Sept. 18, 1928. 1,684,487

R. A. HEALD ET AL

GRINDING MACHINE

Original Filed May 11, 1926 10 Sheets-Sheet 1

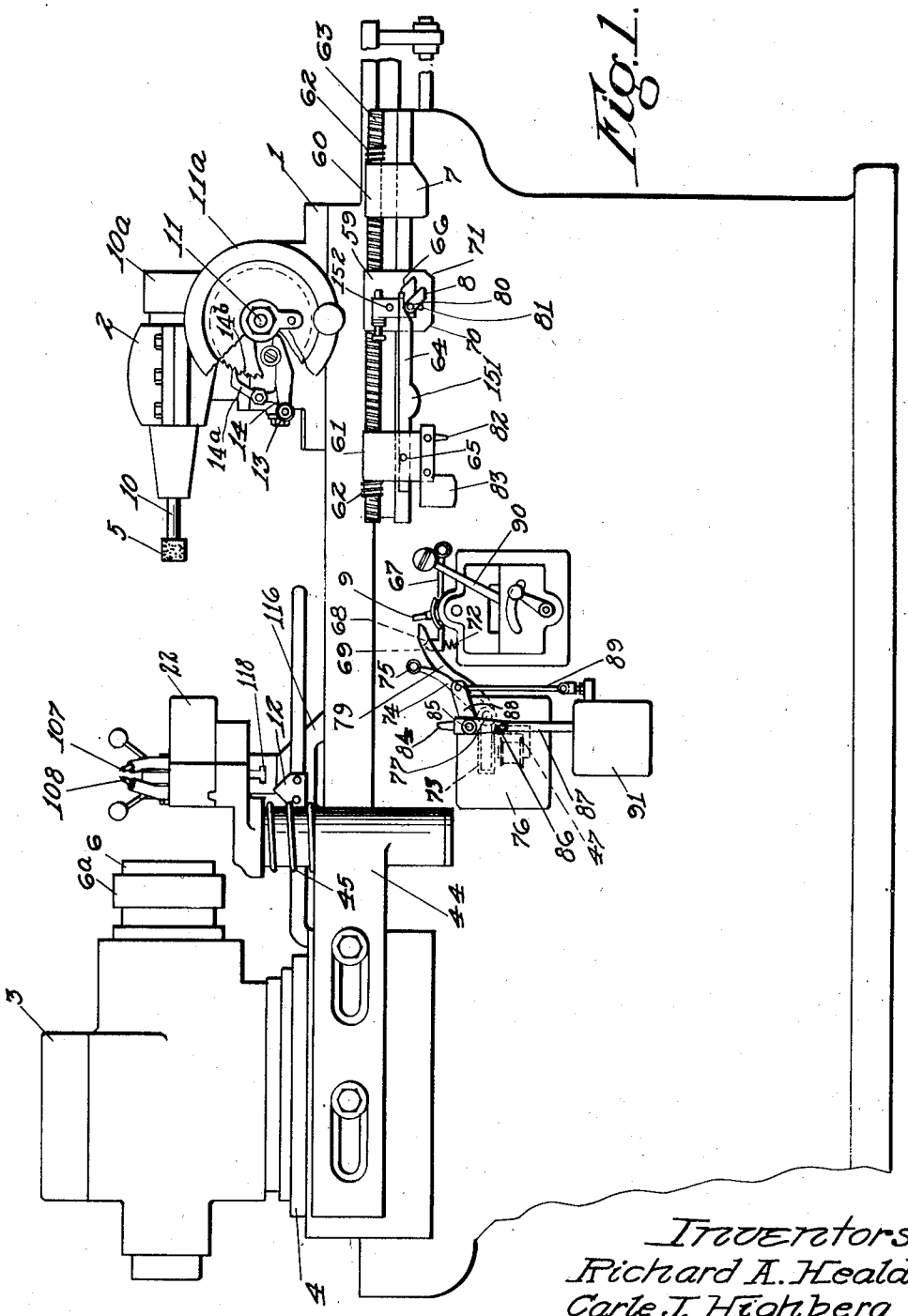


Fig. 1.

