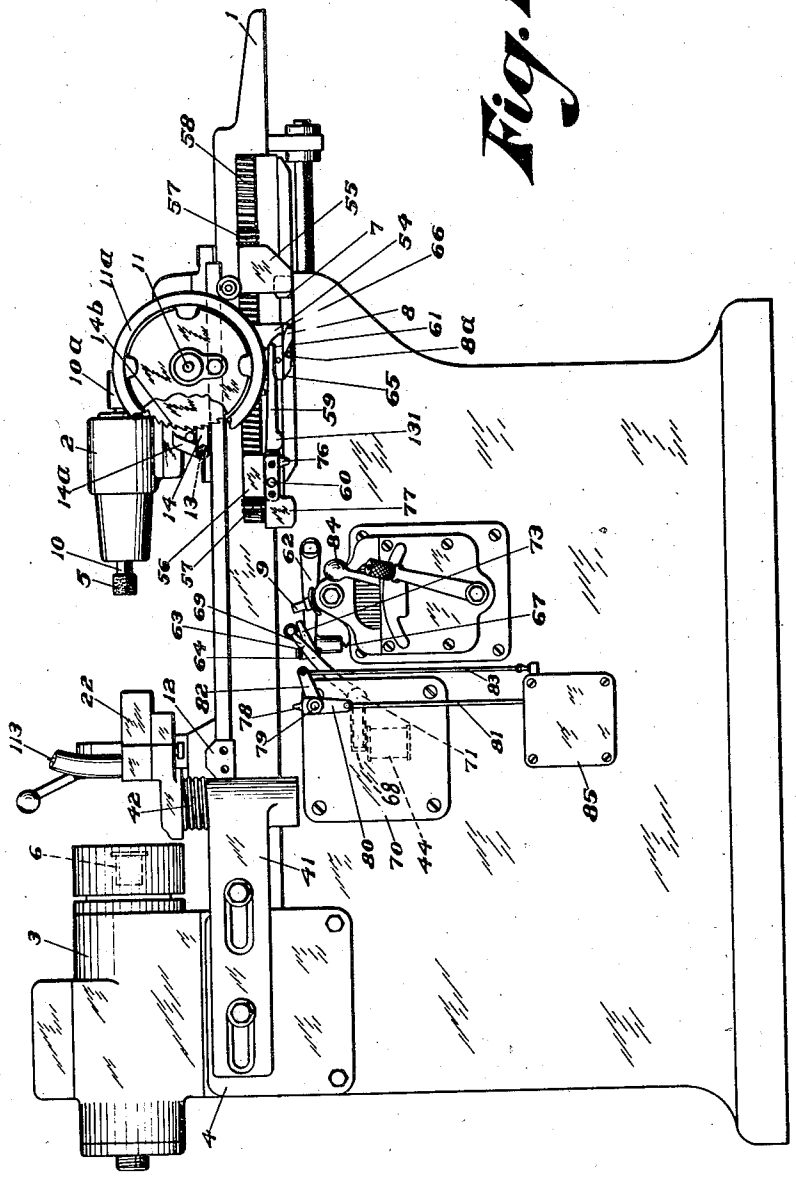
May 12, 1931. W. J. GUILD 1,804,414

GRINDING MACHINE

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Fig. 1



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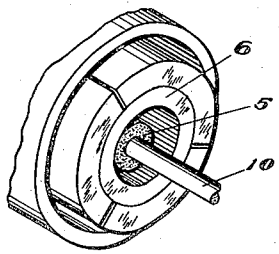


Fig. 1a.

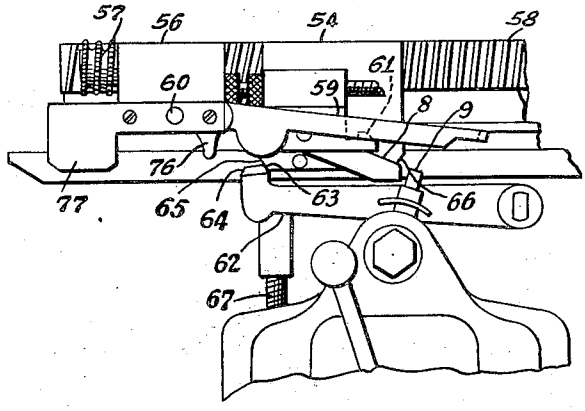


Fig. 1b.

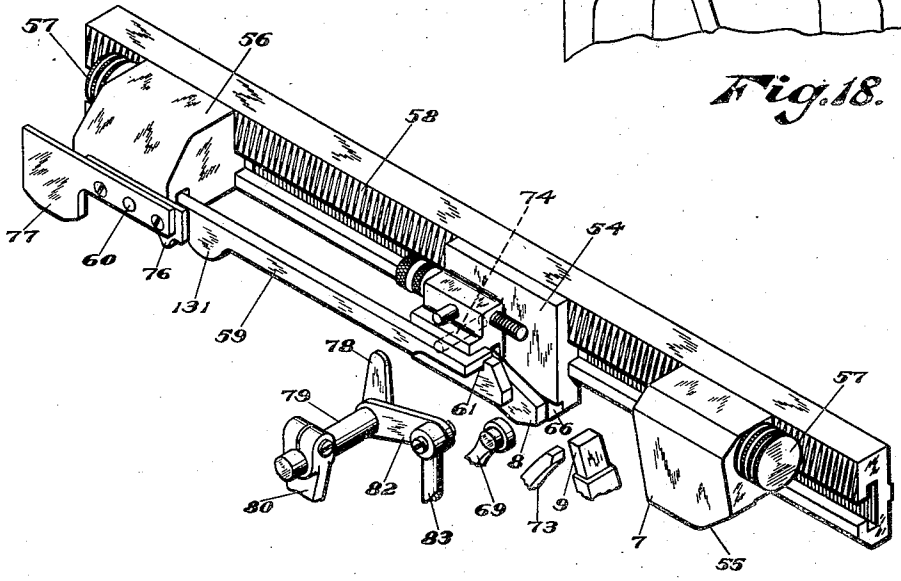


Fig. 2

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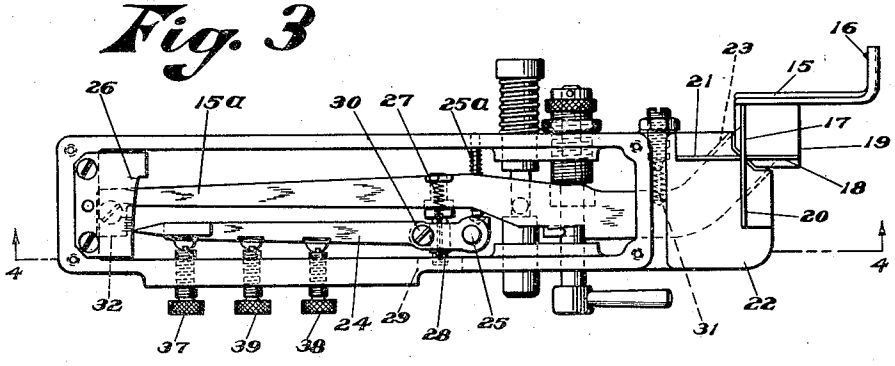
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GRINDING MACHINE

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Fig. 3



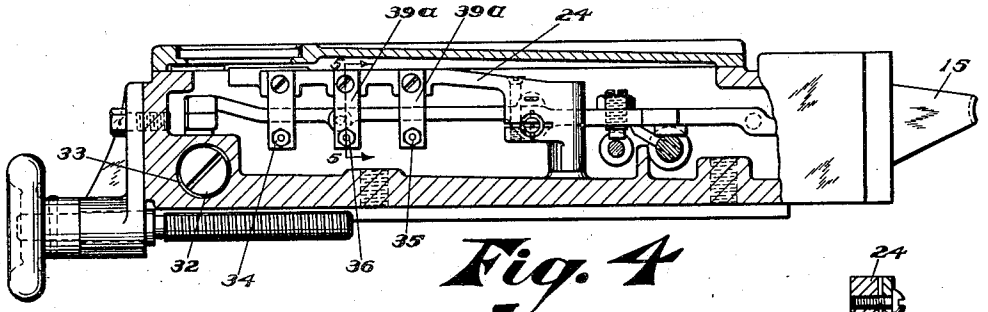


Fig. 4

Fig. 5

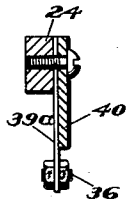


Fig. 6

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GRINDING MACHINE

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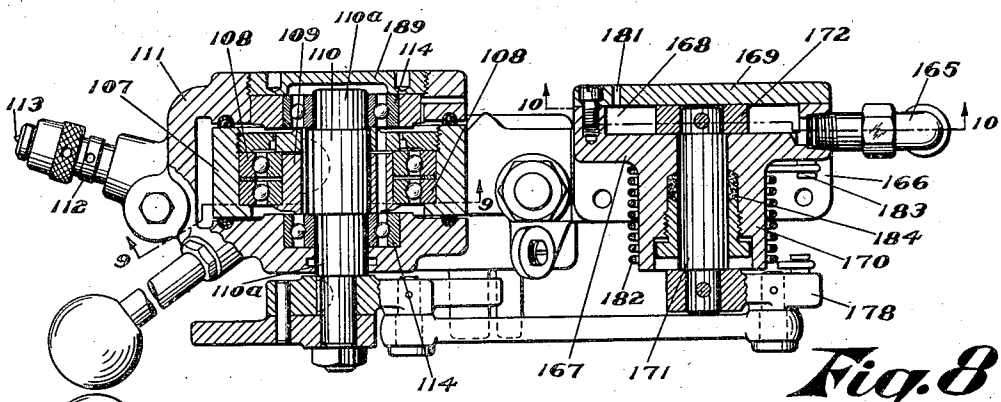


