

May 13, 1969

J. I. POPE ETAL

3,443,399

HIGH SPEED UNIVERSAL SPINDLE FOR A GRINDING MACHINE

Filed Oct. 28, 1966

Sheet 1 of 3

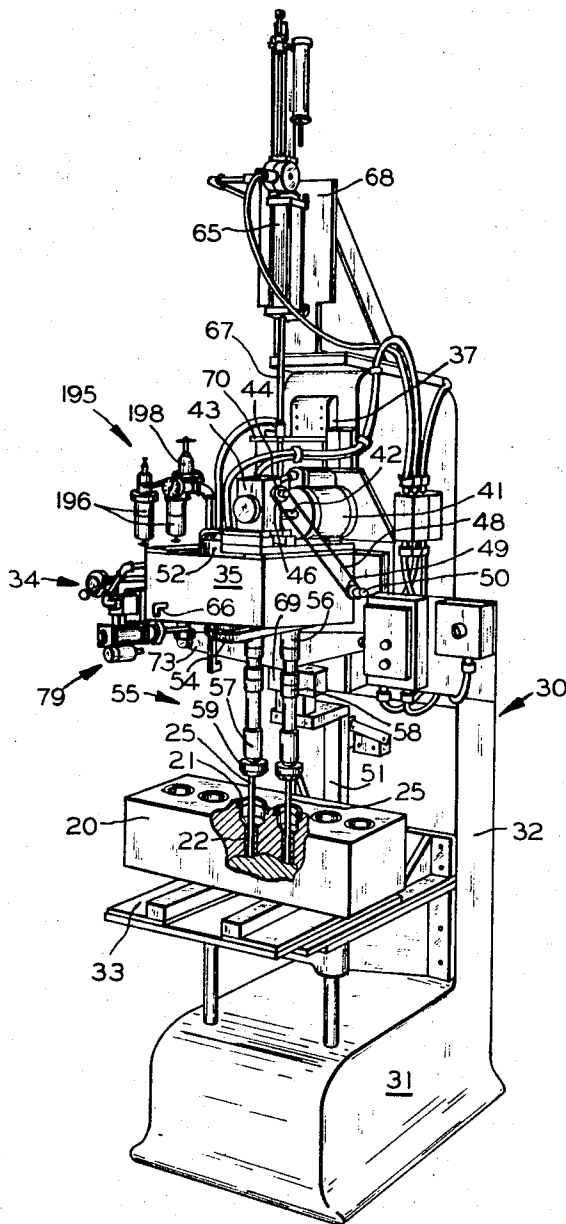


