

Oct. 21, 1930.

J. N. HEALD ET AL

1,779,094

GRINDING MACHINE

Original Filed April 25, 1925 6 Sheets-Sheet 1

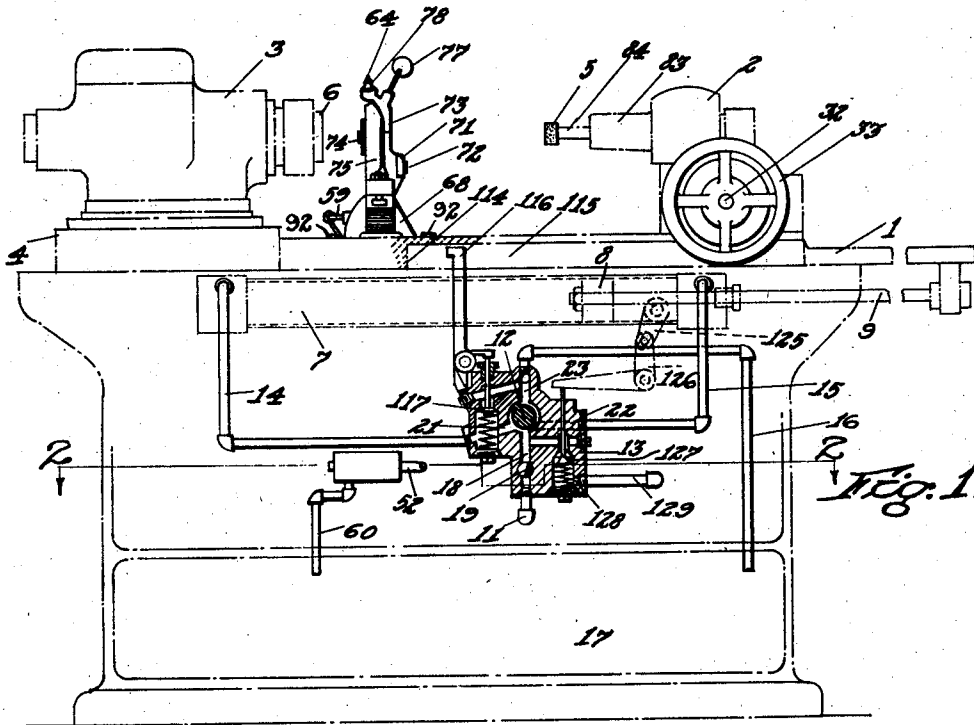


Fig. 1.

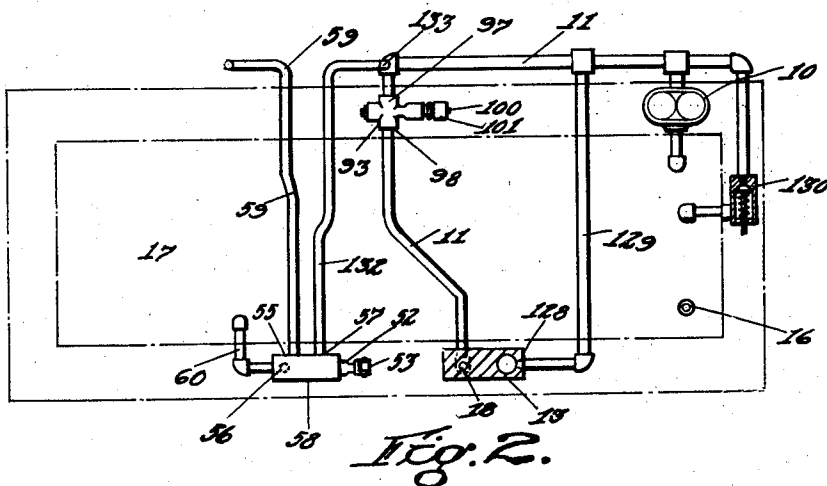


Fig. 2.

Inventors:
James N. Heald
Waldo J. Guild
By Attorney
Geo. W. Kennedy & Co.

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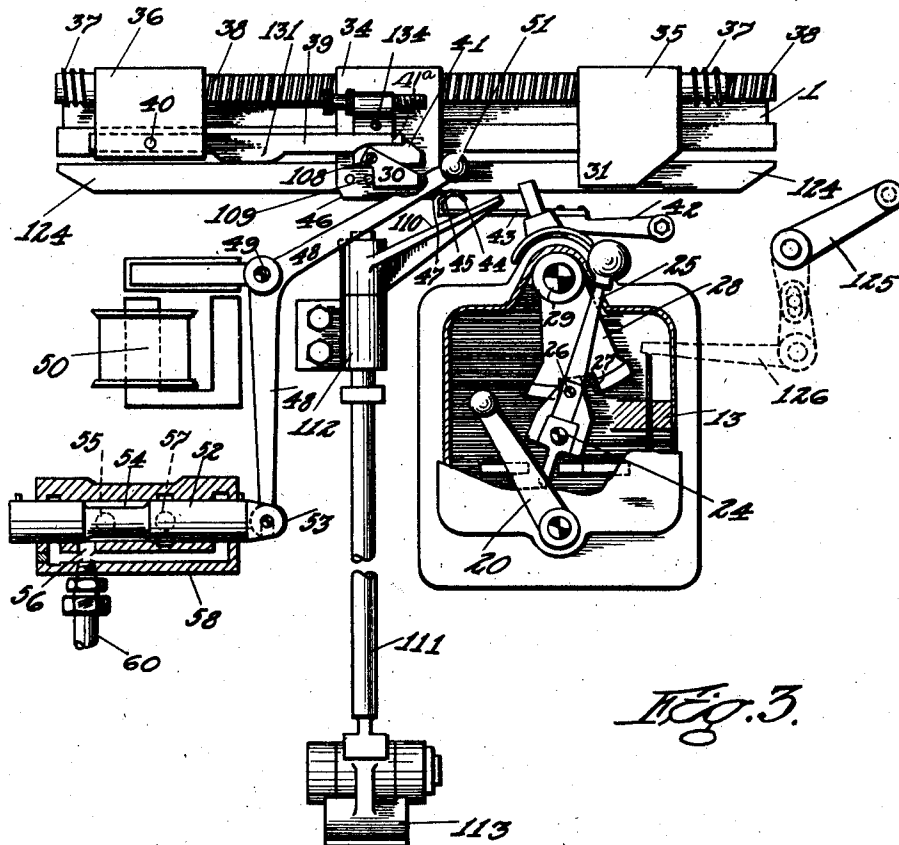


Fig. 3.

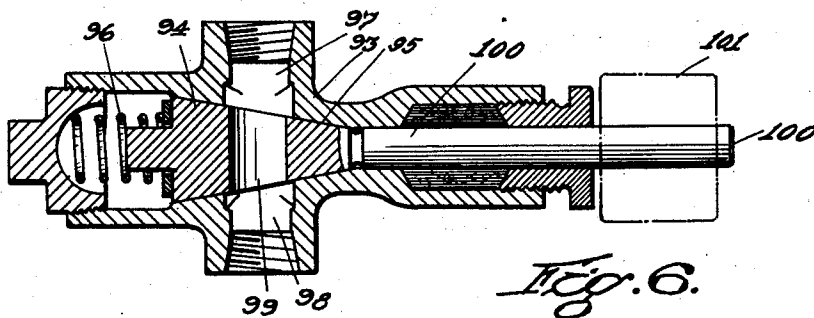


Fig. 6.

Inventors:
James N. Heald
Waldo J. Guild
By Attorney
Geo. W. Kennedy & Co.

