

June 30, 1931.

W. J. GUILD

1,812,003

GRINDING MACHINE

Filed May 31, 1928

4 Sheets-Sheet 1

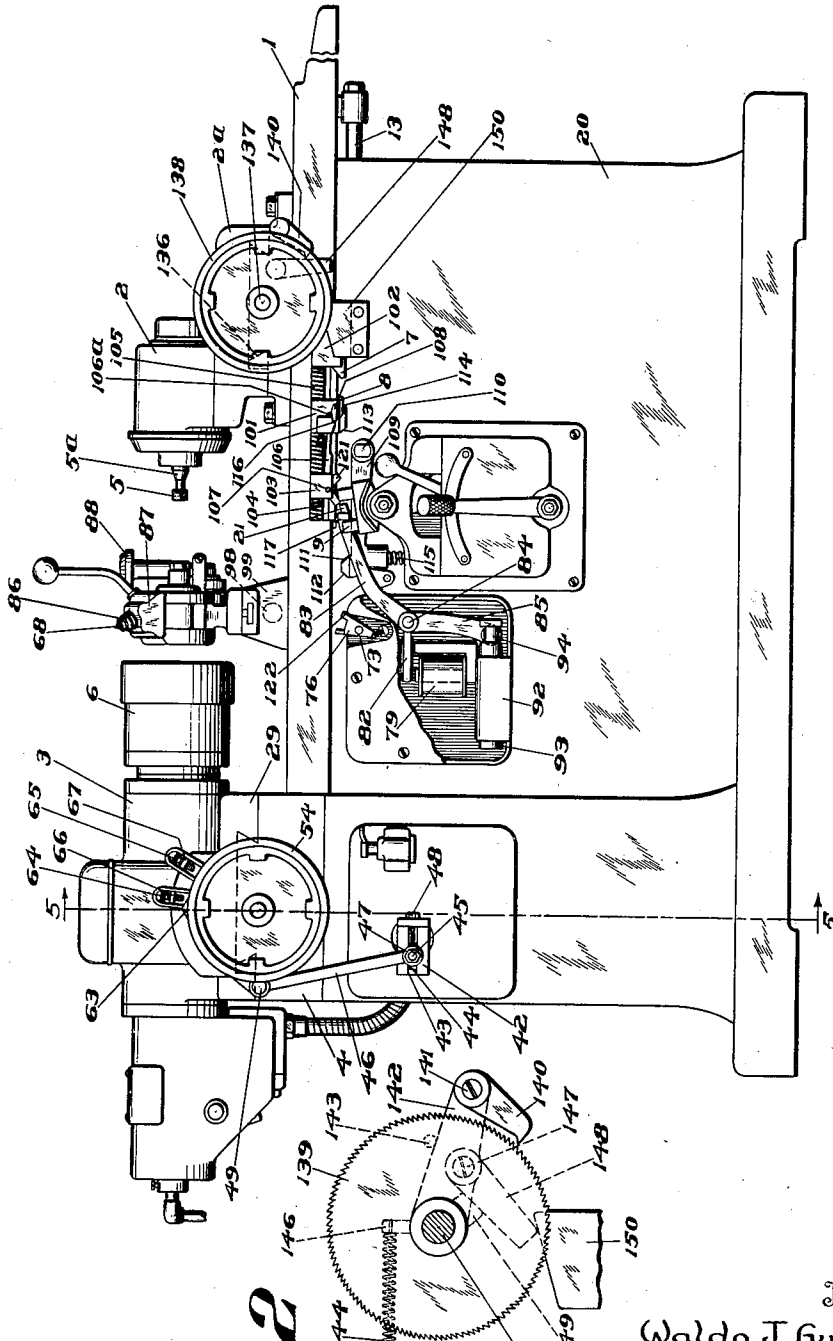


Fig. 1

Fig. 2

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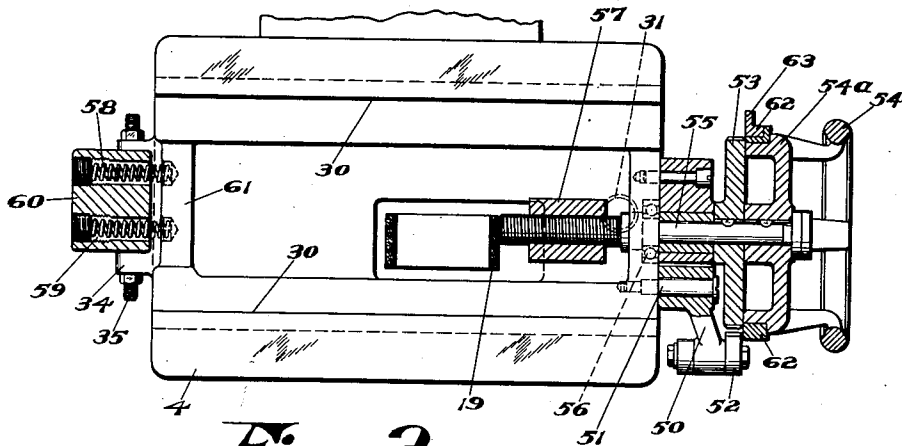


