April 22, 1958 **E. L. GRIGGS** **2,831,296**

GRINDING APPARATUS

Filed May 16, 1956 2 Sheets-Sheet 1

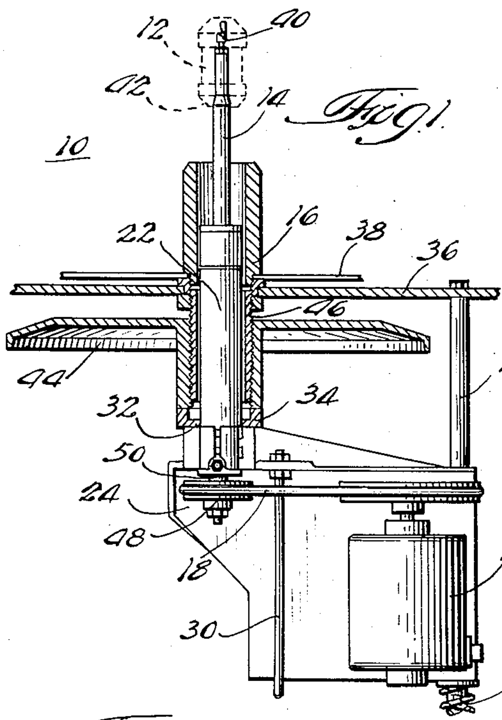
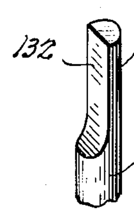


Fig. 1.

Fig. 7.



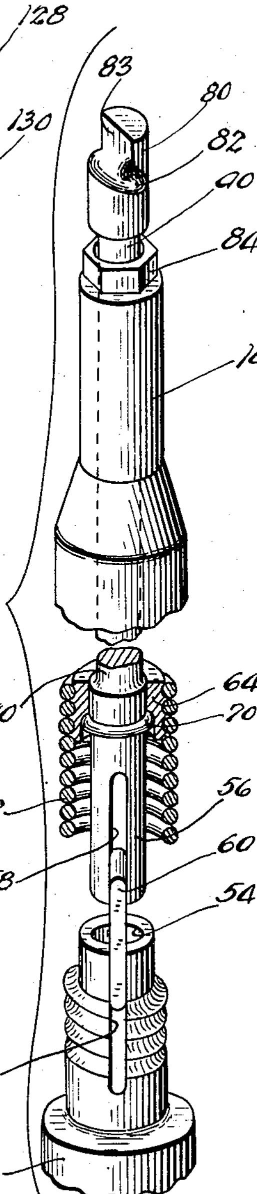


Fig. 3.

Fig. 4.

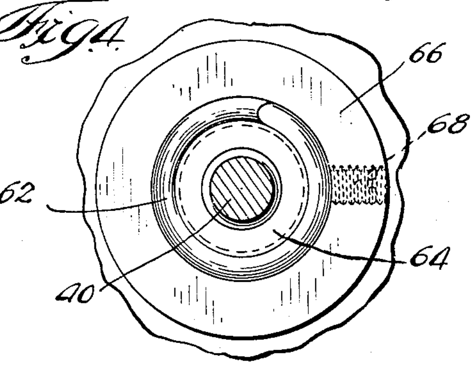
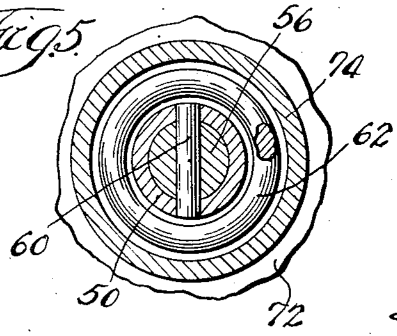


Fig. 5.