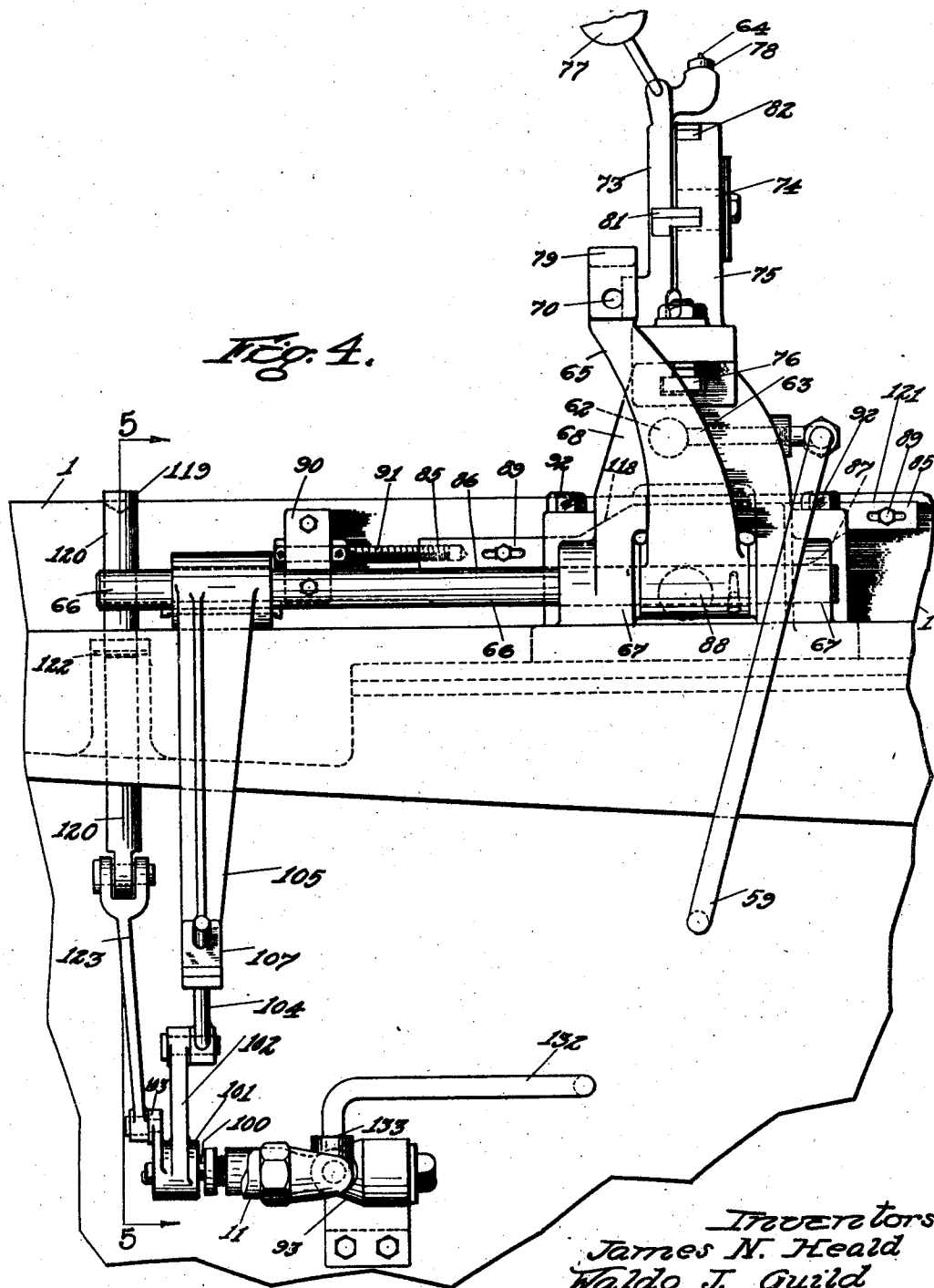
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J. N. HEALD ET AL

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GRINDING MACHINE

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Inventors:
James N. Heald
Waldo J. Guild
By Attorney
Geo. W. Kennedy

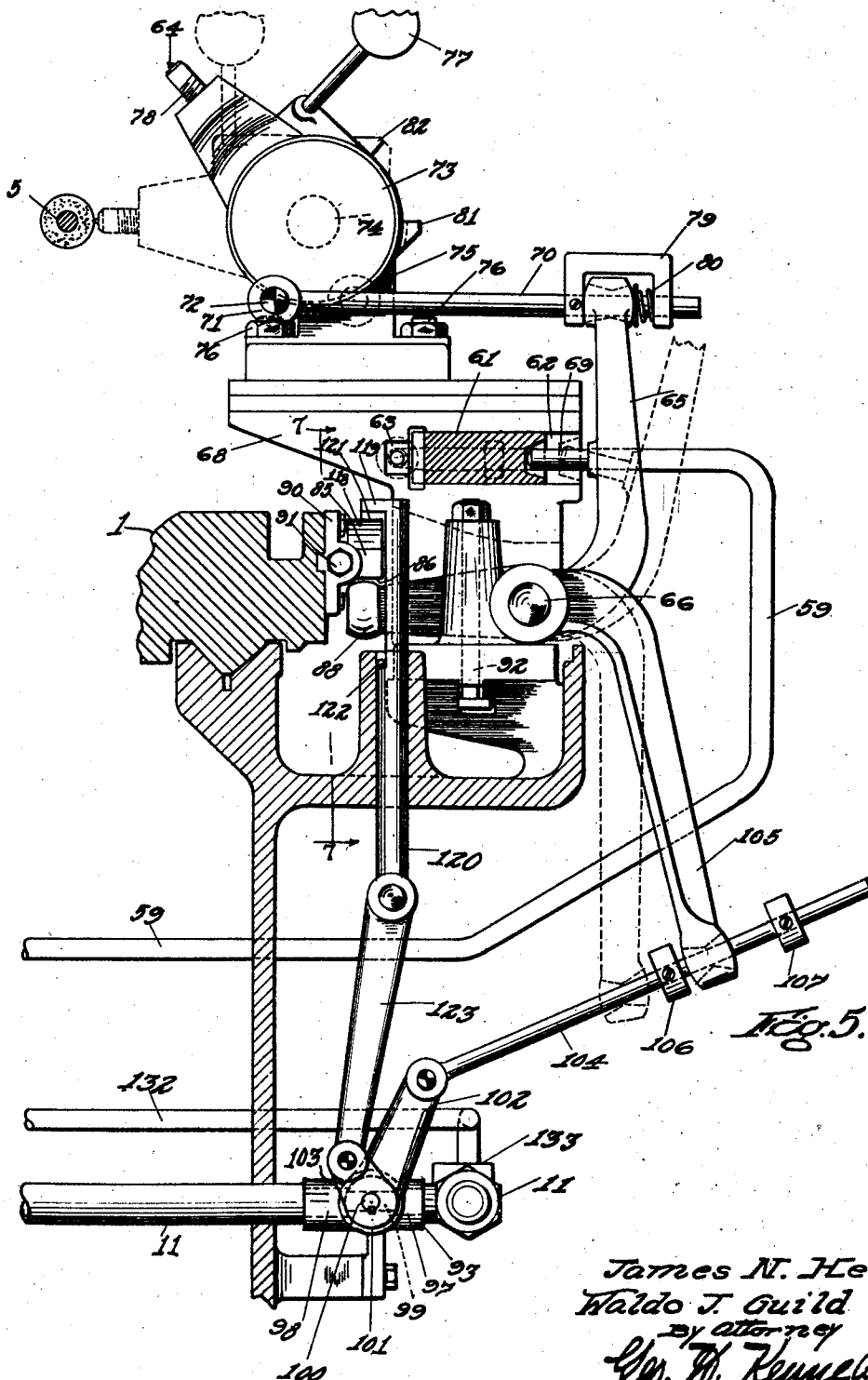
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J. N. HEALD ET AL