*Fig. 3*

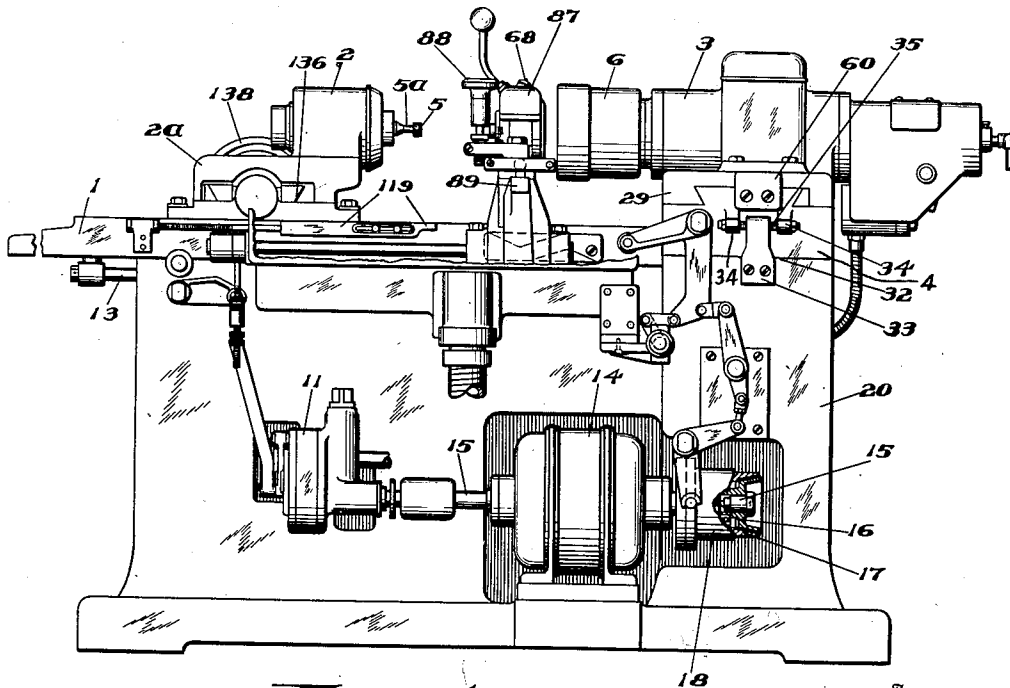


*Fig. 4*

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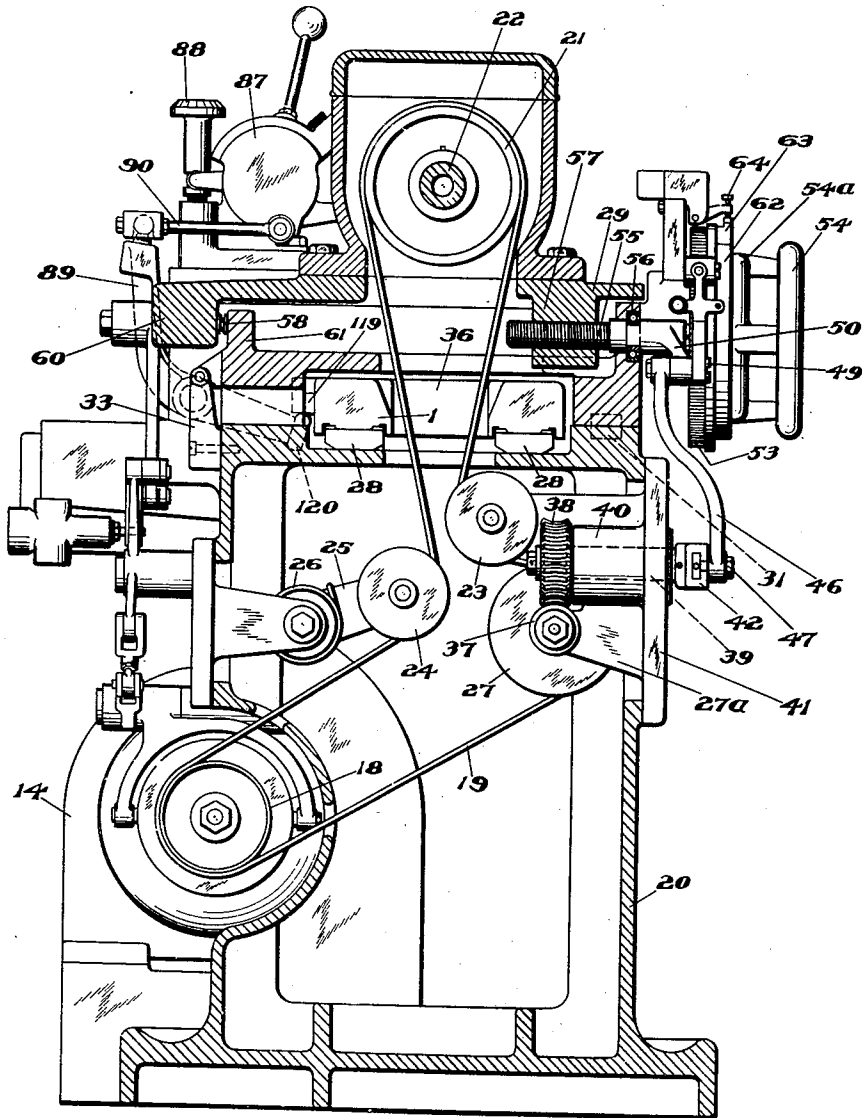