FIG. 1

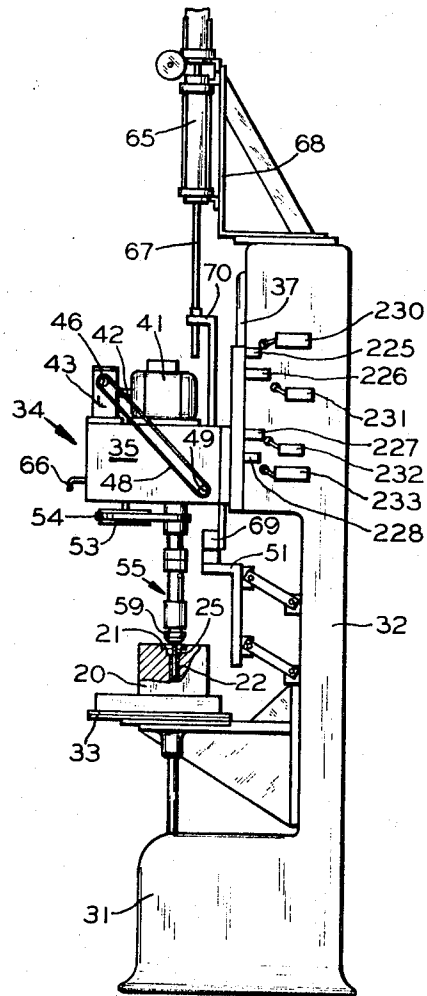


FIG. 2

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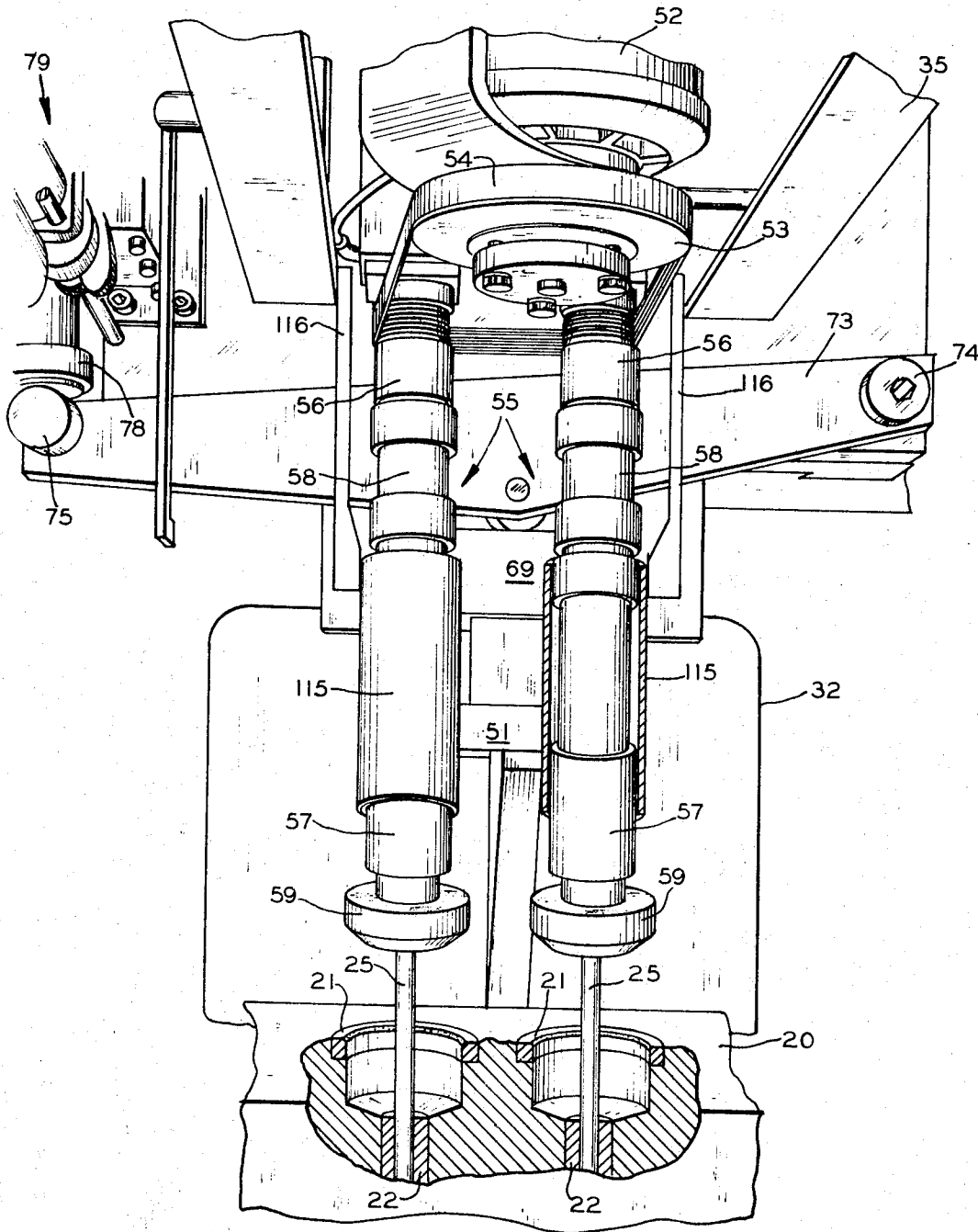


