

June 18, 1946.

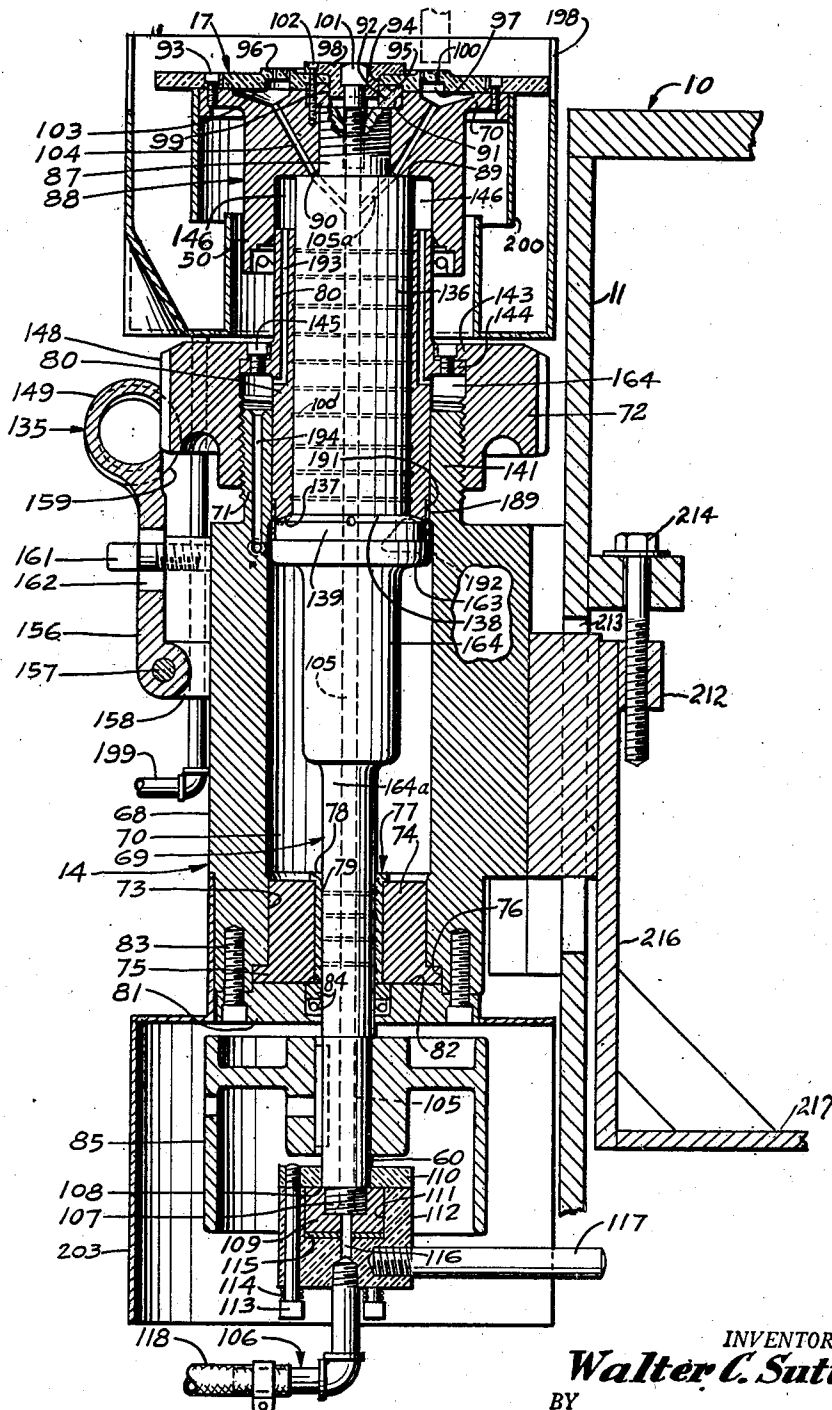
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2,402,305