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GRINDING MACHINE

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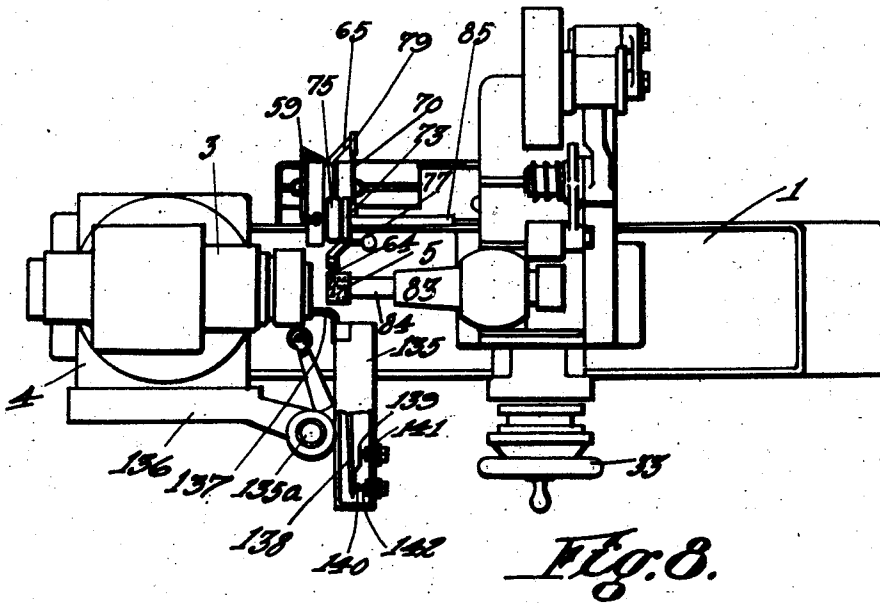
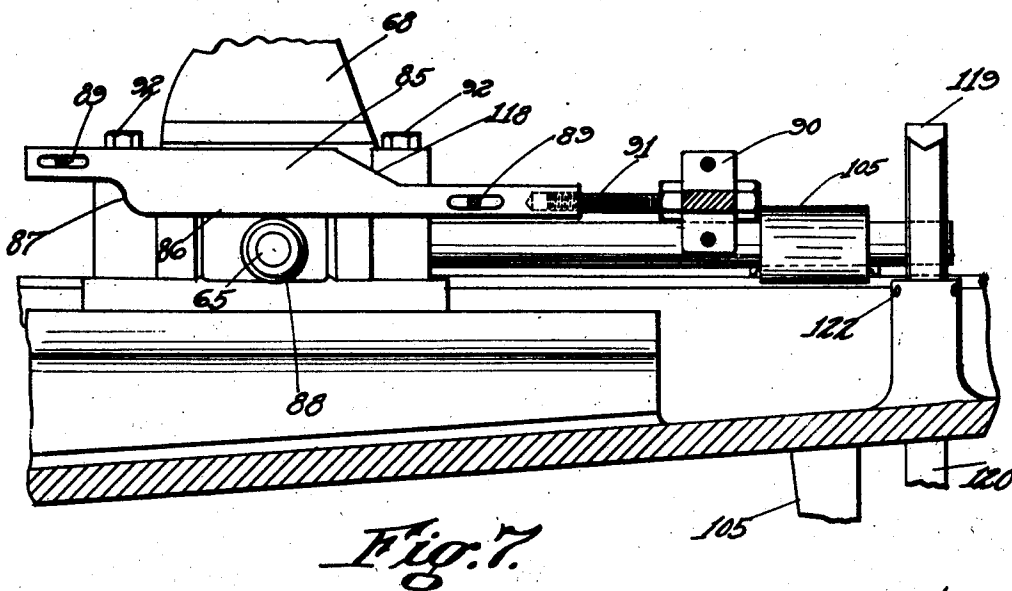
Oct. 21, 1930.

J. N. HEALD ET AL

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GRINDING MACHINE

Original Filed April 25, 1925 6 Sheets-Sheet 5



Inventors:
James N. Heald
Waldo J. Guild
By Attorney
Wes. H. Kennedy

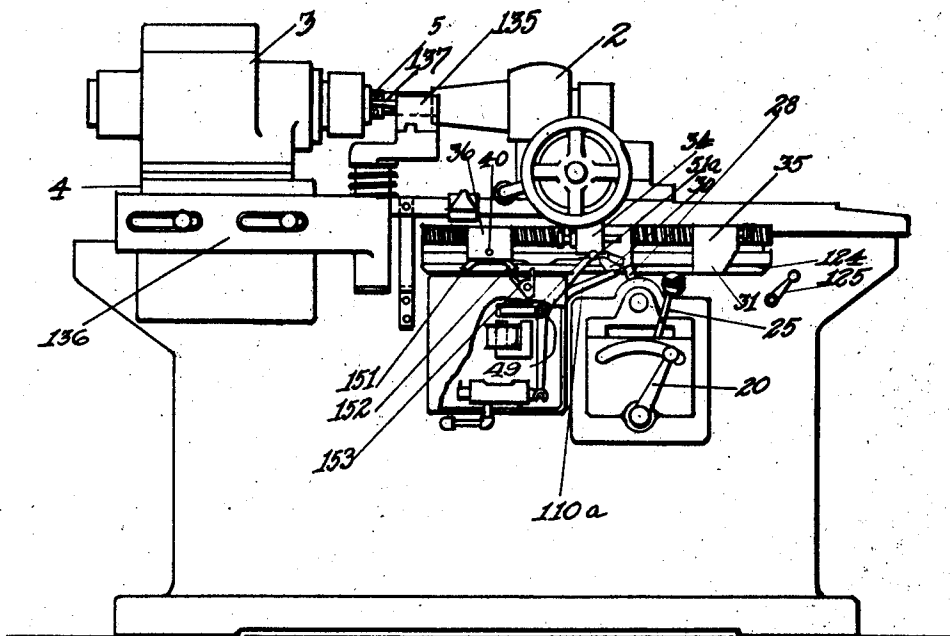
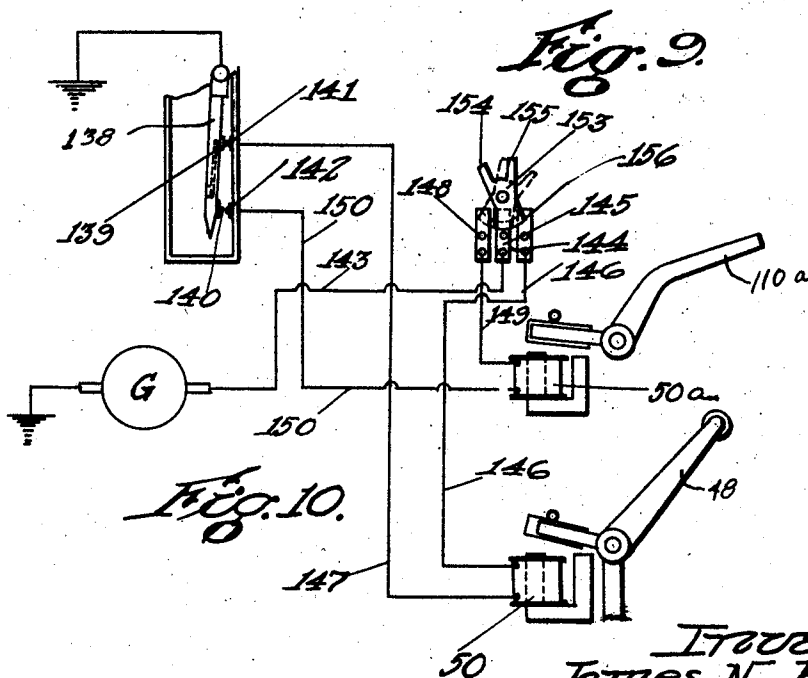
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J. N. HEALD ET AL

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GRINDING MACHINE

Original Filed April 25, 1925 6 Sheets-Sheet 6



Travelers:
James N. Heald
Waldo J. Guild
By Attorney
Chas. H. Kennedy & Co.

UNITED STATES PATENT OFFICE

JAMES N. HEALD AND WALDO J. GUILD, OF WORCESTER, MASSACHUSETTS, ASSIGNORS
TO THE HEALD MACHINE COMPANY, OF WORCESTER, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

GRINDING MACHINE

Application filed April 25, 1925, Serial No. 25,900, and in Great Britain June 4, 1925. Renewed
March 26, 1930.

The present invention relates to grinding machines and wheel dressing mechanism therefor. In certain of its aspects the invention is applicable to any of the various types of grinding machines, but its particular utility is in connection with internal grinding machines for grinding the internal cylindrical or conical surfaces of sleeves, gears, bushings, ball races and like articles.

