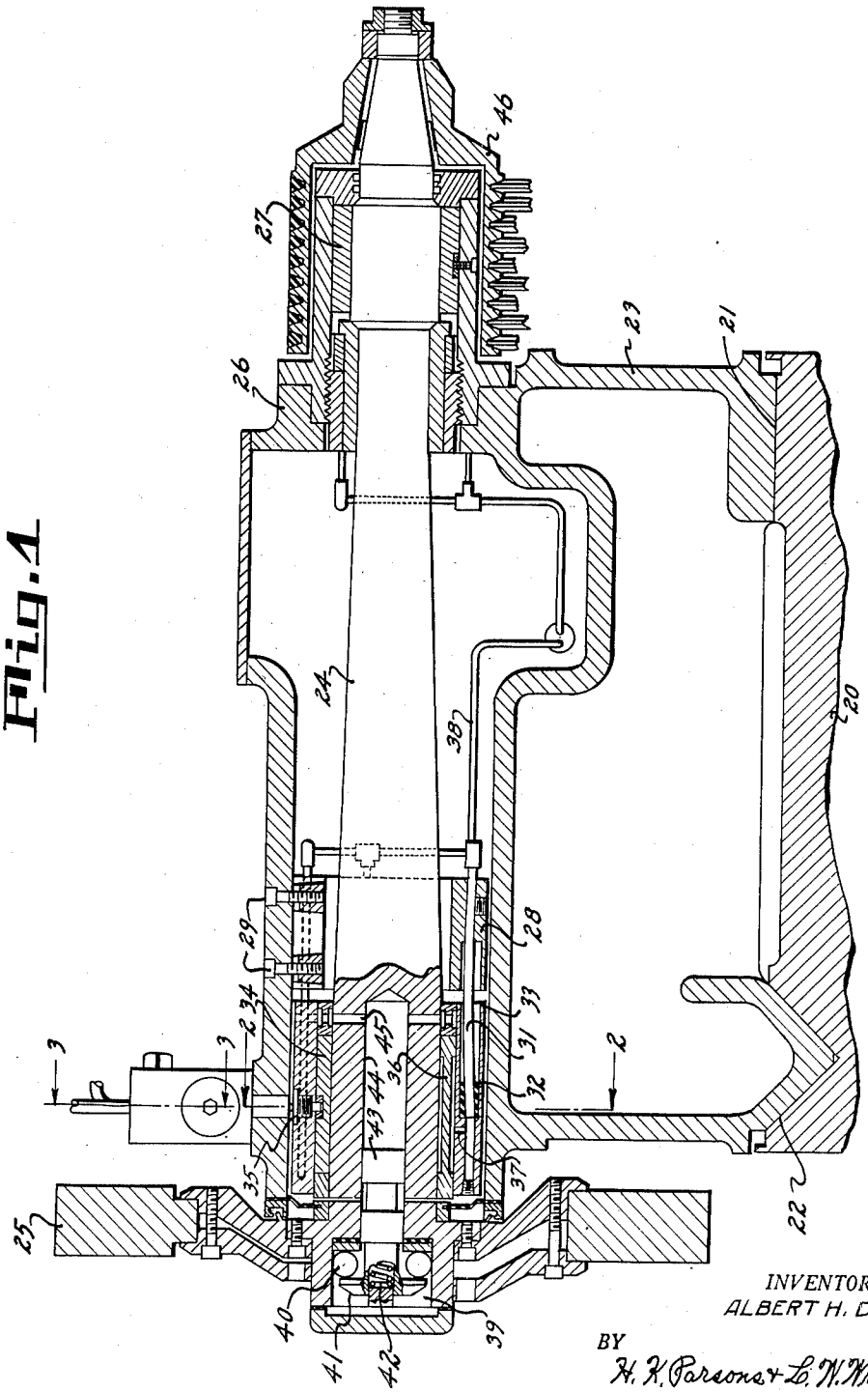
June 10, 1952 A. H. DALL 2,599,698

GRINDING MACHINE

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Fig. 1



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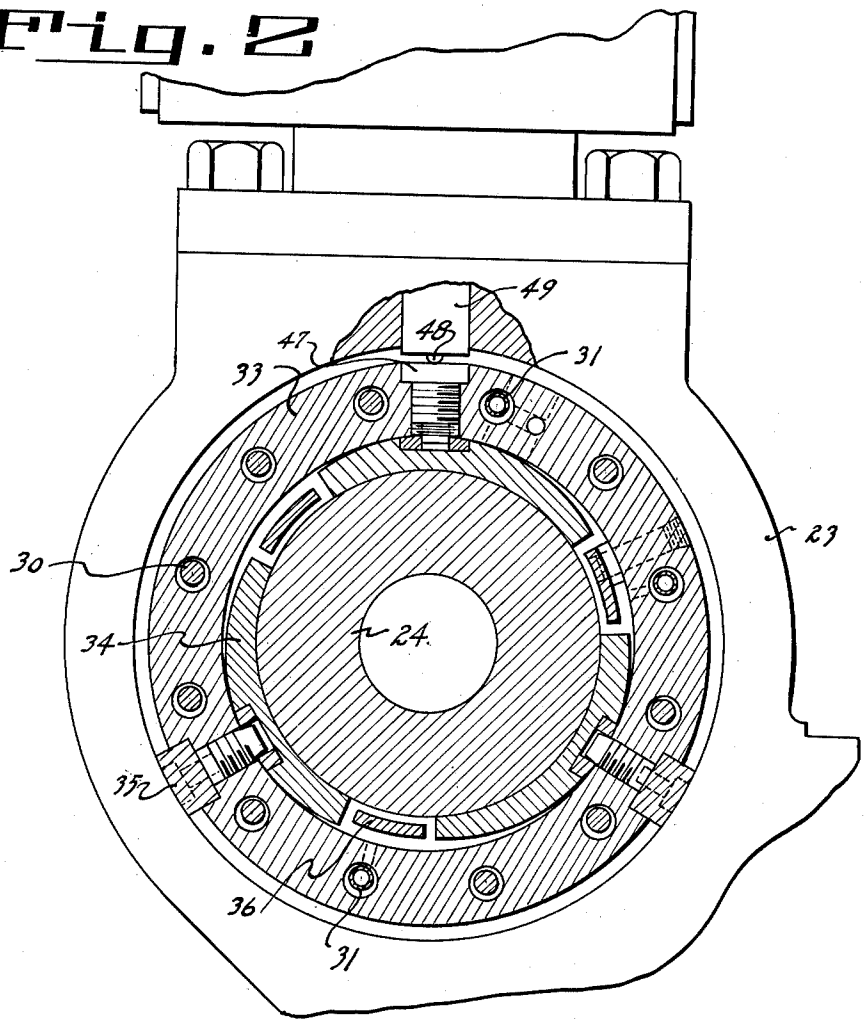
BY
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ATTORNEYS