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GRINDING APPARATUS

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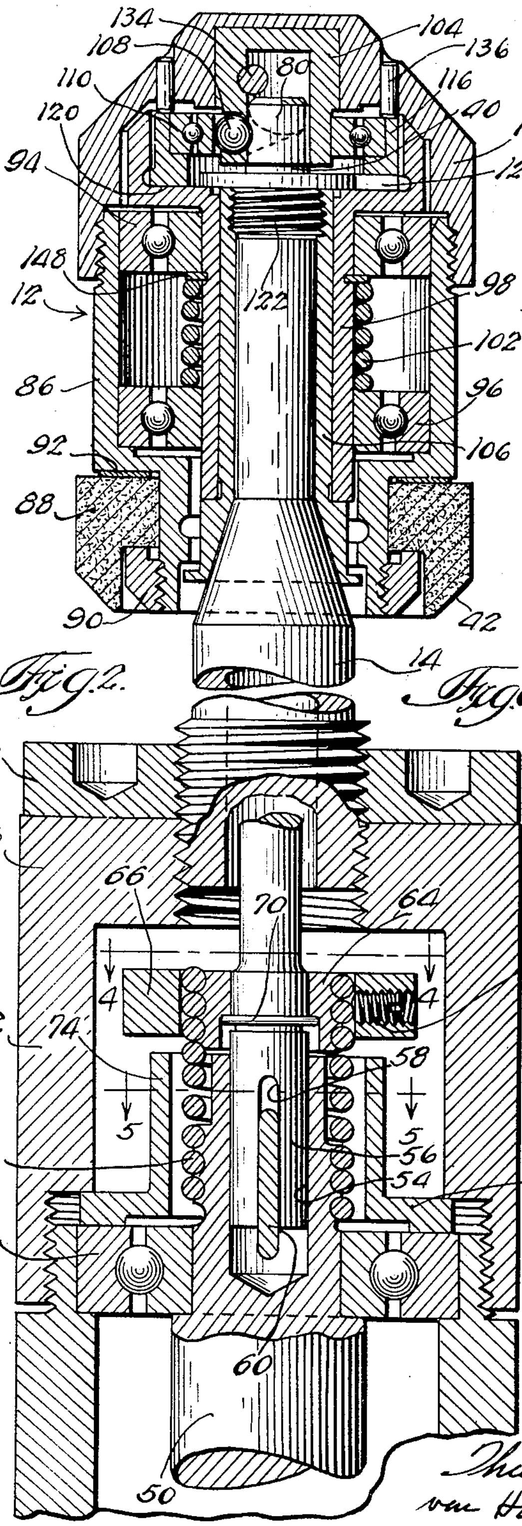

Fig. 2.

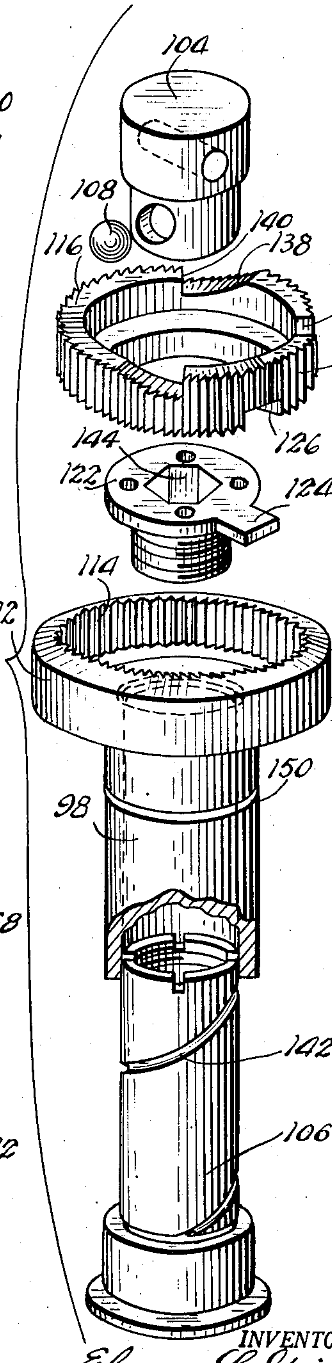

Fig. 6.