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GRINDING MACHINE

Original Filed May 11, 1926 10 Sheets-Sheet 2

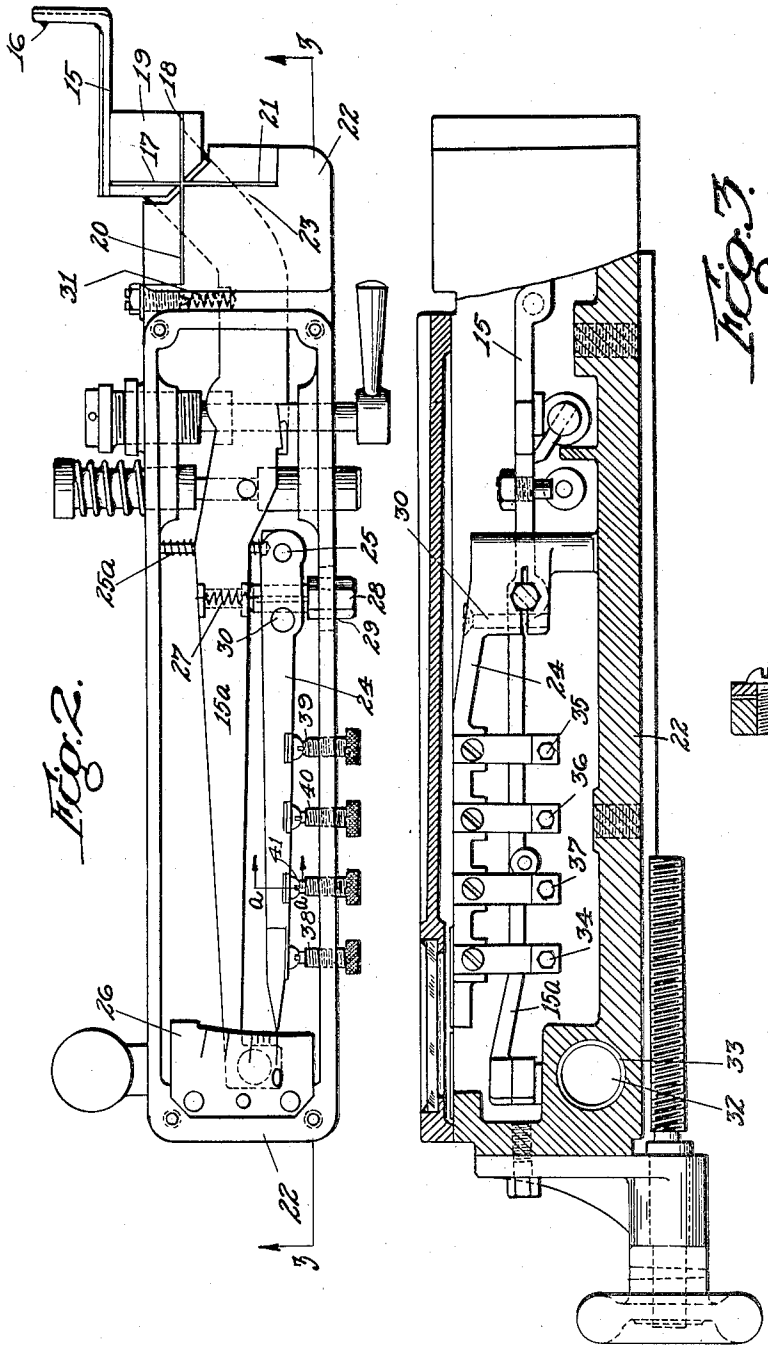


Fig. 2.

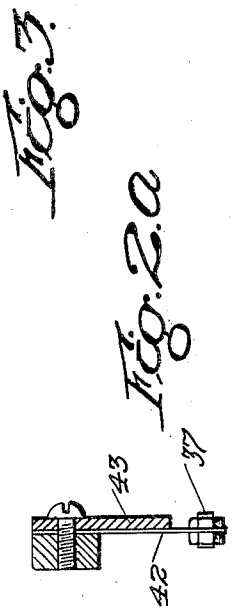


Fig. 2a.

Fig. 3.

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GRINDING MACHINE

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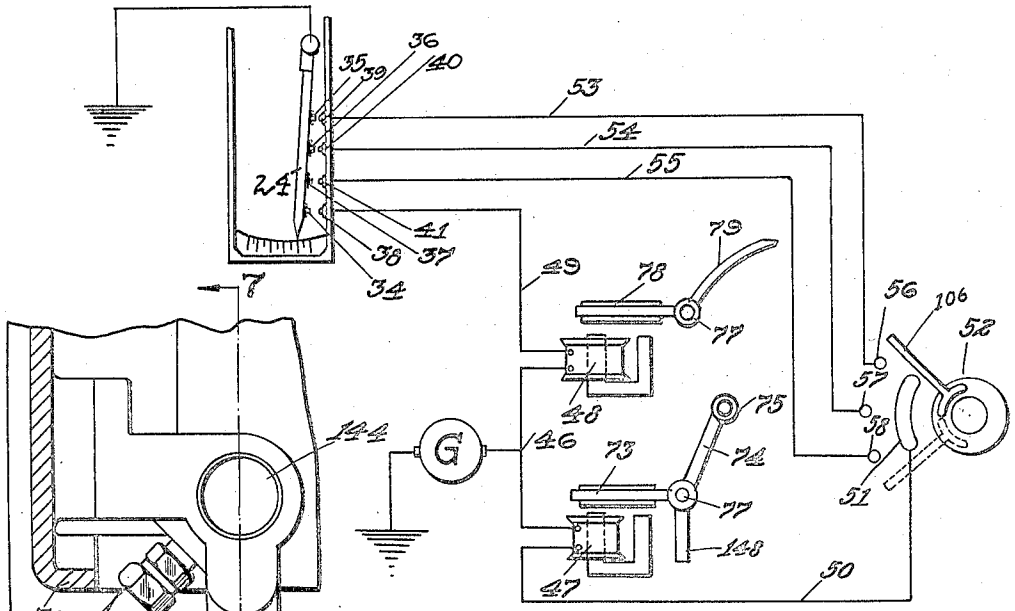


Fig. 4.

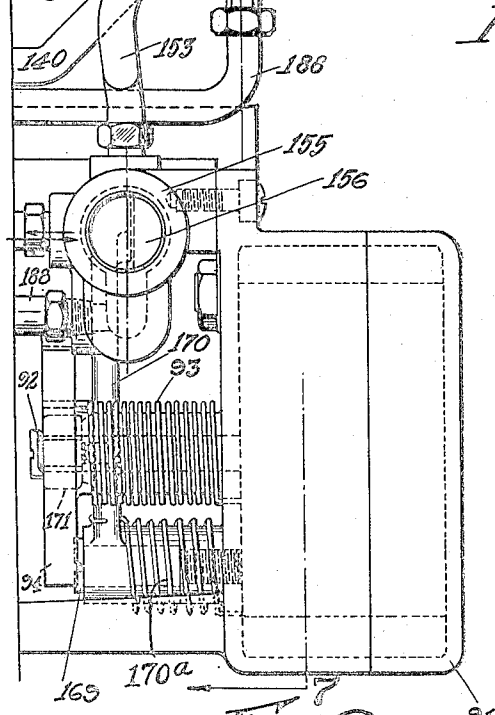


Fig. 6.

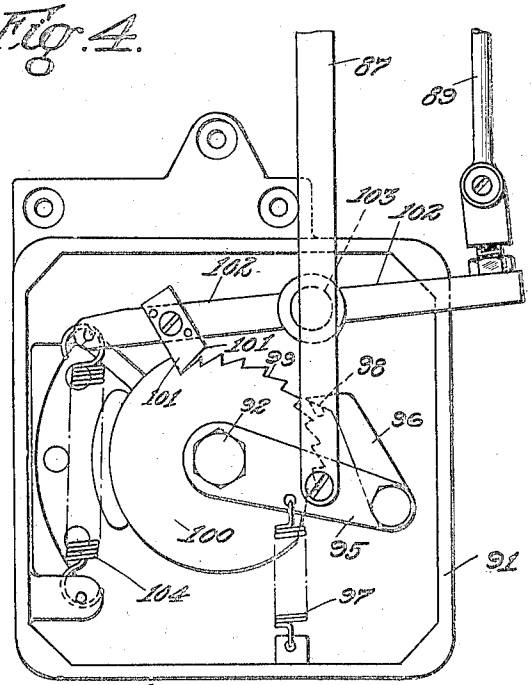


Fig. 5.