METHOD AND APPARATUS FOR GRINDING PLANE SURFACES

Filed Nov. 4, 1943

4 Sheets-Sheet 2



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4 Sheets-Sheet 3

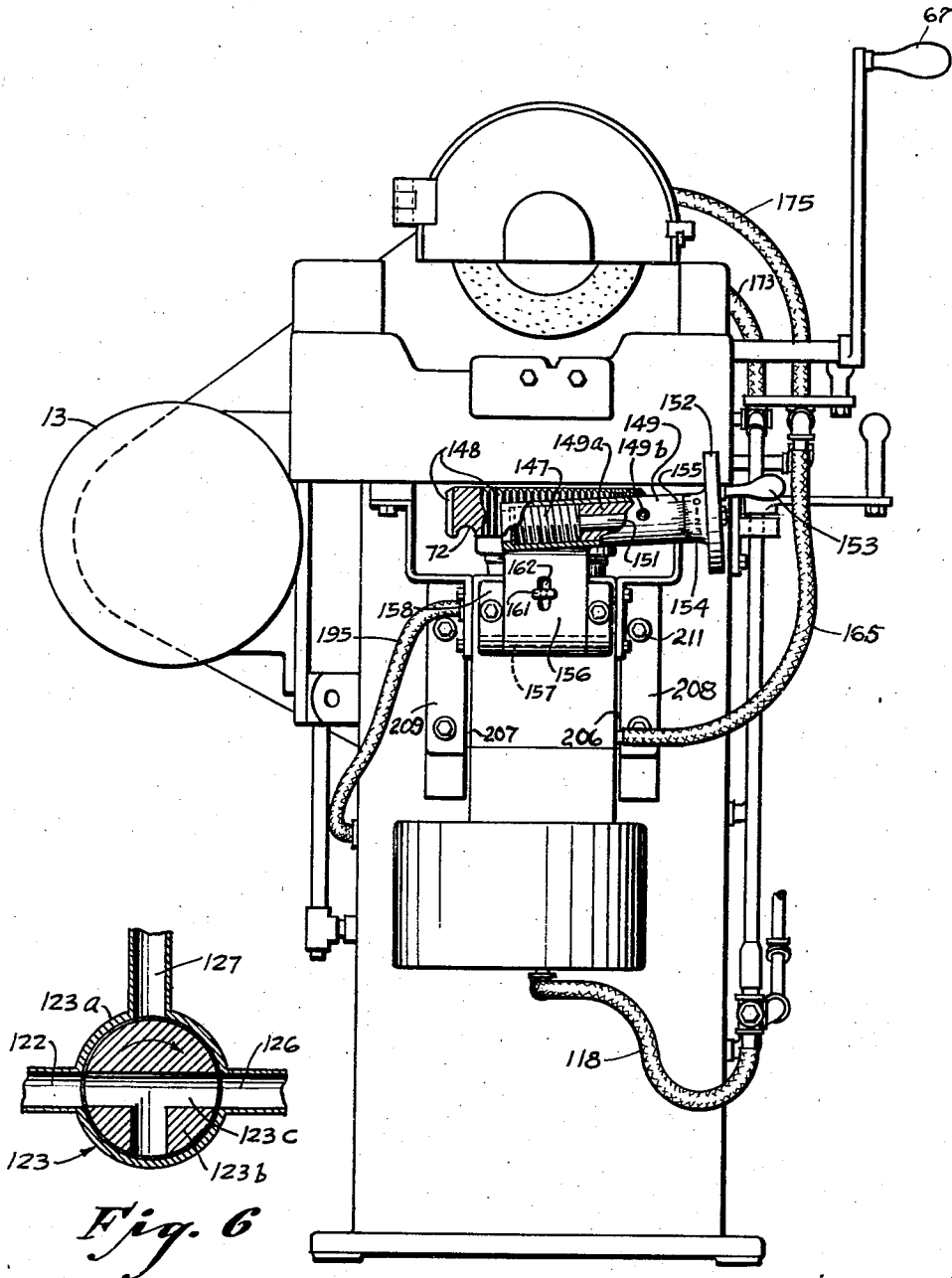


Fig. 6

Fig. 3

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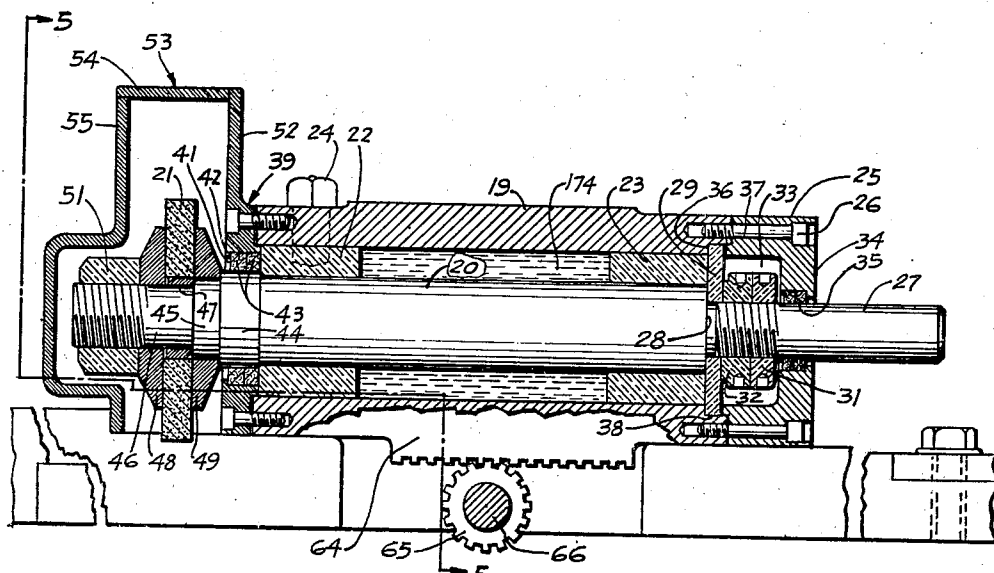


Fig. 4

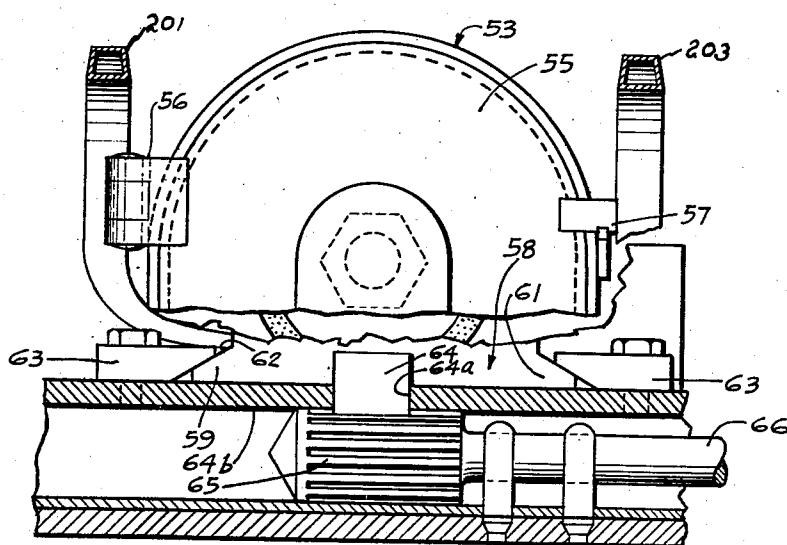


Fig. 5

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR GRINDING
PLANE SURFACES

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Application November 4, 1943, Serial No. 508,931

20 Claims. (Cl. 51—105)

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This invention relates to a method of and apparatus for grinding discs, rings, and the like flat objects, and more particularly to precision mechanism for grinding annular or ring members.

One object of the invention is the provision of a grinder device capable of grinding rings or other annular members within small tolerances, and for duplicating the result within extremely narrow limits.

Another object of the invention is the provision of new and improved means for holding and feeding the work to the grinder mechanism while the latter is being ground.

A further object of the invention is the provision of a new and improved feed mechanism for automatically varying the speed of advance of the work during the grinding operation.

Another object of the invention is the provision of feeding mechanism for a grinder that is automatic in its operation but is under manual control.

Another object of the invention is the provision of new and improved means for advancing the work to the grinder member at a relatively fair speed during the initial advance period, and with a greatly retarded speed during the final portion of the grinding operation.

A further object of the invention is the provision of feeding mechanism that is under manual control but that may be set to operate automatically during the grinding period.

A still further object of the invention is the provision of a new and improved grinder that is simple in construction, effective in operation, positive and accurate in its movement, and that is capable of exactly duplicating its ground products.

Other and further objects and advantages of the invention will appear from the following description, taken in connection with the accompanying drawings in which

Fig. 1 is a side elevation of the apparatus, with parts in section, parts broken away, and parts omitted for the sake of clearness;

Fig. 2 is a vertical section of the work spindle housing and associated parts, shown on an enlarged scale;

Fig. 3 is a front elevation of the apparatus, with parts in section, parts broken away, and parts omitted for the sake of clearness;

Fig. 4 is a longitudinal vertical section of the grinder mechanism, with parts removed and parts broken away;

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Fig. 5 is a section on the line 5—5 of Fig. 4; and

Fig. 6 is a vertical section of one of the valves, shown more or less diagrammatically.

In the construction of high grade precision grinding machinery great accuracy is required in the manufacture of certain parts of the mechanism. In certain products made with such machines tolerances within extremely narrow limits are not uncommon. Such accuracy results in a large percentage of rejects. In the manufacture of certain types of ring or clutch plates having friction faces constructed from powdered metal material, for instance, the tolerances must be held within extremely narrow limits, and the plates must be perfectly flat, parallel and true; i. e., the faces must be perpendicular to the axis of the ring.

The present invention seeks to provide a rotary surface grinder apparatus that is so constructed that plates, rings, annular members, and like flat constructions may be efficiently ground to very accurate dimensions, and be so ground as to be almost perfect duplicates of one another.

Referring now to the drawings, the reference character 10 designates the grinding apparatus, Figs. 1 and 2, which comprises a frame 11 on the upper portion of which is mounted a grinder mechanism 12, a motor 13 for operating the grinder mechanism, feed mechanism 14 including a work spindle, a motor 15 mounted on the lower portion of the frame for operating the spindle, a feed stop mechanism 16, a vacuum or chuck plate 17, and an oil pump 18, operated from the motor 13, for supplying a lubricant to different mechanisms and for raising and lowering the chuck.