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GRINDING MACHINE

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Fig. 2



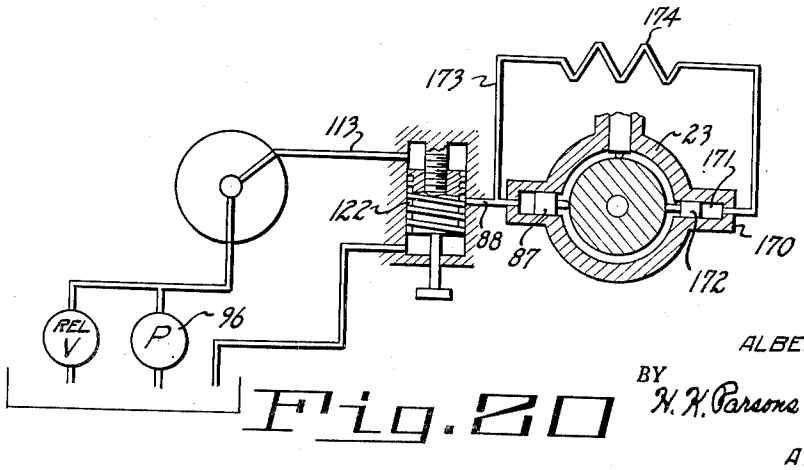


Fig. 2a

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GRINDING MACHINE

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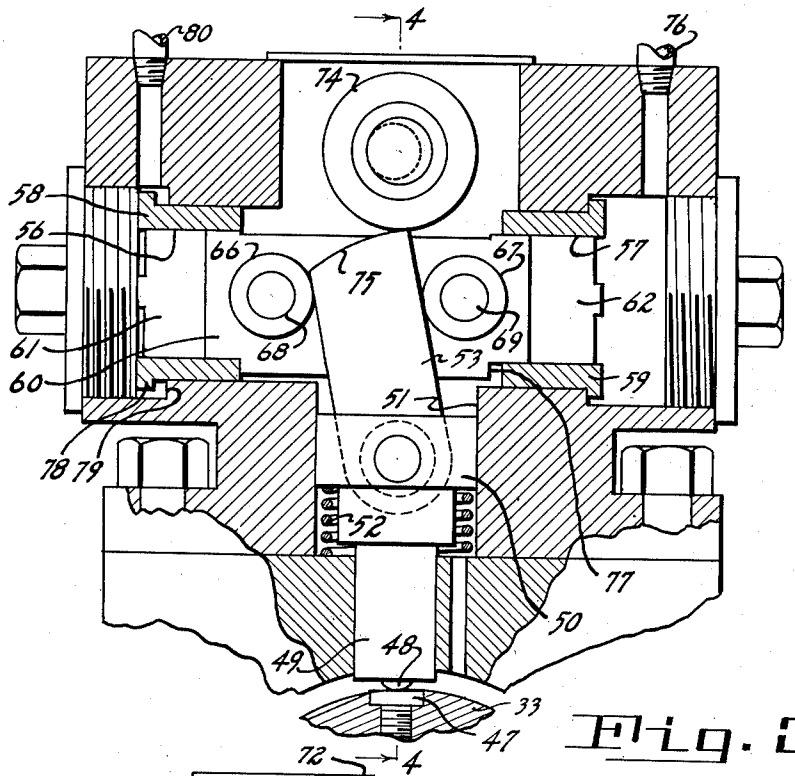


Fig. 3

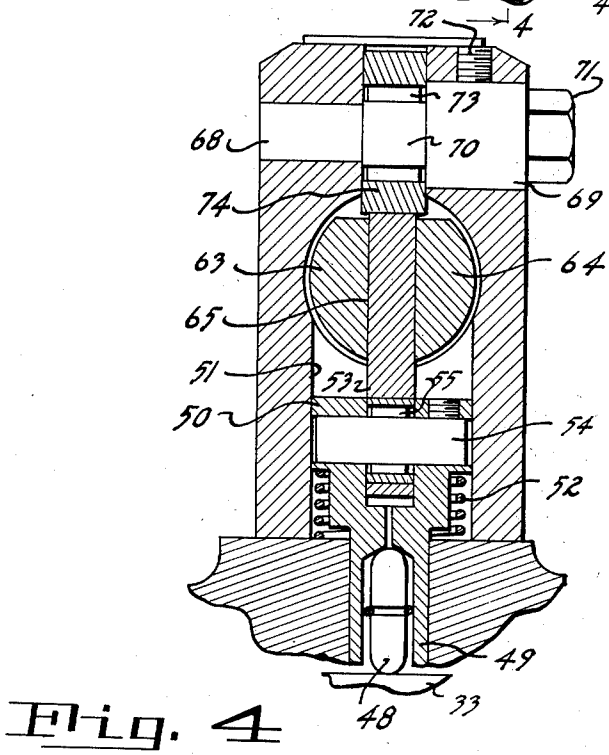


Fig. 4

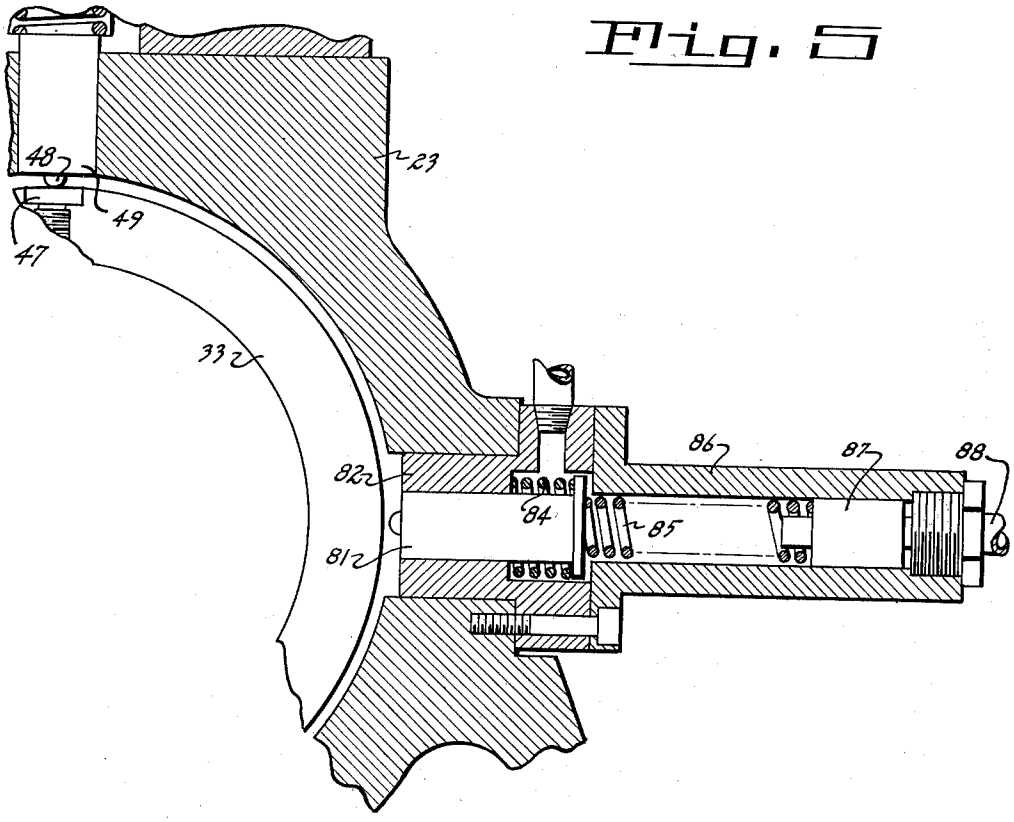
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GRINDING MACHINE

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Fig. 5



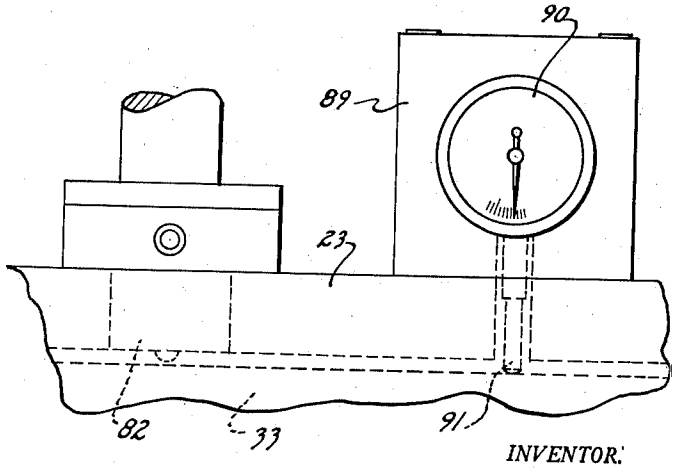


Fig. 6

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GRINDING MACHINE

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Fig. 7

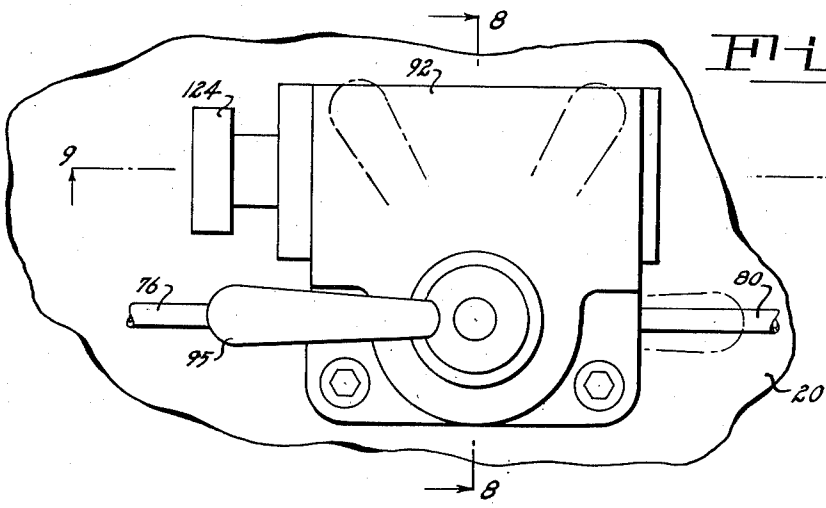


Fig. 8

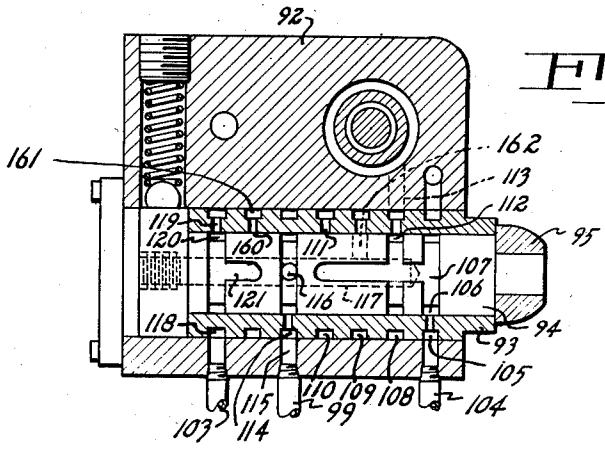
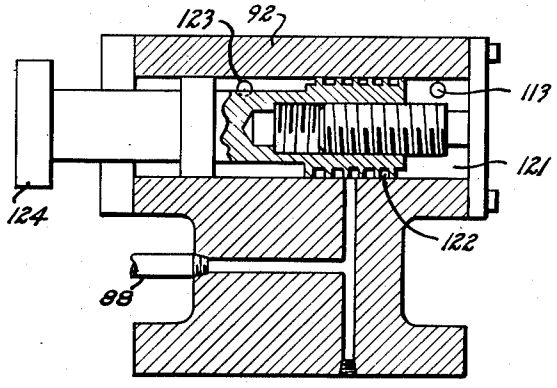


