

April 25, 1967

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3,315,416

GRINDING MACHINE FOR RING-LIKE WORKPIECES

Filed Nov. 27, 1964

3 Sheets-Sheet 1

Fig. 1

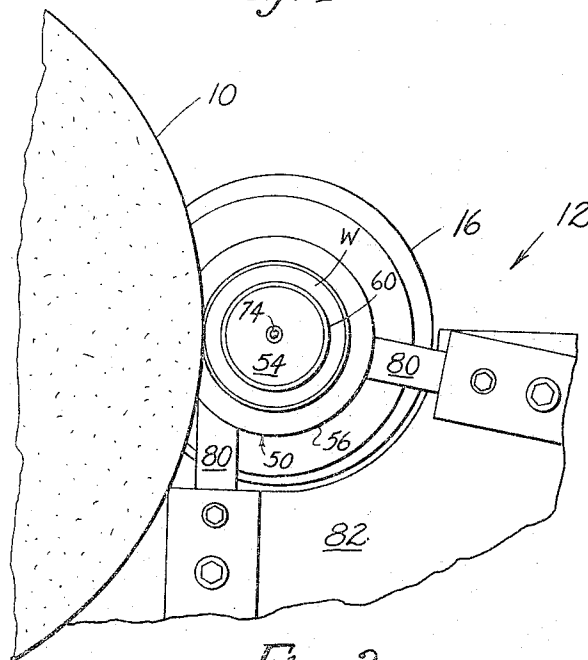
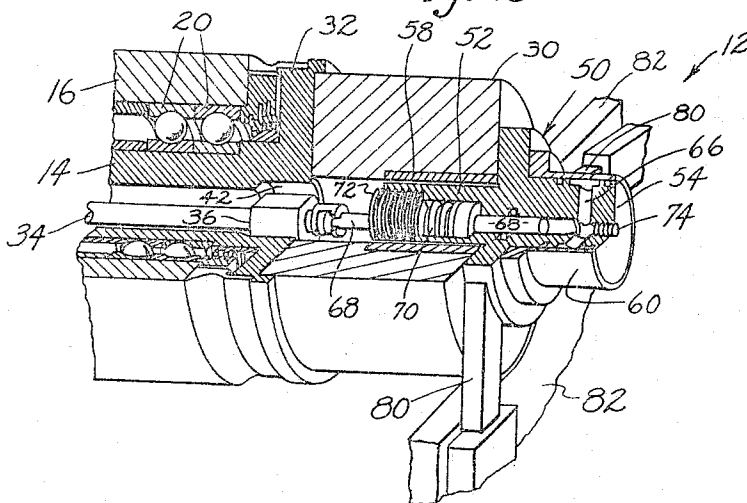