Fig. 8

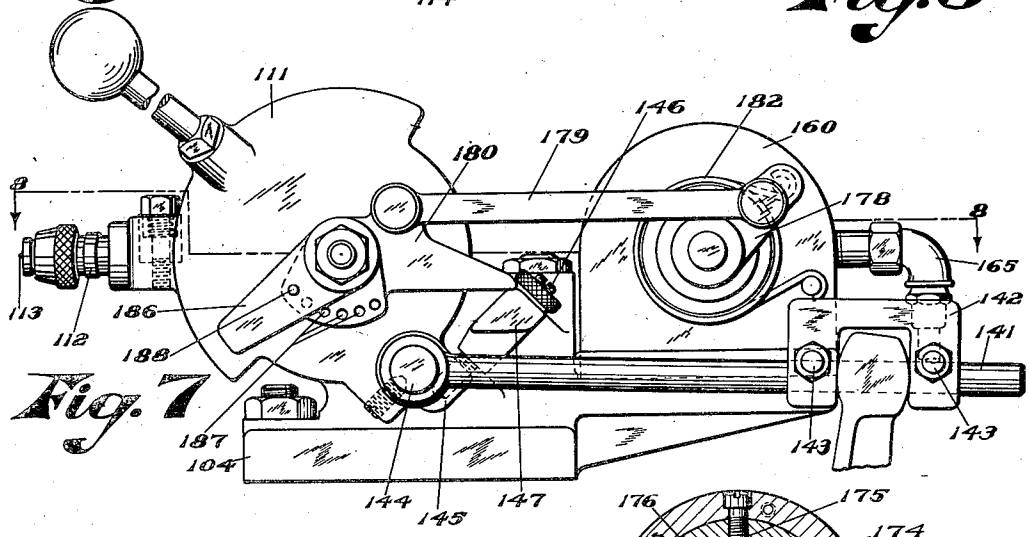


Fig. 7

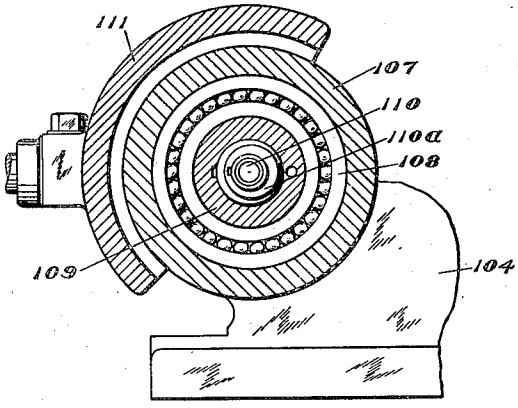


Fig. 9

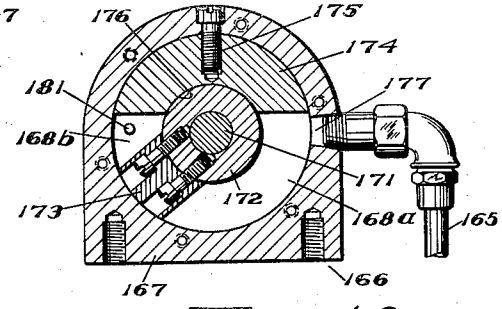


Fig. 10

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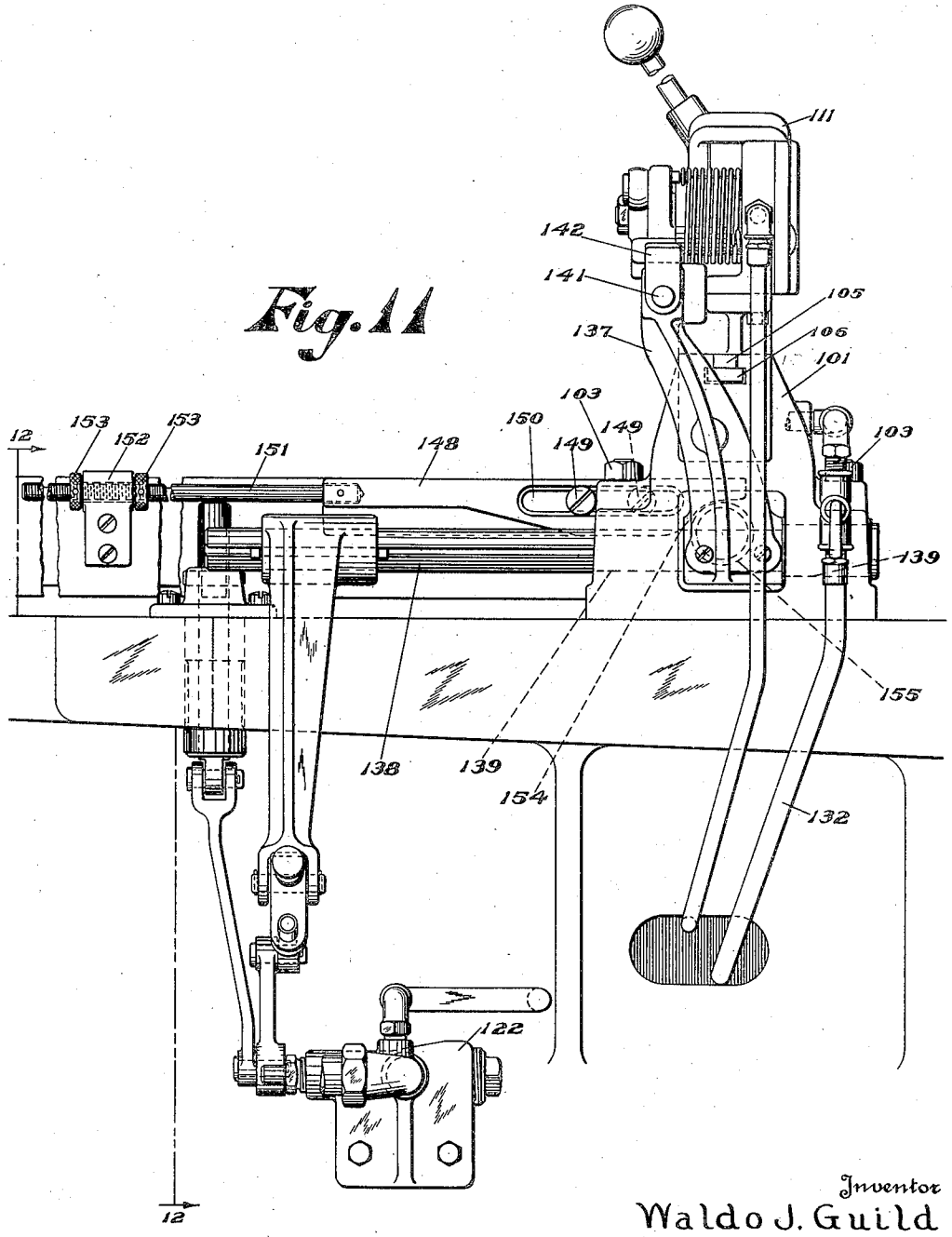
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May 12, 1931. W. J. GUILD 1,804,414