FIG. 3

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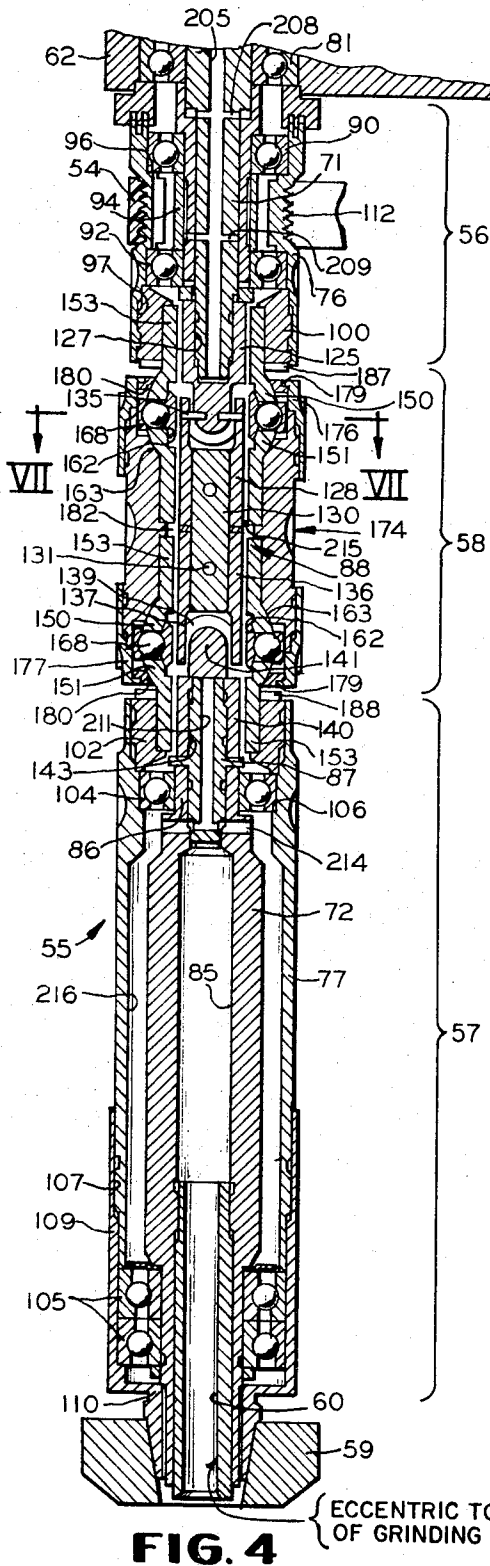


FIG. 4

ECCENTRIC TO AXIS
OF GRINDING WHEEL 59

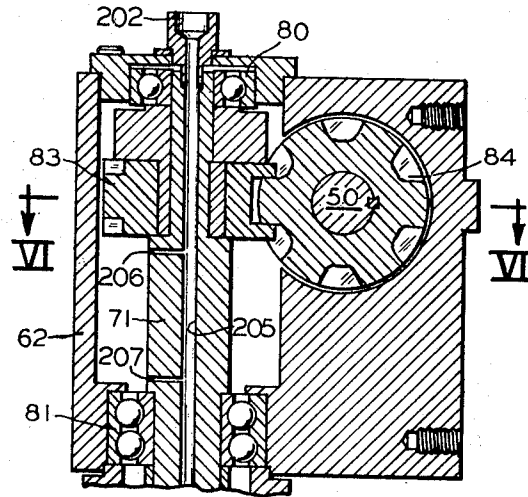


FIG. 5

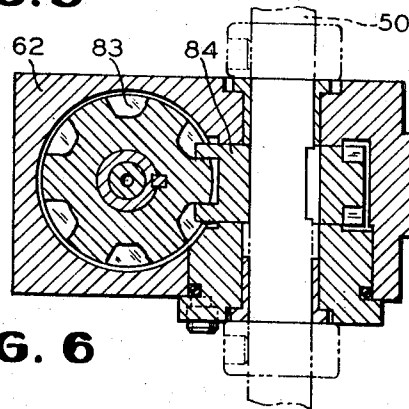


FIG. 6

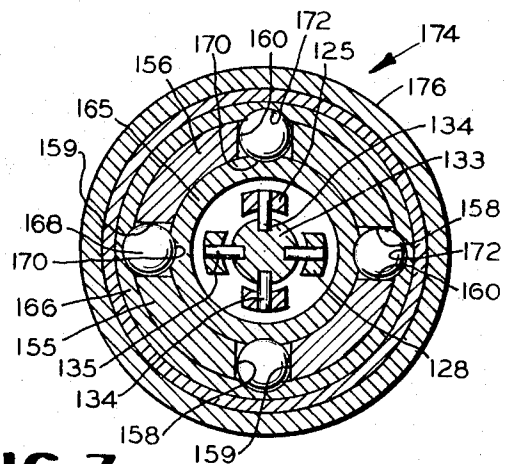


FIG. 7

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3,443,399

HIGH SPEED UNIVERSAL SPINDLE FOR A GRINDING MACHINE

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Filed Oct. 28, 1966, Ser. No. 590,251

Int. Cl. F16c 1/02; F16d 3/00; B24b 15/00

U.S. Cl. 64—2

11 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to high speed grinding machines including the multiple spindle type, and is particularly directed to valve seat grinders in which the grinding wheel driving spindles include positively driven spaced double universal joint means which not only permit relatively great angular and/or lateral adjustment between two or more fixed pilots which may not be in exact parallelism and/or spacing, but also provides positive and unrestricted uniform high speed rotation and simultaneous eccentric gyration of the grinding wheels on said pilots.