*Fig. 5*

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*Fig. 6*

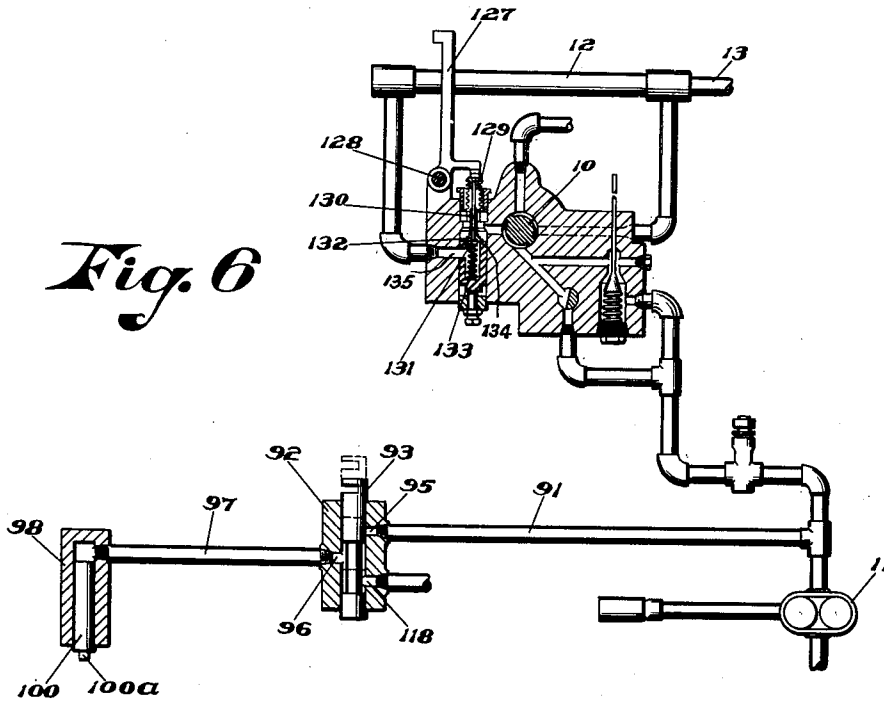
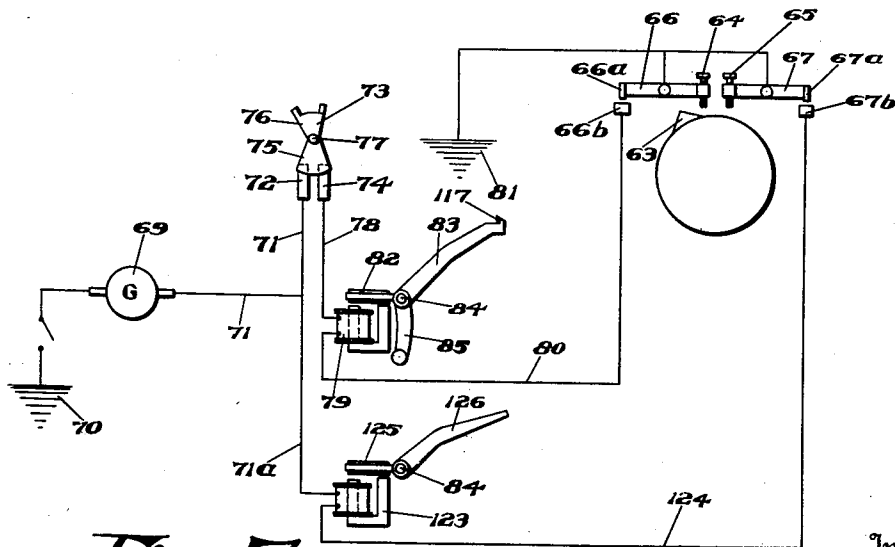


*Fig. 7*



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## UNITED STATES PATENT OFFICE

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## GRINDING MACHINE

Application filed May 31, 1928. Serial No. 281,700.

The invention relates to grinding machines of the general type shown and described in Guild Patent No. 1,682,672 and Taylor Patent No. 1,682,673, both dated August 28, 1928; in the machines of said patents, the work-pieces are automatically ground to a predetermined size, responsive to movement of a transverse feeding mechanism through a predetermined distance, following a dressing operation by which the grinding wheel is made tangent to a given plane. The machines of said prior patents provide a cross feeding mechanism carrying an element which inaugurates a dressing operation when it reaches one point, and which subsequently stops the grinding when it reaches a second point; suitable compensating means being provided to periodically retract this element in relation to the cross feed screw, in order to overcome attrition of the wheel by wear and dressing, and to insure that substantially the same amount of material may be taken off the grinding wheel at each dressing operation.

The present invention contemplates an improvement in machines of this class, by way of separating the transverse feed that moves the grinding wheel, the work head, and the dressing tool in relation to each other, into two separate feeds, one being the normal progressive feed that maintains the grinding wheel and the workpiece in cutting relation, and the other being what may be termed a compensating or dressing feed, which feeds the grinding wheel toward the dressing plane.

In the machine herein disclosed the dressing device is always brought to a fixed position relative to the machine base for the dressing operation, the work head is moved transversely of the machine base to produce the cutting feed, and the grinding wheel is also moved transversely of the machine base to insure contact between it and the dressing device, but other arrangements of these elements and motions can be made, the invention contemplating broadly the separation of the dressing or compensating feed from the normal or grinding feed. In the drawings:—

Fig. 1 is a front elevation of a grinding

machine constructed in accordance with the invention.

Fig. 2 is a fragmentary elevation of the actuating mechanism for the dressing or compensating feed, the hand wheel being removed.

Fig. 3 is a plan view of the supporting ways for the work head, certain parts being shown in section.

Fig. 4 is a rear elevation of the grinding machine.

Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 1.

Fig. 6 is a diagrammatic view of the fluid pressure actuating mechanism and connections.

Fig. 7 is a wiring diagram.

Like reference characters refer to like parts throughout the drawings.

Referring 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 reciprocations 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.

Said back and forth movement of the table 1, to cause a rotating grinding wheel 5 to make the required interior traverse of the workpiece held in the rotating chuck 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 U. S. Letters Patent #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; but as an illustrative embodiment of such it is sufficient to note that

the driving means employed for the reciprocation of the table 1, may produce the reversal of said table at each end of the latter's normal working stroke in response to the engagement by spaced adjustable dogs 7 and 8, carried by the table, with an interposed member 9.