GRINDING MACHINE

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Fig. 11



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GRINDING MACHINE

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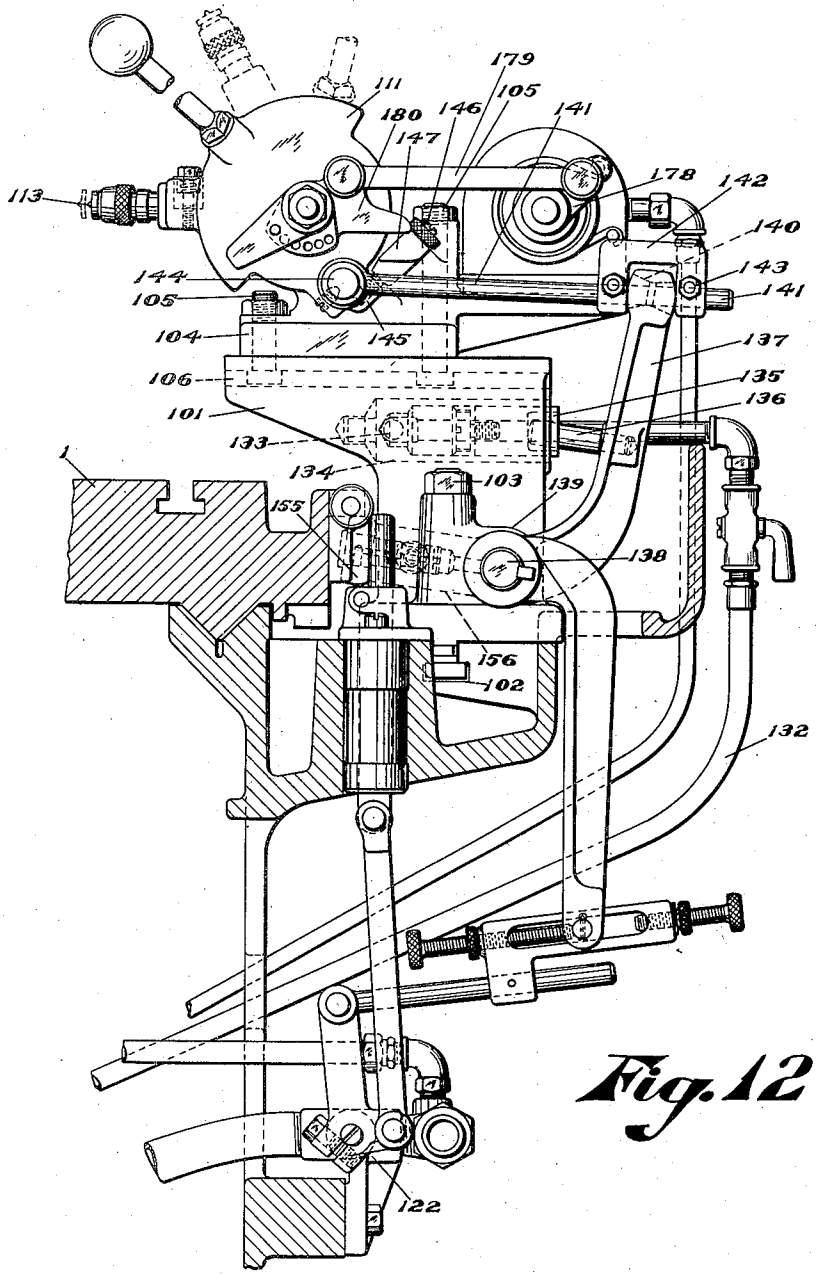


Fig. 12

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GRINDING MACHINE

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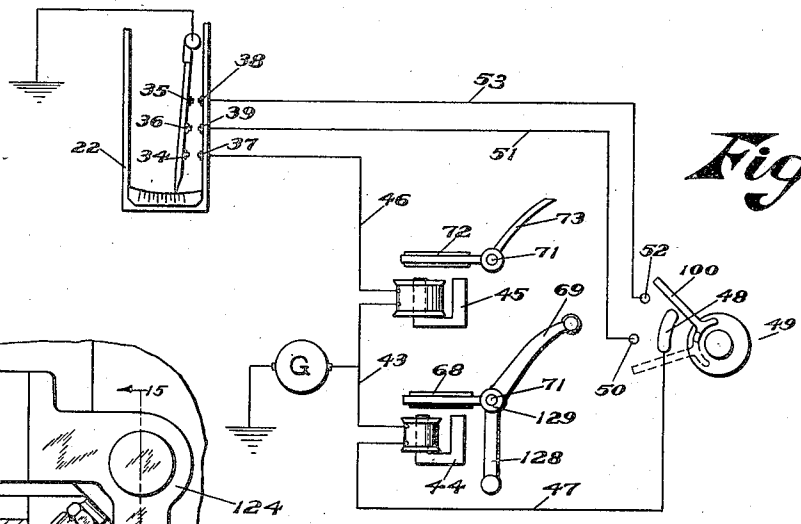


Fig. 16

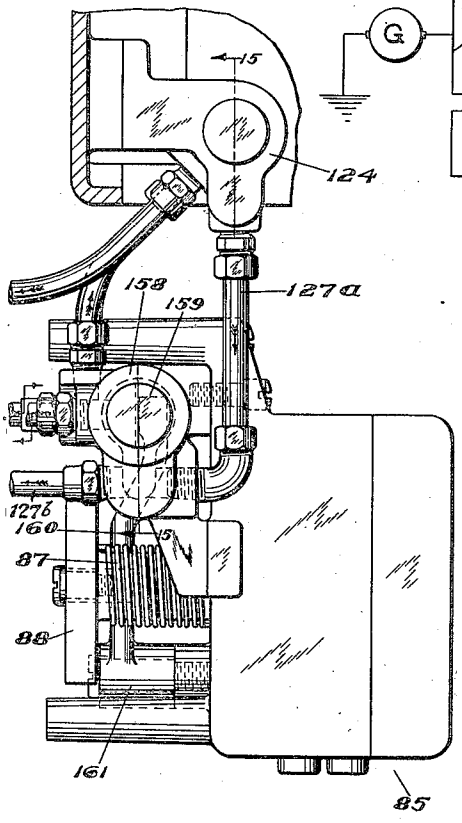


Fig. 13

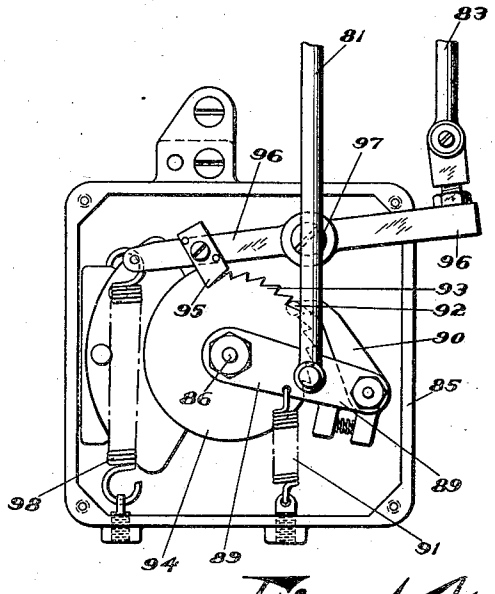


Fig. 14

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GRINDING MACHINE

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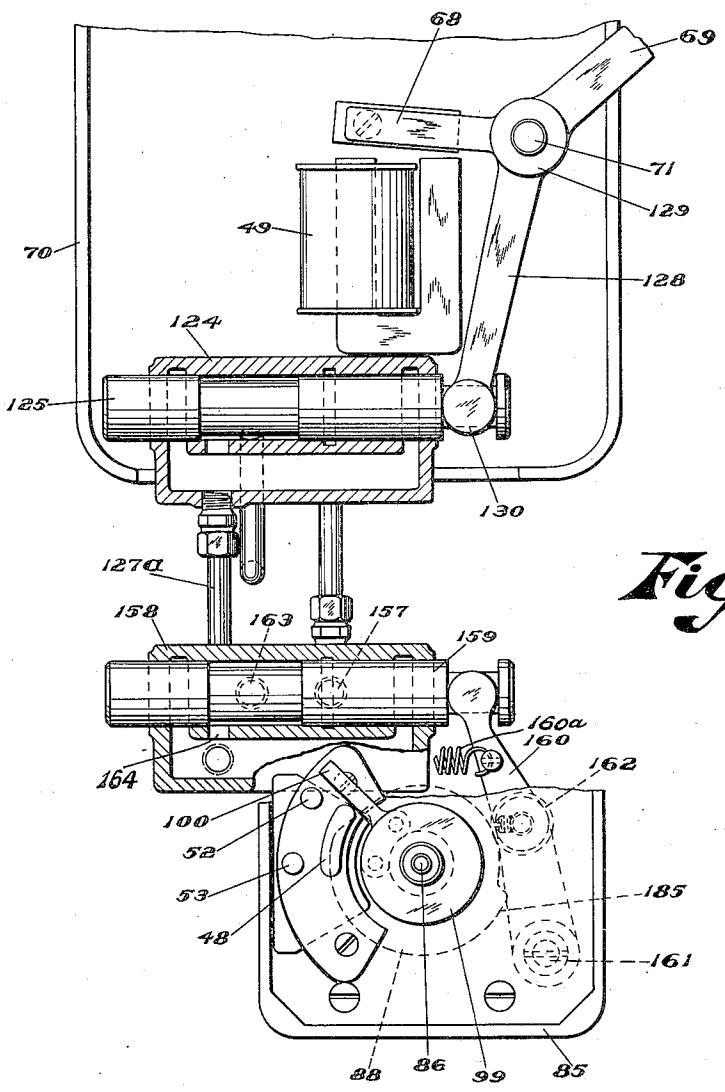