Fig. 9



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GRINDING MACHINE

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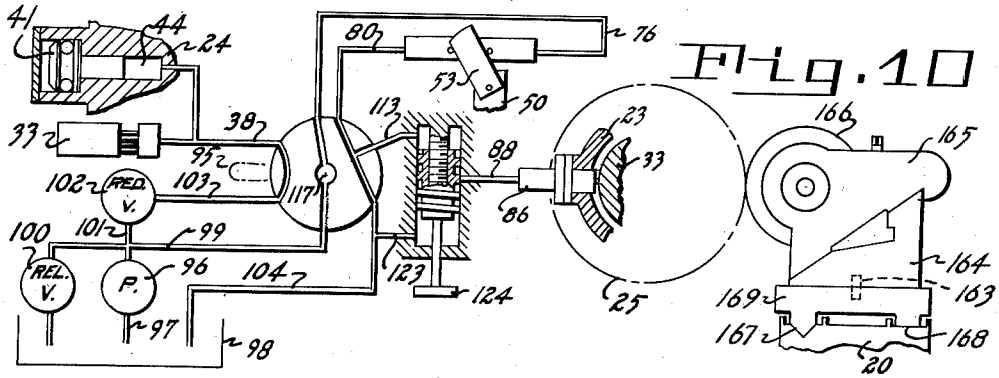


Fig. 10

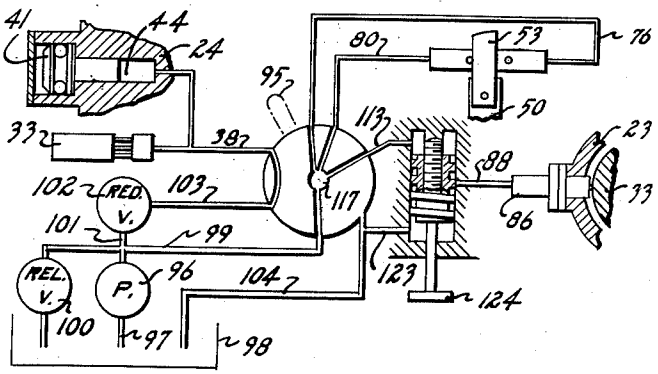


Fig. 11

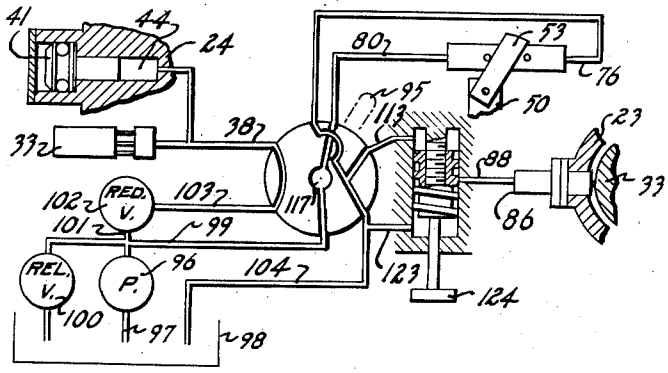


Fig. 12

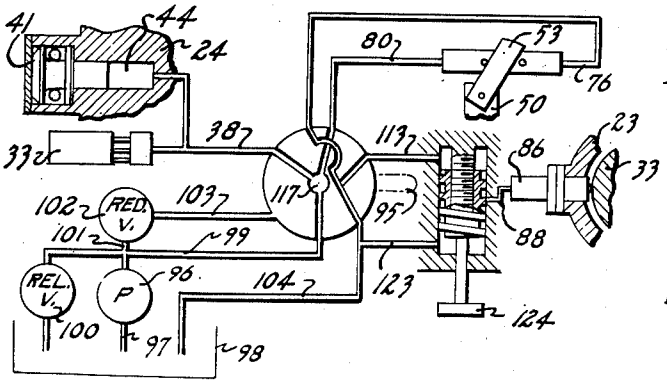


Fig. 13

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GRINDING MACHINE

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Fig. 14

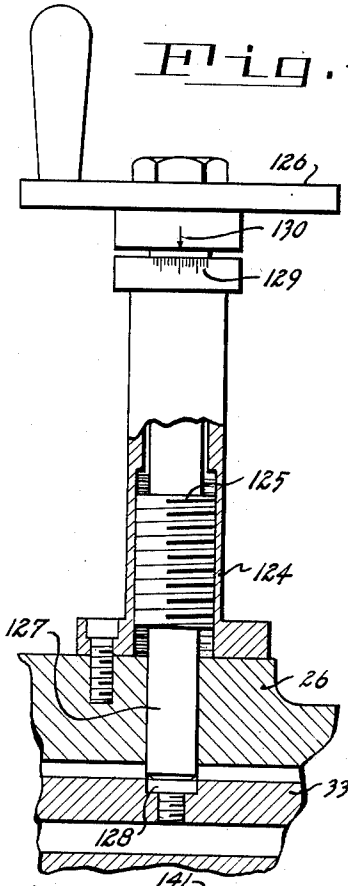


Fig. 15

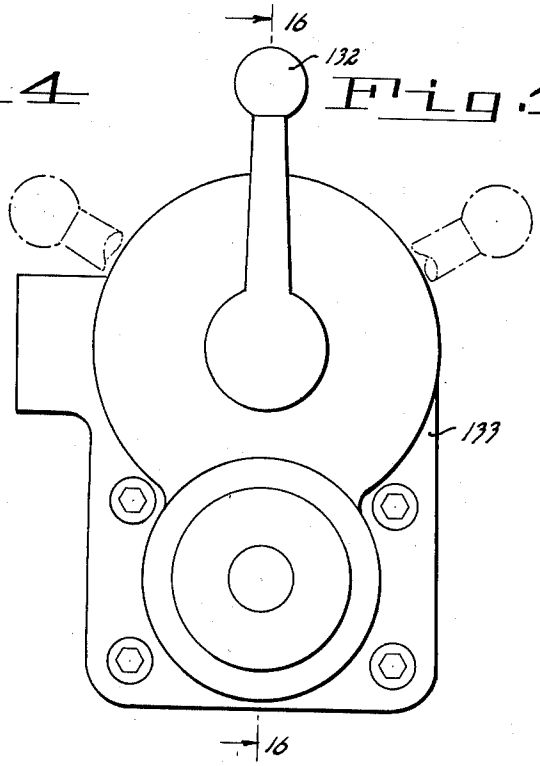
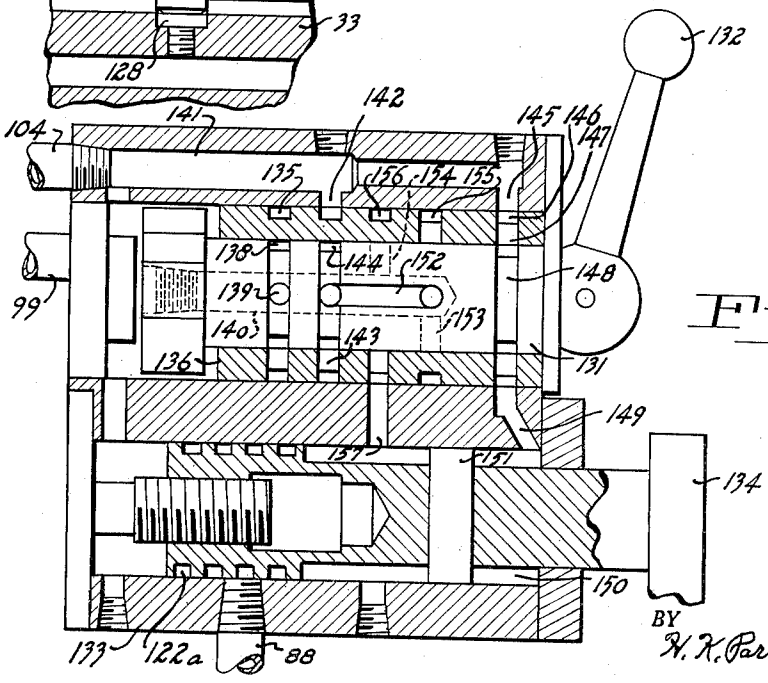