According to the invention, the operation of dressing the grinding wheel may, if desired, be inaugurated manually (by movement of a lever), or it may be inaugurated automatically, as disclosed in the copending application of Heald, Guild, Burns and Garno, Serial No. 4,466, filed January 24, 1925. In either case, coincident with the movement of the dressing device into operative position, (preferably through the medium of fluid under pressure, as hereinafter described), the grinding wheel, by augmentation of its normal traverse relative to the workpiece, is caused to pass across said dressing device at a relatively low linear speed,—this involving, usually, a reduction from the working or grinding traverse speed theretofore employed for the roughing cuts on said workpiece. This reduced speed during dressing insures, even on large-diameter wheels, a surface which, when dressed, is uniform and free from grooves. Said dressing speed is adjustable, as is also the speed that shall prevail when the normal grinding traverse, for the final and finishing cuts on said workpiece, is resumed,—this last-named adjustment permitting any desired finishing speed between the high speed of traverse selected for the roughing cuts and the low speed of traverse selected for the wheel dressing operation.

In the disclosed embodiment of the invention, the above and many other advantageous objects are all effected through the control of a single system of fluid pressure actuation, thus greatly simplifying the machine. The present illustrative embodiment of the invention will appear from the following detailed description of the machine shown in the accompanying drawings, in which—

Fig. 1 is a vertical sectional view of the grinding machine, certain parts being shown in elevation.

Fig. 2 is a horizontal sectional view on the line 2—2, Fig. 1.

Fig. 3 is an enlarged elevational view of certain table operating mechanism.

Fig. 4 is a view from the rear of the machine, showing the improved dresser operating mechanism.

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

Fig. 6 is a sectional view of a valve.

Fig. 7 is a sectional view taken on the line 7—7 of Fig. 5.

Fig. 8 is a plan view of the machine.

Fig. 9 is a front elevation of the machine, showing the application of the present invention to the automatic grinding machine of aforesaid application Serial No. 4,466.

Fig. 10 is a wiring diagram for effecting the automatic electromagnetic inauguration of the motions hereinafter described.

Like reference characters refer to like parts in the different figures.

Referring to the drawings, particularly to Fig. 1, the machine provides the usual reciprocatory table or carriage 1, which is ordinarily provided in any internal grinding machine. In such a machine, either the grinding wheel or the work to be ground may be carried on the table 1, the reciprocation of the latter being utilized in either case to produce a relative traversing movement between the grinding wheel and the work. As here shown, the table 1 supports and carries a wheel head 2 of the usual construction,—while the work which is to be operated upon is held in a work head 3, the latter being carried by a bridge 4 which spans the slideways provided by the machine frame for the back and forth movement of the table 1.

This back and forth movement of the table 1, to cause the rotating grinding wheel 5 to make the required interior traverse of the rotating workpiece 6, is imparted by fluid pressure controlling and reversing mechanism, which is not per se the subject of the present invention, but which is described and claimed in our copending application, Serial No. 100

629,882, filed April 4, 1923. A brief description of such mechanism is however necessary to a clear understanding of the present invention, and will now be given.

As shown in Fig. 1, the machine provides a cylinder 7 containing a double acting piston 8 which is suitably connected to the table 1, as by a rod 9. Fluid under pressure is admitted to one end or the other of cylinder 7, the pressure fluid being forced by a pump 10 (see Fig. 2) into a supply line 11, the latter leading to a reversing valve 12, which is disposed in a suitable apertured casing 13 on the front of the machine. The position of valve 12 determines the flow of pressure medium to one end or the other of cylinder 7 by way of pipe 14 or pipe 15, as the case may be. The return of pressure medium from the reversing valve 12 is by way of a pipe 16, which leads to a pump supply chamber or tank 17, here shown as formed in the lower part of the machine frame.

The valve devices for controlling the pressure fluid are conveniently disposed in the casing 13, which provides a passage 18 to the reversing valve 12 from the fluid pressure supply pipe 11. The passage 18 is provided with a rotatable plug or throttle valve 19, adapted to be adjusted by a handle 20 (see Fig. 3), the position of which, with reference to a suitably graduated scale, not shown, determines the quantity of pressure fluid flowing through the passage 18, and hence the speed at which the table 1 is reciprocated.

Pipes 14, 15 and 16 are connected to the reversing valve 12 by means of passages 21, 22 and 23, respectively. The valve 12 is adapted to be oscillated and is so formed that it will connect passages 18 and 21 at the same time as it connects passages 22 and 23, this being the position of the valve in Fig. 1. In the other position of the valve 12, it connects the passages 22 and 18 together, also the passages 21 and 23. Thus, as will be readily apparent, one position of the valve 12 subjects the left hand side of piston 8 to the pressure of fluid generated by the pump 10, while at the same time connecting the right hand side of the piston to the exhaust pipe 16, and the other position of the valve 12 reverses these conditions.

Thus the direction in which the table 1 moves is reversed every time the valve 12 is moved from one extreme position to the other extreme position, while it is apparent that if the valve 12 is placed midway between its extreme positions, the passage 18 will be covered, and the piston 8 will be moved neither to the right nor to the left. In order to control the oscillatory valve 12, it is fastened to a shaft 24, to which is also secured a hand lever 25, see Fig. 3. As clearly shown in this figure, the hand lever 25 has a pin 26 attached thereto, this pin being disposed in a slot 27 of a swinging member 28 pivoted at 29. The

upper part of the member 28 is adapted to be engaged by spaced adjustable dogs 30 and 31 carried by the table 1.

In the machine herein illustrated, the grinding wheel 5 is rotated at high speed in any suitable or usual manner, and the workpiece 6 is also rotated, but at a slower speed, this rotation being imparted in any suitable manner, as by a belt drive, not shown, from a countershaft. The machine also embodies the usual instrumentalities for both manual and automatic cross feed between work and wheel, here shown as embodied in a screw shaft 32 for feeding the wheel head 2 transversely of the table 1. Said screw shaft 32 may be operated, if desired, by the usual hand wheel 33, or it may be automatically operated by any suitable mechanism, well known in the art for this purpose.

In the machine of the present invention, it is proposed to interrupt the grinding operation on each workpiece, to enable the grinding wheel to be dressed and trued, so that the final and finishing cuts which bring the work to the desired size are always taken with a fresh cutting surface that is straight and true and which produces a smooth and truly cylindrical hole. This dressing and truing operation (which may be inaugurated either manually or automatically, as hereinafter described) involves in any case, firstly, a movement of separation between the grinding wheel and the workpiece, to carry the wheel out of the hole, and secondly, the disposal of a suitable dressing device in position to make contact with the wheel when such separation occurs. The movement of separation firstly mentioned may be effected in the following manner:—

As shown in Fig. 3, the left hand table dog 30, which limits the right hand movement of table 1, is carried by a block 34, which, instead of being secured directly to the table 1, is as the case with the block 35 of dog 31, is mounted so as to be capable of sliding freely longitudinally of said table. Under normal conditions, when the table 1 is making its usual working reciprocations, to traverse the grinding wheel 5 back and forth within the workpiece, the block 34 of dog 30 is held in definite spaced relation to a block 36, which latter, the same as the block 35 of right hand dog 31, is a stationary block, adapted to maintain its predetermined setting or adjustment, longitudinally of the table 1, as given it by any suitable adjustment and holding devices, such for instance as the hand screw nuts 37, 37, applied to both blocks 35 and 36 and engaging with a screw rack 38 on table 1.

The device employed to hold the slidable block 34 in spaced relation to the fixed block 36 is here shown as a latch lever 39, pivoted at 40 on block 36 and having its free end disposed by gravity in abutting relation to a shoulder 41 on block 34, thereby holding

the block 34 at a predetermined distance to the right of block 36.