Fig. 15

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GRINDING MACHINE

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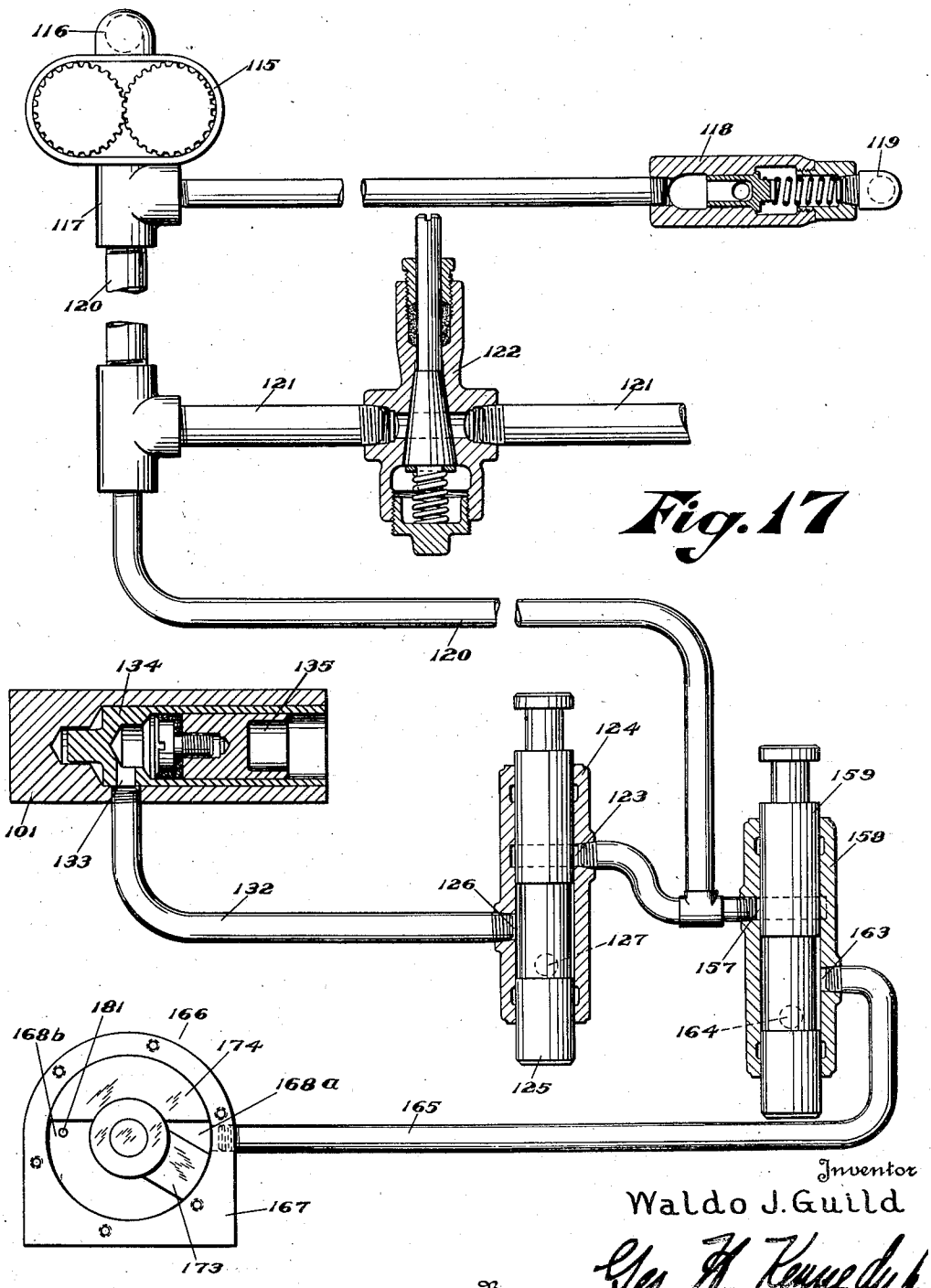


Fig. 17

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Patented May 12, 1931 1,804,414

UNITED STATES PATENT OFFICE

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GRINDING MACHINE

Application filed July 15, 1927. Serial No. 206,085.

The invention relates to grinding machines, particularly those adapted to grind the internal peripheral surfaces of sleeves, gears, bushings, and like articles. The present invention is an improvement on the invention shown and claimed in the copending application Serial No. 108,379 of Heald, Highberg and Taylor, filed May 11, 1926, now Patent #1,684,487, according to which automatic work sizing instrumentalities and a plurality of dressing devices are provided, the former making the latter operative at different stages in the grinding of each workpiece to dress and true the grinding wheel. The present invention likewise involves a plurality of dressing operations on the grinding wheel, to keep its cutting surface sharp and true, but only a single dressing device, shown as a diamond, is provided, and means are provided to move said diamond to different operative positions. Thus the grinding wheel can be dressed and trued at distinctly different stages in the operation of grinding a particular workpiece to size.

In common with the prior invention above referred to, the present invention makes use of the work calipering mechanism shown and described in the copending application Serial No. 4,466 of Heald and others, filed January 24, 1925; U. S. Patent No. 1,751,202, granted March 18, 1930; such use in connection with the present invention is illustrative merely, and the present invention can equally well be associated and combined with my own invention, copending application Serial No. 48,734, filed August 7, 1925, U. S. Patent No. 1,682,672, granted Aug. 28, 1928, with the improvement thereon copending application Serial No. 83,592 of Edward M. Taylor, filed January 25, 1926, U. S. Patent No. 1,682,673, granted Aug. 28, 1928, or with any other suitable sizing device or mechanism, adapted to set in operation the dressing instrumentalities herein shown and described.

The above will more fully appear in the following description, taken in connection with the accompanying drawings, in which—

Fig. 1 is a front elevation of a grinding machine constructed in accordance with my invention.

Fig. 1*a* is an isometric view, showing the grinding wheel engaging a workpiece.

Fig. 2 is an isometric view, showing certain actuating mechanisms that are attached to the grinding machine table in the relative position which they occupy when the grinding wheel is operating upon a workpiece, these latter parts being also shown.

Fig. 3 is a plan view of certain work calipering mechanism.

Fig. 4 is a sectional view on the line 4—4 of Fig. 3.

Fig. 5 is a sectional view on the line 5—5 of Fig. 4.

Figs. 6 and 7 are side elevations of the wheel dresser, its supports, and the mechanism to move it to different operative positions, Fig. 6 showing the parts in the initial operative position.

Fig. 8 is a horizontal sectional view taken on the line 8—8 of Fig. 7.

Figs. 9 and 10 are, respectively, vertical sectional views taken on the lines 9—9 and 10—10 of Fig. 8.

Fig. 11 is a fragmentary elevation of the rear of the machine, showing the dresser moving instrumentalities and associated parts.

Fig. 12 is a view partly in side elevation, and partly in section along the line 12—12 of Fig. 11, of the parts shown in Fig. 11.

Fig. 13 is a fragmentary side elevation of certain valves and certain counting mechanism, which are located on the front of the machine.

Fig. 14 is a front elevation of the aforesaid counting mechanism, the cover of the box in which it is contained being removed.

Fig. 15 is a sectional view taken on the line 15—15 of Fig. 13.

Fig. 16 is a wiring diagram.

Fig. 17 is a diagrammatic showing of the fluid pressure operating system which actuates various instrumentalities of the invention.

Fig. 18 is a fragmentary view of part of the mechanism carried by the table which controls the movement thereof, together with parts on the machine base interacting there-

with, showing particularly the device for resetting the mechanism to produce a normal traverse after the dressing stroke, the condition at the limit of amplified movement being illustrated.

Like reference characters refer to like parts throughout the drawings.

Referring first 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, 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 may be imparted in any well known manner, as for instance, by the use of the fluid pressure controlling and reversing mechanism which forms the subject matter of United States Patent No. 1,582,468, to Heald and Guild, granted April 27, 1926. Such mechanism, or its equivalent, forms no part of the present invention, and a detailed description thereof is therefore unnecessary; it is sufficient to note for the purposes of the present disclosure, that the driving means employed for the reciprocation of the table 1, be it hydraulic drive, or gear drive, or any other type, procures the reversal of said table at each end of the latter's normal working stroke by the use of spaced adjustable dogs 7 and 8, carried by the table 1 and adapted to alternately engage and move a reversing member 9; the latter, during the grinding operation, when the wheel 5 is moving back and forth within the workpiece 6, is situated between the two dogs 7 and 8 in position to be struck alternately by said dogs, and by its consequent movement, first in one way and then the other, effects the reversals in the travel of table 1. In the machine herein illustrated, the grinding wheel 5 is rotated at high speed in any suitable manner, as for instance, by a belt drive for the wheel spindle 10, the latter for this purpose carrying a pulley 10*a*. 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 11 for feeding the wheel head 2 transversely of the table 1. Said screw shaft 11 may be operated, if desired, by the usual hand wheel 11*a*. The automatic operation of said screw shaft 11 is effected in the usual manner, at each reciprocation of the table 1, by a fixed dog or stop 12 which is engaged by a roller 13 on the end of a pivoted arm 14; the movements of said arm are transmitted through a pawl 14*a* and ratchet wheel 14*b* to the screw shaft 11, thereby to obtain the automatic cross feed of the grinding wheel 5 at each reciprocation of the table.