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GRINDING MACHINE

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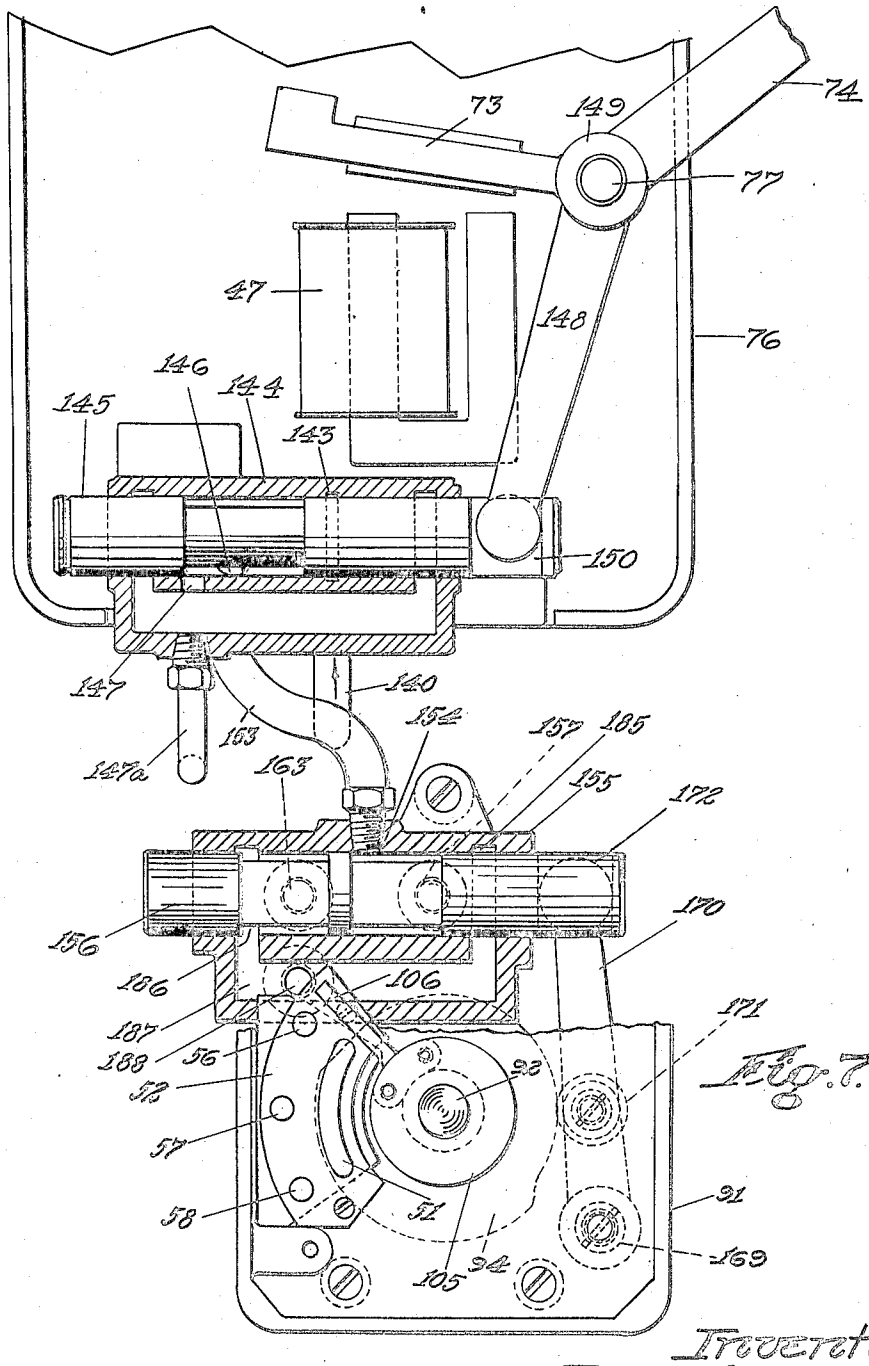


Fig. 7.

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GRINDING MACHINE

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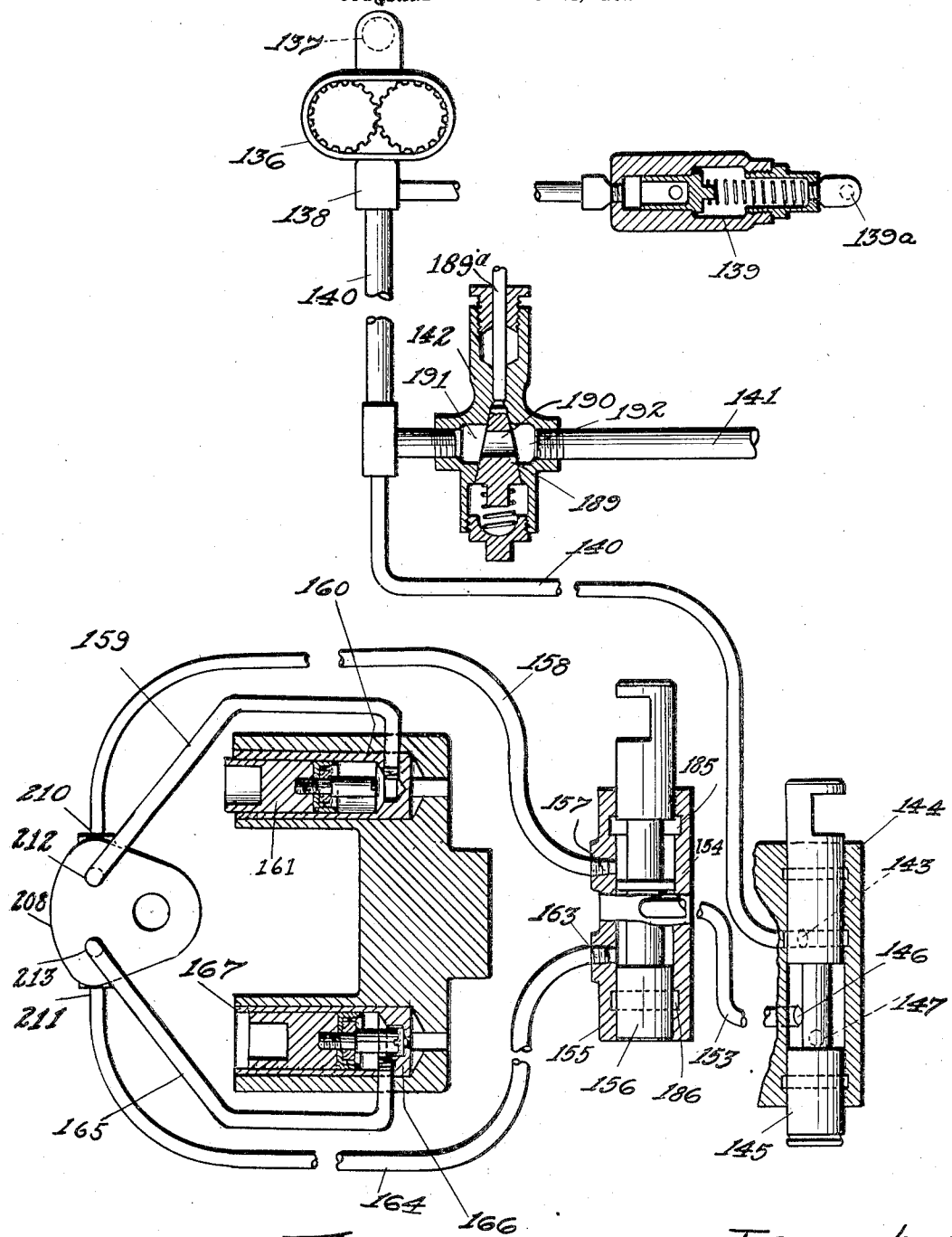