BACKGROUND OF THE INVENTION

Heretofore, grinders have been provided with grinding wheel carrying spindles which are divided into universally jointed upper and lower sections for transmitting eccentric and/or concentric motion to the grinding wheel, but such were limited to Oldham type joints which restricted the amount of angular and/or lateral adjustment and also produced a spurious piloting effect. Accordingly, this invention is further directed to improvements in grinders of such type, examples of which are shown in U.S. Letters Patent Nos. 2,116,498, 2,338, 509, and 3,106,804, the latter showing a multiple spindle machine.

DESCRIPTION OF INVENTION

(a) Objects and advantages

An object of the present invention is to provide an improved grinding machine for more accurately and economically grinding valve seats by uniformly and positively driving the grinding spindles to thereby reduce the possibility of grinding oval seats.

Another object of the invention is to provide a multiple spindle machine with improved grinding spindle means capable of compensating for up to four times greater angular and/or lateral misalignment between fixed pilots in adjacent valve guides without creating undue stresses in the spindles.

Another object of the invention is to eliminate the disadvantages of prior spindles which incorporated Oldham type joints by the use of constant velocity and therefore uniform motion universal joints to positively drive the grinding wheels and prevent piloting thereof by such prior type joints.

A further object of the invention is to produce a simple, efficient, effective and economic high speed and positively driven grinding spindle capable of use in a multiple spindle type grinding machine.

Another object of the present invention is to provide a machine for grinding valve seats with multiple spindles, each spindle having spaced outer sleeve members, inner shaft members, and a pair of spaced double universal joints between said sleeve members and said shaft members for positively and unrestrictedly aligning the spindles with the valve seats.

Another object of the invention is to provide an improved double universal joint for concentric inner and outer shaft ends with yoke means, block means between

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the inner shaft yokes, balls between said outer shaft yokes and inner and outer race means for the balls to align said balls with the axis of the block means.

Another object of the invention is to provide a valve grinding machine spindle with improved lubricating means including oil mist producing means for blowing oil mist into the space between the inner and outer shafts of the spindle to lubricate the universal joints.

Another object of the invention is to provide a valve grinding machine with common means to drive multiple spindles by gear means for the inner slow speed shafts and belt means for the outer high speed shafts or sleeves.

(b) Brief description of views

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a multiple spindle machine incorporating the invention;

FIG. 2 is a schematic side elevation of the machine shown in FIG. 1 showing some of the operation control switches and air cylinders controlled thereby;

FIG. 3 is an enlarged front view of an intermediate portion of the machine shown in FIG. 1 showing the drive means for the outer sleeve members of the spindles and the guide shields for the spindles;

FIG. 4 is an enlarged vertical sectional detail view of one of the spindles shown in FIG. 3;

FIG. 5 is an enlarged sectional detail view of the drive gear box for the spindle shown in FIG. 4;

FIG. 6 is a sectional detail view taken substantially on a line VI—VI of FIG. 5; and

FIG. 7 is a sectional detail view taken substantially on a line VII—VII of FIG. 4.

(c) Detailed description

(1) Multiple spindle machine.—Referring specifically to FIGS. 1, 2, and 3, this invention has been illustrated as embodied in a multiple spindle automatic machine for simultaneously grinding a pair of valve seats in the head 20 of an internal combustion engine, in which each of the valve seats 21 is provided with a central valve guide 22 axially aligned and spaced therefrom. As shown in more detail in FIG. 3, the valve guides 22 may comprise sleeves and the valve seats 21 may comprise rings which are inserted in the cylinder head casting or block 20. Each valve guide 22 may have a removable pilot 25 fitted therein prior to the grinding operation, or this pilot may be carried by the spindle as shown in above mentioned Patent No. 3,106,804.

The multiple spindle machine 30 shown in FIG. 1 comprises a base 31 and a vertical support 32. Positioned above base 31 is a workpiece supporting table 33 to the top of which may be attached a suitable fixture for holding the cylinder head or block 20.

Adjacent to the front of vertical support 32 may be mounted a spindle and tool supporting and feeding unit 34, including a frame or saddle portion 35 which may overhang the work 20 and may be supported on vertical slideways 37. On saddle 35 is mounted a first driving motor 41 having a shaft 42 connected to a gear box 43 having an output shaft 44 mounting a sprocket 46 drivingly connected by chain 48 to a sprocket 49 on the outer end of a cross shaft 50 journaled in saddle 35. Forwardly of shaft 50 is a second or high speed motor 52 (see also FIG. 3) having a vertical shaft on which a pulley 53 is fixed. Motor 52 may be one that is capable of 10,000 r.p.m. as it is used to import rotation through a belt 54

to at least one grinding wheel for insuring a finish grind to a valve seat.