As shown in Figs. 3 and 4, a member 15 has at one end a work calipering point 16 adapted, during the operation of grinding a workpiece, to bear against the internal surface which is being ground, and to maintain its contact with said surface as the hole in the workpiece is gradually enlarged by the grinding action of the wheel. The member 15 is to all intents and purposes a lever, said member, for the movement required of it to maintain the point 16 in constant contact with the interior of the gradually enlarging hole in the workpiece, being supported by a pair of flexible U-shaped flat springs 17 and 18, which springs cross each other, and are attached to two adjacent sides of a rectangular block portion 19 of member 15. At their other ends the crossed springs 17 and 18 are attached to two surfaces 20 and 21 of a box 22, these surfaces 20 and 21 being at right angles to each other, and the box 22 providing an opening 23 of sufficient size to permit the inward extension 15*a*, of member 15, to move freely about the pivotal axis which is afforded by the intersection of the planes of the U-shaped springs 17 and 18. This pivotal movement is accomplished by the flexing of these two springs, and takes place in the entire absence of lost motion, since there is no bearing or pivot pin. Consequently, any movement of the extension 15*a* of member 15 within the box 22, is invariably in exact accordance with the movement of calipering point 16 in maintaining contact with the surface of the gradually enlarging hole in the workpiece.

Such motion of the member 15 is adapted to be transmitted to an indicator lever 24, pivoted at 25 within the box 22, with its free end adapted to move across the graduations of a suitable scale 26. Lost motion may be eliminated at bearing 25 by a spring 25*a*. The connection between extension 15*a* and indicator lever 24 is made by a spring 27, which draws the parts together and maintains the end of a plug 28 carried by the lever 24 in contact with the extension 15*a*, said plug being adjustably carried in lever 24 and extending into a suitably enlarged slot or hole in box 22, so as to permit adjustment from the exterior of said box. By moving the plug 28, the indicator lever 24 can be made to assume any desired position

relative to the member 15*a*, and said plug 28 is maintained in any given setting and displacement thereof prevented by any suitable friction device, such as a binding screw 30. With the arrangement above described, a very slight movement of the calipering point 16 is multiplied many times in being transmitted to the indicator lever 24, as will be readily understood.

In the operation of the mechanism, the calipering point 16 maintains contact with the work, the movement of member 15 for this purpose being obtained by the pressure of a spring 31, and such movement, greatly multiplied, being transmitted through the above described connections to the indicator lever 24.

The extension 15*a* carries a loose piston 32 located in an oil cylinder 33, which arrangement dampens any vibrations which may be imparted to the member 15 in case the workpiece, at the commencement of the grinding operation, is badly out of round. Such dampening means increases the efficiency of the indicating and circuit making mechanism, as vibrations are apt to cause premature making of the circuits, hereinafter to be described.

The multiplied movement of lever 24 is made use of to set in operation the wheel dressing instrumentalities a plurality of times, and finally to bring about a cessation of the grinding to cause the grinding wheel 5 to withdraw from the workpiece 6. To this end the lever 24 carries a plurality of contact terminals, in this embodiment shown as three. The terminal numbered 34 is adapted to bring about the cessation of grinding. The other terminals, namely 35 and 36, are adapted to bring about the several stages of dressing, the dressing diamond, as will hereinafter appear, being moved to a different operative position for the second dressing, brought about by terminal 36, than that which it occupies for the first dressing brought about by the terminal 35. In the paths of the contact terminals 34, 35 and 36, the box 22 provides insulated stationary terminal contacts 37, 38 and 39. Movement of lever 24 causes terminals 35 and 38 to come into contact first; subsequently, terminals 36 and 39, and finally terminals 34 and 37, come into contact. In order to permit this succession of contacts, the moving terminals 34, 35 and 36 are carried by flat springs 39*a*, which normally press against rigid members 40, so that the said terminals have a fixed position of rest relative to the indicating lever 24, but can be readily displaced therefrom in one direction. This construction is shown in Fig. 5, which, while a sectional view of terminal 36, shows equally well the construction of the other flexible terminals 34 and 35.

As clearly described in the aforesaid application of Heald and others, the box 22 is carried by a bracket 41 which provides a pivotal mounting for it, and when the final withdrawal movement of table 1 takes place, withdrawing the wheel 5 from the workpiece 6, a cam member, not shown herein, engages a lever or a roller at the end thereof and swings the box 22 carrying the calipering lever 15 away from the workpiece. A spring 42, see Fig. 1, automatically returns the box 22 to its operative position as the wheel 5 enters a subsequent workpiece 6, and means is provided to allow the calipering point 16, generally a diamond, to enter the new workpiece without striking the mouth of the latter and chipping the point 16. It is not believed necessary to describe this mechanism and the various adjustments in detail, as they have nothing to do with the present invention, and enough of the calipering mechanism has been described to illustrate said present invention.

Referring now to Fig. 16, the instrumentalities whereby a plurality of wheel dressing operations may be automatically inaugurated will now be described. The character G indicates a generator of any desired sort, preferably supplying direct current. One terminal of said generator is grounded and the other terminal is connected by means of a branching lead 43 to the coils of two electromagnets 44 and 45. The other end of the coil of electromagnet 45 is connected by a lead 46 to the stationary terminal 37. The other end of the coil of electromagnet 44 is connected by a lead 47 to a stationary terminal plate 48 of a switch, generally designated by the numeral 49. The stationary terminals 38 and 39 are connected, respectively, by leads 53 and 51 to stationary terminals 52 and 50, also part of said switch 49.

The magnet 44 causes the table 1 to travel beyond its normal working stroke, carrying the grinding wheel 5 out of the workpiece 6, and into the path of the dressing diamond. The instrumentalities whereby this action is brought about will presently be described. Also the magnet 44 actuates a certain hydraulic valve to move the dressing diamond into wheel truing position, which one of its two different wheel truing positions being determined, as will appear, by the position of the moving parts of the switch mechanism 49. The magnet 45, when energized, brings about a cessation of the grinding operation, and prepares the machine for the introduction of a new workpiece.

The mechanism whereby the energization of magnet 44 causes the reciprocatory travel or stroke of table 1 to be amplified, is as follows:—As shown in Figs. 1 and 2, the left hand table dog 8, which limits the right hand movement of table 1, is carried by a block 54, which instead of being secured directly to the table 1, as is the case with the block 55 of dog 7, is mounted so as to be capable of sliding freely longitudinally of said table. Under

normal condition, when the table is making its usual working reciprocations to traverse the grinding wheel 5 back and forth within the workpiece, the block 54 of dog 8 is held in definite spaced relation to a block 56, which latter, the same as the block 55 of right hand dog 7, is a stationary block adapted to maintain its predetermined setting or adjustment longitudinally of the table 1, as given it by any suitable adjustment of adjusting and holding devices, such for instance, as the hand screw nuts 57, 57 applied to both blocks 55 and 56 and engaging with the screw rack 58 on the table 1.

The device employed to hold the slidable block 54 in spaced relation to the fixed block 56 is here shown as a latch lever 59 pivoted at 60 on block 56, and having its free end disposed by gravity in abutting relation to a shoulder or slot 61 on block 54, thereby holding the block 54 at a predetermined distance to the right of block 56. When the latch member 59 is lifted to free its end from the shoulder 61, the normal connection between the slidable block 54 and the fixed block 56 is broken, and when this occurs on the right hand movement of table 1, the dog 8 will bear without effect against the member 9. Thus the right hand movement of the table 1 on this particular stroke will be extended beyond the usual reciprocatory working path, and the grinding wheel will be carried out of the hole in the workpiece to a point just beyond that occupied by the dressing device which, as will be described, has been moved into one of its operative positions as the amplified right hand travel of the table 1 begins. This amplified right hand travel of table 1 involves relative sliding movement between said table and the block 54, owing to the obstruction which the reversing member 9 imposes against the dog 8 to prevent the block 54 from moving with the table; finally, the block 54 brings up against the block 56, whereupon the solid backing thus afforded for the block 54 enables the dog 8 to shift the member 9. 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 62 pivotally mounted on the frame of the machine has a pair of inclined surfaces 63 and 64 for cooperation, respectively, with inclined surfaces 65 and 66 at the lower corners of the block 54. A spring 67 presses said member 62 upwardly. In the normal grinding operation of the machine when the blocks 54 and 56 are connected by latch 59, the surfaces 63 and 64, although in the path of block 54, 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 of the bevelled surfaces 65 or 66, such contact will wedge the spring 67 downwardly, said spring yielding sufficiently to allow the block 54 to pass over the member 62. However, when the block 54 has been freed from the block 56 as above described, to amplify a single right hand stroke of the table 1, the ensuing reversal of said table, with the block 54 still free, finds the surface 63 in position to contact with the corner of said block, and under these conditions the obstruction offered is sufficient to overcome whatever friction there may be tending to cause the block 54 to move to the left with the table. The block 54 being thus held stationary while the table 1 and block 56 continue to move to the left, the latch member 59 finally resumes its normal position relative to the block 54, the end of said latch member dropping behind the shoulder 61 and the parts being thus automatically restored to normal position at the conclusion of each single amplified reciprocation of the table 1. Energization of the magnet 44 attracts an armature member 68, to which is attached a lever arm 69. Movement of this lever arm 69 is adapted to raise the latch lever 59, with the results above set forth.