Fig. 8.

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GRINDING MACHINE

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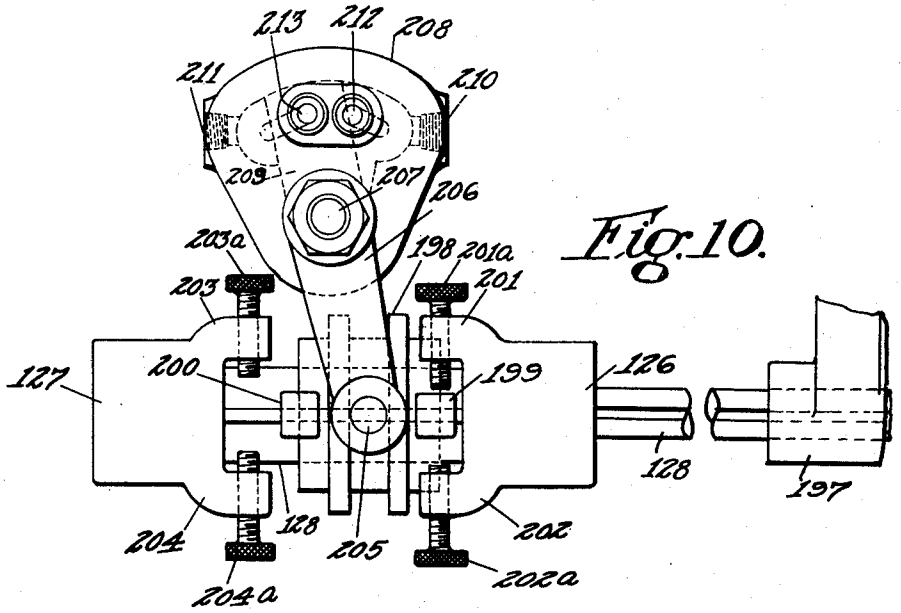


Fig. 10.

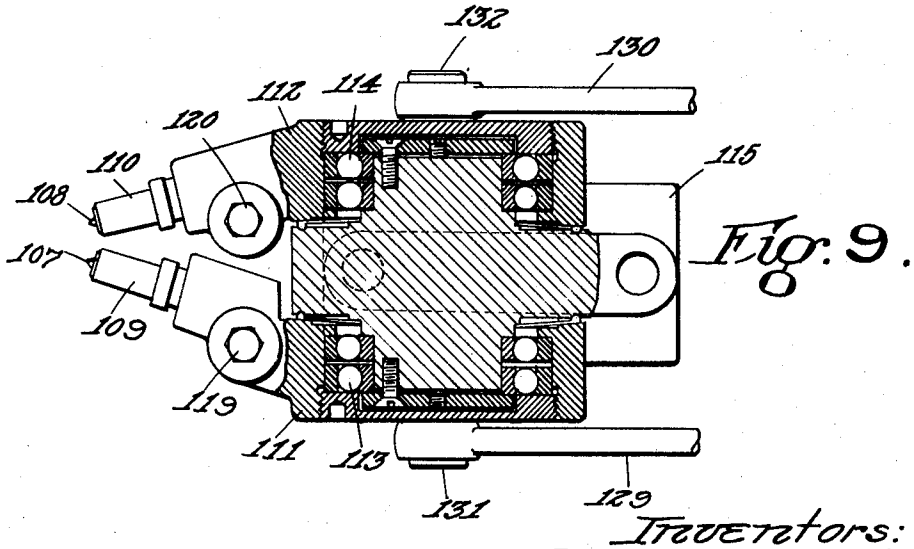


Fig. 9.