When the latch member 39 is lifted, either by hand or by the mechanism described in the aforesaid copending application, Serial No. 4,466, to free its end from the shoulder 41, the normal connection between the slidable block 34 and the fixed block 36 is broken, and when this occurs, on the right hand movement of table 1, the dog 30 will bear without effect against the member 28. Thus the right hand movement of table 1, on this particular stroke, will be extended beyond the usual reciprocatory working path, and the grinding wheel 5 will be carried out of the hole in the workpiece to a point just beyond that occupied by the dressing device, which latter, as hereinafter described, will be moved into operative position as the amplified right hand travel of table 1 begins. This amplified right hand travel of table 1 involves relative sliding movement between said table and the block 34, owing to the obstruction which the reversing member 28 imposes against the dog 30, to prevent the block 34 from moving with the table; finally, the block 34 brings up against the block 36, whereupon the solid backing thus afforded for the block 34 enables the dog 30 to shift the member 28. This procures the reversal of the table 1, and the left hand movement of said table thus inaugurated is caused to restore the parts automatically to normal position in the following manner:—

A member 42, secured rigidly to the frame of the machine, carries a flat spring 43, the free end of which is bent to provide inclined surfaces 44 and 45 for cooperation, respectively, with inclined surfaces 46 and 47 at the lower corners of block 34. In the normal grinding operation of the machine, when the blocks 34 and 36 are connected by latch 39, the surfaces 44 and 45, although in the path of block 34, offer no effective obstruction to the back and forth travel of said block in unison with the table 1, it being obvious that when either lower corner of the block, under these conditions, strikes either bevelled surface 44 or 45, such contact will wedge the spring 43 downwardly, said spring yielding sufficiently to allow the block 34 to pass over its upturned free end. However, when the block 34 has been freed from the block 36 as above described, to amplify a single right hand stroke of the table 1, the ensuing reversal of said table, with the block 34 still free, finds the surface 44 in position to contact with the corner 46 of said block, and under these conditions, the obstruction offered is sufficient to overcome whatever friction there may be tending to cause the block 34 to move to the left with the table. The block 34 being thus held stationary, while the table 1 and block 36 continue to move to the left, the latch member 39 finally resumes

its normal position relative to the block 34, the end of said latch member dropping behind the shoulder 41 and in front of an abutment 41^a on the block 34, and the parts being thus automatically restored to normal position at the conclusion of each amplified reciprocation of the table 1. It should be observed that the free end of latch member 39 is bent over at right angles (in a horizontal plane) so that it may drop between the shoulder 41 and the abutment 41^a.

This single amplified reciprocation of the table 1, for wheel dressing purposes, may be inaugurated automatically, upon the workpiece reaching a predetermined size, through the medium of the work caliper mechanism and the electromagnetic devices described in the aforesaid copending application of Heald, Guild, Burns and Garno, Serial No. 4,466, filed January 24, 1925,—or it may be inaugurated manually by the operator of the machine, when said operator determines either through an inspection of the work, or by the aid of indicating devices described in said application Serial No. 4,466, that the approach of the work to finished size makes the wheel dressing operation desirable, in order that the final and finishing cuts shall be taken with a true and fresh cutting surface. In either case, the amplified dressing stroke is inaugurated by elevation of the latch member 39, through the medium of a lever 48 which is pivoted at 49 to the frame of the machine. Said lever, when swung counterclockwise, either by the electromagnet 50 (in the case of automatic operation), or by a handle 51, (in the case of manual operation), secures the desired elevation of latch member 39, (there being a stud or roller, not shown, behind handle 51 for this purpose), and the ensuing single amplified dressing stroke of the table. Such movement of lever 48 also secures the movement of the wheel dressing secondly mentioned device into operative position in the following manner:—

A valve member 52 is operatively connected to the lever 48, by a suitable connection 53, said valve member 52 being here shown as of the sliding type, with a groove or reduced diameter 54 therein. The groove 54 is adapted to connect two of three ports 55, 56 and 57 provided in a cylinder 58 for the passage of fluid between the said ports. In the left hand position of the valve member 52, shown in Fig. 3, which is its position prior to the above described movement of the lever 48, the groove 54 connects ports 55 and 56. Port 55 is connected, as by a pipe 59, see Fig. 2, to fluid pressure operated dresser moving mechanism, to be presently described, while port 56 is a discharge or exhaust port, adapted to discharge the pressure fluid into the base or tank 17, as by suitable piping 60. Upon movement of the valve member 52 to its right hand position by the lever 48, the groove 54 connects

port 55 with port 57, the latter port being connected to the pressure fluid supply line 11 by suitable pipe 132. Thus the fluid under pressure is directly connected to the dresser operating mechanism.

The latter is shown (Figs. 4 and 5) as embodied in a piston 61 received in a cylindrical chamber 62 provided at the back of the machine. The pipe 59 leads the fluid to the front end of the cylindrical chamber 62 by means of a suitable port 63. Rearward motion of the piston 61 is adapted to lower a suitable dressing point 64, preferably a diamond, into the path of the grinding wheel 5, and for this purpose, there is provided a bell crank lever 65 fastened to a shaft 66 received in suitable journals 67 provided in a base 68. The lever 65 is adapted to be moved by the piston 61 in any suitable way, as by a pin 69 attached to said lever, adapted to be pushed by the end of the piston. The upper end of the lever 65 is apertured for the passage of a link rod 70, whose other end has an enlargement with a hole 71 for the reception of a stud 72 provided by a member 73. Said member 73 is mounted to swing on a trunnion 74, the latter being received in a standard 75 which rises from the base 68 and which is adjustably attached to the latter by means of bolts 76, 76. A handle 77 secured to the swinging member 73, permits the operator to swing said member, to move the wheel dressing point 64 independently of any fluid pressure from the full line to the dotted line position of Fig. 5, and vice versa,—the dotted line position being the operative position, where the diamond point is disposed in the path of the grinding wheel 5. Said diamond point is preferably carried by a screw 78 which is adjustable in and out of the member 73.

For automatic movement of the said diamond point from the bell crank lever 65, an adjustable connection is provided between the said bell crank lever 65 and the link rod 70, here shown as embodied in a U-shaped member through which the link rod 70 passes, said member 79 being adapted to be securely fastened in any desired position on the link rod, in any suitable manner.

On the right hand movement of bell crank lever 65, (Fig. 5), the thrust thereof is taken by a spring 80 to avoid shock to the parts as the swinging member 73 comes to a stop in its downward dotted line position. This latter position is determined by the engagement of a lug 81, on swinging member 73, with a fixed stop 82 on standard 75.

After the grinding wheel 5 has passed forward and back across the dressing diamond 64 and been thereby trued, the diamond 64 is raised again to the full line position of Fig. 5, by cam means to be described, and there maintained until, in the operation of the machine on a succeeding workpiece, it is again time to dress the wheel.

This maintenance of the diamond 64 out of the dressing position is of especial significance, in view of the fact, as hereinafter described, that, at the conclusion of the grinding operation on each workpiece, the table 1 is again automatically run out to the right, to effect high speed withdrawal of the grinding wheel 5 from the working zone. On each such withdrawal movement, the grinding wheel 5 passes through the dressing position, but the dressing of said wheel is avoided by retaining the dresser point 64 in inoperative position. Manifestly, from the standpoint of accuracy in the finished product, the very best time for dressing the grinding wheel and giving it a fresh cutting surface is just before said wheel takes the final and finishing cuts on the workpiece to bring it to the desired finished size. On the other hand, dressing of the wheel in the intervals between operations on successive workpieces is of little value, because the effect of such dressing is lost before the final and finishing cuts can again be taken.

In the present instance, when the grinding operation on each workpiece is interrupted, to provide for the dressing of the wheel just before the final and finishing cuts are taken, its value is direct and immediate, but any further dressing in the intervals between operations on successive workpieces would not only be useless, but would be harmful and wasteful. Harmful, because any contact between the dresser point 64 and the wheel 5, travelling at high speed, would tend to cut a groove in the working surface of the wheel, and wasteful, because at such a time the wheel 5, in bringing the work to size, has been fed so far by the screw 32 that contact with the dresser point would decrease its diameter wastefully, and to no good purpose.

In addition to the above explained reasons for normally maintaining the dressing point 64 out of dressing position, is the further reason that said point, if left in said position, would be in the way of the bearing sleeve 83 (Fig. 1) of the grinding wheel spindle 84, during the working reciprocations of the table 1. Said spindle 84 obviously cannot have any excessive overhang beyond said bearing sleeve, because this would produce vibration that would destroy the accuracy of the grinding operation. Therefore, throughout the working strokes of table 1, the spindle bearing 83 must reciprocate in the dressing position or zone, and the dressing point must be automatically and positively moved to the inoperative full line position of Fig. 5 as the grinding wheel 5 moves into contact with the workpiece 6 at the end of the single amplified dressing stroke described.