Although the driving means for the table 1 might be a gear drive or any other suitable type, I prefer to employ a hydraulic drive, and consequently the reversing member 9 is connected in a manner not necessary to be described herein, to a valve member 10, which is therefore oscillated, and which controls the admission of fluid, put under pressure by a pump 11, to first one side and then the other of a cylinder 12, containing the usual double acting piston whose piston rod 13, as clearly shown in Fig. 1, is connected to the table 1. For further details of a particular hydraulic means for actuating a reciprocating table reference should be had to the aforesaid patent.

As best shown in Fig. 4, the machine may be driven by an electric motor 14 to the drive shaft 15 of which is attached one element of a clutch 16. The other element 17 of the clutch is formed integrally with a pulley 18 around which, as best shown in Fig. 5, the work driving belt 19 passes. The latter extends upwardly inside the hollow base 20 of the machine to a pulley 21 that is fastened to the chuck holding spindle 22, being guided and held under proper tension by a stationary idler pulley 23 and a tensioning idler pulley 24 that is mounted on a pivotal arm 25 and pressed against the belt by means of the usual spring 26. The belt 19 likewise passes around a pulley 27, the consequent rotation of which is utilized to effect the normal transverse feed between wheel and workpiece, as will be hereinafter described. The work head 3, in which the chuck spindle 22 is journaled, is not fastened directly to the bridge 4 that spans the slideways 28, 28 provided for the reciprocatory travel of the table 1, but is fastened to a cross slide 29, which rests upon ways 30, 30 provided by said bridge in order that the work head may be moved transversely of the machine.

The bridge 4 is pivotally attached to the machine at 31, and is adjustably held on the other side by a screw adjustment device 32. Referring to Figs. 3 and 4, this device comprises a bracket 33, fastened to the base and extending upwardly on one side of the bridge, with its upper end between a pair of projecting ears 34, 34. An adjustment screw 35, which passes through the end of the bracket and the ears 34, 34, is provided to permit angular adjustment of the bridge 4 on the machine base. In this manner the angular position of the work head can be regulated to present the axis of the workpiece in a line exactly parallel to the axis of the rotating

grinding wheel 5, or to generate a slight angle between these axes in order to grind workpieces having tapered holes. The table 1 provides a long slot 36 at its left-hand end, as best shown in Fig. 5, in order that it shall not interfere with the belt 19 when the wheel is carried into grinding position.

The pulley 27 is suitably journaled in bearings provided by an arm 27a, and has attached thereto a worm 37 which meshes with a worm wheel 38. The latter is fastened to a shaft 39 journaled in a projecting cylindrical portion 40 provided by a removable front plate 41 attached to the base 20. In order that this mechanism may be readily removed as a unit, the arm 27a is likewise attached to the front plate 41. To the front of the shaft 39 is fastened a crank member 42 having a radial T-slot 43. A block 44 is located in the said slot 43, and said block provides a projecting stud 45 to which a connector 46 may be pivotally fastened as by means of a nut 47. The block 44 can be adjusted to any position lengthwise of said slot as by means of an adjusting screw 48, thus to vary the radius of the circle described by the stud 45 and consequently to vary the oscillations imparted to the connector 46, it being noted that the block may be so positioned as to locate the stud 45 coaxially with the shaft 39 which results in no motion of the connector 46. The upper end of the connector 46 is pivotally attached by means of a stud 49 to an arm 50 which, as best shown in Fig. 3, is pivotally mounted at 51 to the bridge 4. The arm 50 carries a pivotally mounted pawl 52 which, when said arm is raised, is pressed, by devices which it is not necessary to describe herein, against a ratchet wheel 53. Oscillation of the connector 46 and the arm 50 induced by rotation of the shaft 39 imparts oscillation to the pawl 52 and consequently rotates the ratchet 53 intermittently.

The ratchet wheel 53 and a hand wheel 54 are both fastened to a screw shaft 55 which, as shown in Fig. 3, is suitably journaled in bearings 56 provided by the bridge 4 and the screw threaded part of which passes through a nut 57 suitably attached to and depending from the cross slide 29. The "nut" 57 may, as shown in Fig. 5, simply comprise a depending portion of the cross slide which is screw threaded.

It will be apparent that clockwise rotation of the ratchet wheel 53 will result in drawing the cross slide 21 to the front of the machine thus producing a relative feed between the workpiece and the grinding wheel. In order to eliminate lost motion between the nut 57 and the screw 55, as best shown in Figs. 3 and 5, I provide a set of springs 58, fitting in holes 59 provided by a depending projection 60 attached to the cross slide, and pressing against a stationary portion 61 of the bridge 4.

Adjustably fastened in any desired angular position on the hand wheel or the casting 54a is a ring 62. This ring may carry the scale markings which are provided by cross feeding instrumentalities for machine tools for convenience in setting the machine, and at all events it carries a cam projection 63. In the clockwise rotation of the dial ring 62, the cam 63 is adapted to successively engage adjustable screws 64 and 65 located in the path of said cam projection, as best shown in Fig. 1. These adjustment screws 64 and 65 are carried by lever arms 66 and 67, the exact construction of which it is unnecessary to set forth here, as it forms no part of the present invention.

Referring now to the wiring diagram of Fig. 7, the lever 66 which is first rocked by engagement of the cam projection 63 with the screw 64, carries a movable contact point 66a which, when the lever is rocked, closes an electric circuit by contact with a stationary contact point 66b. The closing of this electric circuit as hereinafter described, causes wheel dressing instrumentalities of the machine to be brought into operation. The lever 67 carries a contact terminal 67a which in similar fashion is caused to engage a contact terminal 67b and this closes another electric circuit, procuring longitudinal separation of the grinding wheel 5 from the workpiece, thus terminating the grinding operation.