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GRINDING MACHINE

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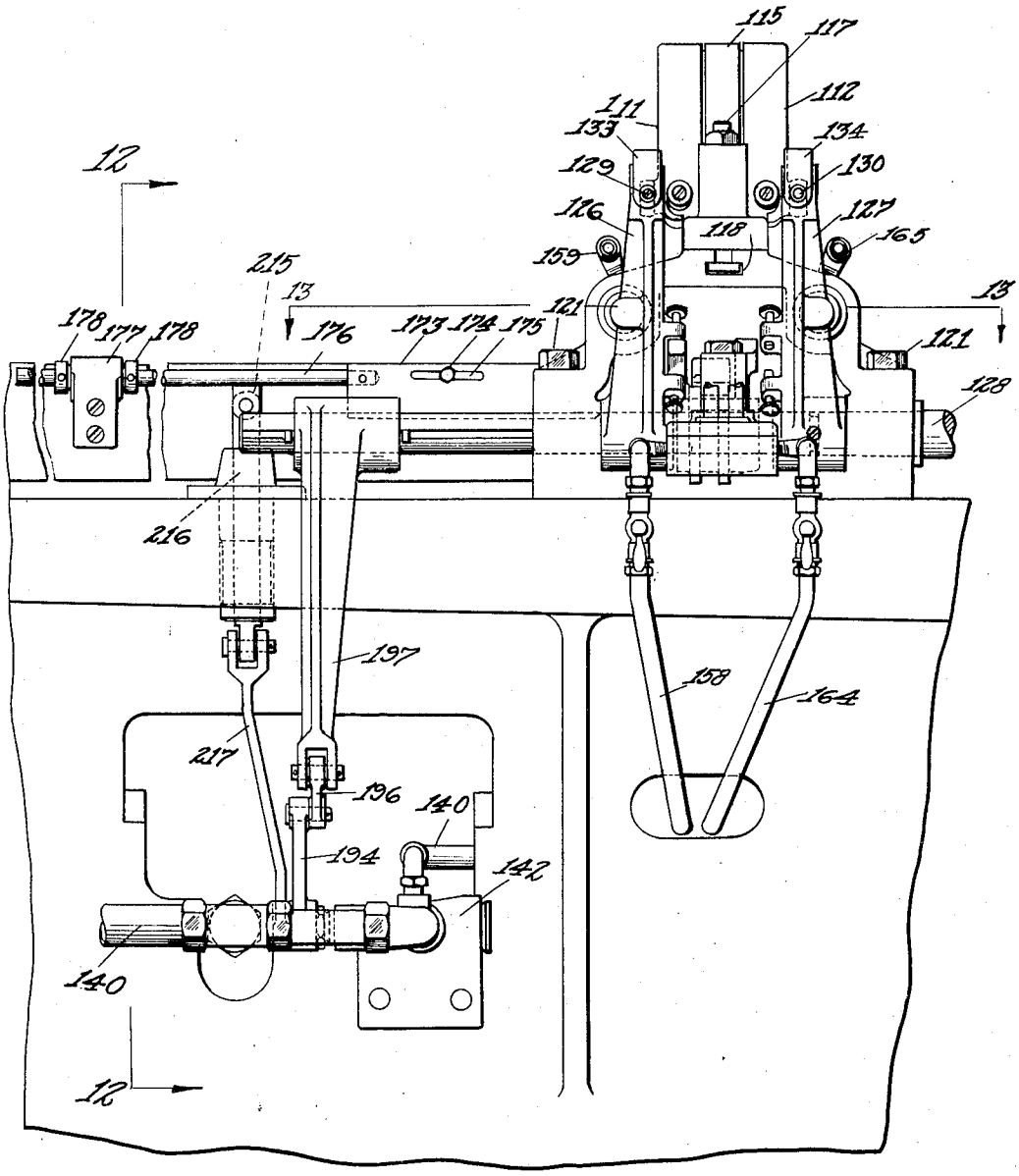


Fig. 11.

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GRINDING MACHINE

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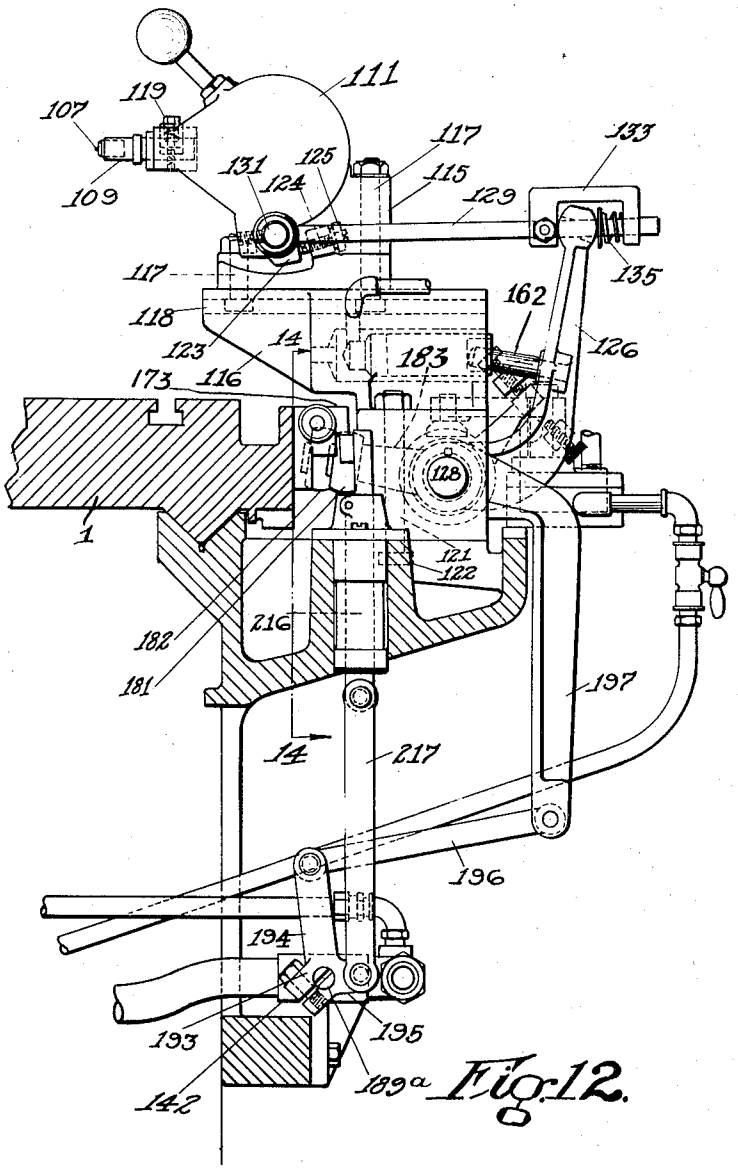


Fig. 12.

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R. A. HEALD ET AL

GRINDING MACHINE

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Fig. 13.