The grinder mechanism 12 is mounted on the upper portion of the frame 11, and comprises a spindle housing 19, Fig. 4, within which is journaled a horizontal grinder spindle 20 on the front end of which is rigidly secured the grinder wheel 21. The housing 19 has a cylindrical bore, within which are mounted Kingsbury bearings 22, 23, at the ends of the housing for the grinding spindle 20. The portion of the bore between the bearings, which are spaced apart, forms a lubricant reservoir for oiling the bearings of the spindle 20. These bearings are held in position in the usual manner, as by means of the pins 24, one for each section of the bearing and one of which is shown in Fig. 4. Since these bearings are well known in the art it is not thought necessary to illustrate or describe the same any further than to state that they are sectional bearings, and

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each section has its ends on different radii, so that the bearings are kept well oiled and very accurately journal the spindle 20.

The rear end of the housing 19, Fig. 4, is provided with a cap or packing retainer 25, which is adapted to be rigidly secured to the rear end of the housing 19, as by means of the screws or bolts 26. The grinding spindle 20 is reduced at what will be termed its outer or rear end, as at 27, to provide a shoulder 28 against which a thrust collar 29 abuts. The thrust collar 29 is clamped in the housing 19 and is loose on the spindle 20. A pair of lock nuts 31, 32 are threaded on the reduced portion 27 adjacent the shoulder 28. The shoulder 28 and nuts 31, 32 cooperate with the fixed washer 29 to hold the spindle axially. The packing retainer or cap 25 is provided with an axial opening through which the reduced end 27 of the spindle extends, and is counterbored, as at 33, for receiving the nuts 31, 32. An additional counterbore 34 is provided for receiving a packing 35 for preventing leakage of lubricant along the shaft.

The outer or rear end of the housing 19 is counterbored, as at 36, and the packing retainer or cap 25 is provided with a reduced inward extension 37, which, when the parts are assembled, forms with the counterbore 36 a peripheral groove 38 in which the thrust collar 29 is held. The forward end of the housing 19 is provided with a packing retainer or plate 39, having an axial opening 41 provided with an inwardly extending flange 42 adapted to retain annular packing members 43 in position against the bearing 22. The annular packing members 43 are mounted on a collar portion 44 on the forward end of the spindle 20.

The end of the spindle 20 forwardly of the collar 44 is slightly reduced, as at 45, and again reduced, as at 46. Mounted on the reduced portion 46 is the grinder member or wheel 21, having a bushing 47 between it and the reduced portion 46. The grinder member 21 is clamped in position by a pair of clamping members or wheel flanges 48 and 49. The flange 49 is mounted on the reduced portion 45, and bears against the collar 44; and the wheel flange 48 is mounted on the reduced wheel portion 46, and the whole assembly is clamped in position by a nut 51 threaded on the forward end of the wheel spindle 20.

The packing retainer 39 is provided with a flange 52, to which a grinder wheel guard 53 is secured. The wheel guard 53 comprises a peripheral portion 54 rigidly connected to the flange 52, and a side or door portion 55, which extends down over the forward end of the grinder spindle 20 and, with the member 53 and flange 52, constitute a safety and dust shield for the grinder wheel. The door 55 is hinged at 56, and is held in closed position by a latch 57, Fig. 5. This closure or door affords access to the grinder wheel and associated parts, when desired. A housing 30, Fig. 1, is provided for inclosing the wheel spindle housing 19, and forms a shield therefor and for associated parts, including the pulley 20^a on the reduced end 27 of the spindle 20.

Suitable means are provided for moving the spindle and grinder wheel member 21 longitudinally of its axis, and this construction will now be described. The lower end of the grinder wheel spindle housing 19 is provided with a supporting portion 58, Fig. 5, which has laterally extending flanges 59, 61. These flanges each have their upper surfaces extending downwardly and out-

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wardly, as at 62, and gibs 63 are provided for engaging these inclined surfaces for forming a guideway for the longitudinally movable grinder wheel spindle 27 and housing 19.

Any suitable means may be provided for moving the housing, together with the spindle 20 and grinder wheel 21, longitudinally of their axes, but in the form of construction selected to illustrate one embodiment of the invention a rack 64, operated by a pinion 65, is employed for this purpose. The rack 64 is rigidly connected to the base 58, and is movable along a slot 64^a in the support 64^b. The pinion 65, Figs. 4 and 5, is secured on or integral with a shaft 66, to the outer end of which is secured a crank handle 67, Fig. 3. It will thus be seen that by manually rotating the handle 67 in one direction or the other the grinder member 21 may be moved either toward the right or to the left, as viewed in Fig. 4. This adjusting arrangement permits the grinder member to be moved back and forth when the same is being dressed, as well as for properly adjusting the grinder member relatively to the work that is being held by the chuck 17, as will be hereinafter explained.

The grinder spindle 20 has a pulley 20^a mounted on its outer or rear end, and this pulley is rotated from the motor 13 through suitable belt means 20^b engaging the pulley 20^a and a pulley 13^a on the outer or rear end of the armature shaft of the motor 13. The motor is located a sufficient distance away so that the belt means 20^b will be long enough to permit the limited longitudinal movement of the grinder spindle.

Suitable means are provided for holding, adjusting and rotating the work, as well as moving the same toward and from the grinder wheel during the grinding operation. In the form of the apparatus shown, which is by way of example only, the feed mechanism 14 comprises a work spindle housing 68, Fig. 2, within which is rotatably mounted the work spindle 69. The work spindle carries at its upper end the vacuum chuck 17. The spindle 69 is elevated to bring the work into contact with the grinder wheel by hydraulic means, as will hereinafter appear. The lower end of the work spindle 69 is reduced, as at 60, and has keyed thereto a pulley 85 by means of which the spindle is rotated. This pulley is operated from the motor 15 by means of suitable belts 86, Fig. 1. The pulley 85 has a wide belt engaging surface so that the spindle 69 and pulley 85 may be raised and lowered, as will appear hereinafter, without stretching the belts.

The housing 68 is provided with a cylindrical axial opening 70, which extends throughout its length, and the upper end of this housing is reduced and threaded, as at 71, for engaging the interior threads of the feed stop gear and nut 72, as clearly shown in Fig. 2 of the drawings. The lower end of the work spindle housing 68 has its axial opening 70 reduced, as at 73, for receiving the upper end of a bushing retainer 74. This bushing retainer has a flange 75 on its lower end, which is received in a counterbore 76 in the lower end of the work spindle housing 68, and the bushing retainer 74 is provided with a reduced cylindrical opening in which is secured a bushing or bearing 77 which may be of bronze or any other material suitable for bearings.

The upper end of the bushing 77 is provided with a flange 78 for engaging the upper end of the bushing retainer 74. The bushing 77 is provided on its interior surface with a plurality of oil rings 79 for lubricating the spindle 69—four

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being shown. The bushing retainer 74 is held in position by a work spindle packing retainer 81, which has on its upper side a cylindrical projection 82 extending into the counterbore 76 and engaging the lower side of the bushing retainer 74, being clamped in position by means of screws 83.

The packing retainer 81 has an axial opening provided with a counterbore on its upper side, within which suitable packing 84 is secured. This packing prevents the loss of lubricating oil from the chamber 70 along the work spindle 69.