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GRINDING APPARATUS

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Application May 16, 1956, Serial No. 585,192

14 Claims. (Cl. 51—90)

This invention relates to improved grinding apparatus and more particularly to improved apparatus for precise grinding on surfaces of revolution.

In grinding surfaces of revolution such as valve seats of internal combustion engines it has heretofore been proposed to provide a rotatably mounted stone and a coaxial pilot to align the stone relative to the valve seat. The pilot accurately positions and supports a cylinder with a valve seat in position to be ground and an operator lowers the stone axially along the length of the pilot to engage the valve seat, whereby rotation of the grinder provides a new surface on the valve seat. Such concentric grinding has not proven wholly satisfactory in that the slightest uncontrolled eccentricity affects the accuracy of the resulting surface and certain areas of the seat may be ground more extensively than others. Furthermore, as it is necessary to engage the entire seat continuously while grinding with a concentric head, substantial motive force is required to drive the grinder.

To overcome these difficulties it has been proposed that a head may be mounted on a pilot shaft to rotate eccentrically relative to the pilot, whereby a grinding stone having a surface of revolution will engage a surface of revolution to be ground along a narrow straight linear area and this line will continuously rotate preferably at a speed which is a known sub-multiple of the speed of the grinder. Such eccentric grinding techniques have produced improved results with reduced power and grinding head wear. However, such eccentric rotating means are difficult to maintain and dress.

Generally, heretofore, an operator has devoted his continuous attention to one such grinding head, gradually moving the head axially relative to the surface to be ground to maintain a constant grinding pressure thereon. Thus, an operator's attention is required continuously and the maintenance of optimum grinding conditions is difficult.

It is therefore one important object of this invention to provide an improved eccentric grinder.

It is another object of this invention to provide an improved grinding head adapted for concentric grinder dressing.

It is still another object of this invention to provide improved grinding apparatus adapted for either concentric or eccentric operation at the option of an operator.

It is still another object of this invention to provide an improved grinder capable of both eccentric and concentric operation wherein the selection of the mode of operation is simple and requires no extensive adjustment or manipulation by an operator.

It is a further object of this invention to provide an improved grinder in which the pressure of the grinder surface on an associated workpiece may be preset and maintained without continuous supervision.

It is still a further object of this invention to provide improved grinding apparatus capable of unattended operation through a preset cycle of operation.

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It is another object of this invention to provide improved grinding apparatus which is more accurate and efficient than any apparatus heretofore known and which produces a cushioning effect on the workpiece whereby the grinding apparatus has an extended useful life.

It is a further object of this invention to provide improved semiautomatic grinding apparatus in which a workpiece is placed in position and a pilot spindle automatically inserted therein.

It is still a further object of this invention to provide improved grinding apparatus whereby a single operator may continuously utilize a plurality of similar grinding means in semiautomatic operation.

Further and additional objects of this invention will become manifest from a consideration of this description, the accompanying drawings and the appended claims.

In one form of this invention a rotatable grinding head is mounted on a pilot spindle in such a manner that the spindle and head are axially movable independently and resiliently urged together and more particularly a head is provided which may be used selectively for either concentric or eccentric operation on an axially movable pilot spindle wherein the head is axially movable and yieldable relative to the spindle.

For a more complete understanding of this invention, reference will now be made to the accompanying drawings wherein:

Figure 1 is a view in elevation and partially in section of one embodiment of this invention illustrating the spindle support in section;

Fig. 2 is an enlarged sectional view of the grinding head and spindle support of Fig. 1;

Figure 3 is a partial exploded view of the spindle support of Fig. 1;

Fig. 4 is a transverse sectional view of the support of Fig. 1 taken on the line 4—4 of Fig. 2;

Fig. 5 is a sectional view of the support of Fig. 1 taken on the line 5—5 of Fig. 2;

Fig. 6 is an exploded view of certain portions of the grinding head illustrated in Fig. 2; and

Fig. 7 is a fragmentary view of an alternative drive shaft adapted for concentric operation.