Also from frame 35 depend two rotatable spindles 55. Each of these spindles 55 may comprise an upper driving shaft section 56 and a lower driven shaft section 57 connected by vertically spaced double universal joints 58 to permit automatic centering of the cutting or grinding tools on the lower ends of the spindles 55, in the event the valve guides 22 and seats 21 for any two cylinders or heads 20 may be out of parallelism and spacing with respect to each other and the spindles. These joints 58 permit both angular and lateral displacements to compensate for any such misalignments and irregularities. At the lower end of each spindle, the tool shown is a grinding wheel 59, which in FIG. 4 is shown to rotate with the lower end of the driven shaft section 57, in which may be located a hollow shaft or sleeve having a socket 60 which is eccentric to the rotating axis of the grinding wheel 59. This hollow shaft or sleeve 60 may be rotated at a different and preferably slower speed than that of the grinding wheel 59 to give a planetary motion thereto, so that the wheel will at any one instance only grind one part of the surface of the seat 21 as is shown in FIG. 3. At the upper end of each spindle is a gear box 62 for rotating sleeve 60 through inner shaft mechanism later to be described, the gear boxes receiving their power from motor 41 through cross shaft 50.

Also mounted on and adjacent the front of the vertical support 32 may be a pedestal 51 to support a plurality of grinding wheel dressing tools (not shown). These tools may be mounted and operated in the manner shown and described in Gray et al U.S. Patent No. 3,106,804 issued on Oct. 15, 1963. Since the grinding wheels 59 have eccentric motion, means including a lever mechanism 66 may be connected to the gear boxes 62 for locking the eccentric sleeves 60 in the same position and from rotation during the dressing operation.

It is to be clearly understood, however, that the grinding wheels 59 may be replaced by other types of cutting tools such as boring, machining, milling, etc., type tools and these tools need not necessarily be driven eccentrically as those disclosed herein, but may be concentrically or angular concentrically or angular eccentrically driven around a hollow shaft in the same manner as the grinding wheel 59 around sleeve 60. These other types of angular guided grinding wheels are specifically shown in FIGS. 10 and 5, respectively, of Hall et al. U.S. Patent Nos. 2,338,509 and 2,338,763 issued respectively on Jan. 4 and Jan. 11, 1944.

Means are provided to move the saddle 35 (see FIGS. 1 and 2) vertically, such means including an air cylinder 65 for fast and coarse adjustments provided with a piston for actuating a piston rod 67. The cylinder 65 is connected to a source of pressure air (not shown) and may be mounted on a bracket 68 secured to the top of the vertical support 32 and piston rod 67 is connected to plate 70 mounted adjacent the rear of saddle 35. For coarse adjustment, there is provided a pre-set stop means 69 to limit the downward movement of saddle 35, which means 69 engages the central part of a cross arm 73 pivoted at one end at 74 to the saddle 35. Projecting outwardly from the other end of arm 73 is a pin 75 adapted to be engaged by a variable feed vertically disposed plunger 78 mounted on and movable relative to the saddle 35. Thus, after the center of the arm 73 engages fixed stop 69, further downward movement of saddle 35 may be controlled by the slow upward movement of the plunger 78 to feed the grinding wheel 59 by gravity the desired distance into the valve seat 21. This fine adjustment of the plunger 78 may be regulated by an adjustable air cylinder motor, rack, pinion and screw mechanism 79 shown mounted on the left side of the saddle 35 in FIGS. 1 and 3.

(2) The spindles.—In the embodiment described herein and as shown in FIG. 4, each spindle 55 includes an

articulated center or inner shaft assembly which comprises a drive or upper section 71 and a driven or lower section 72, and also includes an outer or grinding wheel driving shaft or sleeve assembly concentric with the inner shaft sections 71 and 72. The outer sleeve assembly likewise comprises an upper section 76 and a lower section 77 mounted, respectively, on the shaft sections 71 and 72. The upper and lower sections 71 and 72 of the inner shaft and outer sleeve sections 76 and 77 are connected for driving coaction and at the same time both of the lower sections 72 and 77 are capable of universal angular or tilting and lateral movement with respect to their upper sections 71 and 76 to permit the inner shaft to mount over a guide pilot 25 and also the grinding wheel to accommodate itself to the valve seat 21 to be ground.