Mounted on the upper end of the work spindle 69 is the vacuum chuck, Fig. 2. Suitable means are provided for attaching this chuck in position on the upper end of this spindle, so that the same will properly function to hold the work during the grinding operation. As shown, the upper end of the spindle is reduced, as at 87, and is screw-threaded for engaging in the threaded opening in a vacuum chuck spindle adapter 88, which is adapted to seat on a shoulder 89 formed on the spindle 69 by the reduced portion 87. The chuck adapter and work spindle 69 are provided with cooperating annular cut-out portions which, when the adapter is seated on the shoulder 89, will form an annular air conduit 90 extending entirely around the reduced portion 87, as will presently appear.

The chuck adapter 88 is provided on its lower side with an enlarged counterbore 146, which provides a flange projection 50 extending around the spindle 69 but spaced therefrom for receiving the upper end of a feed stop sleeve 80, hereinafter explained.

The adapter 88 is provided on its upper side with a counterbore 91, within which is seated an annular chuck adapter insert 92, which seats on the upper end of the work spindle 69. The vacuum chuck 17 is in the form of an annular plate, adapted to be clamped to the upper side of the chuck adapter 88, as by means of bolts or screws 93 extending through the plate of the chuck 17, and are tapped into a flange 70 extending outwardly around the adapter 88. The chuck plate 17 is provided with an axial opening, as at 94, which is counterbored below, as at 95, for receiving the upper end of the chuck adapter insert 92.

The chuck plate 17 has an annular elevated work rest 96 on its upper face, which extends above the surface of the upper side of the plate, so that the work may be supported entirely thereon without contacting any other portion of the plate. The plate is provided with an annular recess 97 beneath the elevated work rest 96. A plurality of apertures 100, arranged in concentric rows, extend from the recess 97 to the upper surface of the work rest 96, through which air may be exhausted for holding the work in position on the rest, as will presently appear.

Suitable means are provided for rigidly clamping the central portion of the vacuum plate in position on the vacuum chuck spindle adapter and against the adapter insert. As shown, this means comprises a vacuum chuck work adapter 98, provided with a cylindrical body portion 99 extending through the axial opening 94 in the chuck plate 17, and into the axial opening in the chuck adapter insert 92. Its upper end is flanged to form a head which extends over the chuck plate 17. This member is provided with an axial opening through which a screw-threaded bolt 101 extends, and is tapped in the upper end of the reduced portion 87 of the work spindle. The axial opening through the adapter 98 has its upper end counterbored for receiving the head of

the screw or bolt 101, and the parts are thus rigidly clamped together. In order to further prevent relative rotation of the chuck plate 17 and member 98, one or more pins or screws 102 may extend through the head of the member 98, the chuck plate 17, the chuck adapter insert 92, and be tapped into the vacuum chuck spindle adapter 88.

Appropriate means are provided for holding the work on the work rest 96 of the vacuum chuck plate 17 during the grinding operation. This is done by vacuum. As shown, the upper end of the vacuum chuck spindle adapter 88 is provided with an annular recess 103, which is directly below the recess 97 of the vacuum plate 17, and a plurality of suitable bores 104, converging toward their lower ends, are drilled through the chuck spindle adapter from the recess 103 to the annular recess 90, as clearly shown in Fig. 2 of the drawings. The work spindle 69 is provided with an axial bore or conduit 105 that extends throughout its length. The upper end of this bore is provided with a plurality of reduced branch bores 105^a which diverge upwardly and are in communication with the air conduit or manifold 90, and as a result of this arrangement when air is exhausted through the conduit 105 it will exhaust the air in the recesses 103 and 97, and through the passages 100, for holding the work firmly in position on the work rest or support 96. The lower end of the bore 105 is in communication with an exhaust air conduit 106, which in turn is connected with a vacuum line or with the intake of a suitable vacuum pump.

The connection between the lower end of the spindle 69 and the air conduit 106 will now be described. The lower end of the work spindle 69 is further reduced at 107 to form a shoulder 108, Figs. 1 and 2. The reduced portion 107 is threaded, and is adapted to engage a threaded recess in a cap member 109. This cap member seats against the shoulder 108. A plate 110 is positioned on the spindle above the cap member 109, as shown more clearly in Fig. 2 of the drawings. The cap member 109 is provided with an axial opening below the spindle 69, in alignment with the bore 105 of the spindle. The cap member 109 is adapted to be received within a recess 111 formed in the connector block 112. The upper end of this block seats against the plate 110, and suitable means are provided for resiliently holding the parts in contact for constituting an air-proof joint at this point. The means shown comprises a plurality of bolts 113 extending upwardly through the block member 112, and are threaded into the plate 110. Interposed between the block and the heads of the bolts are springs 114. A gasket 115 is inserted between the cap member 109 and the bottom of the recess 111 for preventing leakage of air into the bore 105 when the air is exhausted therefrom.

The block member 112 is provided with an axial bore 116 below the recess 111, which is in alignment with the bore through the cap member 109, gasket 115, and the bore 105 of the spindle. The lower end of the bore 116 is counterbored and threaded for receiving the upper threaded end of the pipe of the conduit 106. The block 112 may be provided with a threaded opening for receiving a handle member 117 for rotating the block 112 for attaching and releasing the same to and from the pipe of the conduit 106, Fig. 2.

The conduit 106 has a flexible conduit 118 connected thereto, so as to accommodate the raising and lowering of the spindle 69 for raising and

lowering the chuck and the work thereon, as will presently be described. The conduit 118 is attached to a pipe connection 119, to which may be connected a pressure gauge 121, as shown more clearly in Fig. 1 of the drawings. A pipe 122 is attached to the pipe connection 119, and has a three-way valve 123 therein, which may be of the usual or any well known construction. Its description is not thought necessary further than to state that it comprises a valve casing 123^a, Fig. 6, having a rotary cylinder 123^b therein provided with a T-shaped aperture 123^c there-through. The cylinder may be turned to place the conduit 122 in communication with either the conduit 127 or 126.

The valve is operated through the medium of a rod 124, which has its lower end attached to the valve 123 and has a handle 125 at its upper end. By moving the handle either to the right or to the left the valve is operated. Attached to the valve 123 is the conduit 126, to which is connected a conduit 126^a leading to a vacuum tank, and which in turn is connected to a vacuum line or to the intake of a vacuum pump. In practice a vacuum tank is interposed between the conduits 126 and 126^a, and is located in the base of the apparatus. Attached to the three-way valve 123 is an upwardly extending pipe 127, which is connected to a pipe 128, and which in turn connects to a three-way valve 129 in communication with a horizontal pipe 128^a. The valve 129 is similar to the valve 123 described above, and shown in Fig. 6, and need not be further described.

The valve 129 has the two conduits 128 and 128^a connected thereto, and also has an intake port or passage 129^a. When in one position the conduits 128 and 128^a are in communication and the port or nozzle 129^a is closed, and when in another position the conduit 128 and port or nozzle 129^a are in communication and the conduit 128^a is closed.