The magnet 44 may be seen in Fig. 15, and in dotted lines in Fig. 1, being shown as inclosed in a box-like structure 70 on the front of the machine frame. The magnet 45, shown in the wiring diagram of Fig. 16, is located directly behind the magnet 44, the same pivot 71 that serves to hold the armature 68 and lever arm 69 serves also to hold an armature 72 and an arm 73 associated with electromagnet 45. As heretofore stated, energization of magnet 45 is adapted to cause final separation of work and wheel, and this is effected in the following manner:—

Attraction of armature 72 lifts arm 73, interposing the free end of the latter in the path of table dog 8, which dog, as heretofore pointed out, normally, on the right hand working stroke of the table, strikes and moves the reversing member 9 to cause a reversal in direction of table travel. The dog 8 is pivotally mounted at 74 (see Fig. 2) on the carrying block 54 and normally rests by gravity against a pin 8*a*. When the arm 73, as above described, moves upwardly into the path of dog 8, the free end of said dog, on the right hand movement of the table, engages with and rides upon the upwardly inclined surface of arm 73, and is thus carried clear of reversing member 9. The table 1, therefore, continues its movement to the right, carrying the grinding wheel 5 out of the work and well past the dressing device, being finally brought to a stop by any suitable means, such, for example, as disclosed in the aforesaid Patent No. 1,582,468.

Referring to Figs. 1 and 2, the block 56 has attached thereto a pair of switch operating dogs 76 and 77. These dogs are some-

what different in shape, and are in different vertical planes, as may be readily seen from Fig. 2. An arm 78 is fastened to a shaft 79 which is suitably journalled in the box structure 70 on the front of the machine. A second arm 80, likewise fastened to shaft 79, has a link 81 connected to it at its end. The arm 78 is in the path of dog 76. A third arm 82 is loosely mounted on shaft 79, which serves as a pivot for it, and this arm 82 is in the path of dog 77, whose bevelled edges are adapted to depress it. A link 83 is connected to the end of arm 82.

With the table in the position of Fig. 1, which is the position it automatically assumes at the completion of the grinding on a given workpiece, the operator, after placing an unground workpiece in the chuck carried by the wheel head 3, grasps a lever 84 and moves it to the left, which, by connections, not shown, moves the reversing member 9 to the right and sets the table 1 in motion to carry the wheel 5 into the new workpiece. In so moving, the table 1 carries the dogs 76 and 77 past the arms 78 and 82, first depressing the arm 82 and consequently also the link 83, and subsequently rocking the arm 78, raising the link 81.

Referring now to Figs. 13 and 14, a suitable casing 85 is attached to the front of the machine, below the box 70. Suitably journalled in this casing is a shaft 86. As shown in Fig. 13, a coil spring 87 surrounds this shaft, one end of the spring being fastened to a member 88 fastened on the end of shaft 86, and the other end being anchored in the casing 85. At the forward end of shaft 86, see Fig. 14, an arm 89 is pivotally mounted. This arm carries a spring pressed pawl 90 and is itself carried by the lower end of link 81. A spring 91 holds these parts normally in the position of Fig. 14, where a shield member 92 holds the pawl outwardly. When the link 81 is raised, as hereinbefore described, the pawl 90 engages a ratchet segment 93 on a member 94 which is fastened to shaft 86, and thus partially rotates the latter against the tension of the spring 87.

Engagement of the dog 76 with the arm 78 is adapted to move the pawl 90 just far enough to advance the segment 93 through the distance of one tooth. The latter is held in the advanced position by a hold pawl 95 carried by a lever 96 which is pivoted at 97 and has a spring 98 attached to it to hold the pawl 95 in engagement with the teeth of segment 93. The link 83 is attached to one end of lever 96, and depression of the link is adapted to raise pawl 95, as will readily be seen from Fig. 14. In this connection it must be noted that the final tooth of segment 93 is higher than the rest, and depression of link 83 in response to engagement of dog 77 with arm 82 does not raise pawl 95 beyond the level of this last tooth. The result is, that the primary engagement of dog 77 with arm 82 just described, when the table 1 moves to carry the grinding wheel 5 into a new workpiece, leaves the parts as it finds them, in the position shown in Fig. 14. Immediately thereafter, however, by the engagement of dog 76 with arm 78, the member 94 is moved through an angular distance of one tooth of the segment 93 and held there.

Referring now to Fig. 15, an insulating collar 99 is carried by the shaft 86. To the collar is fastened a metal finger 100. This finger 100 is adapted to connect any one of the terminals 52 and 53 with the plate 48. When the table 1 has moved from the position of Fig. 1 to carry the wheel 5 into a fresh workpiece, the finger 100, by the single actuation of the pawl 90 just described, has moved to connect terminal 52 with plate 48. Referring now to the wiring diagram of Fig. 16, it will be seen that the electromagnet 44 will be energized as soon as the terminals 35 and 38 come together. This causes the amplified movement of the table 1, which has been described, and in consequence, the dog 76 rocks the arm 78 twice, once as the table moves outwardly, and again as it moves inwardly, the arm 78 returning to vertical position after dog 76 has passed over it, in either direction, by the action of spring 91 in box 85. This action moves the finger 100 through two more stages, bringing it to rest in contact with terminal 53, where the table will undergo another amplified movement when, and only when contact is made between the terminals 36 and 39 in box 22. From the foregoing, it will be seen that any number of withdrawal movements of the table 1 can be brought about at any number of different stages in the reduction of a workpiece, simply by providing enough caliper controlled contacts in the box 22 and enough progressive switch controlled contacts in the casing 85.

Returning, however, to the specific embodiment of the invention shown in the drawings, the second amplified movement of the table 1 moves the finger 100 into the dotted line position of Fig. 16; subsequent movements of pawl 90 thereafter avail nothing, since there are only a sufficient number of teeth on member 94 to move the finger 100 to the dotted line position so that magnet 44 cannot be further energized, and the grinding wheel 5 proceeds to take the final and finishing cuts on the workpiece, and when the latter has reached the predetermined size, terminal 34 on lever 24 reaches terminal 37, which completes the circuit through magnet 45 (entirely unconnected with switch 49), thus raising the lever arm 73, whereupon the table 1 runs out to the position of Fig. 1. This final withdrawal carries the dog 77 past the arm 82, thus raising pawl 95 and returning all the elements attached to shaft

86 to the original position. This return movement occurs in response to the reaction of spring 87, since pawl 90, except when it is moved, is held away from segment 93 by the shield pin 92.

Referring now to Figs. 11 and 12, the dresser mechanism, hereinbefore referred to, is mounted at the rear of the machine, on a base 101. In order to adjust said mechanism longitudinally of the machine frame, the latter provides a long slot 102; the base being fastened at any position of said slot by T bolts 103, 103. A stand 104 is mounted on the top of the base 101, by means of T bolts 105, 105, and a slot 106, which runs at right angles to the slot 102. The foregoing, of course, simply provides a ready means for adjusting the position of the stand 104 relative to the machine frame.

As shown in the sectional views of Figs. 8 and 9, the stand 104 provides an annular portion 107 in the internal periphery of which fit the outer races of a pair of ball bearings 108, 108. The inner races of the bearings 108, 108 fit the external cylindrical surface of a member 109, which is fastened to a short shaft 110. The shaft 110 is provided with two journals 110*a* which are eccentric to the center line thereof, thereby constituting eccentric means by which the operative position of the dressing device may be readily changed. To that end, an oscillatory member 111, which carries the plug 112 in which the diamond or other dressing device 113 is embedded, is pivotally mounted on the journals 110*a*, preferably by means of ball bearings 114, 114 located on either side of the ball bearings 108, 108.

Assuming now that the plug 112 and diamond 113 have been moved from the normal or inoperative position shown in dotted lines in Fig. 12 to the full line position illustrated in Fig. 12, which is accomplished by movement of the oscillatory member 111, as will be hereinafter described, it will be seen that the exact position of the diamond 113 is determined by the position of the journals 110*a* which support the oscillatory member 111. And the position of the journals 110*a* can be changed by turning them, since they are eccentrically located with respect to the bearings 108, 108. Before describing the automatic means by which the shaft 110 is turned, between the first and second dressing of the grinding wheel 5, so that the second dressing may occur after said wheel has been advanced a substantial amount in cutting relation to the workpiece from the position which it occupied at the first dressing, the means for moving the oscillatory member 111, to carry the diamond 113 into the path of amplified travel of the said grinding wheel, will be described.