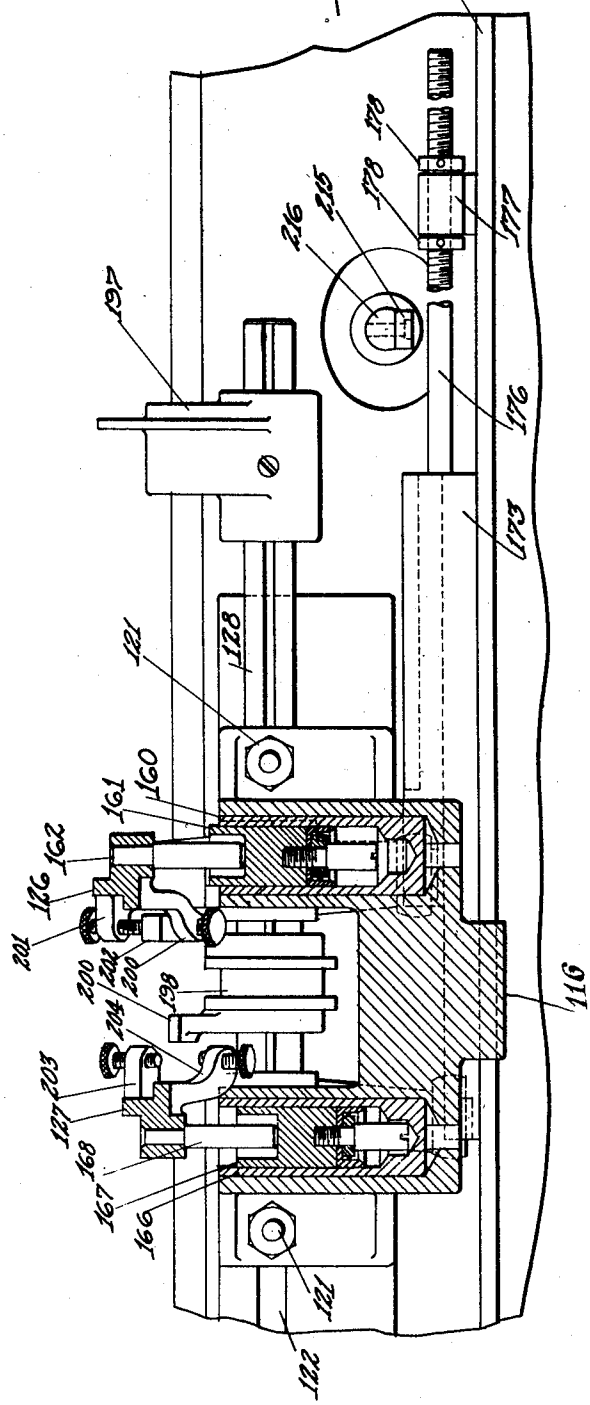
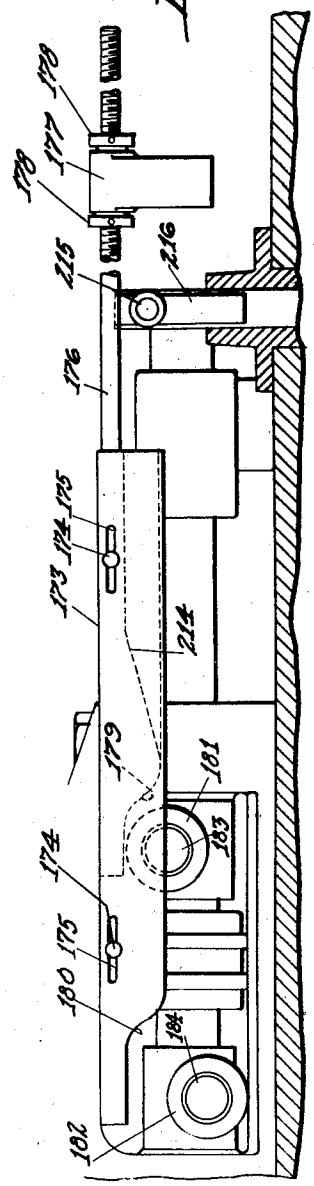


Fig. 14.



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GRINDING MACHINE

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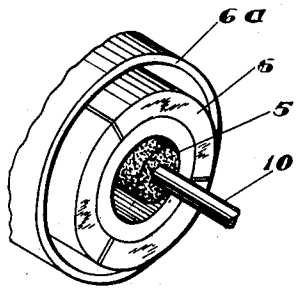
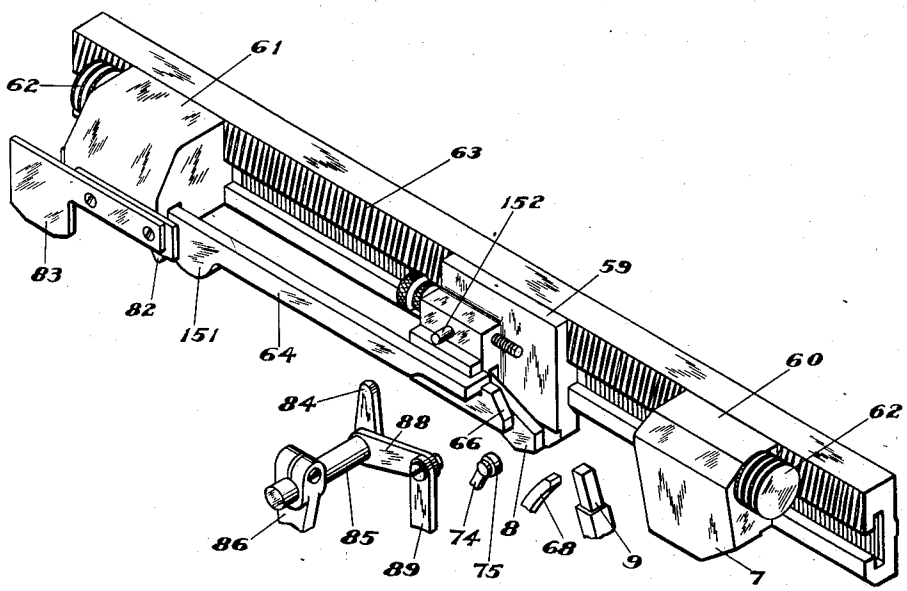


Fig. 15



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Patented Sept. 18, 1928. 1,684,487

UNITED STATES PATENT OFFICE.

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GRINDING MACHINE.

Application filed May 11, 1926, Serial No. 108,379. Renewed April 3, 1928.

The invention relates to grinding machines, particularly those adapted to grind the internal peripheral surfaces of sleeves, gears, bushings, and like articles. The embodiment of the invention described herein and illustrated in the accompanying drawings, is an improvement upon and an addition to the prior invention shown and claimed in the copending application of Kempton and Gallimore, Serial No. 6,689, filed February 4, 1925, and to the prior invention shown and claimed in the copending application of Heald, Guild, Burns and Garno, Serial No. 4,466, filed January 24, 1925, and also to the prior invention shown and claimed in the copending application of Heald and Guild, Serial No. 25,900, filed April 25, 1925. The first two of said inventions provide a calipering mechanism having a member in contact with the internal surface of a workpiece, and mechanism controlled thereby for automatically dressing and truing the grinding wheel at a given stage in the reduction of a workpiece, and further mechanism for automatically separating the grinding wheel and workpiece when the latter has reached the finished size. It is to be understood, however, that the mechanism of the present invention can equally well be applied and added to the invention shown and claimed in the copending application Serial No. 48,734 of Waldo J. Guild, filed August 7, 1925, which shows controlling means for similarly dressing the grinding wheel and causing final separation between wheel and workpiece, said controlling means deriving its movement from the transverse feeding mechanism which feeds the grinding wheel relative to the workpiece in a lateral direction to take successively deeper cuts.