When it is desired to secure the work to be ground to the chuck, the handle 125 is operated to turn the valve 123 to close the conduit 127, Fig. 6, and to place the conduit 126 in communication with the conduit 122 and the hose or conduit 118, and the suction in the conduits 126 and 126^a will cause suction in the chuck 17 to firmly clamp the work to the chuck. The work is released from the chuck by turning the handle 125 to close the suction conduit 126, and to place the conduits 118 and 127 in communication with each other. The valve 129 is now turned to open the conduit 127 to the atmosphere through the port 129^a, and external air will enter the conduit 127 and flow through the conduits 118 and 105 to relieve the vacuum in the chuck for releasing the work.

If desired, means may be provided for employing compressed air for relieving the vacuum in the chuck for releasing the work, and at the same time blow any foreign matter, such as the liquid coolant or ground fragments, from the suction passages of the chuck. As shown, the conduit 128^a is extended to a conduit 131 having a valve 132 therein. The conduit 131 is in communication with a source of compressed air. The valve 129 may be turned to open the passage 128 and close the port 129^a. When in this position, if the valve 132 be opened and the valve 123 be moved to place the conduits 122 and 127 in communication, compressed air will now pass through the conduits 131 and 127, valve 123, conduits 118 and 105, to the chuck for promptly relieving the work and for cleaning the vacuum passages therein.

A pipe connection 130, having a valve 133 therein, may be provided between the conduits 131 and 126, so that by turning the valves 129 and 123 to close the conduits 128^a and 126, respectively, and then open the valves 133 and 132, compressed air may be discharged through the conduit 126^a into the vacuum tank for removing water or foreign matter therefrom. During the normal operation of the apparatus the valve 133 remains closed.

It will thus be seen that when it is desired to secure the work to be ground, such as a disc or ring, on the vacuum chuck 17 the operator moves the handle 125 to operate the three-way valve 123 to close the passage through the pipe 127 and simultaneously open the passage 126 to the source of vacuum for exhausting the air from the chuck through the conduit 106 and bore 105, as will be apparent from an inspection of Figs. 1 and 2.

When it is desired to release the work from the chuck the handle 125 is moved to operate the three-way valve 123 for closing the conduit 126 and opening the passage through the pipe 127 to the air valve 129, if the same be open. If the valve 129 is open to the conduit and to the atmosphere, the air will pass through the passage 129^a, through the passage 127, conduit 106, and bore 105, and through the chuck 17 for releasing the work thereon.

If, however, the valve 129 is turned so that the port 129^a is closed and the conduit 128 and valve 132 open, then compressed air will be admitted and will promptly relieve the suction at the chuck, and simultaneously blow away any foreign matter contained in the air passages of the chuck.

The mechanism for feeding the work or advancing the same to the grinder wheel will now be described. This mechanism comprises the work spindle 69, the feed stop sleeve 80 for limiting the upward movement of the work spindle which carries the chuck, together with means 135 for vertically adjusting the feed stop sleeve. The spindle 69 is so constructed that it functions as a hydraulic plunger or piston for raising and lowering the chuck secured to the upper end thereof. As shown in Fig. 2, the upper portion of the spindle below the reduced portion 87 is cylindrical, as at 136, and is adapted to slide upwardly and downwardly through the feed stop sleeve 80, and the two function as piston and cylinder.

The lower end of the feed stop sleeve 80 has an annular internal bevel to form an annular shoulder 137 for engaging a corresponding inclined surface 138 on an enlargement 139 at the lower end of the cylindrical portion 136 of the spindle 69. The shoulder 137, engaging the inclined surface 138, limits the upward movement of the spindle, and consequently determines the amount of material to be ground from the work that is being operated upon. By adjusting the feed stop sleeve upwardly more material will be ground from the work, and by adjusting it downwardly a correspondingly smaller amount will be ground from the work carried by the chuck 17. Since the stop engages the inclined surface 138 on the work spindle throughout fully 360°, the limit of upward movement of the spindle is extremely accurate because there is no tilting or rocking of the sleeve 80, and as a result the amount of material removed from the work, or rather the thickness of the ground or finished article, will be held to within very narrow limits, and the ground surface will be true.

Suitable means are provided for adjustably raising and lowering the feed stop sleeve 80. As

shown, the upper end of the spindle housing 68 is reduced, as at 141, and a feed stop gear 72 is threaded thereon. The upper end of the feed stop gear above the threads in the axial opening has a flange 143 extending radially inwardly, and the sleeve 80 is provided with a corresponding outwardly extending flange 144 which is adapted to engage beneath the flange 143 and be rigidly secured thereto, as by means of the bolts 145.

As a result of this construction the sleeve 80 is rigidly connected with the feed stop gear 72, and by turning this gear either one way or the other the sleeve may be raised or lowered, thereby raising and lowering the stop 137 for limiting the upward movement of the spindle 69. The flange 144 is positioned a sufficient distance above the upper end of the spindle housing to provide clearance for the movement of the sleeve 80, and also forms a reservoir 164 for receiving oil accumulated above the sleeve 80, as will presently be described. The sleeve 80 has a plurality of annular oil grooves 100', ten being shown, which extend around the interior thereof for retaining oil for lubricating the spindle during its rotation.

It is necessary, in precision grinding, that means be provided for accurately adjusting the sleeve 80 for properly positioning the annular stop shoulder 137. As shown, a worm 147, Fig. 3, is provided for meshing with the teeth 148 of the gear 72 for rotating the same. The worm 147 operates in a casing 149, and is provided with a shaft 151 extending through a bearing block 149^a, rigidly mounted in the casing 149. The worm abuts the block, which prevents its outer endwise movement. An adjusting wheel 152, having a handle 153, is attached to the outer end of the shaft 151 for rotating the same. The hub of the wheel abuts the end of the casing 149 and prevents rearward movement of the worm 147. Micrometer graduations 154 on the hub of the wheel 152 and casing 149 are provided for indicating the accurate adjustment.

By means of this arrangement extremely accurate adjustments may be obtained by rotating the worm 147. The worm 147 and casing 149 are carried by a plate 156, which is pivoted, as at 157, Fig. 3, to a suitable support 158 rigidly mounted on the spindle housing 68. The casing 149 is cut away, as at 159, Fig. 2, for providing clearance for the teeth 148 of the gear 72. The worm is held in engagement with the teeth of the feed stop gear 72 by any suitable means, as by a button member 161, which is adapted, when turned in one position, to pass through a slot 162 in the plate 156, and to be turned crosswise of the slot, as shown in Fig. 3, for holding the plate 156 in the position shown in Fig. 2. The button member 161 is preferably screw-threaded into the support 158, so that when it is turned it will hold the worm firmly in mesh with the teeth of the feed stop gear. By releasing the plate 156 the worm may be disengaged from the gear teeth. It will be seen that by turning the handle 153 the feed stop gear 72 will be rotated for raising and lowering the sleeve 80, and with it the stop shoulder 137 for limiting the upward movement of the spindle 69. A grease nipple 149^b is provided on the casing 149 for introducing lubricant to the bearing in the block 149^a.

Hydraulic means are provided for elevating the spindle 69, and with it the chuck and work thereon. In the form of device selected to illustrate one embodiment of the invention, the hydraulic fluid employed is oil, which is also used for lubricating the parts. As shown more clearly in Fig.

