therefore the amount by which the holding force thereon is decreased, may be controlled in accordance with the length of the draw bar stroke. Another desirable feature of this arrangement is that owing to the gradual diversion of flux from the work piece which takes place when the draw bar is moved rearwardly irrespective of the particular stroke length employed, the force required to move the draw bar is not nearly so large as would be the case otherwise.

In Fig. 6 there is illustrated a modification of the chuck according to the invention wherein the axially movable magnet assembly is adapted to remain stationary while the work piece is being rotatably driven. With reference now to Fig. 6, it will be observed that the modified chuck includes an inner support member **136** projecting from the spindle nose **101** and a pair of concentric face pieces, **142** and **144**, the inner face piece **142** being rigidly attached to the front (rightward) end of support member **136** by means of machine bolts **141**. Face pieces **142** and **144** are similar to face pieces **15** and **20** described in connection with Figs. 1–4 in that they have angularly spaced salient poles disposed in a circle about the axis of rotation of the chuck so as to form an annular driver face for engagement with the work piece **19**. As before, an air gap exists between adjacent poles to effectively isolate them magnetically, and for this same purpose there is provided a spacer ring **146** of non-magnetic material to maintain the body of face piece **144** in proper spaced relation axially and radially to face piece **142**.

Mounted on the support member **136** in the region between the spindle and the face pieces are a pair of loose fitting sleeve members **126** and **127** whose adjacent faces abut one another and are joined together to form an inner guide structure, a part of which, namely the part formed with member **127**, is comprised of non-magnetic material. Member **126**, on the other hand, is comprised of low carbon content steel or the like, and has at its end adjacent the spindle nose a radially projecting flange portion **126'** onto which is threaded an outer guide structure including a pair of magnetic members **120** and **124**, of like material as member **126**, and a non-magnetic member **122** interposed therebetween. As shown, members **120**, **122** and **124** are arranged to provide a continuous cylindrical guide surface concentric about the outer surfaces of members **126** and **127** which are similarly arranged, and between these surfaces is an annular magnet **134** whose faces are rigidly held between a pair of pole pieces **130** and **132**. The magnet and pole pieces are adapted to be moved axially as a unit between these guide surfaces in response to pneumatic or hydraulic pressure introduced through an inlet **200** or an inlet **202**, according to the direction of movement desired, and to limit their movement in the forward direction, the member **124** is internaly threaded to receive an end piece **128**. In addition, the forward end of member **124** is reduced in external diameter to provide a loose fit with a rearwardly projecting portion **144'** of the face piece **144**.

Completing the chuck of Fig. 6, is a lug **125** which is rigidly attached to member **120** and which supports a pin **125'**. Pin **125'** is adapted to register with a bore in a fixed member **103**, to prevent the magnet assembly from rotating. Between the inner support member of the chuck **136** and another fixed member **102**, forming a part of the spindle support structure is an antifriction bearing designated generally by the numeral **104**.

In operation support member **136** is rotatably driven by the spindle **101** and in turn drives the face pieces **142** and **144** against which the work piece is held by magnetic force when the chuck is in an energized condition. The magnet assembly including members **120**, **122**, **124**, **126** and **127** together with the magnet **134** and pole pieces **130**, **132** does not rotate, however, but rather is held stationary when the pin **125'** is engaged with fixed member **103**. To place the chuck in an energized condition, a suitable source of fluid pressure is connected to inlets **200** and **202** through some conventional type of four way valve as is well known to those skilled in the art, and the valve is set so that the fluid under pressure is supplied to inlet **200**, with inlet **202** open to exhaust. This causes the magnet and pole pieces to move forwardly as a unit until pole piece **132** comes into contact with end piece **128**. When pole piece **132** is in this position, the work piece will be firmly held by the chuck since a single closed flux path through the work piece is established. Assuming that the leftward face of the magnet **134** is the north pole and proceeding from north to south as before, the path traverses pole piece **130**, member **126**, member **136**, face piece **142**, and returns through the work piece, face piece **144**, member **124** and pole piece **132**. Contrariwise, when the magnet and pole pieces are caused to assume their positions as shown by changing the valve setting so that inlet **202** is pressurized with inlet **200** open to exhaust, the work piece will be released. This is because a path of relatively lower reluctance, which includes only the pole pieces and the member **120** is established while at the same time, the path or circuit through the work piece is effectively broken. Alternatively, as in the chuck of Figs. 1–4, the holding force on the work piece may be decreased a lesser amount, if desired, by arresting the rearward movement of the magnet and pole piece assembly at a point where pole piece **132** bridges the non-magnetic member **122**. Under these conditions two closed flux paths will be present, one through the work piece and the other directly through member **120**.

It will be apparent to those skilled in the art that my invention is susceptible of various other modifications to accommodate different spindles or different work pieces, for example, that are within the spirit and scope of the invention. Therefore, the invention should not be deemed to be limited to the embodiments herein described in detail by way of illustration, but should be deemed to be limited only by the scope of the appended claims.