This positive movement into inoperative position is effected as follows:—The table 1

carries a cam bar 85, see Fig. 4, which is provided on the lower side with a horizontal surface 86 and an inclined surface 87. The bell crank lever 65 has a roller 88 on its forwardly extending arm which is located just below the cam bar 85, Fig. 5. Travel of the table to carry the grinding wheel 5 into contact with the workpiece positively turns the bell crank lever 65 in a counterclockwise direction into the position shown in Fig. 5, by reason of the camming or wedging effect of the inclined surface 87 on the roller 88. Thereafter, during the inward working traverse of the table, the diamond 64 will be held in its inoperative position by reason of the fact that roller 88 is held down by the horizontal surface 86.

The cam bar 85 is fastened to the table 1 by bolt and slot connections 89, 89 adapted to allow adjustment longitudinally. In order to positively prevent the cam bar from slipping in the direction of the slots once the adjustment is made, a bracket 90 attached to the table 1 serves as an anchorage for a screw member 91 which takes end thrust on the cam bar 85. Provision of the screw member 91 also renders it possible to delicately adjust the longitudinal position of the cam bar 85. The base 68, on which the standard 75 is mounted, is attached to the machine frame by bolts 92, 92, being longitudinally adjustable thereon.

In order to cause the table 1 to travel at reduced speed during the dressing operation, and also, when desired, to cause the wheel 5 to take the finishing cuts on the workpiece 6 at a reduced traversing speed, there is provided a valve 93, see especially Figs. 2 and 6. This valve 93 is located in the fluid supply line 11 and, therefore, is in series with the throttle valve 19, Fig. 1, i. e., the fluid to actuate the table 1 goes by way of line 11 through both valves. This valve 93 may be of any desired construction, being here shown, see Fig. 6, as comprising a conical plug 94 which is seated snugly in a tapered bore 95 by the pressure of a spring 96. Entrance and exit ports 97 and 98 are provided, and the plug 94 has a hole 99 there-through. A shaft 100 is adapted to turn the plug 94 in a manner to be presently described. The position of the hole 99 in relation to the ports 97 and 98 controls the flow of the pressure fluid through the valve.

Referring now particularly to Figs. 4 and 5, a member 101 is fastened to the shaft 100. Said member 101 provides a pair of lever arms 102 and 103, arm 102 having a link rod 104 pivotally attached thereto, with the outward end of link rod 104 passing through a hole in a lever 105, the latter being fastened to the shaft 66, hereinbefore referred to. Rocking of the shaft 66 in response to movement of the dresser operating mechanism as described, bell crank 65 being rigidly fas-

tened to shaft 66, is adapted to move the link rod 104 through the medium of a pair of lugs 106 and 107 provided for the purpose. These lugs are adjustably fastened to the link rod 104 in any suitable manner.

From a consideration of the dotted line indication of the hole 99 in Fig. 5, it will be apparent that the flow of pressure fluid from port 97 to port 98 is unimpeded when the parts are in the position shown by the full lines in this figure. The diamond 64 is up and the wheel 5 is taking the initial cuts on the workpiece 6. Assuming the lever 48 in Fig. 3 to be now moved thereby lifting latch 39, the table 1 takes an extended movement to the right carrying the wheel 5, the diamond 64 is caused to move into the path of the wheel, and this movement is accompanied by a clockwise turning of shaft 66 carrying lever 105 to the dotted line position shown in Fig. 5. With the setting of lug 106 shown in Fig. 5, it is obvious that lever 105, acting through this lug, lever arm 102 and shaft 100 will turn the plug 94 to place the hole 99 in a position to impede the flow of fluid. It is quite obvious that this impedence may be made more or less by setting the lug 106 close to or at a distance from the end of lever 105.

The wheel 5 having been dressed, the table travels to the left to resume the working stroke as described, and the cam bar 85, by forcing down the roller 88, places the dresser point 64 in inoperative position, this action rotating the shaft 66 in a counterclockwise direction and moving the lever 105 back to the full line position of Fig. 5. If now the lug 107 had been placed at the end of link rod 104, the rearward motion of the lever 105 would not restore the conical plug 94 to its original position, and the reduced speed of dressing would be continued, but if the lug 107 had been placed as close to the lever 105 as possible, this rearward motion will restore the plug 94 to the original position to permit the free flow of fluid through the valve 93 to the throttle valve 19. In the latter case, the finishing cuts on the workpiece 6 are taken with the rectilinear speed of the table 1, governed solely by the throttle valve 19, whereas in the former case, the rectilinear speed of the table 1 during the finishing cuts is the same as it is for the dressing stroke. The lug 107 may be placed at any point intermediate between these two positions, whereby the final cuts are taken at a speed slower than the roughing cuts, but faster than the dressing stroke, and the lug 107 is shown in one of these intermediate positions in Fig. 5.

When a given piece of work 6 is finished, it is desirable that the table 1 be operated to separate the workpiece 6 and the grinding wheel 5 and then come to a stop, so that the operator may take out the finished work

and insert another piece for operation in the work head. This may be effected automatically, as shown in the aforesaid copending application of Heald, Guild, Burns, and Garno, Serial No. 4,466, or the withdrawal movement may be brought about manually in the following manner, suitable means, such as the light indication described in said Serial No. 4,466, being preferably provided to notify the operator when the workpiece is ground to the finished size. Referring again to Fig. 3, the left hand table dog 30 is pivotally mounted at 108 on carrying block 34, whereby said dog is normally held by gravity in the position shown in Fig. 3 as against a pin 109 on block 34, wherein the free end of said dog 30, on the right hand travel of the table 1 will engage and move the member 28. An inclined arm 110 is carried by a rod 111, said rod being vertically slidable in a suitable bracket 112 and adapted to be raised by the operator, a foot treadle 113 being shown for the purpose. When the arm 110 is raised upwardly into the path of the dog 30, the free end of said dog, on the right hand movement of the table, engages with and rides upon the surface of said arm. Thus the dog 30 is raised and carried clear of the swinging table reversing member 28, and the table 1 continues the movement to the right, carrying the grinding wheel 5 out of the work, well past the dressing device, said table, finally, being brought to a full stop, at the outward limit of its right hand movement on the machine, by any suitable means, such, for example, as by the engagement of an end wall 114, see Fig. 1, of a groove 115, provided in the underside of the table 1, with a lever 116, thereby operating a valve 117 and establishing a connection between passages 21 and 23, thus relieving the piston 8 of the pressure of the fluid.

It is desirable to return the valve 93, Fig. 5, automatically to the wide open position in all cases before the introduction of a new workpiece, in order that supply line 11 may be relieved of any influence from valve 93 during the first or roughing cuts on said new workpiece. Consequently, the full withdrawal movement of the table just described is made to accomplish this result in the following manner:—

The upper surface of the cam bar 85, Fig. 4, has an inclined portion 118. Upon full withdrawal of the table, to the left in this view, said inclined portion strikes the underneath bevelled edge of a projection 119 on a member 120. This action raises the member 120 so that the underneath portion of projection 119 is on a level with a horizontal upper portion 121 of cam bar 85 in the position shown in Fig. 5. The member 120 is slidably received in a hole drilled through a portion of the frame of the machine. A pin 122 bears against a flat surface on member

120, and prevents it from turning; thus the projection 119 is kept always facing towards the front of the machine, so that it may be engaged by the cam bar 85. A link 123 connects the member 120 to the lever arm 103, being, of course, pivotally connected to each. Thus upward motion of the member 120 will turn the shaft 100 attached to valve plug 94, and the uppermost position of the member 120 just brings the hole 99 to the position where it registers fully with the ports 97 and 98 and does not impede the flow of fluid at all, thereby completing the cycle of operations and functions of this valve, all parts having been returned to normal positions shown in full lines of Fig. 5.

It is quite apparent that when the lug 107 is set close to the lever 105 and thereby the shaft 100 and plug 94 are returned to the position of no impedance directly after the dressing operation, the member 120 will be raised at this time through the lever and link connections described, and during the extended movement of the table 1, the cam bar 85 will have no effect on member 120. But whatever the position of parts when the machine has finished grinding a workpiece 6, they are returned to normal position prior to the introduction of a new workpiece, without any attention on the part of the operator. The friction of the plug 94 against bore 95 by reason of spring 96 is sufficient to hold the parts in any position which they assume until again forced to assume a new position.