Fig. 16



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GRINDING MACHINE

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Fig. 17

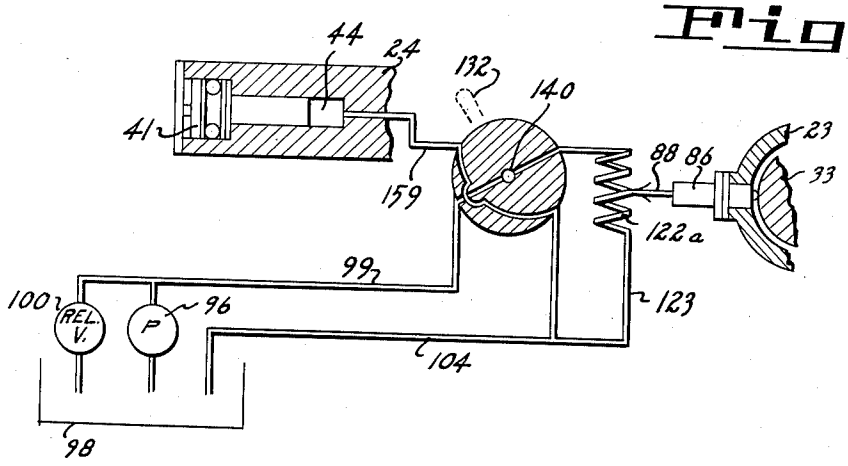


Fig. 18

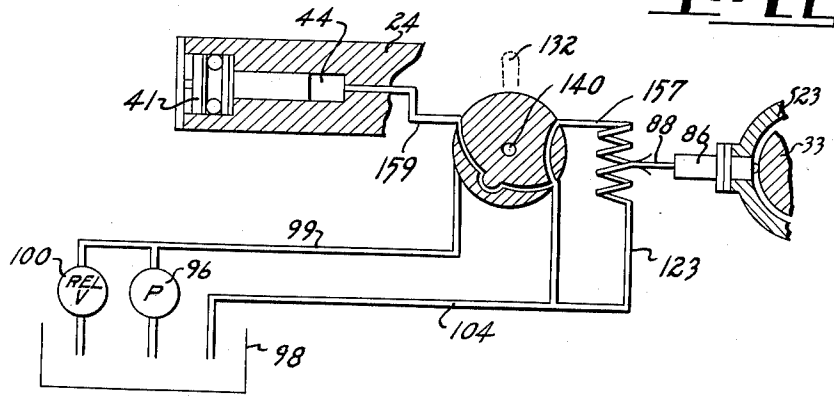
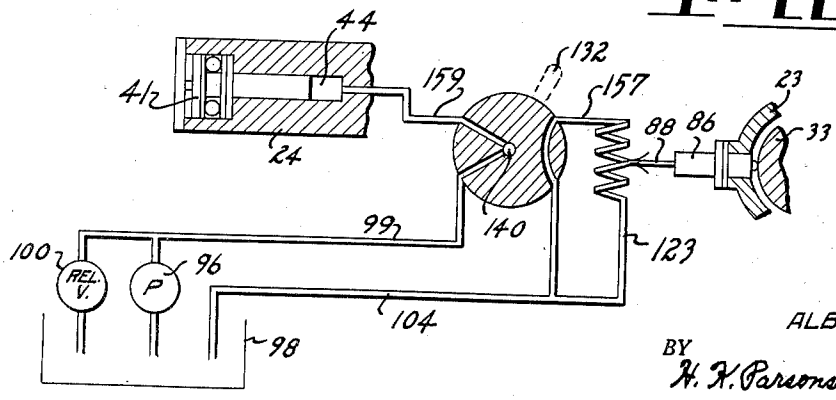


Fig. 19



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Patented June 10, 1952

2,599,698

UNITED STATES PATENT OFFICE

2,599,698

GRINDING MACHINE

Albert H. Dall, Cincinnati, Ohio, assignor to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

Application March 3, 1950, Serial No. 147,507

17 Claims. (Cl. 51—95)

1

This invention relates to improvements in cylindrical grinding machines and has particular reference to improvements in the type of grinding machine disclosed in application of Dall et al., Serial No. 741,076, which issued as Patent No. 2,507,558 on May 16, 1950.

One of the objects of the present invention is the provision of a grinding machine capable of utilization in the production of work of maximum precision due to elimination of vibrations due to unbalance in the grinding structure and the provision of supplemental means for control of relative movement of parts of the machine during final finish grinding operations.

A further object of the present invention is the provision of a grinding machine constructed to avoid damage to the work due to springing of the parts of the machine during a finishing operation and which will maintain a substantially constant minimum pressure between grinding wheel and work during such finishing operation.

An additional object of the invention is the provision in a grinding machine of improved means for selectively controlling the nature of the mounting or supporting of the grinding wheel spindle during the performance of different operations by the machine.

The present invention further contemplates the provision of controlled resilient means for determination of the nature and extent of engagement of the grinding wheel and work during a surfacing operation and of novel structural details for accomplishment of this and the above-referred to objects.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Figure 1 is a sectional view of the spindle portion and associate parts of a grinding machine embodying the present invention.

Figure 2 is a transverse sectional view on the line 2—2 of Figure 1.

Figure 3 is a fragmentary sectional view of one form of spindle clamping means taken on the line 3—3 of Figure 1.

Figure 4 is a vertical section on the line 4—4 of Figure 3.

Figure 5 is a fragmentary vertical sectional

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view illustrating the vertical and horizontal movement controlling means for the grinding wheel spindle.

Figure 6 is a fragmentary plan view illustrating the gage mounting.

Figure 7 is a fragmentary front view of the control valve bracket as utilized in connection with the mechanism illustrated in Figure 1.

Figure 8 is a vertical section on the line 8—8 of Figure 7.

Figure 9 is a horizontal section on the line 9—9 of Figure 8.

Figures 10, 11, 12, and 13 are diagrammatic views illustrating different conditionings of the hydraulic control circuits of the machine effectable by the valve and control mechanism shown in Figures 7 to 9.

Figure 14 is a fragmentary vertical sectional view illustrating a manually operable clamping means for the grinding wheel spindle.

Figure 15 is a view in elevation of a modified form of hydraulic control valve assembly.

Figure 16 is a vertical sectional view as on the line 16—16 of Figure 15.

Figures 17 to 19 are diagrammatic views of the controls selectively effectable by the valving mechanism of Figures 15 and 16.

Figure 20 is a diagrammatic view of another modified form of the present invention.

In the drawings the reference character 20 designates the base or bed of a cylindrical grinding machine having the ways 21 and 22 mounting the movable wheel head 23 which supports the spindle 24 for a grinding wheel 24. The detail mounting of the spindle 24 is substantially that illustrated and claimed in pending application, Serial No. 741,076, which issued as Patent No. 2,507,558 on May 16, 1950. It includes the spindle housing 26 having mounted at one end the bearing structure 27 supporting the right hand end of the spindle for rotary and slight axial oscillatory or gyratory movement. At the left hand portion of the machine there is mounted in the housing 26 a sleeve 28 locked in position as by screws 29 and having secured in position therein an orbital series of spring rods 30 and conduit tubes 31. The opposite ends of these tubes and rods are held by resilient bushings of "Neoprene" or similar material 32 in apertures formed in the bearing sleeve 33 which circumscribes the left hand portion of the spindle 24 and is supported for limited movement within the housing 26. It will be noted by reference to Figure 1, that the resilient rods and tubes are mounted at a slight angle to the horizontal axis of the spindle, or

alternatively, may be given a permanent flexure or set in an upward direction so that their resilient action normally will tend to urge the sleeve 33 upwardly or away from seating position as respects the housing 26. As a result of this construction, the wheel bearing end of the spindle is yieldable or resiliently supported by the tubes and rods with its outer bearing sleeve in clearance relation to the housing such that the spindle and its bearing unit may freely vibrate or oscillate about the bearing 27 as a center for the purpose of unit balancing or other operations as hereinafter described.

Contained within the bearing sleeve for effecting an automatic centering of the spindle with respect to the sleeve under varying load conditions are the conventional rocker shoe bearings 34 supported in position as by pivoted studs 35 and cage unit 36, suitable portings as at 37 being provided from the bores of the resilient tubular members 31 for supply of lubricating medium under pressure as through the piping 38.