The exact manner in which the dressing operation occurs comprises briefly the temporary withdrawal of the grinding wheel 5 from the workpiece, that is to say an amplification of its normal working stroke, and the disposal simultaneously of a wheel dressing member or diamond in the said amplified path thereby to dress and true the periphery of the wheel 5. As shown by the wiring diagram of Fig. 7, electric current may be supplied by a direct current generator 69 driven continuously by any suitable means, not shown, from the same source of power that is used for the rotation of the grinding wheel or the workpiece or from any other source. One terminal of this generator 69 is grounded, as shown at 70, and the other is connected by a supply lead 71 to a bar 72 of a switch,—the latter being designated as a whole by the numeral 73 and being disposed, as shown in Fig. 1, on the front of the machine. Said switch 73 provides an additional contact plate or bar 74 which is adapted to be alternately connected and disconnected from the bar 72 by a connector 75, which is mounted on an oscillatory member 76 comprising part of said switch. The latter is pivoted at 77 and in its normal position, as shown in Fig. 7, disposes the connector 75 in contact with and across the two plates 72 and 74; in the other position of movable member 76 said bars are wholly disconnected.

When the contact plates 72 and 74 are electrically connected, the supply lead 71 from the generator 69 is connected to a lead 78 running from the contact plate or bar 74 to the coil of an electromagnet 79 which, as shown in Fig. 1, is disposed on the front of the machine. A return lead 80 from the coil of the electromagnet 79 connects said electromagnet and the contact terminal 66b. When the circuit is closed at 66a and 66b, as hereinbefore described by the action of the cam 63, the electromagnet 79 is energized since the terminal 66a is grounded, as shown at 81, Fig. 7.

Energization of electromagnet 79 causes attraction of an armature member 82 and the consequent elevation of its attached lever arm 83, these parts being pivoted at 84 on the front of the machine. Integrally attached to the armature 82 and the lever arm 83 is a depending arm 85, which consequently must move when the first two named parts move. In the procuring of the dressing operation as hereinbefore briefly outlined, the lever arm 83 acts to cause amplification of the path of travel of the grinding wheel 5, and the depending arm 85 causes the dressing point or diamond 68 to be lowered into the path of the wheel.

The dressing device or diamond 68 is desirably mounted in a screw plug 86, carried by an oscillatory member 87 which is mounted in bearings provided by a standard located at the rear of the machine, and it may be accurately adjusted as regards its operative position by means of a knob with scale markings 88, all set forth in a patent to Guild and Grimshaw, No. 1,655,903, granted January 10, 1928. Such mounting of the dressing point to swing it into the path of the grinding wheel 5 and to accurately adjust its position of engagement with said wheel, and to hold it firmly against any pressure which may be exerted upon it, forms no part of the present invention and will be found fully disclosed in the patent referred to. Suffice it to say that counterclockwise swinging of a lever 89, Fig. 5, which draws rearwardly a link 90 attached to the oscillatory member 87, serves to lower said dressing diamond 68. The fluid pressure generated by the pump 11 is used to move this bell crank lever 89, a branch lead 91 from said pump leading the fluid to a valve generally designated by the numeral 92. The slidable valve member 93 of said valve is connected, as shown in Fig. 1 at 94, to the depending arm 85, and when the said depending arm is moved in a counterclockwise direction by the magnet 79, the valve 93 is moved from the position shown in full lines in Fig. 6 to the dotted line position of said figure. This admits fluid under pressure through ports 95 and 96 to a pipe 97 that connects to a cylinder 98 formed in a block or casting 99 that extends upwardly from the rear of the machine frame. A piston 100 is located in

said cylinder 98, and a pin 100a provided by it is in engagement with the bell crank lever 89, and consequently rearward movement of said piston, in response to fluid pressure actuation as described, swings said bell crank lever in a counterclockwise direction to lower the diamond 68 into the path of travel of the wheel 5.

Turning now to the manner in which upward movement of the lever arm 83 causes the normal path of travel of the wheel 5 to be amplified, and referring to Fig. 1, the left-hand table dog 8 which limits the right-hand movement of said table is carried by a block 101, which instead of being secured directly to the table 1, as in the case of the block 102 of dog 7, 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 101 of dog 8 is held in definite spaced relation to block 103, which latter, the same as the block 102 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 or holding device, such as the hand screw nut 104, shown in Fig. 1, applied to block 103, there being a similar device provided by the block 102 which is not shown. Said hand screw nuts engage with a screw rack 105 provided by the table 1.

The device employed to hold the slidable block 101 in spaced relation to the fixed block 103 is here shown as a latch lever 106, pivoted at 107 on the block 103, and having its free end disposed by gravity in abutting relation to a shoulder 108 on the block 101, thereby holding the block 101 at a predetermined distance to the right of the block 103. When the latch member 106 is lifted to free its end from the shoulder 108, the normal connection between the slidable block 101 and the fixed block 103 is broken, and when this occurs on the right-hand movement of block 101, 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 5 will be carried out of the hole in the workpiece to a point just beyond that occupied by the dressing device 68, which is moved into operative position in the path of said wheel 5 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 101, owing to the obstruction which the reversing member 9 imposes against the dog 8 to prevent block 101 from moving with the table; finally, the block 101 brings up against the block 103, whereupon the solid backing

thus afforded for the block 101 enables the dog 8 to shift the member 9. This procures reversal of the direction of travel 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 109 pivotally mounted at 110 on the frame of the machine has a pair of inclined surfaces 111 and 112 for co-operation with inclined surfaces 113 and 114 at the lower corners of the block 101. A spring 115 presses said member 109 upwardly. In the normal grinding operation of the machine, when the blocks 101 and 103 are connected by latch 106, the surfaces 111 and 112, although in the path of the block 101, 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 beveled surfaces 111 or 112, such contact will wedge the spring 115 downwardly, said spring yielding sufficiently to allow the block 101 to pass over the member 109. However, when the block 101 has been freed from the block 103 as above described, to amplify a single right-hand stroke of the table 1, the ensuing reversal of said table, with the block 101 still free, finds the surface 111 in position to contact with the corner 113 of said block, and under these conditions, the obstruction offered is sufficient to overcome whatever friction there is to cause the block 101 to move to the left with the table. The block 101 being thus held stationary while the table 1 and block 103 continue to move to the left, the latch member 106 finally resumes its normal position relative to the block 101, the end of said latch member dropping behind the shoulder 108 and the parts being thus automatically restored to normal position at the conclusion of each single amplified reciprocation of the table 1.