Referring now to the drawings and more particularly to Fig. 1, grinding apparatus **10** is illustrated comprising a grinding head **12** rotatably mounted on a pilot spindle **14** which is axially movable in a workpiece guide and housing **16**. The head **12** is in driving engagement with a shaft **40** which is, in turn, driven by coaxial shaft **50** having a sheave **48** secured to its lower end. Sheave **48** is rotated through a flexible belt **18** driven by an electric motor **20**. Shaft **50** rotatably drives grinding shaft **40**, but is axially movable relative thereto. Resilient means continuously urges shaft **40** and shaft **50** together and thus, by properly adjusting hand wheel **44**, a predetermined grinding pressure on the workpiece is provided and a predetermined total grinding travel is also provided, as will be clear from the description which follows. The head **12**, when used in the grinding apparatus **10**, will rotate eccentrically about the pilot spindle **14**, as will be clear from the description that follows, although a concentric head may be employed with the same spindle if desired.

The spindle **14** is threaded into a spindle support **22** which is mounted on a carrier **24**, carrier **24** also supporting motor **20**. The carrier **24** is vertically reciprocable, sliding on shaft **26**, and is normally urged upwardly by a heavy helical spring **28**, shown in Fig. 1. When it is desired to place a cylinder or other workpiece in position for grinding, the carrier **24** and consequently the spindle **14** may be lowered into guide **16** by actuating a pneumatic cylinder (not shown) to lower rod **30** and pull carrier

24 downwardly against the compression of spring 28. When the carrier 24 is free to move upwardly, the carrier rises until the upper edge 32 thereof abuts against a washer 34. The entire assembly to be described is mounted in a rigid frame 36 which has a sheet metal cabinet 38 formed thereover. It is contemplated that a plurality of work positions comprising independent units disposed side by side may be assembled within a single cabinet.

In operation, the head 12 is removed from spindle 14 and the spindle is lowered by actuation of rod 30. The article to be ground, for example, a single cylinder of an aircraft engine, is then placed over guide 16 and the spindle 14 is raised to pass through a valve opening in the cylinder wall and extend into the cylinder cavity. The head 12 is placed on the spindle 14 to drivingly engage rotatable shaft 40 extending upwardly through the spindle, and the pilot 14 and head 12 are gradually lowered until the grinding surface 42 engages the valve surface to be ground. Increased pressure between the grinding surface 42 and the workpiece may then be provided by operation of a hand wheel 44. Hand wheel 44 is threadedly mounted on a threaded sleeve 46 which is secured to the frame 36. Thus, clockwise motion of hand wheel 44 causes the hand wheel and washer 34 to be lowered on sleeve 46, forcing carrier 24 and consequently spindle 14 and head 12 downwardly against spring 28. Predetermined grinding pressure and travel are thus provided.

Referring now to Fig. 2 of the drawings, the resilient coupling between shaft 40 and shaft 50 will be described. Shaft 50 is rotatably mounted on bearing 52 in housing 22. A second similar bearing is disposed near the lower end of housing 22 and not shown. The upper end of shaft 50 has a central cylindrical recess 54 adapted to receive the lower end 56 of shaft 40. The lower end of shaft 40 and the upper portion of shaft 50 are provided with corresponding slots 58 which receive a driving wafer or key 60. Thus, rotational movement of shaft 50 is transmitted to shaft 40, but the shafts are free for relative axial movement. The upper end of shaft 50 is threaded to receive a coil spring 62, and a collar 64 is mounted on shaft 40 and is similarly threaded to receive several convolutions of spring 62. Spring 62 is clamped on collar 64 by an outer clamping ring 66 which is held in place by a set screw 68. Downward movement of collar 64 on shaft 40 is prevented by a retaining ring 70. Thus, as already explained, if the carrier 24 and consequently the shaft 50 and housing 22 are lowered to the point where the grinding elements engage the workpiece, further downward movement of the shaft 50 will cause the spring 62 to extend under tension, thus providing a predetermined axial grinding force.