Fig. 2



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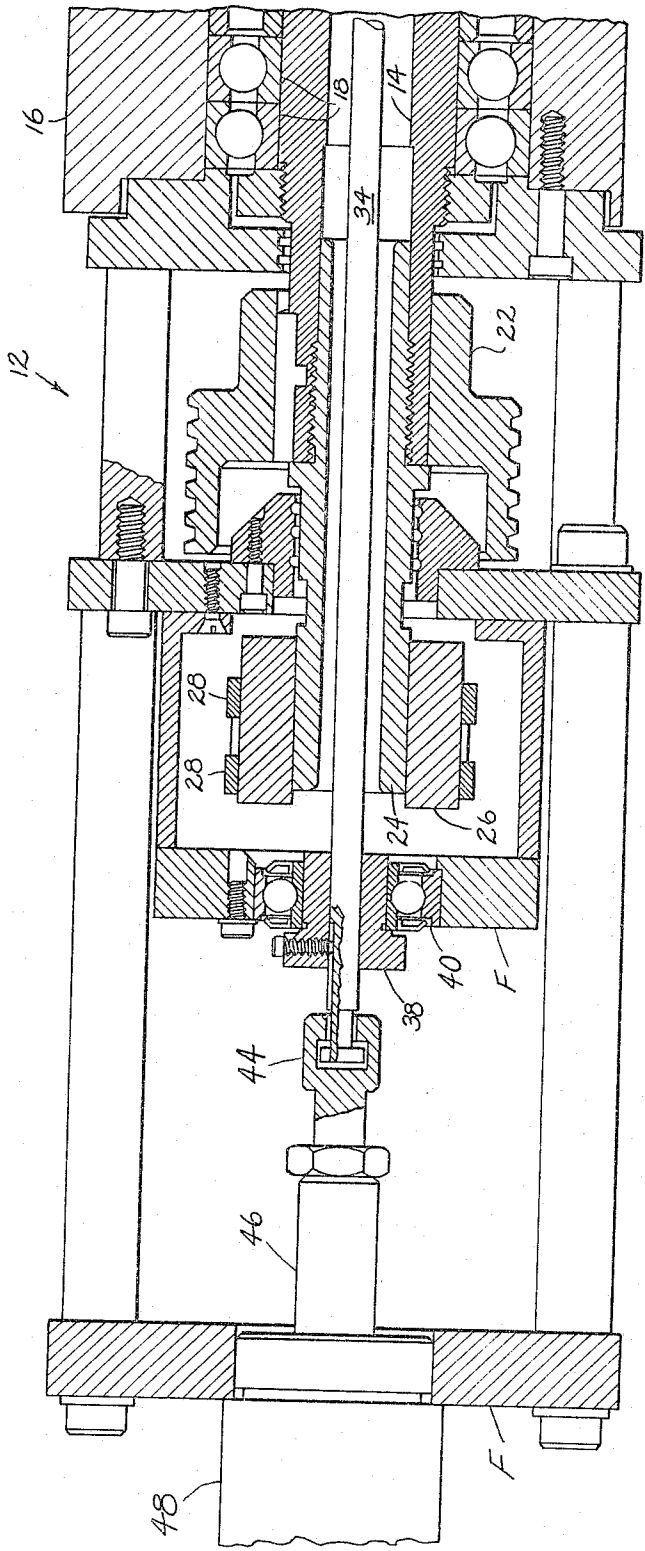
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Fig. 3A



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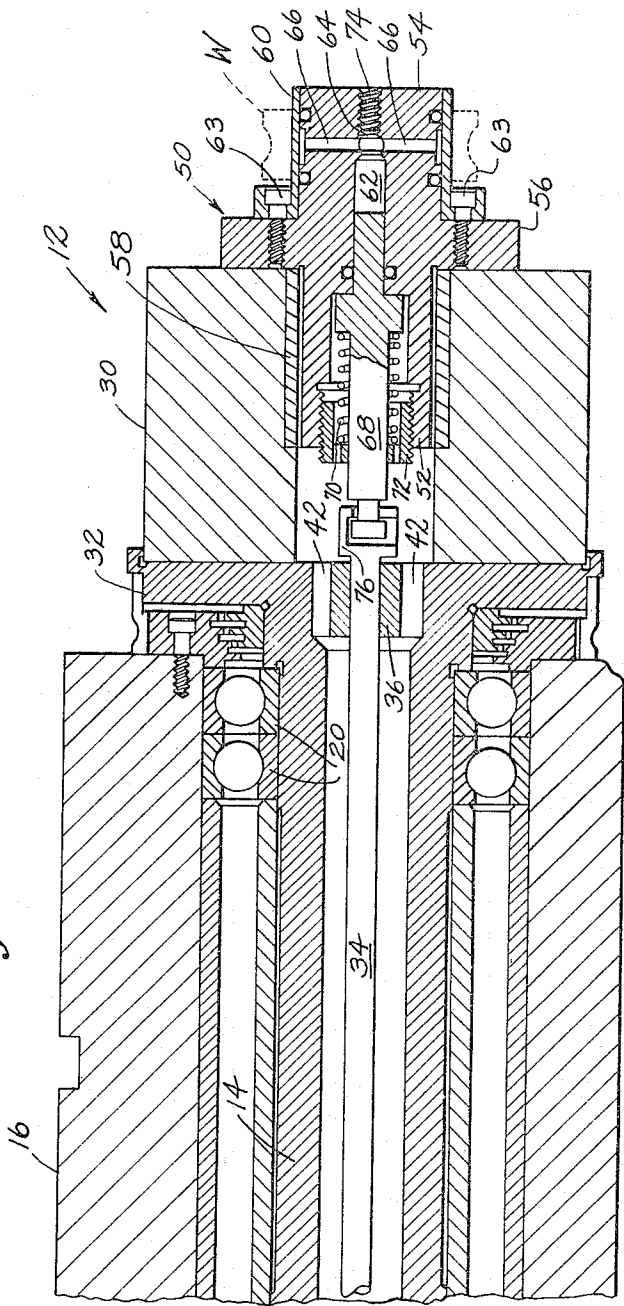
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Fig. 3B



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GRINDING MACHINE FOR RING-LIKE WORKPIECES

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This invention relates to a machine for precision grinding of the peripheral surface of ring-like workpieces such as the inner race ring of anti-friction ball bearing units wherein an annular groove must be ground as nearly perfectly circular as possible on a center which will fall on the axis of a shaft on which the bearing unit is ultimately to be mounted.