At the end of the amplified stroke of the table 1 to cause the dressing of the wheel 5 as just described, the valve member 93 is automatically replaced in its initial position, as shown in full lines in Fig. 6, this operation being brought about by the movement of the table 1. As shown in Fig. 1, the block 101 provides a shoulder 116 which is adapted to contact with a vertical shoulder 117 of the lever arm 83. When the block 101 is in engagement with the block 103 and the dog 8 proceeds to swing over the reversing member 9 as already described, the movement of the table to procure such reversal is just sufficient to cause the shoulder 116 to engage the projecting portion 117 and to swing the parts 82, 83 and 85 in a clockwise direction to their normal position, where they are held by the friction of the valve member 93 in the valve 92, the magnet 79 being deenergized at this

time, as will be described. Such return of the valve member 93 to its original position disconnects the port 95 from the port 96, and shuts off the supply of pressure fluid from the cylinder 98, and in fact opens up said cylinder to the exhaust port 118, as clearly shown in Fig. 6. The dressing diamond 68 is not, however, immediately moved to the position shown in Fig. 1, since the mere opening of the cylinder 98 to an exhaust port exerts no force on the oscillatory member 87, but the subsequent return of the table 1 to normal grinding position procures the elevation of said dressing point 68 by the engagement of a cam member 119 provided by said table 1 with a roller 120 on the end of the bell crank lever 89, as will be apparent from the views of Figs. 4 and 5.

On the right-hand amplified dressing stroke of the table 1, as just described, an arm 121 pivoted at 107 and hanging by gravity, as shown in Fig. 1, strikes an arm 122 of the movable switch member 76, thereby rocking the connecting bar 75 of said switch member away from the contact bar 74 and thus preventing a repetition of the dressing stroke.

The machine is so set and adjusted that the dressing of the wheel 5, as just described, occurs after preliminary grinding of the workpiece. By said dressing operation the grinding wheel 5 is made tangent to a known vertical plane, as determined by the position of the dressing device 68 when it is moved into operative position. At the time of the inauguration of this dressing stroke the axis of the workpiece is located at a definite known position relative to the machine frame, depending only on the adjustment of the cam 63 and the screw 64, and therefore if a predetermined and known amount of cross feed movement of said workpiece is given thereto subsequent to the dressing operation, and the grinding then terminated, it will be apparent that the workpiece will be brought to a definite known size. The wheel 5 having been subsequently returned into the workpiece to finish the grinding operation, the cross feed brought about by rotation of the screw shaft 55, as hereinbefore set forth, proceeds for an exact predetermined amount as measured by the angular turning of the ratchet 53, the dial ring 62 and the cam member 63, until such time as said cam 63 engages the adjustment screw 65. The movement of said screw 65, with consequent rocking of the lever 67 to bring the contacts 67a and 67b together, procures the termination of the grinding operation. As the workpiece has been fed an exact predetermined amount since the location of the cutting edge of the grinding wheel 5 in a definite relation to the axis of the workpiece, the said grinding operation is terminated with the workpiece at the exact desired size.

Referring again to the wiring diagram of Fig. 7 a branch 71a from the lead 71 connects to an electromagnet 123, which is located on the front of the machine directly behind the electromagnet 71 and which since it is desirably of the same form and shape as the other electromagnet, is completely hidden by it in Fig. 1. Said electromagnet 123 is, however, shown in the wiring diagram of Fig. 7. The other terminal of the coil of this electromagnet is connected by a conductor 124 to the contact terminal 67b. From the wiring diagram, without more description, it will be apparent that the electromagnet 123 is energized upon the making of the circuit at the contacts 67a and 67b.

Pivotally mounted on the same pivot shaft 84 that carries the armature member 82, the lever arm 83, and the depending arm 85, is an armature member 125 and an inclined lever arm 126, desirably formed in a single piece. The inclined lever arm 126 is in the path of travel of the table dog 8, which is pivotally attached to its carrying block 101. When the lever arm 126, the end of which is shown in Fig. 1, is raised by the energization of the magnet 123 and consequent attraction of the armature member 125, the reversing dog 8, by reason of its pivotal mounting, is free to ride on the upper surface of said lever arm; thus the striking end of said dog 8 is carried clear of the reversing member 9, and the table 1 continues its movement to the right carrying the grinding wheel 5 out of the workpiece and well past the then inoperative dressing device 68, said table ultimately carrying the grinding wheel 5 into the position illustrated in Fig. 1, and there being brought to a full stop by any suitable means, such as that shown in the aforesaid patent to Heald and Guild.

Referring to Fig. 6, such stoppage of the table 1 is herein illustrated as being brought about by the striking of a pin, not shown, carried by the table 1 against a lever 127. Said lever 127 is pivotally mounted at 128 and one end of said lever engages a cap 129 which is spring pressed upwardly, and which is mounted on the top of a rod 130. The rod 130 terminates in a head 131 below a poppet valve 132, the latter being pressed upwardly by a heavy coil spring 133. The spring 133 holds the poppet valve 132 away from its seat 134, and consequently normally allows the fluid to flow through a port 135 to the left-hand of the cylinder 12, but when, by striking of the pin against the lever 127, the rod 130 is depressed, thus compressing the spring 133, the valve 132 is closed by the pressure of the fluid, and this brings the table 1 to a stop.