A retaining ring 72 is provided to clamp the bearing 52 in place and has an upstanding flange 74 which prevents sediment or sludge from accumulating between the bearing races. The housing 22 is formed in two parts which are threaded together, and the pilot spindle 14 is threaded into the upper part 76. To permit initial adjustment of the pilot 14 relative to housing 76, the pilot 14 may be freely adjusted axially by rotation, and once the proper setting is obtained, the pilot is secured in place by a lock nut 78.

In Fig. 3, the essential parts of this embodiment necessary for tensioning, are clearly illustrated, wherein it can be seen that the lower end 56 of drive shaft 40 fits into a hollow recess 54 of shaft 50 with aligned slots 58 positioned to receive the connecting wedge 60. It can be seen that the shaft 40 extends upwardly through the pilot spindle 14 and terminates in a connector 80 which has a spiral groove 82 formed therein and a cut-away portion 83. The upper end 84 of spindle 14 is formed with a hexagonal cross section for positive engagement with a portion of the grinding head, to be described.

The grinding head 12 which forms an important part of this invention is shown in detail in Fig. 2. The head comprises a housing 86 having a grinding wheel 88 clamped thereon by a threaded clamping ring 90. A resilient washer 92 is disposed between the housing 86 and wheel 88 to provide a resilient mounting therefor. The housing 86 has a pair of internally mounted bearings 94 and 96 which are mounted in turn on a cylindrical support 98. A housing cover 100 is threaded onto housing 86 to retain the cylindrical support 98 and bearings 94 and 96 in place and the bearings are normally urged apart against the housing 86 and cover 100 by a coil spring 102. A drive bushing 104 is secured in cover 100 and has a central aperture therein to receive the free end 80 of drive shaft 40 or any other drive shaft adapted to operate the grinding head. Thus, if the cover 100 and housing 86 are rotated, the assembly rotates on bearings 94 and 96 about the outer cylindrical surface of support 98.

The aperture extending through support 98 is eccentrically disposed relative to the aixs of the outer cylindrical surface so that when the grinding head is rotating on bearings 94 and 96 it is rotating about an axis slightly disposed from the axis of pilot spindle 14 and drive shaft 40. The cylindrical support 98 is rotatably mounted on a hollow shaft 106 which fits snugly on pilot spindle 14. Thus, hollow shaft 106 and pilot spindle 14 are axially aligned and are adapted to accurately align with the axis of a valve seat to be ground. It is desirable in a grinding head of this type that the axis of eccentricity of the grinding wheel 88 be continuously rotated about the axis of pilot spindle 14. That is, it is desired that the axis of rotation of grinding wheel 88 gradually moves in a circle having as its center the axis of pilot spindle 14. This motion is provided by the mechanism in the upper portion of head 12.

When the drive shaft connector 80, shown best in Fig. 3, is inserted in the bushing 104 and partially rotated, the spiral recess 82 rides along the ball connector 108 until the termination of the recess 82 is reached so that the ball 108 is urged outwardly into engagement with the inner race of a bearing 110. As best shown in Fig. 6, the upper cupper portion 112 of cylindrical support 98 has an internal cylindrical surface formed with a plurality of serratons or ratchet teeth 114. A corresponding ring 116 is disposed within the cup 112. The ring 116 has its outer circumference serrated or formed with ratchets 118 whereby the ring 116 and cup 112 may be placed in driving engagement. The ring 116 has a predetermined number of serrations about its periphery and the cup 112 has an internal diameter slightly larger than the outer diameter of ring 116 and has a greater number of ratchet teeth or serrations. In the particular embodiment disclosed, ring 116 is provided with one less serration than the cup 112. The ring 116, as best shown in Fig. 2, rests on the upper shelf-like surface 120 of support 98 and receives the bearing 110.