It is the general object of the invention to provide a machine for the aforementioned purpose and which will perform the grinding operation with a "centerless" grinding technique and wherein the workpiece is so supported and rotated while being ground that the accuracy and precision with which the grinding is performed will not depend upon the bearing or mounting precision of the workhead spindle which effects rotation of the workpiece.

It is a more specific object of the invention to provide an arbor for supporting ring-like workpieces so that their peripheral surfaces can be ground as nearly perfectly cylindrical as possible and wherein the accuracy of the grinding operation for this purpose depends only upon the accuracy with which the arbor is constructed and not upon the precision of operation of other machine elements.

The drawings show a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawing and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawings:

FIG. 1 is a front elevational view of a portion of the grinding wheel and the workhead which are operatively associated in the machine of the present invention;

FIG. 2 is a perspective view of the front end portion of the machine workhead and showing a longitudinal section taken along the axis of the workhead spindle;

FIG. 3A is a longitudinal vertical sectional view taken through the workhead on the spindle axis, the view being on an enlarged scale and showing only the rear end portion of the spindle; and

FIG. 3B is like FIG. 3A but shows the front end portion of the workhead spindle and the attachments thereto.

A grinding machine provided in accordance with the present invention includes as essential elements a driven rotatable grinding wheel 10 and a workhead which is indicated generally by the reference numeral 12. The grinding wheel 10 is rotated on a horizontal fore-and-aft axis and is driven by conventional means not shown. The said grinding wheel and the workhead 12 are movable relative to each other and, preferably, for this purpose the workhead 12 can be mounted in place of a regulating wheel assembly in a centerless grinder such as shown in Healy et al. U.S. Patent No. 3,080,686. When so mounted, the workhead 12 can be reciprocated laterally toward and away from the periphery or operating surface of the grinding wheel 10. The means for so reciprocating the workhead are conventional and are not shown since they form no part of the present invention. However, it is to be understood that the workhead 12 is moved laterally toward the grinding wheel to engage a workpiece there-

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with for grinding and it is then moved laterally away from the grinding wheel for removal of the ground workpiece and replacement by a workpiece to be ground.

FIGS. 2, 3A and 3B illustrate the details of the workhead necessary for an understanding of the present invention. Included in this workhead is an elongated hollow workhead spindle 14 which is rotated on a horizontal axis substantially parallel to the axis of the grinding wheel 10. The said spindle 14 is supported for rotation in a spindle housing 16 on rear anti-friction ball bearing units 18, 18 and similar front units 20, 20.

As seen in FIG. 3A, the rear end of the hollow spindle 14 projects outwardly from its housing 16, and a pulley 22 is secured thereto for rotating the said spindle, the said pulley being connected to a suitable drive motor by belting (not shown).

An elongated hollow adapter or mount 24 is also coaxially secured to the extending rear end of the workhead spindle 14, this mount being provided for a collector ring 26 having brushes 28, 28. The said collector ring and brushes are provided to receive electrical power from a source (not shown) so that electrical conducting wires can be extended from said ring through the bore of its mount 24 and forwardly through the bore of the spindle 14 to energize an electromagnetic chuck 30 (FIG. 3B) which is secured to a flange 32 on the front end of the spindle 14 and which is also hollow or annular and coaxial with the said spindle. An actuating rod 34 extends rearwardly from the bore of the magnetic chuck 30 through the bore of the spindle 14 and the collector ring mount 24. This actuator rod is used in a control function which will be described hereinafter, and it is supported adjacent its front end in a bushing 36 at the front end of the spindle 14 and it is also supported adjacent its rear end in a bushing 38 located in the bore of an anti-friction ball bearing unit 40 in the fixed frame structure F which is located rearwardly of the workhead spindle housing 16. The said front bushing 36 is provided with suitable peripheral flats 42, 42 which accommodate the wires extending to the magnetic chuck 30 from the collector ring 26.