Formed at the end of the spindle is a counterbore 39 receiving the balancing balls or weights 40 normally locked in position by the disc 41 urged into said locking position by spring 42. A piston plunger 43 slidable in cylinder 44 is actuable by pressure medium introduced through porting 45 from the tube 31 which may be utilized to move the piston 43 outward to effect temporary unclamping of the weights or balls 40 for effecting dynamic balancing of the parts.

In conditioning the machine for grinding operations, the spindle 24 is rotated by power applied to the multiple sheave 46, and the piston 43 is initially hydraulically outwardly urged to release the members 40 and permit them automatically to take up the necessary positions for effecting proper vibration eliminating dynamic balancing of the wheel and spindle structure. The hydraulic pressure is then released or reduced so that the member 41 will move to position to clamp the balancing devices in this automatically selected position.

For performance of normal grinding operations, truing of the grinding wheel and the like, it is desirable that the spindle be maintained in a fixed or non-shifting position with respect to the wheelhead. This may be accomplished automatically by utilization of a mechanism such as particularly illustrated in Figures 3 and 4, for example. As there shown, the sleeve 33 is provided with a hardened insert or anvil 47 engageable by the ball or other hardened tip 48 on the plunger or locking member 49. This plunger has a piston portion 50 slidably in the casing 51 and outwardly urged by spring 52. Mounted in a slot of the piston portion is a wedge block or link 53 constituting a clamp actuator oscillatable about pin 54 on the interposed bearings 55, whereby provision is made for free adjusting movement of the link under pressure conditions.

The casing 51 is provided with a transverse bore providing opposed cylinders as at 56 and 57. Slidable in these cylinders are the flanged piston bushings 58 and 59 which, in turn, support for sliding movement the clamp piston 60 having the terminal cylindrical piston portions 61 and 62 and the intermediate slotted body portion providing the furcations 63 and 64, the clamp link or lever 53 fitting into the slot 65 between these furcations. The position of the link in the slot and its movement with the piston 60 on reciprocation thereof is controlled by the antifriction rollers 66 and 67 carried by the pivots 68 and 69 extending transversely of the slot and connecting the members 63 and 64, the members 66 and 67 being disposed in close interfitting but rolling engagement with the opposite sides of the member 53.

Extending transversely of the casing 51 and disposed above the transverse bore therein is an abutment stud comprising the co-axial portions 68 and 69 journaled in the casing 51 with an intermediate eccentrically disposed portion 70. The stud is provided with a head or nut-like member as at 71 to facilitate rotary adjustment and thus positioning of the eccentric 70 and can be locked in desired rotative adjusted position by screw 72. Mounted on the eccentric are the antifriction bearings 73 rotatably supporting an adjustable abutment in the form of a roller 74 in position to engage the upper arcuately formed cam or eccentric wedge terminal portion 75 of the clamp link or lever 53.

By reference to Figure 3, it will be noted that introduction of pressure into the cylinder or piston chamber 57, as through conduit 76, serves to force piston 62 and piston bushing 59 to the left, roller 67 correspondingly moving link 53 which by reaction between roller 74 and surface 75 tightly forces the clamp plunger 49 downward against the bearing sleeve 33 to clamp the sleeve in position within the wheelhead housing so that the spindle is rigidly locked in place with respect to the housing as indicated in Figure 1.

At this time it will be noted that the shoulder 77 on the web or furcation 64 of the piston member has moved to the left a distance sufficient to clear the end of the piston bushing 59. At this point the piston is in its extreme left hand position and the flange 78 on the piston bushing 58 has a clearance as respects the stop shoulder 79 of the member 51.

In the event that it is desired to effect a slight release of the clamping action while maintaining a controlled and predetermined steadying of the bearing sleeve 33, pressure may be introduced into the left hand end of the cylinder 56 by way of conduit 80 while pressure is still maintained in the conduit 76. This pressure will react on the piston bushing 58 moving the same to the right until the flange of the bushing is seated against the casing 51 while at the same time the shoulder 77 of the piston member will be seated against the bushing 59. With the parts in this position the piston is, therefore, rigidly held against movement in either direction and the clamp link 53 and plunger 49 correspondingly rigidly maintained in position to limit any upward or vertical movement effected by the reaction of the spring rods 30 and tubes 31 as respects the bearing sleeve 33. Dispositioning of the sleeve, however, permits of a limited back and forth oscillatory movement of the sleeve and thus of the grinding wheel spindle 24 and wheel 25 as guided by the inter-engagement of the tip 48 with anvil 47. The arrangement of the spring rods or supports for the sleeve is such that their automatic influence normally effects the upward releasing movement only. To create a controlled inward or forward yielding deflection reaction as respects the bearing, a spindle, tending to yieldingly maintain the wheel in engagement with the work, use is made of the plunger 81 slidably mounted in the bushing 82 secured in the rear portion of the wheel head 23 and normally held in retracted position as indicated in Figure 5 by the spring 84. A compression spring 85 contained within sleeve 86 carried by the bushing 82

bears at one end against the member 81, and at its outer end against the hydraulically actuable piston 87, actuating medium for the piston 87 being supplied through conduit 88 connected to the outer end of sleeve 86. It will be evident that movement toward the left of piston 87 will tend to compress spring 85, overcoming the force of spring 84 to an extent dependent upon the pressure created against pressure 87 and thus shift member 81 toward the left and into engagement with the bearing sleeve 33, creating a controlled resilient pressure of the grinding wheel against the work piece in manner such that the wheel itself may yield relative to the supporting housing 23, eliminating any possible springing effect between the base of work supporting portion of the machine and the wheel head when extremely fine finishing cuts or the like are to be taken. To determine the amount of resilient movement effected during such finish grinding, a gage block 89 is mounted on the wheel head 23 in proximity to the piston 81, this block being provided with a dial gage or the like 90 having a movable operating plunger 91 extending through the casing into engagement with the sleeve 33 to register the extent of its controlled resilient movement. By observations of the extent of this movement suitable adjustments may be made of the actuating pressure introduced through the conduit 88 and thus the permissible movement of the resilient supported grinding wheel during this finishing operation. The structure and manner of control of the parts just described will be particularly apparent by reference to Figures 7 to 13 inclusive. Mounted on the base or bed 20 of the machine is a control bracket 92 having a bore in which is pressed bushing 93 receiving the rotatable valve member 94 actuable by handle 95. These parts are of conventional hydraulic valve design in which the bushing 93 is provided with a series of external circumferential grooves, forming in connection with the bracket 92 a series of axially spaced closed passages, having inwardly extending portings as indicated in Figure 8 for cooperation with the valve member 94. This valve member is, in turn, provided with a central bore, and interconnected annular and axially extending grooves by which various hydraulic porting connections may be effected as particularly illustrated in Figures 10 to 13 inclusive.

Suitable hydraulic pressure creating devices are employed, such as the pump 96 having an intake at 97 extending into the tank or reservoir 98 and a pressure conduit 99, the amount of pressure being controlled as by relief valve 100. A branch conduit 101 extending from the conduit 99 through pressure reducing valve 102 supplies by way of conduit 103 low pressure hydraulic medium as for power lubrication as distinguished from actuation purposes while a return conduit 104 provides a reservoir connection for exhaust of fluid from the several potential actuating mechanisms. As shown in Figure 8, this conduit 104 is continuously coupled by a port 105 with the groove 106 of valve 94 and thence to the surface groove 107 in said valve which extends in an axial direction to the extent of grooves 108, 109 and 110 of the bushing 93. By selective rotary positionings of the valve, this groove may therefore be aligned with proper portings of the bushing such as the porting 111 of groove 110 to couple the several grooves to reservoir in one or more positions of the valve member. The valve is provided with a second groove 112 extending circumferentially of a major portion thereof so that conduit 113 will be coupled with reservoir during most of the positionings thereof.

The valve body 94 is provided with a third peripheral groove as at 114 in constant communication with the main pressure conduit 99 by way of port 115. This groove communicates through the cross drilling or passage 116 with the axial pressure bore 117 in the valve body which extends through most of the length of the valve body and is selectively couplable with various of the control grooves such as 108, 109, and 110, by means of the selected radial portings such as 162 in the valve body 95.

The primary connections for various selected operations of the machine have been diagrammatically illustrated in Figures 10 to 13 inclusive.

In Figure 10, as in Figure 7, the control handle 95 for determination of the position of the valve body 94 is indicated in its extreme left hand or counterclockwise position. In this position the low pressure conduit 103 is coupled by way of bushing groove 118, port 119, valve groove 120, surface grove 121, port 160, groove 161 to piping 38 extending to the clamp release cylinder 44 and to the bearing cylinder 33 for lubrication at low pressure of the bearing shoes 34. At the same time the high pressure conduit 99 is coupled by way of groove 110 and conduit 75 to the right hand piston chamber 57 for clamping the parts in the position indicated in Figure 3. In this position the left hand piston chamber and conduit 88 to the resilient spindle backing up structure particularly illustrated in Figure 5 are connected to reservoir.