The present invention provides means for automatically dressing the rapidly rotating grinding wheel a plurality of times during the grinding of a workpiece, said several dressing operations being achieved by moving into the path of the grinding wheel a plurality of different truing devices, desirably diamonds. To that end, in the present illustrative embodiment of the invention, these several truing devices are mounted on different members which are movable into and out of the path of said grinding wheel, and thus the latter is trued at distinctly different stages in the grinding of a given workpiece. It is within the contemplation of the invention, however, that a given dressing device might be made to assume two different operative positions, and thus it will be seen that the present invention contemplates, broadly, the automatic dressing of a grinding wheel at distinctly different positions of said wheel in its transverse movement in cutting relation to a workpiece.

The purpose for the above is to keep the grinding wheel sharp and free cutting and true in shape at all stages in the grinding of a workpiece, thus greatly increasing the accuracy of these machines over what was possible by the prior art. Other and further objects of the invention will appear from the following detailed description taken in connection with the accompanying drawings, in which—

Fig. 1 is a front elevation of a grinding machine built in accordance with the invention.

Fig. 2 is a plan view of the work calipering mechanism and contact box.

Fig. 2ª is a fragmentary sectional view on the line *a*—*a* of Fig. 2

Fig. 3 is a sectional view on the line 3—3 of Fig. 2.

Fig. 4 is a wiring diagram of the machine.

Fig. 5 is a front elevation of certain progressive control mechanism controlling the different dressing operations, the cover of the box in which the same is contained being removed.

Fig. 6 is a side view, partly in section and partly in elevation of the mechanism shown in Fig. 5, together with certain hydraulic valves.

Fig. 7 is a sectional view on the line 7—7 of Fig. 6.

Fig. 8 is a diagram of the pressure fluid connections between the aforesaid hydraulic valves and the dresser moving mechanism.

Fig. 9 is a horizontal sectional view showing the movable dressers and their mountings.

Fig. 10 is a detail view of a certain control device.

Fig. 11 is a rear elevation of the dresser moving mechanisms and certain speed control devices.

Fig. 12 is a view partly in section and partly in elevation of the mechanism of Fig. 11, the section being taken on the line 12—12.

Fig. 13 is a sectional view on the line 13—13 of Fig. 11, and

Fig. 14 is a sectional view on the line 14—14 of Fig. 12.

Fig. 15 is a perspective view of the table dogs and associated mechanism in the position which they occupy when the grinding wheel is operating upon the workpiece.

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 a 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. Except in connection with the slow down valve hereinafter described, 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 application, 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 transverse 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. 2 and 3, 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 inner surfaces 20 and 21 of a box 22, (which in Fig. 1 is shown turned away from its calipering position) 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 screw 28 carried by the lever 24 in contact with the extension 15^a, said screw

being adjustably threaded in lever 24 and passing at its head end through a suitably enlarged slot or hole 29 in box 22, so as to permit adjustment from the exterior of said box. By turning the screws 28, the indicator lever 24 can be made to assume any desired position relative to the member 15, and said screw 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 15ª 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 four, all of which are uninsulated from the lever 24, which is grounded into the machine frame through its pivot 25. The terminal numbered 34 is adapted to bring about the cessation of the grinding operation. The other terminals, namely 35, 36 and 37, are adapted to bring about the several stages of dressing, and as will hereinafter appear, it is possible to cause the grinding wheel to be dressed and trued a greater number of times than the number of distinct and different dressing diamonds. That is to say, the mechanism can be arranged to cause the grinding wheel to be dressed a plurality of times by one of the several dressing diamonds and but a single time on the others, or it can be arranged to cause the wheel to be dressed a plurality of times by each. As illustrated, however, there are but three terminals controlling the dressing operations, and just two dresser moving devices are shown, so necessarily the grinding wheel is dressed twice by one diamond and once by the other. And as actually shown, the terminal 35, which makes the first contact, causes the wheel to be dressed by one device, while the terminals 36 and 37, which subsequently make contact in the order named, cause the grinding wheel to be dressed by the other dressing device. In the paths of the contact terminals 34, 35, 36 and 37, the box 22 provides insulated stationary terminal contacts 38, 39, 40 and 41. As above indicated, the movement of lever 24 causes terminals 35 and 39 to come into contact first; subsequently terminals 36 and 40, 37 and 41, and finally terminals 34 and 38 come into contact. In order to permit this succession of contacts, the moving terminals 35, 36 and 37 are carried by flat springs 42, which normally press against rigid members 43, 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 clearly shown in Fig. 2ª, which, while a sectional view of terminal 37, shows equally well the construction of the other two flexible terminals 35 and 36.

As clearly described in the aforesaid application of Heald, Guild, Burns & Garno, the box 22 is carried by a bracket 44 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 45, 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. 4, 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 46 to the coils of two electromagnets 47 and 48. The other end of the coil of electromagnet 48 is connected by a lead 49 to the stationary terminal 38. The other end of the coil of electromagnet 47 is connected by a lead 50 to a stationary terminal plate 51 of a switch, generally designated by the numeral 52. The stationary terminals 39, 40 and 41 are connected, respectively, by leads

53, 54 and 55 to stationary terminals 56, 57 and 58, also part of said switch 52.

The magnet 47 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 a dressing diamond. The instrumentalities whereby this action is brought about will presently be described. Also the magnet 47 actuates a certain hydraulic valve to move one of the dressing diamonds into the wheel truing position, which one of the several dressing diamonds is moved, being determined, as will appear, by the position of the moving parts of switch mechanism 52. The magnet 48, when energized, brings about a cessation of the grinding, and prepares the machine for the introduction of a new workpiece.

The mechanism whereby the energization of magnet 47 causes the reciprocatory travel or stroke of table 1 to be amplified, is as follows:—As shown in Fig. 1, the left hand table dog 8, which limits the right hand movement of table 1, is carried by a block 59, which instead of being secured directly to the table 1, as is the case with the block 60 of dog 7, is mounted so as to be capable of sliding freely longitudinally of said table. Under normal conditions, when the table is making its usual working reciprocations to traverse the grinding wheel 5 back and forth within the workpiece, the block 59 of dog 8 is held in definite spaced relation to a block 61, which latter, the same as the block 60 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 62, 62 applied to both blocks 60 and 61 and engaging with the screw rack 63 on the table 1.