It is desirable that the withdrawal movement of the table 1 be accomplished as quickly as possible. To this end, the carrying block 34 of dog 30 has secured thereto an elongated cam bar 124, Fig. 3, the right hand end of which is spaced from the striking end of dog 30 by a distance slightly less than that between member 28 and the end of an arm of a lever 125 in the path of cam bar 124. In the normal working reciprocations of the table 1, when the grinding wheel is in contact with the work, the lever arm 125 is not reached by the cam bar 124, since the dog 30 will always strike the member 28 to reverse the table at a time when the cam bar and the lever arm are a slight distance apart. However, when the dog 30 is raised to pass over the member 28 and thereby to inaugurate the full withdrawal movement of the grinding wheel from the work, the cam bar 124 will engage and move the lever 125. The latter is operatively connected to another lever 126, and movement of the latter will open a valve 127, Fig. 1, thus connecting the passage 18, above the throttle valve 19, directly to the supply line 11 by means of a port 128 and a pipe 129. Referring now particularly to Fig. 2, it will be seen that the pipe 129 is in "parallel" with the portion of line 11 that leads through the valve 93 and the throttle valve 19 to the upper part of passage 18. Thus the pressure fluid arrives

at the port 128 uninfluenced by either of these valves, and the full speed withdrawal movement is made regardless of settings of said valves and without disturbing their settings.

5 This accelerated table speed is never obtained on the dressing stroke, for the reason that cam bar 124, being secured to block 34, shifts to the left with said block relative to the table 1, and does not reach the lever arm 125 during
10 said dressing stroke.

In order that the pump 10 shall not generate excessive pressures in any of the piping, or at any of the valves and cylinders described, a relief valve 130 is provided, adapted to discharge fluid directly into the base 17
15 upon the pressure exceeding a certain amount. One manner of connecting and location for said relief valve is clearly shown in Fig. 2, the relief valve itself being somewhat diagrammatically shown, it being understood that any type of relief valve may be employed.

As a further measure of safety, there is provided means for insuring that the dresser operating piston 61 will be relieved of pressure at the outward limit of table travel during the dressing stroke, so that the dresser point 64 may be forced into the inoperative position by the cam means described, without undue strain on the parts. To this end, the
30 latch 39, Fig. 3, has a downwardly extending cam portion 131, which will strike the roller back of the handle 51 and automatically move the lever 48 at or before the reversal of the table during the dressing stroke, the latch
35 bar being backed up at this time by pin 134. Thus the lever 48 is forced back into its original position, even if the operator neglects to reposition it, and the groove 54 connects the ports 55 and 56 and thus the diamond operating mechanism is relieved of fluid pressure. It is obvious that the cam portion 131
40 could be directly attached to block 34 instead of being on the latch 39, as movement of the block 34 in reversing the member 28 when backed up by block 36 provides sufficient motion to reposition the lever 48.

It should be noted that neither the slow down valve 93, nor the regular throttle valve 19, has any influence on the pressure operating to move the diamond 64 into operative position. An inspection of Fig. 2 illustrates one method of keeping the diamond moving pressure lines free from influence of these valves 19 and 93. The port 57 is shown connected to the supply line 11 by piping 132,
55 which joins line 11 at a point 133 nearer the pump 10 than either of the valves. Thus piping 132 is in "parallel" with line 11 between the point 133 and the passage 18 as is also
60 piping 129.

The machine is adapted for manual operation in a manner that has been already indicated in the description. However, as also indicated, the most useful embodiment of the
65 invention contemplates a machine that is

completely automatic from the time a given workpiece is loaded in the work head 3, till it is completely finished, and we desire to claim our invention as such.

In connection with Fig. 3, we have already described how the wheel dressing motions may be inaugurated manually or in response to energization of electromagnet 50. The final movement of separation between wheel and work has been described as inaugurated by raising the inclined arm 110 through foot pedal means. Figure 9 shows the fully automatic embodiment of the invention in which the inclined arm, therein designated 110^a is in the form of a lever pivoted on the same pivot pin 49 that holds the lever 48. Arm 110^a is electromagnetically operated by a magnet 50^a, directly behind the magnet 50. In said Fig. 9 all the other parts and instrumentalities, including the blocks 34, 35, 36 and the dogs 30 and 31, are exactly as shown in the larger detail view of Fig. 3, excepting, of course, the rod 111, the bracket 112 and the treadle 113.

The electromagnets 50 and 50^a may be operated by contacts made by the work caliper instrumentalities of the aforesaid application Serial No. 4,466, or they may be operated responsive to any other automatic instrumentalities adapted to energize the said magnet 50 at that stage in the grinding of a workpiece that is appropriate for dressing as already explained, and adapted to energize the magnet 50^a when the grinding operation is finished. As one illustrative embodiment of the manner in which the instrumentalities of the present invention are rendered automatic, we will now briefly explain the main features and mode of operation of the caliper mechanism of said application Serial No. 4,466.

Referring to Figs. 8 and 9, a work caliper mechanism is contained in a box-like structure 135 that is pivotally attached at 135^a to a bracket 136 fastened to the bridge 4. During the grinding operation the box 135 is in the position shown in Figs. 8 and 9, thus maintaining a work caliper lever 137 in contact with the internal periphery of the gradually enlarged workpiece. Movement of lever 137 is transmitted to a contact making lever 138. The exact detail of construction of these levers and associated mechanism, is not germane to the present invention, but suffice it to say that the motion of lever 137 is transmitted greatly magnified to lever 138. The latter carries two contact terminals 139 and 140, adapted to ground successively two stationary terminals 141 and 142.

Referring now to Fig. 10, any source of electricity, such as a generator G, has one terminal grounded as shown, while the other terminal is connected by a conductor 143 to a contact bar or plate 144. On the right of bar 144 is another bar 145 which leads, by a

conductor 146, to electromagnet 50. The other terminal of magnet 50 is connected by a conductor 147 to terminal 141. On the left of bar 144 is a bar 148 which connects by a conductor 149 to electromagnet 50^a, the other terminal of which connects, by a conductor 150 to terminal 142.

Referring now also to Fig. 9, the pivot pin 40 described in connection with Fig. 3, besides holding the latch 39, carries a pair of arms 151 and 152 which, as one is located directly behind the other, are in different vertical planes. An oscillatory device 153 which is pivotally mounted on the front of the machine, carries a pair of arms 154 and 155 which are located respectively, in the paths of movement of the arms 151 and 152. The device 153 has associated therewith any usual sort of snap over device, so that it tends to assume an extreme position. In one position thereof, a connector 156 carried by the device 153, electrically connects bars 144 and 145, while in the other position thereof, said connector connects bars 144 and 148.

The automatic operation of the machine is as follows:—Assuming that the table is in the position shown in Fig. 1, with the wheel head 2 withdrawn from the work head 3, that a fresh unground workpiece 6 has been placed in the work head 3 and said workpiece and the grinding wheel 5 set in rotation, the operator will grasp the hand lever 25 and start the table 1 moving to the left. As it so moves, the arm 151 strikes the arm 154, and moves the oscillatory member 153 to bring the connector 156 into contact with bars 144 and 145. Immediately thereafter dog 30 rides over the striking part of member 28 to leave it between said dog and dog 31, whereupon the normal work cutting traverse commences, and the machine proceeds to take the roughing cuts on the workpiece. During this stage of grinding the speed of reciprocating traverse is governed solely by the position of valve 19 determined by the setting of lever 20.