2, the spindle 69 is provided with a collar 163 integral with and below the enlargement 139, and which is of slightly larger diameter than the enlargement 139. The spindle is then sharply reduced, as at 164, immediately below the enlargement 163 and within the space between the sleeve 80 and the upper end of the bushing retainer 74. This space constitutes a cylinder or chamber 70 for containing a hydraulic fluid which, in this instance, is oil. Below the reduced portion 164 the spindle is further materially reduced, as at 164^a, and the reduced portion 164^a extends through the bushing 77 below the chamber 70.

The operating fluid, such as lubricating oil, is introduced into the lower end of this chamber through a flexible conduit 165, Fig. 1, and, due to the reduction in diameter of the lower end of the spindle, will force the spindle upwardly, thus elevating the chuck. The discharge for the hydraulic fluid is back through the conduit 165 to a three-way valve 185, as will now be described.

The circulation of lubricant to the hydraulic cylinder and to the different bearings may be traced as follows: The lubricant is contained in a tank 167, Fig. 1, and is pumped therefrom through the conduits 18^a and 18^b by the pump 18, and discharged into a conduit 169 through the discharge pipe 168. A pressure relief valve 171 is provided in a by-pass 172, so that when the pressure in the conduit 169 rises above a predetermined amount a portion or all of the liquid will be discharged into the pipe 172 through the pressure relief valve, which in turn discharges into the intake of the pump or back to the oil reservoir 167. The liquid passes along the conduit 169 and is divided, and a portion passes upwardly through a conduit 173 into the oil chamber 174 in the spindle housing 19, and from thence is discharged into a return conduit 175 through a T-connection 176 into a conduit 177 which passes back to the oil tank 167.

A conduit 178, branching from the conduit 177, carries a portion of the return oil to the lower part of a filter 179, and after passing through the filter is conducted by a passage 181 back to the oil tank. A pressure gauge 182 is provided in the conduit 175 for indicating the pressure contained within the reservoir 174. A needle valve 183 in the pipe 175, posterior to the gauge 182, is provided for controlling the pressure in the reservoir 174 for insuring proper lubrication of the grinder spindle bearings.

The remainder of the oil passing along the conduit 169 is conducted over to a three-way valve 185, which is operated by a handle 186. Attached to one portion of the T-connection 176 is a pipe or conduit 184, leading over to the three-way valve 185. When the valve 185 is set in the position shown in Fig. 1, the passage 165 from the lower portion of the chamber 70 to the passage 184 is opened and the passage 169 is closed.

A valve 188 is provided in the passage 184 for controlling the rate of flow of the liquid there-through. By controlling the flow of liquid or lubricant through the passage 184 the rapidity with which the spindle 69 will descend may be controlled independently of the three-way valve 185. By turning the handle 186 to a predetermined position, the passage 169 is closed and the conduit 165 is placed in communication with the conduit 184 through which the oil from the cylinder 70 is discharged, and the weight of the cylinder causes it to descend.

In grinding accurate work it is desirable that the rate of speed of the feed be reduced as the

grinding operation nears its completion, so that the ground faces of the finished product will be accurate and have a maximum smoothness. This is partially accomplished by reason of the fact that the portion 164^a of the spindle is much smaller than the portion 164, so that as the spindle is forced upwardly by the oil a relatively larger portion of the smaller diameter of the spindle will occupy the space within the chamber 70, and consequently more oil will be required to move the spindle a predetermined distance. This results in a gradual lessening of the rate of speed of the feed.

Suitable means are also employed for providing a dash pot action of the upward movement of the spindle, so that the final upward feeding movement of the work spindle is very greatly retarded as it reaches its upper limit. The mechanism for accomplishing this will now be described. A feed stop dash pot cylinder 139, which is in the form of a metal band, is provided which extends about the enlarged portion 139, tightly engages the same, and rests on the ledge formed by the enlarged portion 139, as shown more clearly in Fig. 2 of the drawings. This band extends above the beveled or inclined edge 138, and when this inclined edge is in contact with the lower end of the feed stop sleeve 80 the upper edge of the band 189 will be received in a rabbet 191 extending about the lower end of the feed stop sleeve 80, and which, with the inner surface of the work spindle housing, forms an annular groove for receiving the upper edge of the band 189. The inclined or beveled face 138 of the enlargement 139 is provided with radial grooves 192, and the inner surface of the feed stop sleeve 80 is provided with a plurality of oil grooves on its interior surface, ten being shown, for lubricating the cylindrical portion 136, which constitutes the upper journal for the spindle 69.

When the spindle 69 is elevated and nears the upper limit of its movement, the band 189 enters the rabbet or groove 191 and traps the lubricant contained in the upper portion of this band, and the further upward movement of the spindle forces some of this oil upwardly between the cylindrical portion of the spindle 136 and the sleeve 80. This will materially retard the upward movement of the spindle, and the oil will be finally forced into the space or counterbore 146 above the sleeve 80. This arrangement not only retards the upward movement of the spindle during its final movement, but will also thoroughly lubricate the spindle within this sleeve by what may be termed a force feed.

Suitable provision is made for returning the oil collected in the space or counterbore 40 back to the main oil reservoir 167. The sleeve is provided with one or more downwardly extending passages 193, which permits the oil to flow down into the space or reservoir 164 formed between the upper end of the work spindle housing 68 and the flange 144 of the sleeve. A bore 194, extending downwardly in the work spindle housing 68 and outwardly to the surface of the housing, provides a conduit for conducting the oil from the reservoir 190. A suitable drain 195, Fig. 1, is connected to the lower end of the conduit 194, and conducts the oil back to the oil tank 167.

If desired, a coolant may be discharged onto the work while it is being ground. As shown in Fig. 1, a conduit 196, leading from a pump or suitable source of coolant, conducts the same to a nozzle 197 which is arranged to discharge the coolant onto the work on the chuck. A coolant

pan 198, surrounding the chuck, is provided for collecting the coolant discharged across the work. This pan is provided with a discharge conduit 199 for removing the liquid from the pan 198. A shield or skirt 200, secured to the flange and extending around the same, is provided for protecting the parts against the drippings of coolant from the suction chuck 17, and directs the coolant into the pan 198. Other shields may be provided for protection against moving parts of the mechanism, such as the shield 203, which forms a housing for the pulley 85.

Under some conditions it is desirable that air be employed as the coolant and as a means for removing dust and other fine material removed from the work by the grinder. An exhaust conduit is provided for this purpose. This conduit is bifurcated, the furcations 201 and 202 being shown in Fig. 5, and these furcations are positioned at opposite sides of the grinder. Atmospheric air will be caused to flow across the work and into this exhaust conduit which carries the dust away from the machine.