The inner shaft upper section 71 is journaled in the bearings 80 and 81 in gear box 62 (see FIG. 5) and is driven therefrom through gears 83 and 84 mounted on the section 71 and the cross shaft 50 respectively. The lower section 72 (see FIG. 4) is provided with a longitudinally extending bore 85 which is concentric to the axis of the upper section 71 and terminates in an upper or inner reduced portion 86 threaded to receive a coupling 87 for a sleeve yoke member of a double Cardan type universal joint 88 for universally connecting the upper 71 and lower 72 sections of the inner shaft together as hereinafter described.

The drive section 76 of the outer sleeve is mounted concentrically on the shaft section 71 on upper and lower sets of ball bearings 90 and 92 respectively, which are held in spaced relation on the shaft section by a bushing 94 interposed between the inner races thereof and mounted in the sleeve section 76. The upper end of the sleeve section 76 in the present instance, is shouldered at 96 to receive the outer race of the upper ball set 90, and its lower end, below the ball set 92, is internally threaded at 97. A ring 100 threads into the lower end portion of said sleeve 76 in engagement with the adjacent end of the outer race of the ball set 92.

The lower sleeve section 77 is rotatably mounted on the shaft section 72 on upper and lower spaced sets of ball bearings 104 and 105, which are concentric to the axis of longitudinal center of the shaft section 72. A shoulder 106 on the sleeve section 77 engages the outer race of the inner ball bearing set 104 and the sleeve section 77 terminates at the outer race of the ball bearing set 105. The sleeve section 77 is threaded at 107 to receive the threaded end of an enlargement 109 of the hub 110 of the grinding wheel 59.

The adjacent end portions of the sleeve sections 76 and 77 are connected, in the present instance, by a double universal joint of the constant velocity type to be described hereinafter. This provides a floating connection between the two sections and permits a yielding driving of one spindle section by the other and also allows for any relative tilting or adjusting movement of one section relative to the other.

The sleeve sections 76 and 77 are intended to be driven at high speed, in the present instance, through a multiple V-sheave 112 or other drive sheave from a suitable drive means such as belt 54 to drive pulley 53 on the shaft of the second motor 52. This belt also drives a similar sheave 112 on the other spindle in this assembly. This gives a high speed grinding action to the grinding wheels 59. The speed of driving of the inner shaft is slower so that in the case of eccentric grinding, for which the present device is adapted, the point of contact of the grinding wheel with the valve seat is caused to progressively travel around the seat during the grinding action, as well understood in the art.

In order to adapt the present device for eccentric grinding, the shaft section 72 may have the pilot receiving portion or sleeve 60 disposed with its axis offset slightly or eccentric with respect to the axis of the shaft section 72. The spacing of the two axes is slight, but sufficient, how-

ever, so that the grinding wheel is positioned with respect to the valve seat to cause it to have grinding coaction with one side only of the seat at a time, which point of engagement progresses therearound as the shaft is rotated. Further description is believed unnecessary as such features and advantages are fully disclosed in the above noted prior Patents Nos. 2,116,498 and 2,338,509.

Guide means in the form of sleeves or shields 115 are provided for the spindles 55 to prevent undue erratic motion when the spindles are retracted and disengaged from their pilots 25. In other words, due to the high speed rotary motion of the spindles 55 and the double universal joint connections therein, the lower ends of the spindles would tend to flap unless restrained until rotation is stopped. The shields 115 are fixed to the lower portion of frame 35 by bracket arms 116 so as to move vertically with the frame and thus with the spindles 55. Therefore, motor 52 preferably also is provided with means for immediately braking its rotation as soon as its current is cut off by the starting of the withdrawal of the grinding wheels from the valve seats after they have been ground.

(3) The double universal joints.—As particularly shown in FIGS. 3 and 4, the upper and lower shaft sections, as well as the upper and lower sleeve sections, are connected by the spaced double universal joint elements 58. The joints between the shaft sections 71 and 72 may be simple Cardan type joints as the shaft is rotated at comparatively slow speed. Thus, these joints may include a sleeve yoke 125 internally threaded to receive the lower threaded end 127 of shaft section 71 and a sleeve yoke 128 in which one end of a connecting plug or pin 130 is secured as by rivet 131. Between the yoke ends of yokes 125 and 128 is block 133 (see FIG. 7) pivoted at 134 to yoke 125 and at a right angle thereto as at 135 to yoke 128. Secured to the opposite end of pin 130 is sleeve yoke 136 pivoted at 137 to opposite sides of a block 139, another sleeve yoke 140 being pivoted at a right angle to yoke 136 to block 139 as at 141. Yoke 140 is threaded at 143 to receive the threaded coupling 87 to connect the joints to lower shaft section 72.