Referring to the fluid pressure diagram of Fig. 17, any suitable pump 115 is provided to supply fluid under pressure for the actuation of the table 1 and to operate the dresser moving and adjusting instrumentalities. As herein shown, this pump is individual to the machine, but it will be readily understood that one main supply pump can be utilized to supply pressure fluid to a battery of machines. The pump draws the fluid from any main supply source, not shown, by means of piping 116. The discharge end of the pump is indicated at 117 and it has been found desirable to connect a relief valve 118 of any usual sort at this point, the discharge of said relief valve leading by piping 119 to the supply source. Line piping 120 connects to the discharge end of the pump, and connected to said line piping is a branch 121 which leads to the reversing valve and pressure fluid cylinder that actuates table 1. As aforesaid, such reversing valve is not shown herein, as it forms no part of my invention, but Fig. 17 shows the relationship between such and the hydraulic means to actuate and adjust the dresser. In the branch piping is a slow-down or table speed reducing valve 122, shown in section in Fig. 17 and in elevation in Figs. 11 and 12. This valve slows down the speed of the table 1 for each amplified dressing stroke, but as it forms no part of the present invention neither it nor its operating mechanism will be further described herein.

The supply line 120 leads to an entrance port 123 of a valve 124, shown in vertical section in Fig. 15, in end elevation in Fig. 13, and diagrammatically in Fig. 17. A valve member 125 is adapted, in one position, to connect the port 123 with a port 126 which leads the pressure fluid to the diamond moving mechanism. In the other, or inoperative position, which is illustrated by Figs. 15 and 17, the port 123 is entirely closed, the port 126 being connected to an exhaust port 127 which communicates by piping 127*a* (see Fig. 13) with the source of fluid supply. The valve member 125 is moved to the operative position whenever the electromagnet 44 is energized, and to this end a depending arm 128 is attached to the hub portion 129 which holds the armature 68 and lever arm 69, these parts of course, being conveniently made in a single piece. The manner in which magnet 44 is successively energized to bring about the several dressing operations has been already described. Each separate energization thereof attracts the armature 68, and by means of the arm 128 and a suitable connection 130, draws the valve member 125 to the operative position. The amplified movement of the table 1 is made use of to return the parts to the original position in the following manner. A cam portion 131, Figs. 1 and 2, is carried either by the block 54, the block 56, or some member attached to either of these. As actually shown herein, this cam portion forms

a part of the latch 59. At all events, it is in the path of the arm 69, and is so located that when the table 1 has reached approximately the extreme outer limit of its amplified dressing stroke, said cam portion 131 engages the arm 69 and forcibly turns the parts 68, 69, and 128 in a clockwise direction to their original position. This positive means of returning the valve 125 to the position of Figs. 18 and 19 is highly desirable, because, as will be hereinafter described, the dresser moving devices are mechanically repositioned by the return movement of table 1 after its amplified withdrawal, and such repositioning should not take place until the dresser moving cylinder has been relieved of fluid pressure.

The port 126, Fig. 17, of the valve 124 connects by means of piping 132 to the entrance port 133 of cylinder 134, which is located in the base 101. A piston 135 is slidably received by the cylinder 134. Referring now to Figs. 11 and 12, the piston 135, when forced outwardly by fluid pressure admitted to the cylinder 134 by way of the piping 132 and port 133, pushes against a pin 136 and rocks a lever 137 to which said pin 136 is attached. The lever 137 is attached to a shaft 138, which is journalled in bearings 139, 139 provided by the base 101; the foregoing, as far as the present invention is concerned, simply constituting a pivotal mounting for the lever 137. The upper end of the lever 137 has a hole 140 therein, and a link rod 141 passes therethrough, any suitable device, such as a U shaped member 142, with holes through the arms thereof and tightening bolts 143, 143, being provided to adjust the position of the link 141 in the said hole 140 provided by the lever 137.

The other end of the link 141 is pivotally fastened by means of a pin 144 to the oscillatory member 111. Thus it will be seen that when the valve 125 is moved, making fluid pressure active in cylinder 134 to move piston 135, the lever 137 is actuated, and the oscillatory member 111 is moved counterclockwise to lower the diamond carrying plug 112, placing the diamond 113 in the path of amplified travel of the grinding wheel 5. In order that the said diamond may be brought to the exact desired position (as regards height), an abutment 145 on the member 111 strikes an adjustable screw 146 mounted in a lug 147 formed on the stand 104.

As aforesaid, the dresser point is raised, and the piston 135 is replaced by mechanical means. Still referring to Figs. 11 and 12, a cam member 148 is suitably fastened to the table 1 at the rear thereof, as by bolts 149, 149, provision being made for longitudinal adjustment of said cam member, as by providing a slot 150 through which said bolts pass, and an adjustment rod 151, which also takes the end thrust, said rod 151 being anchored to the table 1 by means of a lug 152 and nuts 153, 153. This adjustable cam member 148 has an inclined surface 154 which, when the table 1 has started back from its amplified dressing stroke and the wheel has completely passed the dressing tool, bears the relation shown in Fig. 11 to a roller 155, the latter being carried by a forward extension 156 of the lever 137. The remaining movement of the table 1 to the right, Fig. 11, to carry the grinding wheel 5 back into the workpiece 6, forces the roller 155 downwardly, thus rocking the lever 137 in a counterclockwise direction (Fig. 12). This action restores the diamond 113 to the inoperative position, and forces back the piston 135. Fluid is consequently ejected from the cylinder 134 and, the valve member 125 having already been repositioned in the manner described, the fluid exhausts by way of the valve 124, the port 127 and the exhaust piping 127*a*.

As already stated, the present invention distinguishes from the invention described and claimed in application Serial No. 108,379 in that but a single dressing point 113 is provided according to the present invention, means being provided to automatically place the said dressing point at distinctly different operative positions for the two or more dressing operations. To that end, the invention provides automatic means under the control of the progressive counting mechanism in the box 85 for turning the shaft 110 with its eccentric journals 110*a* which constitute the pivot for the oscillatory member 111, between the first and second dressing of the wheel 5. Referring again to Figs. 15 and 17, the fluid supply line or piping 120, besides leading the pressure fluid to the port 123 of valve 124, is at all times in communication with a port 157 provided by a valve 158. A valve member 159, which may be a substantial duplicate of the valve member 125, is located in said valve 158 and is adapted to be slidably moved therein by a lever 160. The lever 160 is pivotally mounted at 161 back of the box 85 (see Figs. 13 and 15) and provides a roller 162 which contacts with the periphery of the member 88, the lever 160 being drawn in a counterclockwise direction, to cause the said roller 162 to follow the peripheral surface of the said member 88 by means of a spring 160*a*. Said member 88 is a cam, and as heretofore pointed out, is fastened to the shaft 86. Therefore, in consequence of the turning of said shaft, as the ratchet 93 is progressively actuated by the pawl 90, the cam 88 is turned, and thus the valve member 159 is moved, through the medium of the lever 160.

The valve 158 provides a port 163 which is adapted to lead pressure fluid to an hydraulic actuating device 166 to turn the shaft 110. Normally, as shown in Figs. 13, 15 and 17, the port 163 is in communication only with an exhaust port 164 provided by said

valve 158 and connected thereby to an exhaust pipe 127*b*, which is a continuation of the exhaust pipe 127*a*, (see Figs 13 and 15) being out of communication with the fluid entrance port 157, but when the lever 160 and, therefore, the valve member 159 is moved, port 164 is cut off and ports 157 and 163 are connected, and the pressure fluid is made active, by way of piping 165 to actuate the said hydraulic device 166.

Referring to Figs. 6, 7, 8 and 10, the device 166 is mounted on the stand 104. It comprises a member 167 which has a shallow cylindrical chamber 168 at one end closed by an end plate 169. The member 167 also provides a hub portion 170. A shaft 171, coaxial with the chamber 168, extends from said chamber through the hub portion 170. A collar 172, whose length is exactly equal to the length of the chamber 168, is fastened to the shaft 171 in the chamber 168, and to this collar 172 is fastened a radial arm 173, which also fits closely between the base walls of the cylinder 168 and the arcuate end of which touches the cylindrical surface of said chamber. A segmental member 174 fits in the chamber 168, being fastened to the member 167 by a screw 175; member 174 has an arcuate portion 176 which fits closely against the collar 172.

It will be seen from the above that the chamber 168 is divided into two parts by the radial arm 173 and the segmental member 174, and that the volume of the part designated 168*a*, Fig. 10, will be increased as the arm 173 moves clockwise, and diminished as it moves counterclockwise. The piping 165 communicates with the chamber portion 168*a* by means of a port 177, and when the pressure fluid flows by way of piping 165 through port 177, the arm 173 is forced from the position shown in the diagram of Fig. 17 to the poistion shown in Fig. 10. This turns the shaft 171 in a clockwise direction, moving an arm 178 attached to said shaft where it extends outside of the hub 170. The arm 178 is connected by a link 179 to an arm 180 fastened to the shaft 110, and thus actuation of the device 166 turns said shaft 110 until the parts assume a position as shown in Fig. 7.

In order to allow the above movement of the arm 173, the chamber portion 168*b* has a hole 181 therein, which may extend through the plate 169. This prevents air pressure formed in said chamber portion 168*b* from resisting the movement of said arm. In order to return the parts to the position of Fig. 17 when the valve 159 has been returned to close the fluid entrance port 157, and to open the exhaust port 164, a coil spring 182 surrounds the hub 170, one end of said spring being attached to the arm 178, and the other end being attached to a stationary pin 183 provided by the member 167. Of course a suitable stuffing box 184 prevents fluid from leaking by the shaft 171.