In the operation of the grinder, starting with the chuck in its lowered position, the work is placed in proper position on the vacuum chuck and the valve 123 opened to secure the work to the chuck by suction. The motors 13 and 15 are set in operation for rotating the grinder and the chuck and the oil pump for lubricating certain of the parts, including the grinder spindle which rotates at a higher speed than the work spindle. The valve 185 is opened for applying oil under pressure to the work spindle 69 for advancing the work to the grinder. As the spindle 69 rises its speed is reduced, and when near its upper limit oil trapped by the band 189, operating as a dash-pot, materially reduces the final advance movement of the spindle so that great accuracy in grinding is obtained, and the ground face of the work is smooth and true. Some of the trapped oil is forced upwardly between the cylindrical portion 136 of the spindle 69 and the sleeve 80, and lubricates the bearing at this point. When the inclined surface 138 engages the sleeve stop the valve 123 is turned to permit the escape of oil from the space 70 for permitting the spindle 69 to lower, after which the valve 123 is operated to shut off the vacuum connection to the chuck and connect the chuck to the atmospheric air orifice 129^a to release the work from the chuck. If necessary, the valve 129 may be operated to blow compressed air into the chuck to remove the work, thus completing the cycle.

The construction shown is designed to grind annular plates or rings having an axial opening of a diameter but slightly greater than the head of the adapter 98, so that this head will centrally position the plate or ring when placed on the chuck whereby the work is coaxial with the work spindle.

When adjusting the feed stop means the worm 151 may be first disengaged from the gear teeth 148 and the nut 72 turned to raise or lower the stop to within the neighborhood of the proper adjustment, after which the worm is reengaged with the teeth and the accurate adjustment made with the aid of the micrometer arrangement by turning the wheel 152.

After the machine has been in operation for some time, the grinder wheel 21 will become worn and reduced in diameter. Since the adjustment obtainable by means of the nut 72 is of rather limited extent, provision has been made to provide a greater vertical movement of the spindle

as the grinder wheel 21 becomes smaller in use. As is shown in Figs. 2 and 3, the feed mechanism 14 is mounted for vertical movement as a unit. For this purpose, it is provided with side flanges 206 and 207 of similar construction to the flanges 59 and 61 of the grinder housing as shown in Fig. 5. These flanges 206 and 207 are engaged by gibs 208 and 209 which are bolted at 211 to the flange of the machine. At the rear of the feed mechanism 14 is secured a flange 212 extending through a slot 213, see Fig. 2, in the main frame. An adjustment bolt 214 is provided to move the grinder mechanism vertically. Extending downwardly from the flange 212 is a vertical member 216 carrying a horizontal member 217 which forms the support for the motor 15.

When the grinder wheel 21 becomes worn to such an extent that the adjustment provided by the nut 72 is insufficient to raise the work and to engage therewith, the nuts 211 on the gibs 208 and 209 are loosened slightly and the whole grinder assembly moved vertically by turning the adjustment bolt 214, after which the gibs are again clamped in place.

While the levers or handles 125 and 186 are shown separated some distance apart, in practice they are coaxial, and the handles may be of such lengths that they may both be grasped in the hand and moved together, if desired.

It is thought from the foregoing, taken in connection with the accompanying drawings, that the construction and operation of my device will be apparent to those skilled in the art, and that changes in size, shape, proportion and detail may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a grinding apparatus, a chuck, a grinder member, suction means for holding work to be ground securely against said chuck, means for rotating said chuck, means for rotating said grinder member, hydraulic means for advancing said chuck toward said grinder member for grinding said work, stop means comprising an adjustable sliding member forming an adjustable shoulder and means rigid with said hydraulic means for contacting said shoulder for limiting the movement of said chuck toward the grinder.

2. In a ring grinder, a chuck, means for rotating said chuck, hydraulic means for moving said chuck longitudinally of its axis a rigid shoulder on said last named means, an adjustable stop for abutting said shoulder for limiting such longitudinal movement of said chuck, a grinder member, means for rotating the same, suction means for holding work to be ground firmly against said chuck, means for moving said grinder member in the path of said chuck for grinding said work.

3. In a grinding apparatus, a work spindle, a housing for the same, a chuck carried by the upper end portion of said spindle and adapted to support work to be ground, suction means for holding said work in position on said chuck, a grinder member, means for moving said grinder member parallel with the face of said chuck, hydraulic means for moving said spindle for feeding said work to said grinder member, means for rotating said spindle, means for rotating said grinder member, a feed stop sleeve for limiting the feeding movement of said work, and means for adjusting the position of said feed stop sleeve.

4. In a grinding mechanism, a work spindle, a housing for the spindle, hydraulic means for raising and lowering said spindle, said spindle having an upper cylindrical piston portion, a re-

duced intermediate portion and a further reduced lower portion, an annular shoulder portion between said upper and intermediate portions, a feed stop sleeve slidably mounted in the upper end of the spindle housing and constituting a hydraulic cylinder for the piston portion of said spindle, means for raising and lowering said feed stop sleeve, the lower end of said sleeve cooperating with said shoulder for limiting the upper movement of said spindle, and a chuck for holding the work to be ground on the upper end of said spindle.

5. In a rotary surface grinder, a rotary grinder member, a horizontal spindle for the same, means for adjusting said spindle along its axis, means for rotating said spindle, a vertical work spindle, means for rotating the same, a housing for said work spindle, a stop sleeve slidable in the upper end of said housing, said work spindle having an upper cylindrical portion journaled at its upper end in said sleeve and slidable there-through, the lower end of said sleeve cooperating with an enlargement on said work spindle for limiting its upper movement, means closing the lower end of the work spindle housing and constituting a bearing for the lower end of said work spindle and forming with said sleeve a liquid reservoir, the intermediate portion of said spindle within said reservoir being reduced and its lower end being further reduced and extending into said reservoir whereby when a liquid under pressure is forced into said reservoir the work spindle will be forced upwardly at a relatively high speed during its initial movement but at a greatly reduced speed as it nears its upper limit of movement, means on the upper end of said spindle for holding work to be ground, and means for forcing a liquid under pressure into said reservoir for elevating said work spindle for feeding said work to said grinder member.

6. In a rotary grinder apparatus, a grinder spindle, a grinder wheel on said spindle, a work spindle extending at right angles to said grinder spindle, a chuck for holding work to be ground on the upper end of said work spindle, means for rotating both of said spindles, hydraulic means including a piston member rigid with said work spindle for moving said work spindle to bring said work into contact with said grinder wheel, and means for causing the advancement of said work toward said grinder wheel at a slower rate of speed as said wheel nears the limit of its grinding operation, and suction means comprising conduits extending longitudinally of said work spindle for holding work on said chuck.

7. In a ring grinder, a chuck, a grinder member, suction means for holding work to be ground securely against said chuck, means for rotating said chuck, means for rotating said grinder member, hydraulic means including a piston rigid with said chuck for advancing said chuck toward said grinder member for grinding said work, a rigid shoulder on said piston limiting the advance of said chuck, means for materially reducing the speed of movement of said chuck toward said grinder member as it nears the limit of its movement, and an adjustable stop for positively engaging said shoulder for limiting the advancing movement of said chuck.

8. In a device of the class described, a vacuum chuck for holding work to be ground, a rotating spindle, a chuck plate having an annular recess on its under face mounted on said spindle and rotatable therewith, an annular raised portion on its upper face provided with apertures in com-

munication with said recess for supporting work to be operated upon, means for raising and lowering said spindle, and means including a passage extending longitudinally through said spindle for exhausting air from said recess for holding work on said chuck by air pressure.