If the mechanism already described were provided and no more, the grinding wheel 5 would be dressed and trued but once, since the wearing away of the grinding wheel

which always results in use would reduce it below its original size, and on subsequent movements through the dressing position it would not make contact with the dressing diamond 68. Workpieces ground in the machine would, under such conditions, not be brought to proper size, since the known amount of the cross-feed subsequent to the dressing operation would give an unknown size of workpiece, there having been no contact between the dressing device and the wheel. In the prior machines employing this principle of sizing the work disclosed in the copending applications already referred to, the grinding wheel 5 is moved relative to the dressing device between grinding operations, such feed being an additional or compensating feed projected upon the normal cross-feed, which is in said applications disclosed as an absolute movement of the grinding wheel. The present invention distinguishes from the subject matter of the aforesaid applications in the separation of the normal or cutting feed from the compensating feed. The first of these two, involving absolute movement of the work head, has already been described, and the automatic instrumentalities for periodically moving the grinding wheel in order to insure contact between it and the dressing device will now be set forth.

As best shown in Fig. 1, the wheel head 2 is not carried directly by the table 1 but is carried by an interposed cross-slide 2a, which is mounted on cross-slide ways 136 which may be similar to the ways provided for the movement of the cross-slide 29. A screw shaft 137, to which is attached a hand wheel 138, is provided to move said cross-slide transversely of the table 1, there being a nut, not shown, depending from the cross-slide 2a which may be in all respects similar to the nut 57. Suitably fastened to the screw shaft 137 or the hand wheel 138 is a ratchet wheel 139, which is shown in Fig. 2;—movement of the table 1 to the position shown in Fig. 1 causes a pawl 140 to move said ratchet wheel 139 through a limited distance, thus causing movement of the cross-slide 2a on the ways 136 by a predetermined amount.

As shown in Fig. 2, the pawl 140 is pivotally mounted at 141 on an arm 142 which is in turn pivotally mounted on the shaft 137. A stop pin 143 is provided to normally locate the arm 132 in the position shown in Fig. 2, a spring 144 holding it in this position, said spring extending between a stationary pin 145 and the pin 146 projecting from the hub of the lever arm 142. Pivotally mounted at 147 on the arm 142 is an arm 148 which normally hangs downwardly in the position shown in Fig. 1, said arm 148 being entirely free on the arm 142 except when, as shown in Fig. 2, said arm 148 en-

gages a stop lug 149 projecting from the hub of the arm 142. Such engagement is brought about by travel of the table 1 to the position shown in Fig. 1, and on its said outward movement, the arm 148 is rocked to the position shown in Fig. 2 by means of an inclined cam 150. When the parts have reached the position shown in Fig. 2 no further movement of the arm 148 can take place without swinging the arm 142 on its pivot 137;—such movement does take place and moves the pawl 140 through a limited distance, said pawl being caused to engage the teeth of the ratchet wheel 139 by cam devices which are very familiar to those skilled in this art and need not be described. This action procures limited turning of the screw shaft 137, but it should be noted that the subsequent return of the table 1 to its operative position has no effect on the said screw shaft, since the depending arm 148 can swing to any extent to the right on its pivot 147.

Of course the hand wheel 138 can be manually moved at any time to adjust the axis of the spindle 5a, carrying the grinding wheel 5, relative to the machine base. Inasmuch as the hand wheel 138 may provide a suitable scale, the adjustment of the machine for different sizes of workpieces is facilitated. Moreover, in the machine of the present invention, the relationship of the three elements which determine the proper grinding to size of workpieces, such elements being the axis of rotation of the workpiece, the axis of rotation of the grinding wheel, and the operative position of the diamond, may at all times be known by providing proper scale markings. Although it should be understood that such will not entirely eliminate the method of trial and error in setting the machine to grind a given size of workpiece, since no matter how carefully a machine is made, the spring in the various parts, slight play in bearings, and expansion or contraction of the metal due to varying temperatures, as well as the actual wear of the diamond point 68 itself make such method of trial and error necessary, nevertheless what may be termed a prima facie setting of the machine may be effected by the several scales provided by the hand wheels 54 and 138 and the knob 88. Furthermore the scale markings which may be provided in connection with the hand wheel 138 register quickly, not only the amount of compensation given to the grinding wheel 5 between successive grinding operations, but serve to register the sum total of compensations, and thus serve to remind the operator of the gradual diminution of the size of his grinding wheel involving the ultimate replacement of the same. Other advantages of the present arrangement will readily occur to those skilled in the art.

Although not herein described, because 130

forming no part of the present invention it should be understood that separation of the grinding wheel head 2 and the work head at the termination of the grinding operation 5 causes the clutch elements 16 and 17 to be separated, thus stopping the rotation of the spindle 22 and furthermore stopping the automatic actuation of the cross-feed shaft 55. This allows the operator to reposition the 10 cross-slide 29 by manual rotation of the hand wheel 54.