A nut 122 is threaded into the upper end of shaft 106 and has a radially extending key 124. The key 124 engages a corresponding notch 126 formed in ring 116. Thus, the pilot spindle 14, nut 122, and ring 116 are secured together in such a manner that the parts may not rotate relative to one another. However, the ring 116 is free to move radially within predetermined limits. Thus, as the drive shaft rotates, bushing 104 and housing 86 rotate on bearing 110. As the ball 108 is urged against the bearing 110, urging the ring 116 radially outwardly at that point into engagement with cup 112, the point of engagement between cup 112 and ring 116 makes one revolution for each revolution of the head. As already stated, cup 112 has one serration more than ring 116 and thus one revolution of head 86 produces relative movement between ring 116 and cup 112 through a distance equal to the length of one tooth or serration. As the ring 116 is fixed against rotation by the key 124, it is obvious that the eccentric support 98 will rotate in the direction of rotation of housing **86** through an angle equal to one tooth for each revolution of the housing. Thus, the support **98** will gradually rotate about the hollow shaft **106** and the eccentricity of the head will be gradually shifted in a similar manner. The grinding surface **42** of wheel **88** will engage the valve face to be ground along a narrow line and this narrow line will effectively move about the entire valve seat as the head rotates.

When it is desired to dress the stone **88** to improve and renew the abrasive surface thereof it is desirable to rotate the head about a single fixed axis. To accomplish this, it is only necessary that means be provided for driving the head which will not engage ball **108**. The upper end **128** of one typical dressing drive shaft **130** is illustrated in Fig. 7. Therein, it can be seen that a semicylindrical portion has been removed from the end **128** to provide a flat diametric face **132**. The shaft **130** may be mounted in a spindle similar to spindle **14** or any appropriate support and the head placed thereon. The dressing shaft **130** will extend into bushing **104** without engaging ball **108** and will drive the head through a transverse dowel pin **134** extending through a recess in bushing **104**. As the ball **108** is not forced outwardly, there will be no motion of ring **116** relative to cup **112** and thus the head will rotate about a single fixed axis displaced slightly from the axis of pilot **14**. A dressing wheel may then be brought into abutment with grinding face **142** in a conventional manner. It is preferred that a rotatable dressing wheel mounted on an axis parallel to face **42** be employed whereby the technique of crush dressing may be employed.

A pair of pins **136** are disposed in apertures in the housing cover **100** and normally rest on ring **116**. As shown best in Fig. 6, ring **116** has a plurality of tapered notches **138** and as long as the head **12** is rotated in a clockwise direction the pins **136** will not engage the notches **138** to affect normal operation. However, in initially placing the head **12** on pilot **14**, it is desirable to partially rotate the head **12** in a counterclockwise direction whereby the pins **136** will engage the steep faces **140** of ring **116** and thus allow all of the parts of the head to move as a unit to insure proper seating of the notch **126** on key **124** and ball **108** in recess **82**.

As shown in Fig. 6, a spiral recess **142** is cut in the outer surface of hollow shaft **106** whereby small particles and accumulated grease and sludge may travel down the spiral recess without producing excessive wear between the closely fitted faces of shaft **106** and cylindrical support **98**. Nut **122** is provided with a central hexagonal aperture **144** to receive the upper hexagonal portion **84** of pilot **14** producing positive registry between the pilot and the nonrotating portions of head **12**. A snap ring **148** is secured in a circular recess **150** whereby helical spring **102** may be compressed between the ring **148** and the lower bearing **96** to facilitate assembly.