9. In a flat surface grinder, a grinder wheel, a housing therefor, a grinder spindle for said wheel, said wheel spindle journaled in said housing, means for rotating said spindle, a work spindle extending at right angles to said grinder spindle, a housing for said work spindle, an elongated bearing for one end of said work spindle and having an annular shoulder thereon, an enlargement on said work spindle for engaging said shoulder for limiting the longitudinal movement of the work spindle toward the grinder wheel spindle, a chuck carried by the end of said work spindle adjacent to said grinder wheel for holding work to be ground, means for rotating the work spindle, means including a worm gear for adjusting said stop shoulder along said work spindle for arresting the advance of said work spindle toward the grinder wheel during the grinding operation, means for advancing said work spindle toward said wheel, and means for rotating said chuck beneath said grinder wheel.

10. In a grinding apparatus, a chuck, a grinder member, suction means for holding work to be ground securely against said chuck, means for rotating said chuck, means for rotating said grinder member, hydraulic means for advancing said chuck toward said grinder member for grinding said work, an annular shoulder for limiting the advance movement of said chuck, and manually operated means for controlling the speed of advance and return of said chuck.

11. In a grinder device, a rotating grinder member, a chuck member for holding work to be ground rotating about an axis at an angle to that of said grinder member, means for moving said members relatively toward each other for grinding said work, said chuck comprising a work rest having air passages therein, means for conducting air from said chuck through said passages for holding work on said rest, and manually controlled means for admitting atmospheric air to said passages or for admitting compressed air to said passages for releasing said work.

12. In a grinding apparatus, a work spindle, a work spindle housing for said spindle, said spindle having an upper cylindrical piston portion, a stop sleeve surrounding said piston portion and telescoping into the upper end of said housing and forming a bearing for said piston portion, an enlargement on said piston portion for engaging said stop sleeve for limiting the upward movement of said spindle, a chuck mounted on the upper end of said spindle, a feed stop gear threaded on the upper end of said housing and surrounding said housing, means for rigidly connecting said gear to said stop sleeve, a worm engaging said gear, a handle for turning said gear for elevating and lowering said stop sleeve, a hinged support for said worm, and releasable means for holding said worm in mesh with said gear.

13. An adjusting stop mechanism for a grinding apparatus comprising an adjustable nut, a work spindle housing threaded at its upper end for receiving said nut, a sleeve telescoped into the upper end of said housing and beveled at its lower end to form a stop shoulder, said nut having gear teeth extending around its exterior periph-

ery, a worm engaging said gear, a casing for said worm, a shaft for said worm journaled in said casing, a hand wheel having a hub engaging said housing for turning said worm for rotating said nut for adjusting the height of said sleeve, the adjacent surfaces of said hub and casing having micrometer graduations thereon for accurately adjusting the position of said sleeve, and means whereby said worm and gear teeth may be disengaged for adjusting said nut manually.

14. In a grinding apparatus having a longitudinally movable work spindle provided with an enlargement, a chuck carried by said spindle, a housing for said spindle, a stop sleeve for engaging said enlargement for limiting the longitudinal movement of said spindle in one direction through said sleeve, means including micrometer mechanism for accurately adjusting the position of said stop sleeve, and hydraulic means for moving said chuck and spindle longitudinally of the axis of said spindle.

15. In a grinding apparatus, a grinder wheel, a grinder spindle for rotating said wheel, a spindle housing surrounding said spindle and providing a chamber for containing lubricating oil surrounding said spindle, a work spindle, a work spindle housing surrounding said work spindle, said last-named housing forming a chamber for containing lubricating oil surrounding said work spindle, said work spindle having an enlargement constituting a piston in said last named chamber a chuck on the upper end of said spindle, and means for forcing the lubricating oil into said piston and said housings for lubricating said spindles and for moving said chuck toward said grinder wheel.

16. In a grinding apparatus, a grinder wheel, a grinder spindle for rotating said wheel, a spindle housing surrounding said spindle and providing a chamber for containing lubricating oil surrounding said spindle, a work spindle, a work spindle housing surrounding said work spindle, said last-named housing forming a chamber for containing lubricating oil surrounding said work spindle, an enlargement on said work spindle for forming a piston in the chamber surrounding said work spindle a chuck on the upper end of said spindle, an oil reservoir for containing a lubricant for said spindles, means including a pump for forcing said lubricating oil into said chambers for lubricating said spindles and for moving said chuck toward said grinder wheel, a filter, conduits for returning said oil from said spindles to said reservoir, and branch conduits for shunting a portion of the returning oil through said filter.

17. In a grinding apparatus, a chuck, a spindle for said chuck a grinder member, suction means for holding work to be ground securely against said chuck, means for rotating said grinder member, means for moving said grinder member transversely to said spindle hydraulic means including a piston on said spindle for advancing said chuck longitudinally of its axis toward said grinder member for grinding said work, means for discharging a liquid coolant onto the face of said work during the grinding operation, and means for collecting said liquid coolant and for conducting the same from the apparatus.

18. In a grinding apparatus, a chuck, a spindle therefor, a grinder member, a spindle therefor, suction means for holding work to be ground securely against said chuck, means for rotating said chuck and its spindle, means for rotating said grinder member and its spindle, hydraulic means

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comprising lubricating oil for advancing said chuck toward said grinder member for grinding said work, means for utilizing said oil for lubricating said spindles and means for exhausting air across said work during the grinding operation for removing the dry dust material from said grinding apparatus.

19. In a grinding apparatus, a work spindle, a housing therefor, said housing having an enlarged axial bore, a stop sleeve slidable in the upper end of said housing, a feed stop gear threaded on the upper end of said housing and rigidly connected to said sleeve, means for rotating said gear for raising and lowering said stop sleeve, a work spindle extending through said sleeve and housing and having an upper cylindrical portion forming a close fit in said sleeve, said sleeve having oil grooves surrounding said cylindrical portion for holding oil for lubricating the latter, a chuck adapter secured to said spindle and having a downwardly extending flange portion telescoping over the upper end of said sleeve and forming with said sleeve and spindle an oil chamber, a chuck secured to said adapter, the lower end of said sleeve having an external rabbet, an enlarged projection on the spindle adapted to engage said sleeve for limiting the upward movement of said spindle, said enlargement having a reduced portion forming an annular ledge, an annular band seated on said ledge, said spindle

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having a plurality of reduced portions on its intermediate portion, a sleeve forming a bearing having internal oil grooves for the lower end of said spindle, means including an oil reservoir and a pump for forcing oil from said oil reservoir into said work spindle housing between said sleeves for lubricating the lower bearing formed by the lower sleeve and for elevating said spindle for causing said band to enter said rabbet for trapping oil between said cylindrical and enlarged portions on said spindle for causing oil to flow upward between said cylindrical portion and first-named sleeve into said chamber for lubricating said work spindle, and conduits for returning said oil back to said reservoir.

20. In a grinder device, a grinder member, a chuck member for holding work to be ground rotating about an axis at an angle to that of said grinder member, a piston member for advancing said chuck to and from said grinder member, means for rigidly connecting said chuck to said piston member, means for holding a work piece to said chuck by suction, a rigid shoulder on said piston, an adjustable stop for positively engaging said shoulder for limiting the upward movement of said piston and chuck, and means for causing said chuck to move at a greatly reduced speed as it nears the limit of the movement toward said grinder.

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