The projecting rear end portion of the actuating rod 34 is engaged by a clevis-like element 44 on the end of a piston rod 46 which is reciprocated axially in a fluid motor cylinder 48. The fluid motor cylinder 48 is fixedly mounted in another portion of the frame F rearwardly of the workhead spindle housing 16, and the clevis-like connection it has with the rear end of the actuating rod 34 permits the said rod to rotate with the spindle 14, but this connection permits the fluid motor to move the said rod rearwardly and forwardly in the control function to be described.

An arbor 50, (FIGS. 2 and 3B) is an important element in the present invention. This arbor includes a rearwardly projecting cylindrical shank 52 and a forwardly projecting cylindrical shank or hub 54 which is coaxial with the shank 52, and it also includes a coaxial cylindrical flange 56 interposed between the said shanks. The said arbor is located on the front end of the magnetic chuck 30 with its rearwardly projecting shank 52 extending into the bore of the said chuck in loosely fitting relationship, which is greatly exaggerated in FIG. 3B, to permit limited radial movement of the said arbor 50 relative to the said chuck 30. When engaged with the chuck, the rear face of the cylindrical flange 56 engages the front face of the chuck 30 for radial sliding movement relative thereto. A bronze bushing 58 is located in the bore of the chuck 30 to divert the flux path of the said magnetic chuck from passage through the rearwardly extending shank 52 of the magnetic arbor 50. This causes the flux path to be concentrated in the magnetic flange 56 of the arbor in a circular path which flows through the chuck

and its bore forwardly in the arbor to the flange and then radially outwardly back into the chuck.

The other or forwardly projecting shank 54 of the arbor 50 extends into the plane of the grinding wheel 10 and is adjacent to the periphery of the said grinding wheel. A cylindrical sleeve 60 is mounted on the forwardly projecting shank 54 in snug relationship thereto as by screws 63, 63 projecting through a radial flange on the rear end of said sleeve and into the cylindrical flange 56 of the arbor. This sleeve is used for the mounting of a workpiece W such as the inner race of an anti-friction bearing unit, the said race or ring being thrust over the sleeve on the bore of the ring.

In keeping with the present invention, the sleeve 60 is to be radially expanded to engage the bore of the workpiece W in a non-slip fit whereby the said workpiece will be firmly held and can be rotated in engagement with the grinding wheel 10. The sleeve can also be relaxed to permit removal and replacement of the said workpiece with a similar piece. To accomplish this, the arbor 50 defines a self-contained hydraulic fluid system. More specifically, the said arbor is provided with a rearwardly extending axial bore 62, a forwardly extending axial bore 64 in the front shank 54, and a plurality of radially extending bores 66, 66 in the said forwardly extending shank. A plug 68 is located in the rearwardly extending passage 62 and is biased to a closed or normal position therein by a spring 70 which is seated on a seat 72 threaded into the rear end portion of the rearwardly projecting arbor shank 52. The spring 70 provides sufficient force when adjusted by the seat 72 to maintain the plug 68 in the position shown in FIGS. 2 and 3B and thereby to establish sufficient hydraulic pressure to expand the sleeve 60 into the non-slip engagement with the bore of a workpiece W. The said required hydraulic pressure within the system is created or established by an adjustable plug 74 which is threaded into the end of the forwardly extending passage 64. By threading the plug 74 inwardly, the pressure on the hydraulic fluid within the system is increased to the desired level. Thus, normally, pressure is maintained in the arbor to expand the sleeve 60 into the non-slip working engagement with the workpiece W.

This pressure is reduced so that the sleeve 60 will relax and permit removal and replacement of the workpiece W by rearward movement of the previously mentioned plug 68. The plug 68 is moved rearwardly to reduce the hydraulic pressure and against the bias of the spring 70 by the fluid motor 46, 48 which engages and moves the actuating rod 34 rearwardly. The said actuating rod is provided with a clevis-like element 76 at its front end which engages the rear end of the plug 68. When the fluid motor is operated to move the actuating rod 34 rearwardly, it in turn retracts or moves the plug 68 rearwardly to increase the passage volume in the arbor 50 and thereby to reduce the hydraulic pressure therein. This, of course, is done only when the workhead 12 has been shifted laterally away from the grinding wheel 10 to a position wherein workpieces can conveniently be interchanged on the forwardly projecting shank of the arbor 50. After a ground workpiece has been removed and replaced by an unground workpiece, the fluid motor pressure is released which releases the plug 68 so that it will resume its normal position under the force of the spring 70.