The joints between the sleeve sections 76 and 77 are of the positive constant velocity type and comprise pairs of driving and driven yoke members 150 and 151 which include sleeve portions 153 from which project opposed yokes 155 and 156 having faces 158 (see FIG. 7) that in the assembled relation of the joint are mutually parallel with the opposing faces 159 and 160 of the other yokes. The yokes 155 and 156 have inner 162 and outer 163 spherical surfaces for receiving spherical surfaces of inner and outer ball races 165 and 166, respectively.

Rolling members, preferably balls 168, are interposed between each pair of opposed faces 159, 160 and bridge the space therebetween by a press fit to eliminate lost motion. The centers of the balls 168 are all held in a plane which intersects the center of the joint by means of the relation between the balls and a spherical groove 170 in the inner race 165.

The outer race 166 surrounds the joint assembly and is provided with a spherical groove 172 somewhat more shallow than groove 170 so that the race 166 may be forced over the balls 168 to complete the assembly and retain the balls within the groove 170 in inner race 165.

Adjacent ends 154 of the yoke members are press fit in an intermediate sleeve member or housing 174 having closure means at its opposite ends in the form of rings 176 and 177 having internal threaded engagement with the sleeve member 174 and an inwardly directed flange or lip 179 for engaging and retaining an annular seal 180 against the outer spherical surface of the yoke 150 adjacent the sleeve portion thereof. An annular rib 182 may be provided in the bore of sleeve member 174 to serve as a spacer between the adjacent ends of the yoke members.

The outer ends of the yoke members are press fit in annular plugs or rings 100 and 102 having threaded en-

gagement in sleeve sections 76 and 77, respectively. The rings 100 and 102 are provided with projections 187 and 188 adapted to be engaged by a suitable tool to facilitate assembly and disassembly of the yoke members 150 and 151 in the spindles 55.

Thus, the coupling connection between the sleeve sections 76 and 77 imparts positive and uniform high speed rotation from one to the other, and at the same time, permits the lower section 77 to have not only angular or rocking movements relative to the section 76, but also to have lateral bodily shifting movements relative to such section so that the axis of one section may be moved out of register with that of the other section. This enables the shaft section 77, which is intended to receive and have centering engagement with a pilot 25, to accommodate itself to the position of such pilot which may be out of alignment with respect to the axis of the shaft and sleeve sections 71 and 76, or may be positioned so that its axis is out of coinciding or intersecting relation to the axis of the sections 71 and 76, or both of such conditions may be present.

(4) Spindle lubrication.—Due to the high speed rotation of the spindles, complete lubrication of the parts thereof is essential. To accomplish this, an air-oil mist may be supplied to the interior of each spindle 55 from a source such as an atomizer indicated generally at 195 (see FIG. 1) including a pair of oil supply bowls 196 connected to an air control valve 198 to which pressure air is supplied from a compressor (not shown). The proportion of air and oil may be controlled by the valve 198, and the mixture may be passed to the upper end of section 71 of upper shaft of the spindles 55 through suitable tubing connected as at 202 thereto (see FIG. 5).

The drive section 71 is provided with a longitudinal bore or duct 205 (see FIG. 4) extending the full length thereof and from which radially extend spaced outlets or nozzles 206, 207, 208, and 209 so that the air-oil mist is directed outwardly to lubricate the bearings 80 and 81, gears 83 and 84, and bearings 90 and 92 from which the lubricant passes through the space 215 between the inner and outer double joints to lubricate the same, and then to bearing 104 and through space 216 to lower double bearing 105. Coupling 87 is also provided with a longitudinal bore or duct 211 to pass lubricant from lower inner joint to radial outlets or nozzles 214 opening into the space 216 between the driven section 72 of the lower shaft and lower outer sleeve 77 to also supply the lower ends of spindles 55 and bearing 105 with lubricant. Means are provided to insure actuation of the air-oil mist supply prior to operation of the spindles 55.

(5) The machine operation.—Referring now again to FIGS. 1 and 2, there may be provided a series of cams 225, 226, 227, and 228 mounted on the vertically movable saddle 35 which cooperate respectively with control switches 230, 231, 232, and 233 which control the automatic operation of the device.