I claim:

1. The combination with a grinding machine comprising means for supporting the 15 work, means for supporting a grinding wheel, means for producing a reciprocating motion of one of said before mentioned means with relation to the other, means to so control said motion as to cause a relative 20 traversing motion between the wheel and the work, one past the other in contact, or to cause the withdrawal of one from contact with the other and subsequent restoration to contact, a tool for dressing the grinding 25 wheel so mounted that it is engaged by said wheel when the contact between the work and grinding wheel has been so interrupted, feeding mechanism to feed the workpiece transverse to the said traversing motion to 30 maintain grinding contact, and separate feeding mechanism to feed the grinding wheel transverse to said traversing motion and toward said dressing tool; of devices operated directly by said first named feeding mechanism and operable on said motion controlling 35 means to cause the withdrawal motion and then to restore the contacting traversing relation of work and grinding wheel, and means for periodically moving the feeding mechanism that feeds the grinding wheel, whereby the grinding may proceed by a succession of uninterrupted traversing motions confined to the surface to be ground and at a stage determined directly by the movement of the feeding 40 mechanism the contact of grinding wheel and work is automatically interrupted, the grinding wheel being dressed despite wear because of its periodic advance toward the dressing tool, the traversing contact with 45 the work being then resumed.

2. The combination with a grinding machine comprising means for supporting the work, means for supporting a grinding wheel, means for producing a reciprocating 55 motion of one of said before mentioned means with relation to the other, means to so control said motion as to cause a relative traversing motion between the wheel and the work, one past the other in contact, or to cause the withdrawal of one from contact with the other 60 and subsequent restoration to contact, a tool for dressing the grinding wheel so mounted that it is engaged by said wheel when the contact between the work and grinding wheel has been so interrupted, feeding mech-

anism to feed the workpiece transverse to the said traversing motion to maintain grinding contact, and separate feeding mechanism to feed the grinding wheel transverse to said 70 traversing motion and toward said dressing tool; of devices operated directly by said first named feeding mechanism and operable on said motion controlling means to cause the withdrawal motion and then to restore the 75 contacting traversing relation of work and grinding wheel, means for automatically operating the work feeding mechanism during the traversing contact of the work and grinding wheel before and after the withdrawal motion, and means for periodically moving 80 the feeding mechanism that feeds the grinding wheel, whereby the grinding may proceed by a succession of uninterrupted traversing motions confined to the surface to be ground and at a stage determined directly by 85 the movement of the feeding mechanism the contact of grinding wheel and work is automatically interrupted, the grinding wheel being dressed despite wear because of its periodic advance toward the dressing tool, 90 the traversing contact with the work being then resumed.

3. In a grinding machine, a grinding wheel, mechanism for procuring a cross-feed 95 between said wheel and a workpiece, a dressing tool, means directly actuated and controlled by said cross-feed mechanism in the grinding of each workpiece and set in operation only after said cross-feed mechanism has caused preliminary grinding of a given work- 100 piece to procure a dressing operation on said grinding wheel, means for automatically procuring cessation of the grinding operation on each workpiece upon the feeding movement of said cross-feed mechanism through 105 a predetermined distance beyond the point where said dressing occurred, and an entirely separate mechanism for procuring a cross-feed between said grinding wheel and said dressing tool periodically in order to insure 110 contact between it and the grinding wheel.

4. In a grinding machine, a grinding wheel, a feeding element which, when moved, causes said grinding wheel and a workpiece to approach or recede, a dressing device, a 115 second feeding element which, when moved, causes said grinding wheel and a dressing device to approach or recede, further means for moving said grinding wheel and dressing device one relative to the other in a line 120 parallel to a geometrical element of the surface of said wheel while maintaining the dressing device a fixed distance from the line of contact of said workpiece as hereinafter defined, thus to remove material 125 from said grinding wheel, automatic means to move said first named feeding element, measuring means associated with said automatic feeding means to measure increments of said feed, the means for moving said 130

- measuring means and dressing device relatively being set in operation by said measuring means, means to periodically move said second named feeding element, whereby the means for moving the grinding wheel and dressing device relatively may be caused to operate after preliminary grinding at a given point in the movement of said first named feeding element, contact between the wheel dressing device being insured by periodic movement of said second feeding element, means to cause the automatic feeding means to cease moving the first element, said means being also actuated by said measuring means, said measuring means and the means to cause the automatic feeding means to cease operation being thus adapted to measure off a fixed element of said movement after causing said dressing operation the aforesaid line of contact of said wheel and workpiece being defined at the moment said feeding means has moved said last element.
5. In a grinding machine, a longitudinally movable carriage, a pair of transversely movable cross slides, one of said slides being mounted on said carriage for movement substantially at right angles to the movement of said carriage, a grinding wheel carried by one of said cross slides, workholding and rotating means carried by the other of said cross slides, and a dressing device, movement of either of said cross slides being thus adapted to change the relative positions of the axes of the wheel and workholding means, and movement of one of said cross slides being adapted to change the relation between the axis of the wheel and the dressing device, and automatic means to periodically move the last named cross slide.
6. In a grinding machine, a longitudinally movable carriage, a pair of transversely movable cross slides, one of said slides being mounted on said carriage for movement substantially at right angles to the movement of said carriage, a grinding wheel carried by one of said cross slides, workholding and rotating means carried by the other of said cross slides, and a dressing device, movement of either of said cross slides being thus adapted to change the relative positions of the axes of the wheel and workholding means, and movement of one of said cross slides being adapted to change the relation between the axis of the wheel and the dressing device, means to cause said carriage to move to separate the grinding wheel and workholding means and to bring them together again, to permit the changing of workpieces, and means operated during said extended movement to operate the cross slide that procures a relative change between the grinding wheel and the dressing device.
7. In a grinding machine, the combination with a work head, a grinding wheel, and means for moving said parts one in relation to the other to produce a cutting feed, of a dressing device, means to move said wheel in relation to the said dressing device to fix the cutting edge of the former at a definite known relationship to the machine frame to produce accuracy in a series of workpieces ground by the machine, and means for periodically giving said wheel a feed towards the dressing device to compensate for gradual diminution in size of said wheel, said means being absolutely independent of the means producing the cutting feed.
- WALDO J. GUILD.