The main spindle, by virtue of the secure clamping of its bearing sleeve 33 is thus rigidly held in position within the wheelhead and the machine continued for what is known as rough grinding or appreciable stock removal from a work piece for truing or other standard operations. In this manner the essential stock removal and proper generation of the desired cylindrical or like surface of revolution on a work piece may be rapidly and satisfactorily effected.

However, when it is desired to produce an extremely accurate surface or surfaces of high finish, as for example in the grinding of rolls for use in production of metal foil or the like it has been found that even with most accurate setting of the parts capable with ordinary grinding machine constructions, during the final finish grinding operation there is a certain tension release in the parts of the grinding machine. This may cause a grinding wheel to slightly dig into or mar the highly polished surface which it is desired to produce within an accuracy of tenths of thousandths of an inch. Likewise even the slightest run-out of the wheel spindle or surface of the wheel during such finishing operation may produce like deleterious results.

These are eliminated or minimized to a maximum extent by utilization of the parts hereinabove described in the manner indicated in connection with the diagrammatic view, Figure 11. Here the control handle 95 has been shifted in a clockwise direction to the position indicated in the dotted lines in Figures 7 and 11. As there indicated, the low pressure lubrication conduit 103 is still coupled with the spindle bearing and clamp structures, maintaining a low pressure but of insufficient amount to cause any loosening of the balance mechanism clamping device. The high pressure through conduit 99, however, is

coupled by way of the central bore 117 of the valve body to groove 110 and conduit 76 as before, but additionally to groove 109 and thence to conduit 80, causing balancing pressures against the piston bushings 58 and 59 so that the clamp 49 is slightly released, freeing the bearing sleeve 33 for slight resilient movement of the spindle 24 as previously described. At the same time the pressure bore 117 is coupled by way of groove 108 to conduit 113, discharging into chamber 121 whence it passes by way of the spiral resistance groove 122 to permanent reservoir connection 123. This resistance is variably adjustable with respect to the intermediate pressure conduit 88 by means of the adjusting screw 124 so that the value of pressure in conduit 88 reacting against piston 87 can be delicately adjusted and controlled.

It will be evident that in this particular relationship of the parts the clamp 49 is sufficiently released so that the member 3 and spindle are slightly upwardly deflected to an extent limited by the locked position of the members 53—49 and at the same time any pressure between the grinding wheel and work will tend to exert a yielding rearwardly of the grinding wheel by flexure of the rods and tubes 30 and 31 which normally hold the spindle axis in a fixed vertical plane. The amount of resistance to such pressure effected flexure of these resilient supporting members or the maintenance of the various parts under a predetermined light pressure against appreciable flexure or displacement is determined by the setting of the variable resistance 122 determining the reaction of the spring 85 against the plunger. In this manner the grinding wheel is maintained against the work with a very light pressure but in a manner entirely independent within the fine limits under consideration of any possible slight relative springing action of the work support and grinding wheel support and the wheel itself through the flexible mounting of its spindle being permitted automatically to adjust or compensate for any slight out-of-round or other irregularities of either the wheel surface or work surface, permitting production of an extremely accurate surface of high finish and preventing damage to work surface during this final finishing operation. It will be appreciated that this resilient action may involve a very slight substantially constant horizontal angular displacement of the grinding wheel spindle, slightly varying the previous parallelism existing between the wheel surface and work surface or alternatively that if the wheel has been worn slightly from a true cylinder during previous grinding operations, such tilting may restore the parallelism. In the event that these improvements are applied to a standard universal grinding machine or grinding machine in which the work support or table has a vertical pivotal mounting or swivel adjustment, the angle of relative traverse of the work and grinding wheel surface may be set exactly parallel to avoid any feed line or other deleterious markings on the work surface, thus attaining utmost satisfactory action in connection with the final resilient or yielding engagement finishing operation.

When the control handle 95 is shifted to the second dotted line position as shown in Figure 7, or the position indicated in Figure 12, it will be noted that pressure is coupled to the conduit 80, completely releasing the clamped mechanism while the conduits 76 and 113 are coupled to reservoir. In this condition, the spindle bearing unit 33 is completely released for checking up as to the balanced condition of the spindle and grinding wheel.

Further movement in a clockwise direction to the third dotted line position in Figure 7 or the Figure 13 position maintains this released or unlocked condition of the spindle but at the same time couples the high pressure conduit 99 with the piping 38, building up the general pressure in the bearings and at the same time a sufficient pressure in the chamber or cylinder 44 to release the balancing member clamp 41 so that the balancing elements 40 may be moved automatically by vibratory centrifugal force resultant from any out of balance condition to take up the necessary position to counteract and compensate for said out of balance condition in the spindle and associated parts. The spindle having been permitted to run in this condition sufficient time for the weights properly to establish their position and dynamically balance the structure, the handle is shifted back to the Figure 12 position for tryout as to correctness of the automatic balancing and then moved into either the Figure 11 or Figure 10 position, depending on whether a stock removal type grinding or a strictly finishing type grinding operation is to be performed.

In this connection, attention is invited to the fact that by the employment of the yielding bushing mountings 32 for the members 30 and 31, while the parts are firmly and securely anchored in position, a slight relative angling movement is permitted, eliminating the possibility of any canting or tendency to misalignment of the bearing unit 33 and contained parts when moving from clamped to unclamped position or when freed for spring pressure grinding operations.

In Figures 14 to 19 there has been illustrated a slightly modified form of control mechanism in which the control of clamping of the floating bearing sleeve 33 is manual in place of hydraulic. In this instance the housing 26 supports the sleeve nut 124 receiving the clamp screw 125 having at its upper end the operating or pilot wheel 126, and at its lower end the stud position 127 is movable into clamping engagement with the hardened insert 128. It can be understood that as in the hydraulically controlled form the downward movement of the stud 127 may securely lock the spindle in position within the housing. Alternatively, a slight loosening will allow of the necessary free floating for the final grinding operation. To facilitate determination of the exact backing off from clamping position, the sleeve 124 is preferably provided with suitable graduations at 129 for cooperation with the pointer 130 on pilot wheel 126.

The functions of release of the balancing members and of control of the spring backing up pressure for the spindle movement during finish grinding are determined as before by suitable couplings of hydraulic pressure which is effectable through the positionings of valve 131 rotatable by handle 132. This valve is mounted within the casing 133 which corresponds in substance to the valve block or casing 93 and contains a hydraulic resistance varying element 134 corresponding in all respects to the member 124 of Figure 9.

As particularly illustrated in Figure 16, the pressure conduit 99 of the hydraulic system is coupled to the outer groove 135 of the valve bushing 136 and thence by way of porting 137 to the valve groove 138 and through port 139 to the

central pressure chamber or bore 140 axially disposed within the valve. Likewise, the exhaust or return conduit 104 is connected to the passage 141 in the valve block 133 and by way of porting 142 to the outer groove of the bushing and thence through porting 143 to the distributor groove 144 circumscribing the valve body 131. An additional porting 145 connects by way of groove 146, porting 147 with the drain groove 148, in turn coupled by passage 149 to the space 150 back of the piston portion 151 of the variable resistance control valve 134 to take care of any leakage into this space and prevent building up of back pressure condition.

The peripheral groove 144 communicates with a groove or passage 152 preferably extending in an axial direction on the surface of the valve 131 and selectively couplable as by the portings 153 and 154 with the grooves 155 and 156 of the bushing. Groove 155 of the bushing is coupled by way of conduit 159 with the piston chamber 44 for effecting release of the balancing ball clamp head 41 while groove 156 is correspondingly coupled with the passage or conduit 157 extending to the variable resistance control groove 122*a*.

The several hydraulic couplings effectable by movement of handle 132 and thus of valve 131 to its different positions, as illustrated in Figure 15, will be best understood by reference to the diagrammatic views, Figures 17, 18, and 19. In Figure 17, the handle has been indicated in its left hand position so that the parts are conditioned for a finish grinding operation. In this instance, the conduit 159 is connected by way of the peripheral groovings of the valve to the exhaust conduit 104 while the pressure conduit 99 is connected through the central bore or passage 140 and the porting to passage 157 leading to the resistance determinator 122*a* introducing the selected pressure through the intermediate take-off conduit 88 to react on the piston 87 and thus determine the force exerted by spring 85 by way of member 81 against the sleeve 33, limiting its rearward movement under the effect of grinding pressure.

This operation and the structural parts are the same as those previously described in detail in connection with Figure 5 of the drawings.

When the handle 132 is moved to its central position, as shown in the full lines in Figure 15, the circuit is conditioned as indicated in Figure 18. In this form the conduits 159 and 157 are both coupled to the return or low pressure conduit 104 while the pressure conduit 99 is blanked off as respects reaction on any of the pressure shiftable elements. In this position, if the screw 125 is in its lowered or clamping position the machine is conditioned for regular grinding or truing operations while if it is released, the balanced condition of the machine may be determined.