While the workhead spindle 14 and magnetic chuck 30 engage the arbor 50 to rotate it and a workpiece W thereon for grinding, they do not locate the axis of rotation of the said arbor and workpiece. This is done by a pair of shoes 80, 80 (FIGS. 1 and 2) which are suitably mounted on a bracket 82 carried by the workhead 12. The shoes 80, 80 are located in circumaxially spaced apart relationship to engage the cylindrical periphery of the arbor flange 56. These shoes when engaging the said arbor flange support the said arbor and its associated workpiece for rotation on an axis which is independent of the work-

head spindle and magnetic chuck and their common axis. Preferably, the shoes 80, 80 are respectively located on opposite sides of a vertical plane which includes the axis of the workhead spindle and, preferably, the said shoes are so located as to shift the independent axis of rotation laterally away from the spindle axis toward the grinding wheel and downwardly from the said spindle axis.

With the arrangement described, the annular ball groove in the peripheral surface of the workpiece W can be ground nearly perfectly circular. That is, the grinding is accomplished, due to the fact that the arbor 50 can "float" relative to the spindle 14 and chuck 30, without depending for accuracy upon the alignment of the workhead spindle and its ability to rotate without an out of round path. Preferably, after the sleeve 60 has been mounted on the forwardly projecting shank 54 of the arbor 50, its periphery is ground or otherwise machined concentrically or coaxially with the cylindrical periphery of the arbor flange 56 which is engaged by the shoes 80, 80. Thus, error is minimized in grinding the workpiece by supporting the arbor on its flange.

In effect, what is accomplished by this means and technique of grinding is that the peripheral surface of the workpiece is ground on the axis of the arbor and more particularly on the common axis of the arbor flange 56 and the sleeve 60, and this axis is duplicated or very substantially duplicated by the axis of the shaft on which the workpiece is ultimately installed. Thus, we have an inner bearing race or ring which is accurately ground with reference to the axis of the shaft upon which it is applied.

It is to be understood that the bore of the workpiece W may be out of round, but since this bore is snugly or press fit in the non-slip engagement on the arbor when it is ground, the out of round error is minimized in the grinding of the ring. Also, the out of round bore is similarly fit on the shaft of ultimate use. When the workpiece ring is relatively thin, the expansion of the arbor sleeve may well expand the ring, and in such event, any out of roundness of the bore may well be eliminated and the peripheral surface is ground in very substantial concentricity therewith. Then, when the thin ring is relaxed, the ground surface assumes the out of round condition of the relaxed bore. However, when the ring is later installed in a press fit on a shaft, its bore may well again be expanded into roundness and the ground surface will again be quite concentric.

The invention claimed is:

1. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having a driven spindle and a driving disk secured to one end thereof; an arbor comprising a cylindrical flange and a coaxial forwardly projecting shank, means for exerting a driving connection between the disk and flange when in surface contact but permitting limited radial movement of the flange relative to the disk, a sleeve mounted on said shank, said arbor defining a closed fluid system for exerting outward pressure on the sleeve, means for selectively varying the pressure respectively to expand the sleeve into non-slip engagement with the bore of a workpiece to be ground and to release said workpiece for replacement, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle with the workpiece in engagement with the grinding wheel and while the spindle and disk rotate the arbor and workpiece on said independent axis.

2. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having a driven spindle and a magnetic chuck secured to one end thereof; an arbor comprising a cylindrical flange and a coaxial forwardly projecting shank, the flange being adapted for magnetic face to face driving engagement with the chuck while being permitted limited radial movement

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relative to the chuck, a sleeve mounted on said shank, said arbor defining a closed fluid system for exerting outward pressure on the sleeve, means for selectively varying the pressure respectively to expand the sleeve into non-slip engagement with the bore of a workpiece to be ground and to release said workpiece for replacement, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle with the workpiece in engagement with the grinding wheel and while the spindle and chuck rotate the arbor and workpiece on said independent axis.

3. A grinding machine as set forth in claim 2 wherein said shoes are arranged to locate said independent axis at a position which is laterally offset toward the grinding wheel from the spindle axis and which is also offset downwardly from the spindle axis.

4. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having a driven spindle and a magnetic chuck secured to one end thereof; an arbor comprising a cylindrical flange and a forwardly projecting coaxial shank, a sleeve mounted on said shank and having a cylindrical outer surface which is machined with reference to the cylindrical surface of the flange, said arbor flange being adapted for magnetic engagement by said chuck in face to face contact therewith but permitting limited radial movement of the flange relative to the chuck, said arbor defining a closed fluid system for exerting outward pressure on the sleeve, means for selectively varying said pressure respectively to expand the sleeve into non-slip engagement with the bore of a workpiece to be ground and to release said workpiece for replacement, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle with the workpiece in engagement with the grinding wheel and while the spindle and chuck rotate the arbor and workpiece on said independent axis.

5. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having a driven spindle coaxially supporting an annular magnetic chuck; an arbor comprising oppositely projecting coaxial shanks and an interposed cylindrical flange and having one shank extending into the central opening of the chuck for limited radial movement therein with the flange engaging and moving along the end face of the chuck and with the other shank projecting forwardly into the plane of the grinding wheel adjacent the periphery thereof, a cylindrical sleeve mounted on said forwardly projecting shank, said arbor defining a closed fluid system for exerting outward pressure on the sleeve, means for selectively varying said pressure respectively to expand the sleeve into non-slip engagement with the bore of a workpiece to be ground and to release said workpiece for replacement, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle with the workpiece in engagement with the grinding wheel and while the spindle and magnetic chuck rotate the arbor and workpiece on said independent axis.

6. A grinding machine as set forth in claim 5 wherein the said shoes are respectively located on opposite sides of the vertical plane which includes the spindle axis.

7. A grinding machine as set forth in claim 6 wherein the said sleeve is provided with a cylindrical peripheral surface which is machined with reference to the periphery of said arbor flange.

8. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having

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a driven hollow spindle coaxially supporting an annular magnetic chuck; an arbor comprising oppositely projecting coaxial shanks and an interposed coaxial cylindrical flange and having one shank extending into the central bore of the chuck for limited radial movement therein with the flange engaging and moving along the face of the chuck and with the other shank projecting forwardly into the plane of the grinding wheel adjacent the periphery thereof, a cylindrical sleeve mounted on said other shank, said arbor having axial and radial passages containing hydraulic fluid under pressure which expands said sleeve into non-slip engagement with the bore of a workpiece to be ground, a plug retractable rearwardly in said axial passage to reduce said pressure and thereby to relax said sleeve for the replacement of said workpiece, means extending through said spindle for selectively retracting said plug, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle with the workpiece in engagement with the grinding wheel and while the spindle and magnetic chuck rotate the arbor and workpiece on said independent axis.

9. A machine for peripheral grinding of a ring-like workpiece including a driven grinding wheel and a workhead which are relatively movable, the workhead having a driven hollow spindle coaxially supporting an annular magnetic chuck; an arbor comprising oppositely projecting coaxial shanks and an interposed coaxial cylindrical flange and having one shank extending into the central bore of the chuck for limited radial movement with the flange engaging and movable along the face of the chuck and with the other shank projecting forwardly into the plane of the grinding wheel adjacent the periphery thereof, a sleeve mounted on said other shank, said arbor defining a closed system for maintaining hydraulic fluid under pressure which system includes an axial passage in each shank and radial passages in said other shank, a plug biased forwardly to a closed position in the axial passage of said one shank, an adjustable plug in said other shank to set a pressure in said system capable of expanding said sleeve into non-slip engagement with the bore of a workpiece to be ground, a fluid motor mounted on the rear of said spindle having means extending therethrough and connected with said biased plug to retract the same and reduce pressure in said system whereby to relax the sleeve for replacement of said workpiece, and a pair of circumaxially spaced shoes engaging the periphery of the arbor flange to support the arbor and workpiece on an axis independent of the spindle and with the workpiece in engagement with the grinding wheel and while the spindle and chuck rotate the arbor and workpiece on said independent axis.

10. A grinding machine for a ring-like workpiece as set forth in claim 9 wherein said shoes are respectively spaced on opposite sides of a vertical plane including the axis of the spindle and are also arranged to locate said independent axis at a position laterally displaced from the spindle axis toward the grinding wheel and displaced downwardly from the spindle axis.

11. A grinding machine for a ring-like workpiece as set forth in claim 10 wherein said sleeve is provided with a cylindrical periphery which is machined with reference to the periphery of said arbor flange.

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LESTER M. SWINGLE, *Primary Examiner.*