Thus, in the automatic operation of the machine after the work piece 20 has been clamped onto the table 33, an electric control cycle button may be pushed which first starts the saddle 35 to descend rapidly until cam 227 operates control switch 232 which may operate a solenoid valve in an air line to the air-oil mist control valve 198 to initiate lubrication of the spindles prior to energization of motors to rotate the spindles 55. Next, the cam 228 contacts the switch 233 to start the motors 41 and 52 indicating that the saddle has now reached the position at which the grinding or cutting operation can commence, after which a switch 231 may be actuated by cam 226 to start the fine adjustment feeding mechanism 79. At the limit of the fine adjustment feeding, a time delay switch 230 is operated by cam 225 to first stop the feeding and then, after the delay, to simultaneously stop the motors 41 and 52 and operate a solenoid valve to move the piston in cylinder 65 to raise the saddle 35 and the spindles 55 out of engagement with the pilots 25 in position in the

work piece 20. After the motors are de-energized, the flow of lubricant may also be shut off by switch 230. The work piece 20 is then removed and the next piece is inserted and clamped in its place on table 33, and the start button pushed again to repeat the cycle.

While the device shown has been particularly described for use in connection with a multiple spindle grinding machine, it will be understood that its use is not limited to grinding machines, and particularly valve seat grinders, but may be used in any connection for which it may be adapted, and also that the device may be used separately from such a machine and as an individual unit in either grinding or other operations for which it may be adapted.

It will also be understood that while the sections 56 and 57 of the spindle 55 for convenience have been referred to as upper and lower sections, inasmuch as the devices are usually used above the work, it is not intended or desired by such description to restrict the device to use above the work. The upper and lower shaft and spindle sections also may be considered as inner and outer sections, respectively, but this terminology is not used in the specification, as it tends to cause confusion where reference is made to the inner and outer end portions of the respective parts.

It will also be understood that while a valve seat grinding means embodying the invention is capable of use in a single spindle machine where only one valve seat at a time is ground, it is particularly intended for use in a multiple spindle machine wherein the separate grinding means acts simultaneously on a plurality of valve seats and wherein, in practice, the condition is encountered of variance in centers between one or more grinding spindles of the machine and of the valve seats operated on.

While there is described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example, and not as a limitation to the scope of this invention.

What is claimed is:

1. A universal spindle for a machine, said spindle comprising:

- (A) an outer rotating sleeve having axially spaced driving and driven sections,
- (B) an inner rotating shaft having axially spaced driving and driven sections,
- (C) a pair of spaced double universal joints along said sleeve and shaft in the space between and connecting said sections,
- (D) an eccentric socket in said driven shaft section, and
- (E) guide means extending longitudinally of at least a portion of said spindle.

2. A universal spindle according to claim 1 for a grinding machine for grinding valve seats, comprising a grinding wheel mounted on said driven sleeve section.

3. A grinding machine according to claim 2 wherein said means to rotate said spindles includes gear means for

rotating said inner shafts and belt means for rotating said outer sleeves.

4. A grinding machine according to claim 3 having a parallel pair of said spindles wherein the belt means is common to both said spindles.

5. A universal joint spindle according to claim 1 and further including a source of air-oil mist lubrication and means to connect said source to said inner shaft.

6. A universal spindle according to claim 5 wherein said inner shaft sections are provided with longitudinal ducts for said lubricant.

7. A universal spindle according to claim 5 wherein said outer sleeve sections are spaced from said shaft sections to provide a longitudinal channel for said lubricant.

8. A universal joint spindle according to claim 1 wherein said universal joint between said sleeve sections comprises a constant velocity joint means to positively and uniformly drive said driven sleeve section from said driving sleeve section.

9. A universal spindle according to claim 1 wherein said double universal joint comprising:

- (A) a pair of shafts end to end having first yokes at their adjacent ends,
- (B) a block means between said first yokes, and
- (C) a pair of pivots at right angles to each other for connecting said first yokes to said block means to form an inner universal joint.
- (D) a pair of sleeves, spaced from each of said shafts and having second yokes at the adjacent ends of said sleeves, and
- (E) balls between adjacent arms of said second yoke means, the centers of opposite pairs of the balls being aligned with the axes of said pivots to form an outer universal joint.

10. A double universal joint according to claim 9 and including inner and outer race means for retaining said balls in the plane of said axes.

11. A double universal joint according to claim 10 and including an intermediate sleeve for said outer universal joint for retaining said outer race means.

References Cited

UNITED STATES PATENTS

1,774,701	9/1930	Davenport	64—1 X
1,868,540	7/1932	Myers	64—21
2,455,870	12/1948	Maul, et al.	64—1 X
2,466,359	4/1949	Beverlin	51—90
2,570,335	10/1951	Fitch	64—2
3,106,804	10/1963	Gray et al.	51—90

HALL C. COE, *Primary Examiner*.

U.S. CI. X.R.

51—90; 64—6, 21