Summarizing the operation of the grinding apparatus described herein, the apparatus is especially adapted for eccentric grinding of valve seats with provisions for concentric operations of the head during dressing of the grinding faces. Resilient means is provided to produce a predetermined grinding pressure at all times without continuous supervision by an operator. Thus, a single operator may operate several spindles concurrently, greatly improving the efficiency of engine maintenance operations. The grinding apparatus of this invention may be utilized in renewing any surfaces of revolution, either cylindrical or conical, and these are generally included within the term "circular surfaces." Various modifications of the structure employed herein will occur to one skilled in the art, but any structures capable of performing as described are believed within the spirit and scope of this invention. For example, while the cup **112** and ring **116** are shown with serrated engaging surfaces it will be clear that a friction drive, small spur gear teeth, or the like, may be substituted therefor. Also, a grinder head similar to the head described, but eliminating the mechanism for producing eccentric motion, may be employed interchangeably for conventional concentric grinding operation.

Without further elaboration, the foregoing will so fully explain the character of my invention that others may, by applying current knowledge, readily adapt the same for use under varying conditions of service, while retaining certain features which may properly be said to constitute the essential items of novelty involved, which items are intended to be defined and secured to me by the following claims.

I claim:

1. Grinding apparatus comprising a cylindrical support, an abrasive grinding element rotatably mounted on said cylindrical support and having an outer grinding surface concentric with said support, a supporting shaft, said cylindrical support being eccentrically mounted on said supporting shaft, and means connecting said cylindrical support and supporting shaft, said means comprising a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, and pressure means rotatable with said grinding element and urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support.

2. The grinding apparatus recited in claim 1 wherein said cylindrical surface and said second cylindrical surface are correspondingly serrated.

3. The grinding apparatus of claim 2 wherein said cylindrical surface has a plurality of serrations and said second cylindrical surface is similarly serrated and has one less serration than said cylindrical surfaces.

4. The grinding apparatus of claim 1 wherein said supporting shaft is hollow to pass a driving shaft therethrough, said grinding element being drivingly connected selectively to one of a plurality of driving shafts, at least one of which engages said pressure means to provide relative rotation of said supporting shaft and said cylindrical support.

5. A grinding head comprising a cylindrical support, a housing surrounding said cylindrical support and mounted for rotation thereon, an abrasive grinding element secured to said housing and having an outer grinding surface concentric with said support, said support having a longitudinal aperture therethrough displaced from the central axis thereof, a hollow supporting shaft rotatably mounted within said longitudinal aperture, a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, said housing having a central aperture to drivingly receive a driving shaft, radially movable pressure means mounted in said housing and engageable by said driving shaft, said pressure means urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support.

6. Apparatus for driving a grinding head and for maintaining a predetermined axial pressure between such grinding head and a workpiece comprising a rotatable shaft having a free slotted end, a concentric grinding head supporting shaft having a slotted portion in spaced relationship to said slotted end, key means disposed within said slotted portion and said slotted end to provide a driving connection therebetween while permitting relative axial movement therebetween, and helical spring means threaded onto the outer surface of said slotted end and threadedly engaging said slotted portion permitting limited resilient axial movement therebetween.

7. Grinding apparatus comprising a fixed pilot to en-

gage and align a workpiece, a hollow supporting shaft mounted on said fixed pilot, a cylindrical support eccentrically mounted on said supporting shaft, an abrasive grinding element rotatably mounted on said cylindrical support and having an outer grinding surface concentric with said support, and means connecting said cylindrical support and said supporting shaft, said means comprising a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, and pressure means rotatable with said grinding element and urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support.

8. Grinding apparatus comprising a fixed hollow pilot to engage and align a workpiece, a coaxial driving shaft extending through said hollow pilot, a hollow supporting shaft mounted on said fixed pilot, a cylindrical support eccentrically mounted on said supporting shaft, an abrasive grinding element rotatably mounted on said cylindrical support and having an outer grinding surface concentric with said support, and means connecting said cylindrical support and said supporting shaft, said means comprising a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, and pressure means rotatable with said grinding element and urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support.