This stage of grinding is determined or finished when the hole in the workpiece has been enlarged to that point where, by movement of the caliper 137, the lever 138 is moved to cause terminal 139 to reach terminal 141. Thereupon, since connector 156 is then connecting bars 144 and 145, the electromagnet 50 is energized, thus raising latch 39 and causing the table 1 to extend its travel to the right for one stroke; at the same time moving valve member 52 and making the pressure fluid active against the piston 61 to lower the diamond 64 into the path of the rotating grinding wheel 5. This action, as previously explained, moves the depending arm 105, so that, if the lug 106 has been set to cause it, the speed of travel of table 1 on its extended stroke is reduced, owing to the partial rotation of the plug 94. The table 1, in moving to the right in its extended

or amplified path of travel, causes arm 152 to strike arm 155, thus placing the connector 156 across the bars 144 and 148, but it does not move far enough to cause any effective contact between arms 151 and 154. As the table moves inwardly, the cam portion 131, acting on the roller behind handle 51, which in Fig. 9 has been given the numeral 51^a resets the valve member 52, so that the piston 61 is now relieved from fluid pressure. Substantially coincidentally therewith the cam portion 87 engages the roller 88 and thus mechanically and positively repositions or raises the diamond 64. This same action also replaces the depending arm 105, so that, assuming the lug 106 was set so that plug 94 was turned, it will now be turned back again, either completely or partially, or else it will remain unaffected, all depending on the prior setting of the lug 107. The final and finishing cuts are now taken on the workpiece, at practically any speed desired between the full speed of the table as limited by the power of the pump 10, and a speed so slow as to be hardly noticeable with the eye. When the workpiece reaches the finished size, contact is made between terminals 140 and 142, which causes energization of magnet 50^a alone, owing to the position of connector 156 as stated, and the dog 30 now is automatically passed over the striking end of member 28 so the table continues to the right. And even if the table was moving at an extremely slow rate of speed, once the cam 124 reaches the lever 125, the table runs out rapidly to the right at its maximum speed. This is owing to the arrangement of the fluid pressure system as clearly shown in Fig. 2, and as already described. In so running out, the table automatically resets the plug 94, if it had been moved, by means of the cam surface 118 and connections. The table is automatically stopped, as already set forth, through the medium of valve 117, and the next workpiece may now be automatically ground to the same size, in exactly the same manner.

The present invention, as distinguished from application Serial No. 4,466, contemplates the fluid pressure actuation of the dresser point 64 to place it into the path of the wheel. It contemplates further a fluid pressure system so organized as to allow of the variation of table speed set forth. In combination, it involves both these matters embodied in an automatic, or an electromagnetically controlled machine. In certain of its aspects, moreover, it involves variable speed regulating mechanism, as set forth in the subjoined claims, however carried out.

We claim:

1. In a grinding machine, means for causing relative traverse between the grinder and work while the grinder is operating on the work, means for extending the traverse to include the wheel dressing point in the

path of reciprocation so that the wheel may be dressed, and a control adapted to cause the speed of reciprocation while the grinder is operating on the work prior to the dressing operation to be different from the speed of reciprocation while the grinder is being dressed and to cause the speed of reciprocation subsequent to the inclusion of the dressing point in the path of reciprocation to be at a third rate of speed.

2. In a grinding machine, means for causing relative traverse between the grinder and work while the grinder is operating on the work, means for extending the traverse to include the wheel dressing point in the path of reciprocation so that the wheel may be dressed, a control adapted to cause the speed of reciprocation while the grinder is operating on the work prior to the dressing operation to be different from the speed of reciprocation while the grinder is being dressed and to cause the speed of reciprocation subsequent to the inclusion of the dressing point in the path of reciprocation to be at a third rate of speed, means for causing the traversing mechanism to finally separate the grinder and the work, and another control adapted to cause said final movement of separation to be at a fourth rate of speed.

3. In a grinding machine, means for producing relative traverse between a rotating grinding wheel and the rotating work holding means, means for causing the preliminary cuts of said wheel to be made at a predetermined speed of traverse, means for automatically reducing said speed for the dressing of said wheel, and means for causing the finishing cuts on the workpiece to be made at any speed between said roughing traverse and said dressing traverse.

4. In a grinding machine, the combination with a grinding wheel, a dressing tool, and a table carrying one of said parts, of means for reciprocating said table, fluid pressure means for moving said dressing tool from a point out of the relative path of reciprocation of said wheel to a point in said relative path, and mechanical means actuated by the motion of said table for replacing said dressing tool in its former position.

5. In a grinding machine, the combination with a table, means to reciprocate said table, a grinding wheel dressing tool and means to move said dressing tool into operative position, of means actuated by the means to move said dressing tool for slowing down the speed of reciprocation of said table.

6. In a grinding machine, the combination with a table, means to reciprocate said table, a grinding wheel dressing tool means to move said dressing tool into operative position, and further means to subsequently move said dressing tool into inoperative po-

sition, of means actuated by the means that causes movement of said dressing tool into operative position for slowing down the speed of reciprocation of said table, and means actuated by the means that causes subsequent movement of said dressing tool into inoperative position for further altering the speed of said table.

7. In a grinding machine, the combination with a table, means to reciprocate said table, a grinding wheel dressing tool, means to move said dressing tool into operative position, and further means to subsequently move said dressing tool into inoperative position, of means actuated by the means that causes movement of said dressing tool into operative position for slowing down the speed of reciprocation of said table, and means actuated by the means that causes subsequent movement of said dressing tool into inoperative position for causing the further working movement of said table to occur at any speed between normal working speed and said reduced speed.

8. In a grinding machine, the combination with a grinding wheel, a table, means to reciprocate said table to produce a traversing motion between the grinding wheel and a workpiece, mechanism adapted to effect a change in the grinding operation, from the preliminary rough grinding, to the final and finishing fine grinding just prior to the workpiece being brought to the correct size, and a control device to govern the speed of reciprocation of the said table, of means to set said control device to reduce the speed of reciprocation of said table a given amount after a plurality of reciprocations comprising the rough grinding, and means brought into operation at the final movement of said table after the said fine grinding, to reset said control device completely.

9. In a grinding machine, the combination with a grinding wheel, a table, means to reciprocate said table to produce a traversing motion between the grinding wheel and a workpiece, mechanism adapted to effect a change in the grinding operation, from the preliminary rough grinding, to the final and finishing fine grinding just prior to the workpiece being brought to the correct size, and a control device to govern the speed of reciprocation of the said table, of means to set said control device to reduce the speed of reciprocation of the said table a given amount after a plurality of reciprocations comprising the rough grinding, and means, adjustable at the will of an operator, and brought into operation automatically and after a single stroke of said table at reduced speed, to reset said control device either partially or completely.

10. A grinding machine comprising in combination a grinder, a support, a work holder and a truing tool mounted on said support, means for causing relative traverse between

the grinder and said support including means permitting altering the extent of said traverse between two ranges, one of which carries the parts through operative traverse between the grinder and work holder alone and the other of which carries the parts through operative traverse between the grinder and both the work holder and truing tool, means for moving said truing tool on said support, and means inaugurated by said last mentioned means for changing the speed of said traverse.

11. A grinding machine comprising in combination a grinder, a support, a work holder and a truing tool mounted on said support, means for causing relative traverse between the grinder and said support including means permitting altering the extent of said traverse between two ranges, one of which carries the parts through operative traverse between the grinder and work holder alone and the other of which carries the parts through operative traverse between the grinder and both the work holder and truing tool, a valve for changing the speed of said traverse, and connections between said valve and the means for moving said truing tool whereby a change of speed of traverse may be inaugurated coincident with the movement of said truing tool.

12. A grinding machine comprising in combination a grinder, a support, a work holder and a truing tool mounted on said support, means for causing relative traverse between the grinder and said support including means permitting altering the extent of said traverse between two ranges, one of which carries the parts through operative traverse between the grinder and work holder alone and the other of which carries the parts through operative traverse between the grinder and both the work holder and truing tool, a valve for changing the speed of said traverse, and connections between said valve and the means for moving said truing tool whereby a change of speed of traverse may be inaugurated coincident with the movement of said truing tool, said connections being adjustable so that the speed of traverse may be adjusted.

13. A grinding machine comprising in combination a grinder, a support, a work holder and a truing tool mounted on said support, means for causing relative traverse between the grinder and said support including means permitting altering the extent of said traverse between two ranges, one of which carries the parts through operative traverse between the grinder and work holder alone and the other of which carries the parts through operative traverse between the grinder and both the work holder and truing tool, a valve for changing the speed of said traverse, and connections between said valve and the means for moving said truing tool whereby a change of speed of traverse may be inaugurated coincident with the movement of said truing

tool, and separate means for repositioning said valve.

14. A grinding machine having, in combination, a grinding wheel, a head stock adapted to support the work, a carriage supporting one of said parts, hydraulic operating means for reciprocating said carriage thus to reciprocate the grinding wheel in relation to the work, means governed by the progress of the grinding operation, and valve means controlled by said last named means adapted to slow down the speed of reciprocation when the grinding has proceeded to a predetermined point.

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JAMES N. HEALD.
WALDO J. GUILD.

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