When in this released position, if it is desired to effect automatic readjustment of the balancing mechanism the handle is then moved in a clockwise direction to a third position indicated in the dotted lines in Figure 15 and diagrammatically in Figure 19. In this position it will be noted that the pressure conduit 99 is coupled by way of 140 to the balancing ball release conduit 159 while the conduit 157, as well as conduit 123, are connected to reservoir so that there is no reaction on the piston 87.

From the foregoing it will be evident that in connection with a releasable or potential resilient

or free mounting of the grinding wheel spindle, permitting of a limited back and forth play of the same so that the amount of resistance to horizontal movement may be controlled to effect a very light resilient pressure of the wheel and spindle as an entirety toward the work, which movement, being relative to the wheelhead, will be independent of release of any slight mechanical stress existing between the supporting bed or base and the wheelhead which might otherwise interfere with the accuracy of finish of the work piece. It will be further noted that for utmost efficiency the amount of this spring action may be controlled by a variable hydraulic pressure, reacting against the grinding wheel spindle in a direction toward the work, the strength and compressibility of the intervening spring 85 shown determining whether the reaction of the hydraulic pressure on piston 87 effects a direct or resiliently dampened action as respects the pressure or potential fluctuation of this spindle. It will also be noted that in both of the forms shown operation of a single lever determines the conditioning of the machine for balancing, grinding, and finish grinding operations, although the actual locking of the spindle against vibratory or oscillatory movements may be effected either directly manually or indirectly through hydraulic mechanism also under the control of said lever and valving.

It will be understood that the present invention may be employed with various forms of conventional grinding machines, as for example, the machine shown in Patent 2,101,644. As diagrammatically illustrated in connection with Figure 10, the machine includes ways 167, 168 formed on the bed 20 which support the reciprocating carriage 169. Swiveled on this carriage as at 163 is the table 164 provided with work supporting means 165 for maintaining the work piece 166 in proper opposing relation to the grinding wheel 25. In this form of machine, the in and out or feeding movement is applied to the grinding wheel while the relative translatory movement is effected by axial shifting of the work piece and its supporting table and carriage along the bed 20. Due to the pivotal connection between the carriage and work table it is possible, if desired, during the finishing operation to effect a slight angular positioning of the axis and thus the surface of the work with respect to the axis of the spindle housing 26. This adjustment may also be effected by slight angling of the wheel spindle support as provided in various commercial grinding machines. This permits of compensation for any minute angular displacement of the surface of the wheel 25 due to the potentially free horizontal movement of its spindle during the finishing operation so that the surfaces of the wheel and work may be maintained exactly parallel, thus reducing the possibility of formation of feed lines on the work due to greater pressure of one edge or the other of the wheel against the work.

Figure 20 illustrates diagrammatically an additive feature of the invention capable of utilization with the forms previously described and particularly adapted for employment when extremely light finishing cuts are being taken or in instances where the relationship of work and grinding member may be such as to tend to cause slight undesirable vibratory movement of the grinding wheel spindle. This form is most advantageously utilizable, for example, in the final finishing of large rolls which frequently are sev-

eral feet in diameter by ten feet or more in length. Such rolls are used for production of metal foil or the like and must be of extreme accuracy and unblemished surface throughout.

As has been previously pointed out, the mounting of the grinding wheel spindle **24** and its releasable journal or bearing sleeve **33** are such, that as an entirety they may pivot about the bearing **27** when the clamping element **48** is released. In Figure 5 there has been illustrated in detail the yielding pressure member **81** and associate elements for reaction on the member **33** to effect an urge of the spindle **24** in a direction to effect engagement of its supported grinding wheel **25** with the work piece **166**.

It will be understood that this is entirely sufficient and effective for many grinding operations. On the other hand, there may arise conditions in which an irregularity in form or mounting of the work piece or other grinding conditions may tend to create a variance in position of the grinding wheel during traversing which might set up a vibratory reaction in the spindle **24**, or in which it is desired that a greater potential backing up pressure be given to the spindle to resist rearward deflection by work engagement, which pressure will be of a nature to more than overcome the force of the resilient axial centralizing members such as **31**.

For greatest operating efficiency under these varying conditions, there may be provided at a suitable point on the housing or support **23** a supplemental housing **170** providing a cylinder **171** to receive a pusher piston **172** as has been indicated in Figure 20. By reference to this figure, it will be noted that the diameter of the cylinder and chamber is preferably less than the diameter of the cylinder for the piston **87** with the result that if equal pressures be introduced into the respective chambers for reaction on these pistons a greater force will be exerted by the piston **87** than by the piston **172**, creating a predominating urge of the spindle and its supported grinding wheel in the direction of the work to counteract the reaction force between work and grinding wheel during the grinding operation. In Figure 20 there has been indicated, as in preceding views, the conventional pressure source **96** which may be coupled by valving mechanism as heretofore described to the conduit **113** extending to the variable resistance groove **122** so that the pressure reaction may be varied as respects the conduit **88**. Branching from conduit **88** is the auxiliary pressure conduit **173** coupled with chamber **171** for actuation of the piston **172**; varying the effective pressure in conduit **88** will proportionately vary the pressure reactions against the respective pistons. The conduit **173** has been shown as including a resistance or choke coil **174** to retard or damp out the flow reactions between the cylinders for pistons **87** and **172**. It will be understood that as pressure is built up in conduit **88**, since there is no separate drain or outlet for the chamber **171**, equal unit pressures will be created as respects the respective pistons although a different actual force will be exerted therein due to the differential between the piston area on which said unit pressure reacts. The choke **174**, however, will damp out instantaneous pressure reactions between the cylinders produced by pressure variants on the wheel **25** or otherwise, thus steadying and stabilizing the pivotal or floating action of the spindle **24**. The piston **171** thus acts as an opposed yielding resistor which reacts on the spindle in opposition to the pressure members **87—81**.

The viscous damping coil **174** serves to damp out any high frequency motions due to close pitched undulations in the work piece caused by prior grinding operations. On the other hand, the coil will not damp out motions caused by run-out of the work piece which have relatively low frequency motion. Nor will it damp out motions caused by slight changes of parallelism of the work periphery and its direction of motion.

These changes in work run-out and parallelism are the result of thermal changes in the work piece or machine during long finishing operations on such things as large rolls for rolling mills.

On finishing operations on rolls, the condition of the face of the grinding wheel is very critical. Constant pressure between this face and work is highly desirable over long periods. Changes in work dimension due to temperature will create large variations in pressures between wheel and work where the wheel is held very rigidly. Thus, it is desirable to have in a machine the possibility of holding the wheel rigidly for rough grinding and elastically for finish grinding, such as is attained by the hereinabove described structures.

What is claimed is:

1. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, said means for yieldingly supporting the spindle including deflectable resilient members having a portion fixed with respect to the housing and a second portion fixed with respect to the wheel supporting portion of the spindle, said means for yieldingly urging the wheel supporting portion of the spindle in the direction of the work support including a pressure actuable piston, a source of pressure medium for supplying pressure to the piston, and a pressure regulator for determining the reaction force exerted by said means on the piston.

2. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, said means for yieldingly supporting the spindle including deflectable resilient members having a portion fixed with respect to the housing and a second portion fixed with respect to the wheel supporting portion of the spindle, said yielding means for urging the wheel supporting portion of the spindle in the direction of the work support including a separate expansion spring element, a piston backing member for said spring element, and a source of pressure medium for supplying pressure to urge the piston against the element.

3. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member,

a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, said means for yieldingly supporting the spindle including deflectable resilient members having a portion fixed with respect to the housing and a second portion fixed with respect to the wheel supporting portion of the spindle, said yielding means for urging the wheel supporting portion of the spindle in the direction of the work support including a separate expansion spring element, a piston backing member for said spring element, a source of pressure medium for supplying pressure to urge the piston against the element, and a pressure regulator to adjust the pressure reacting on said piston.

4. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, a locking device carried by the housing and reacting on the spindle rigidly to secure the spindle in position with respect to the housing, a hydraulic actuator for the locking device, a source of hydraulic medium, and a shiftable valve intervening said source and the locking device to determine the flow of actuating medium from the source to the locking device.

5. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, and a locking device carried by the housing and reacting on the spindle rigidly to secure the spindle in position with respect to the housing, said locking device havng a first hydraulically determinable position for rigidly securing the spindle and a second hydraulically determinable position for effecting a limited release of the locking device with respect to the spindle, a source of hydraulic actuating medium and a two-position valve intervening the source and the locking device and selectively positionable to determine the positions of the locking device effectable by said hydraulic medium.

6. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, and a locking device carried by the housing and reacting on the spindle rigidly to secure the spindle in position with respect to the housing, said locking device having a first hydraulically determinable position for rigidly securing the spindle and a second hydraulically determinable position for effecting a limited release of the locking device with respect to the spindle, a source of hydraulic actuating medium and a two-position valve intervening the source and the locking device and selectively positionable to determine the positions of the locking device effectable by said hydralic medium, a pressure device engageable with the spindle to effect a directional urge against the spindle, said pressure device including a hydraulically shiftable piston, the valve having conduit portions for determining the effective coupling of the source of pressure medium with said piston to effect said directional urge.

7. A grinding machine including a bed, a work support and a wheel support mounted on the bed for relative reciprocating and feeding movements, said wheel support including a housing member, a wheel spindle supported within the housing member for yielding movement relative thereto, said spindle having a wheel supporting portion, means for yieldingly urging the wheel supporting portion in a direction toward the work support, and a locking device carried by the housing and reacting on the spindle rigidly to secure the spindle in position with respect to the housing, said locking device having a first hydraulically determinable position for rigidly securing the spindle and a second hydraulically determinable position for effecting a limited release of the locking device with respect to the spindle, a source of hydraulic actuating medium and a two-position valve intervening the source and the locking device and selectively positionable to determine the positions of the locking device effectable by said hydraulic medium, a pressure device engageable with the spindle to effect a directional urge against the spindle, said pressure device including a hydraulically shiftable piston, the valve having conduit portions for determining the effective coupling of the source of pressure medium with said piston to effect said directional urge, and a pressure variator for determining the force hydraulically exerted against said piston.

8. A grinding machine spindle structure including a housing or support, a first spindle bearing mounted on the support for oscillation relative thereto, a second spindle bearing, means resiliently supporting the second spindle bearing for bodily movement relative to the support, a grinding wheel spindle journaled in said bearings, releasable clamp means for rigidly securing the resiliently supported bearing in position on the support, a pusher member carried by the housing in position to engage and effect a unidirectional urge against the resiliently supported bearing, and means for actuating the pusher member in the direction of the bearing, whereby on release of the clamping means said pusher member will be effective for oscillating the spindle and said first bearing for determining the position of the resiliently mounted bearing and the spindle supported therein with respect to the support.

9. A grinding machine spindle structure including a housing or support, a first spindle bearing mounted on the support for oscillation relative thereto, a second spindle bearing, means resiliently supporting the second spindle bearing on the support, a grinding wheel spindle journaled in said bearings, releasable clamp means for rigidly securing the resiliently mounted bearing in position on the support, a pusher member carried by the housing in position to engage and effect a unidirectional urge against the resiliently supported bearing, means for actuating the pusher member in the direction of the bearing, whereby on release of the clamping means said pusher member will be effective for determining

the position of the resiliently mounted bearing and the spindle supported therein, and means for varying the force exerted by the actuating means against the pusher member.

10. A grinding machine spindle structure including a housing or support, a first spindle bearing mounted on the support for oscillation relative thereto, a second spindle bearing, means resiliently supporting the second spindle bearing on the support, a grinding wheel spindle journaled in said bearings, releasable clamp means for rigidly securing the resiliently mounted bearing in position on the support, a pusher member carried by the housing in position to engage and effect a unidirectional urge against the resiliently supported bearing, means for actuating the pusher member in the direction of the bearing, whereby on release of the clamping means said pusher member will be effective for determining the position of the resiliently mounted bearing and the spindle supported therein, and means for establishing a substantially constant force reaction of the pusher member against the resiliently mounted bearing.

11. A grinding machine spindle structure including a housing or support, a first spindle bearing mounted on the support for oscillation relative thereto, a second spindle bearing, means resiliently supporting the second spindle bearing on the support, a grinding wheel spindle journaled in said bearings, releasable clamp means for rigidly securing the resiliently mounted bearing in position on the support, a pusher member carried by the housing in position to engage and effect a unidirectional urge against the resiliently supported bearing, means for actuating the pusher member in the direction of the bearing, whereby on release of the clamping means said pusher member will be effective for determining the position of the resiliently mounted bearing and the spindle supported therein, and means for establishing a substantially constant force reaction of the pusher member against the resiliently mounted bearing, said means including a hydraulically actuable piston element, a source of actuating medium reactable on the piston for urging the same in the direction of the pusher member, means for controlling the coupling of the source with said piston element, and means for varying the pressure exerted by the hydraulic medium against the piston.

12. A grinding machine spindle structure including a housing or support, a first spindle bearing mounted on the support for oscillation relative thereto, a second spindle bearing, means resiliently supporting the second spindle bearing on the support, a grinding wheel spindle journaled in said bearings, releasable clamp means for rigidly securing the resiliently mounted bearing in position on the support, a pusher member carried by the housing in position to engage and effect a unidirectional urge against the resiliently supported bearing, means for actuating the pusher member in the direction of the bearing, whereby on release of the clamping means said pusher member will be effective for determining the position of the resiliently mounted bearing and the spindle supported therein, means for establishing a substantially constant force reaction of the pusher member against the resiliently mounted bearing, said means including a hydraulically actuable piston element, a source of actuating medium reactable on the piston for urging the same in the direction of the pusher member, means for controlling the coupling of the source with said piston element, means for varying the pressure exerted by the hydraulic medium against the piston, and a compression spring member intervening the pusher element and the piston for resiliently transmitting the forces exerted by the piston to the pusher member.

13. In a grinding machine, the combination with a housing, of a spindle mounted therein for movement relative thereto, and means for controlling the movement of the spindle with respect to the housing including a locking member for said spindle, an abutment for cooperation with said locking member, a wedge block intervening the locking member and said abutment, a hydraulically actuable piston for shifting said wedge block as respects the abutment and locking member to tighten or release the engagement of the locking member with respect to said spindle, a source of hydraulic actuating medium and a valve intervening said source and the piston to determine the reaction of the pressure medium on the piston, independent hydraulically actuable piston means to effect a limited releasing movement of the wedge block, a source of hydraulic actuating pressure for said piston and said piston means, and means for determining the reaction of the pressure medium as respects the piston and the piston means, said means including a valve having a first series of portings to determine the coupling of the pressure medium to the piston, and additional portings to determine the coupling of the pressure medium to said piston means.

14. In a grinding machine, the combination with a housing, of a spindle mounted therein for movement relative thereto, and means for controlling the movement of the spindle with respect to the housing including a locking member for said spindle, an abutment for cooperation with said locking member, a wedge block intervening the locking member and said abutment, a hydraulically actuable piston for shifting said wedge block as respects the abutment and locking member to tighten or release the engagement of the locking member with respect to said spindle, a source of hydraulic actuating medium and a valve intervening said source and the piston to determine the reaction of the pressure medium on the piston, independent hydraulically actuable piston means to effect a limited releasing movement of the wedge block, a source of hydraulic actuating pressure for said piston and said piston means, and means for determing the rection of the pressure medium as respects the piston and the piston means, additional hydraulically actuable means to exert a radial urge against the spindle to resist work displacement thereof, and a control valve intervening the several hydraulically actuable means and the source of hydraulic pressure, said valve having a first set of portings for coupling the pressure medium to the wedge block piston and a second series of portings positionable simultaneously to couple the actuating pressure to the piston means and the hydraulically actuable means.

15. In a grinding machine having a work piece support and a resiliently supported grinding wheel spindle, a yielding pressure member reacting on the spindle to urge same in a direction to effect engagement of its supported grinding wheel with a work piece held by the work piece support, and an opposed yielding resistor reacting on the spindle in opposition to said pressure member variably to resist movement of the spindle toward the work piece support, a source of hydraulic pressure and conduit means coupling said source with the pressure member and with

the resistor to determine their respective reactions on the spindle.

16. The combination with a precision grinding machine including a support and a grinding wheel spindle mounted thereon for limited oscillatory movement with respect to the support, of means reactable on the spindle for controlling its oscillatory movement with respect to the support, said means including a first hydraulic cylinder, a piston movable therein and hydraulically actuable in a direction toward the spindle for effecting movement of the spindle in one direction, a second hydraulic cylinder carried by the spindle support and of less diameter than the first cylinder, said cylinder being disposed in opposed relation to the first cylinder, a resistor piston carried by said second cylinder having a less effective area than the effective area of the first piston, a source of hydraulic pressure medium, means to connect said source to the first cylinder for actuation of the piston carried thereby, conduit means interconnecting the cylinders, and a resistance element in said interconnecting conduit means for damping the reaction effects of the pressure conditions in the respective coupled cylinders.

17. A grinder structure of the character described including an oscillatable grinding wheel spindle, a first yielding means for supporting the spindle in a centralized position, a pressure actuable member for effecting an oscillation of the spindle in one direction, a resistor reacting on the spindle in opposition to said pressure member, means providing a hydraulic circuit for supplying actuating pressure to said member and to said resistor, and means for proportionately varying the pressure reactions on the pressure member and the resistor.

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