What is claimed is:

1. A magnetic chuck to rotate a work piece about a central axis comprising: an axially mounted annular magnet having oppositely poled faces; first and second pole pieces, said magnet faces being rigidly held between said pole pieces; a pair of interfitting face pieces presenting a plurality of coplanar pole faces to receive the work piece; first and second magnetic coupling members in engagement with said face pieces, respectively, said coupling members having cylindrical inner surfaces of common radius in slidable contact with said pole pieces respectively; and means to move said pole pieces axially so that both of said pole pieces are in contact with said second coupling member, to provide a magnetic circuit between said pole pieces whereby flux is diverted from the work piece when it is desired to remove the same from the chuck.

2. A magnetic chuck to rotate a work piece about a central axis comprising: an axially disposed non-magnetic support member of generally cylindrical shape; an annular magnet having oppositely poled faces mounted on said support member; first and second pole pieces of generally annular shape rigidly mounted on said support member with their adjacent end surfaces abutting the respective pole faces of said magnet, first and second magnetic coupling members disposed concentrically about said first and second pole pieces respectively and having cylindrical inner surfaces of common radius in slidable contact therewith, respectively, said second coupling member having a forwardly projecting portion of enlarged inner diameter disposed concentrically about said first coupling member; a spacer member of non-magnetic material disposed between said coupling members to space

the same both radially and axially; first and second interfitting face pieces presenting a plurality of coplanar pole faces to receive the work piece, said face pieces being adapted to be held in engagement with said coupling members respectively; and means to move said support member axially of the chuck to place both of said pole pieces in contact with said second coupling member, whereby flux is diverted from the work piece when it is desired to remove the same from the chuck.

3. A magnetic chuck to rotate a work piece about a central axis comprising: an axially mounted annular magnet having oppositely poled faces; first and second pole pieces, said magnet faces being rigidly held between said pole pieces; first and second magnetic coupling members having inner cylindrical surfaces of common radius in slidable contact with said pole pieces respectively; a first face piece in engagement with said first coupling member; said first face piece being provided with a number of angularly spaced salient poles disposed about the central axis and having pole faces in the form of annular sectors; a second face piece in engagement with said second coupling member, said second face piece being provided with an equal number of similar poles and being apertured to receive said first-named poles in interfitting angularly spaced relation with the second-named poles such that the pole faces of all the poles extend in a single plane; spacer means between said face pieces to maintain the same fixedly positioned with respect to one another; and means to move said pole pieces axially as a unit to cause both of said pole pieces to contact said second coupling member, whereby flux is diverted from the work piece when it is desired to remove same from the chuck.

4. A magnetic chuck for a workpiece comprising: a central shaft to rotate said workpiece; a pair of guide structures disposed concentrically about said central shaft to form a cylindrical cavity of annular cross-section, said structures being rotatably mounted on said central shaft and being provided with means to magnetically isolate from one another axially spaced portions of the walls of said cavity, a driver face attached to said central shaft for engagement with the work piece, said driver face being formed with at least two poles, means to magnetically connect said wall portions to said driver face poles, respectively; an annular magnet disposed within said cavity, said magnet having oppositely poled faces; and means for moving the magnet axially between a first position wherein the magnet poles are individually magnetically connected to said wall portions, and a second position wherein the magnet poles are both magnetically connected to a single one of said wall portions.

5. A magnetic chuck according to claim 4 including a pair of pole pieces of generally annular configuration, said magnet being rigidly held between said pole pieces, and said pole pieces having cylindrical surfaces individually contacting said wall portions when said magnet is in said first position and jointly contacting a single one of said wall portions when said magnet is in said second position.

6. A magnetic chuck to rotate a workpiece about a central axis, said chuck comprising: a pair of guide structures disposed concentrically about the central axis to form a cylindrical cavity, said structures including means to magnetically isolate from one another axially spaced portions of the walls of said cavity, a driver face for engagement with the workpiece, said driver face being formed with at least two poles, means to magnetically connect said wall portions to said driver face poles, respectively; an annular magnet disposed within said cavity, said magnet having oppositely poled faces; a pair of pole pieces of generally annular configuration, said magnet being rigidly held between said pole pieces, and means for moving said pole pieces axially between a first position wherein said pole pieces have cylindrical surfaces individually contacting said wall portions and a second position wherein said pole pieces have cylindrical surfaces jointly contacting a single one of said wall portions, one of said pole pieces being of axial dimension greater than the spacing between said wall portions whereby the same is adapted to contact both of said wall portions simultaneously in the course of its movement between said first and second positions.

7. A magnetic chuck according to claim 4 wherein said driver face is formed with a plurality of angularly spaced poles disposed about the central axis and having combined work piece engaging surfaces of generally annular configuration.

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