The operator finds the machine at rest with the parts in the position indicated by Fig. 1. Having placed a piece of work 6 to be ground in the chuck carried by the work head 3, made all adjustments and started the work and wheel spindles revolving, he moves the lever 84, which causes the table 1 to move to the left, carrying the rotating grinding wheel 5 into the workpiece, and swinging the caliper box 22 so that the caliper point 16 may contact the inside of said workpiece. As the table 1 so moves, the pivotally mounted dog 8 lifts upwardly and drops behind the reversing member 9, whereupon the table starts its normal work traversing stroke, as determined by the setting of dogs 7 and 8. As already stated, as the wheel first enters the hole in the workpiece, the ratchet disk 94 is advanced one tooth, and since the angular movement of one ratchet tooth is not sufficient to bring about a movement of valve 159, said valve remains in the position shown in Fig. 15 and, consequently, the hydraulic actuating device 166 is held by the action of spring 182 in the position shown in Fig. 6. The finger 100 has, however, been brought into contact with the terminal 52 and the plate 48, and consequently, when the the workpiece 6 has been ground to that point where the contacts 35 and 38, in the caliper box 22, come together, the magnet 44 is energized, the table 1 partakes of an amplified stroke to the right, and the diamond 113 is lowered to dress and true the wheel 5, whereupon it is raised again as the wheel 5 returns to normal work traversing stroke. During the occurrence of this, the first dressing operation, the dog 76 strikes the arm 78 twice, causing two movements of the pawl 90, and thus moving the finger 100 from the contact 52 to the contact 53. This causes partial rotation of the cam 88, and the second movement of said cam, occasioned by the inward movement of the table 1, and consequent tilting of the arm 78, brings the surface of greater radius 185 of said cam 88 under the roller 162 with consequent rocking of the lever 160 and movement of the valve 159. This, as fully described, causes actuation of the hydraulic device 166, and turns the shaft 110. It should be noticed, however, that the shaft 110 is not turned till the wheel 5 has broken contact with the dressing device 113, so that the first dressing will have taken place before the eccentric shaft 110 is turned. As before stated, the position of the parts up to and during this first dressing operation has been as shown in Fig. 6, which corresponds to the lower dotted line showing of the diamond 113 in Fig. 12; as the lever 78 is tipped on the inward stroke of the table 1, the arm 178, the link 179, and the arm 180 move to the position shown in Fig. 7, which by turning the shaft 110 on which the oscilla-

tory diamond carrying member is pivoted, moves said diamond slightly to the rear, to the full line position of Fig. 12. Immediately, however, it is swung upwardly to the upper dotted line position of said Fig. 12, ready to come down again to the position of Fig. 7, or the full line position of Fig. 12, when the grinding has proceeded far enough to bring the contacts 36 and 39 (in the box 22) together.

The second dressing of the grinding wheel 5 occurs substantially later in the grinding of a workpiece than the first dressing, and indeed, as the amount of grinding advance between dressings, as measured by the movement of the cross feed screw shaft 11, can be set or determined by adjusting the screws on which the contacts 38 and 39 are mounted, so according to the present invention, the amount of movement of the diamond 113 as brought about by the hydraulic device 166 can be varied in the following manner:

Referring to Figs. 6 and 7, the arm 180, when it is moved to the position of Fig. 7, contacts the upper side of the lug 147, which therefore determines and fixes the amount of movement in one direction of the diamond position moving parts. The return movement, however, in response to the action of the spring 182 is variable, being set by an adjustment arm 186, loosely mounted on the shaft 110, which when the device 166 is not subjected to hydraulic pressure rests against a third part of the stop lug 147. The adjustment is made by fastening the arm 180 to the arm 186 in different relative positions, and this is effected by means of a plurality of holes 187 in one of these parts, a single hole in the other, and a pin 188 to hold them together. Thus the initial angular position of the eccentric shaft 110 may be varied, and as the position to which it is moved is always the same, the distance between the two operative positions of the diamond 113 may be adjusted. It will be noticed that the arms 180 and 186 are shown fastened together in two different relative positions in Figs. 6 and 7. When, in Fig. 7, stop 180 locates diamond 113 for final dressing, centers of shaft 110 and eccentric journals 110*a* are in horizontal alignment. This makes possible accurate final setting, as inaccuracies of the stop 147 are overcome, due to the fact that the movement of eccentricity moves the diamond in substantially a vertical plane.

The control of the position of a diamond by means of an eccentric mounting for its oscillatory carrying member, together with automatic means for turning the said eccentric, as disclosed by the present invention, makes it possible to bring about small changes of position with great accuracy. The ball bearing construction shown in Fig. 8 is compressed together by a side plate 189, but the particular arrangement and assembly of the said bearings, whereby all play is eliminated, being made the subject matter of another application, need not be described herein, although it will perhaps be evident from a study of Fig. 8. Although I consider the oscillating eccentric to be the best means of changing the position of the dresser point, I wish to claim the automatic change of position of the said point broadly, however carried out.

I claim,

1. In an internal grinding machine, the combination with a grinding wheel, a work holding device, and means for reciprocating one of said parts relative to the other, of a wheel dressing device having a plurality of operative positions in the path of said grinding wheel, means supporting said dressing device which, when actuated, shifts said dressing device from a condition in which it will assume one operative position to a condition in which it will assume another operative position, and automatic means for extending the amplitude of said reciprocation a plurality of times during the operation on a single workpiece, and for actuating said dresser supporting and shifting means, whereby to dress said wheel a plurality of times during said operation from distinctly different positions of said dressing device.

2. In a grinding machine, a grinding wheel, a wheel dressing device normally out of the path of said grinding wheel, a work sizing mechanism, means responsive to movement of said sizing mechanism for bringing said dressing device into the path of said wheel, said dressing device then occupying a given point, and means responsive to further movement of said sizing mechanism for again bringing said dressing device into the path of said wheel at a different point.

3. In a grinding machine, a grinder, a single wheel dressing device, a work sizing mechanism, and means automatically set in operation by said sizing mechanism for changing the operative relation of said single dressing device to said grinder.

4. In a grinding machine, a grinding wheel, wheel dressing mechanism comprising a pivotally mounted diamond, electromagnetic inaugurated means for moving said diamond into the path of said wheel a plurality of times during the grinding operation on a single workpiece, and fluid pressure actuated means for changing the operative position of said diamond after each such movement.

5. In a grinding machine, the combination with a grinding wheel, work holding means, means for reciprocating one of said parts relative to the other, and means for transversely feeding one of said parts relative to the other, of automatic means for extending the amplitude of said reciprocation a plurality of times during the operation on a single workpiece at different stages of said transverse feed, a dressing diamond,

and means for bringing said dressing diamond into the path of said wheel at different points during each of the several amplified reciprocations.

6. In a grinding machine, a wheel dressing device, hydraulic means automatically brought into action to move said device into the path of the grinding wheel at different stages in the reduction of a workpiece, separate means to change the exact operative position of said device, and a progressive mechanism to actuate said last named means.

7. In a grinding machine, automatically actuated means for bringing a dressing device to a given operative position, automatically actuated means for bringing said device to a second operative position, and control means operated by the grinding machine to determine to which position said device will be brought.

8. In a grinding machine, a grinding wheel, means for feeding said wheel in cutting relation to a workpiece, means for dressing said wheel by a dressing device located substantially in the plane of the wheel axis which contains the cutting line of the wheel, means for causing said wheel to be dressed by the same dressing device, located in the same plane but at a different position in the line of feed, a work sizing mechanism, and a progressive control mechanism, the latter, in response to movement controlled by the work sizing mechanism determining at which position in the line of feed the dressing device will be brought to.

9. In a grinding machine, a dressing device, a member holding said device, a pivotal mounting for said member, fluid pressure means to change the position of said pivotal mounting, means to move the member holding the dressing device, a valve to make the fluid pressure active to change the position of said pivotal mounting, and means progressively actuated every time the member holding the dressing device is moved, adapted to control the operation of said valve.

10. In a grinding machine, a dressing device, a member holding said dressing device, a pivotal mounting for the member holding the dressing device, a pivotal mounting for the aforesaid pivotal mounting, one of said pivotal mountings being eccentric with respect to the other, a member adapted to oscillate on an axis, a closed chamber surrounding said member, said member being connected to one of said pivotal mountings, whereby when said oscillatory member is moved, the pivotal axis of the dressing device is changed, and means to cause fluid pressure to be made active in said chamber to move said oscillatory member.

11. In apparatus as claimed in claim 10, the combination with the parts therein named, of spring means tending to return the member in the closed chamber to its original position.

12. In a grinding machine, a grinding wheel, a wheel dressing diamond, work sizing means, means responsive to said work sizing means for moving said diamond into the path of said wheel a plurality of times during the grinding operation on a single workpiece, and further means responsive to one of the aforesaid means for automatically changing the operative position of said diamond after such movement.

Dated this eighth day of July, 1927.

WALDO J. GUILD.