9. Grinding apparatus comprising a fixed hollow pilot to engage and align a workpiece, a coaxial driving shaft extending through said hollow pilot, a hollow supporting shaft mounted on said fixed pilot, a cylindrical support eccentrically mounted on said supporting shaft, a housing surrounding said cylindrical support and mounted for rotation thereon, an abrasive grinding element secured to said housing and having an outer grinding surface concentric with said support, a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, said housing having a central aperture to drivingly receive a driving shaft, radially movable pressure means mounted in said housing and engageable by said driving shaft, said pressure means urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support.

10. The grinding apparatus of claim 9 wherein the shape of said driving shaft determines the actuation of said pressure means.

11. The grinding apparatus of claim 9 wherein a plurality of driving shafts are interchangeably provided, at least one of said shafts actuating said pressure means.

12. Grinding apparatus comprising a cylindrical support, an abrasive grinding element rotatably mounted on said cylindrical support and having an outer grinding surface concentric with said support, a supporting shaft, said cylindrical support being eccentrically mounted on said supporting shaft, means connecting said cylindrical support and supporting shaft, said means having a fixed condition whereby said grinding element rotates on said cylindrical support about a single fixed axis and a condition providing positive movement of said cylindrical support relative to said supporting shaft whereby said grinding element rotates about a plurality of axes, the locus of said axes defining a cylinder, and means for driving said grinding element and for maintaining a predetermined axial pressure between said grinding element and a workpiece comprising a rotatable shaft having a free slotted end, a concentric grinding element supporting shaft having a slotted portion in spaced relationship to said slotted end, key means disposed within said slotted portion and said slotted end to provide a driving connection therebetween while permitting relative axial movement therebetween, and spring means connecting said slotted end and said slotted portion permitting limited resilient axial movement therebetween.

13. Grinding apparatus comprising a fixed hollow pilot to engage and align a workpiece, a coaxial driving shaft extending through said hollow pilot, a hollow supporting shaft mounted on said fixed pilot, a cylindrical support eccentrically mounted on said supporting shaft, a housing surrounding said cylindrical support and mounted for rotation thereon, an abrasive grinding element secured to said housing and having an outer grinding surface concentric with said support, a cylindrical surface integrally connected to said cylindrical support, a second cylindrical surface of substantially smaller diameter fixed against rotation relative to said supporting shaft and radially movable relative thereto to engage said cylindrical surface along a single line, said housing having a central aperture to drivingly receive a driving shaft, radially movable pressure means mounted in said housing and engageable by said driving shaft, said pressure means urging said second cylindrical surface into engagement with said cylindrical surface along said single line which rotates about said cylindrical support, and means for maintaining a predetermined axial pressure between said grinding element and a workpiece comprising a rotatable shaft having a recessed and transversely slotted free end, said coaxial driving shaft being correspondingly slotted and coaxially mounted in said recessed free end, key means disposed within said recessed free end and connecting the slots thereof and said slotted portion to provide a driving connection therebetween, while permitting axial movement therebetween, and spring means connecting said free end and said slotted portion together.

14. Apparatus for rotatably driving a grinding head and for maintaining a predetermined axial pressure between said grinding head and a workpiece while permitting limited relative movement between said head and the support therefor, said apparatus comprising a grinding head supporting member adapted to engage said workpiece and accurately support said grinding head relative thereto, said head being axially movable on said supporting member, a driving shaft having a free end and rotatably supported in said supporting member, a grinding head engaging shaft generally coaxial with said driving shaft and having an end portion adjacent said free end, said grinding head engaging shaft being freely mounted in said supporting member for axial and rotative movement, connecting means between said free end and said end portion permitting relative axial movement therebetween while providing a rotative driving connection, and spring means connecting said free end and said end portion and urging said grinding head toward said workpiece.

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