The device employed to hold the slidable block 59 in spaced relation to the fixed block 61 is here shown as a latch lever 64 pivoted at 65 on block 61, and having its free end disposed by gravity in abuttitng relation to a shoulder 66 on block 59, thereby holding the block 59 at a predetermined distance to the right of block 61. When the latch member 64 is lifted, as hereinafter described, to free its end from the shoulder 66, the normal connection between the slidable block 59 and the fixed block 61 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 reciprocatotry 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 devices, one of which, as will be described, has been moved into operative position as the amplified right hand travel of table 1 begins. This amplified right hand travel of table 1 involves relative sliding movement between said table and the block 59, owing to the obstruction which the reversing member 9 imposes against the dog 8 to prevent the block 59 from moving with the table; finally, the block 59 brings up against the block 61, whereupon the solid backing thus afforded for the block 59 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 67 pivotally mounted on the frame of the machine has a pair of inclined surfaces 68 and 69 for cooperation, respectively, with inclined surfaces 70 and 71 at the lower corners of the block 59. A spring 72 presses said member 67 upwardly. In the normal grinding operation of the machine when the blocks 59 and 61 are connected by latch 64, the surfaces 68 and 69, although in the path of block 59, 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 70 or 71, such contact will wedge the spring 72 downwardly, said spring yielding sufficiently to allow the block 59 to pass over the member 67. However, when the block 59 has been freed from the block 61 as above described, to amplify a single right hand stroke of the table 1, the ensuing reversal of said table, with the block 59 still free, finds the surface 68 in position to contact with the corner 70 of said block, and under these conditions the obstruction offered is sufficient to overcome whatever friction there may be tending to cause the block 59 to move to the left with the table. The block 59 being thus held stationary while the table 1 and block 61 continue to move to the left, the latch member 64 finally resumes its normal position relative to the block 59, the end of said latch member dropping behind the shoulder 66 and the parts being thus automatically restored to normal position at the conclusion of each single amplified reciprocation of the table 1. During normal reciprocation of the table 1 a roller 75 is underneath the latch lever 64 and energization of the magnet 47 attracts an armature member 73, to which is attached a lever arm 74 carrying said roller 75. Movement of this lever arm 74 is thus adapted to raise the latch lever 64. The provision of the roller 75 is, of course, merely to reduce wear, and it may be dispensed with without detriment, especially if the parts are hardened.

The magnet 47 may be seen in Fig. 7 and in dotted lines in Fig. 1, being shown as inclosed in a box-like structure 76 on the front of the machine frame. The magnet 48, shown

in the wiring diagram of Fig. 4, is located directly behind the magnet 47, the same pivot 77 that serves to hold the armature 73 and lever arm 74 serves also to hold an armature 78 and an arm 79 associated with electromagnet 48. As heretofore stated, energization of magnet 48 is adapted to cause final separation of work and wheel, and this is effected in the following manner:—

Attraction of armature 78 lifts arm 79, 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 80 (see Fig. 1) on the carrying block 59 and normally rests by gravity against a pin 81. When the arm 79, 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 79, 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 devices, being finally brought to a stop by any suitable means, such, for example, as disclosed in the aforesaid patent to Heald and Guild, No. 1,582,468.

Still referring to Fig. 1, the block 61 has attached thereto a pair of switch operating dogs 82 and 83. These dogs are somewhat different in shape, and are in different vertical planes. An arm 84 is fastened to a shaft 85 which is suitably journalled in the box structure 76 on the front of the machine. A second arm 86, likewise fastened to shaft 85, has a link 87 connected to it at its end. The arm 84 is in the path of dog 82. A third arm 88 is loosely mounted on shaft 85, which serves as a pivot for it, and this arm 88 is in the path of dog 83, whose bevelled edges are adapted to depress it. A link 89 is connected to the end of arm 88.

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 6^a, grasps a lever 90 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 82 and 83 past the arms 84 and 88, first depressing the arm 88 and consequently also the link 89 and subsequently rocking the arm 84, raising the link 87.

Referring now to Figs. 5 and 6, a suitable casing 91 is attached to the front of the machine, below the box 76. Suitably journalled in this casing is a shaft 92. As shown in Fig. 6, a coil spring 93 surrounds this shaft, one end of the spring being fastened to a member 94 fastened on the end of shaft 92 and the other end being anchored in the casing 91. At the forward end of shaft 92, see Fig. 5, an arm 95 is pivotally mounted. This arm carries a spring present pawl 96 and is itself carried by the lower end of link 87. A spring 97 holds these parts normally in the position of Fig. 5, where a shield member 98 holds the pawl outwardly. When the link 87 is raised, as hereinbefore described, the pawl 96 engages a ratchet segment 99 on a member 100 which is fastened to shaft 92, and thus partially rotates the latter against the tension of the spring 93.

Engagement of the dog 82 with the arm 84 is adapted to move the pawl 96 just far enough to advance the segment 99 through the distance of one tooth. The latter is held in the advanced position by a hold pawl 101 carried by a lever 102 which is pivoted at 103 and has a spring 104 attached to it to hold the pawl 101 in engagement with the teeth of segment 99. The link 89 is attached to one end of lever 102, and depression of the link is adapted to raise pawl 101, as will readily be seen from Fig. 5. In this connection it must be noted that the final tooth of segment 99 is higher than the rest, and depression of link 89 in response to engagement of dog 83 with arm 88 does not raise pawl 101 beyond the level of this last tooth. The result is, that the primary engagement of dog 83 with arm 88 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. 5. Immediately thereafter, however, by the engagement of dog 82 with arm 84, the member 100 is moved through an angular distance of one tooth of the segment 99 and held there.

Referring now to Fig. 7, an insulating collar 105 is carried by the shaft 92. To the collar is fastened a metal finger 106. This finger 106 is adapted to connect any one of the terminals 56, 57 and 58 with the plate 51. When the table 1 has moved from the position of Fig. 1 to carry the wheel 5 into a fresh workpiece, the finger 106, by the single actuation of the pawl 96 just described, has moved to connect terminal 56 with plate 51. Referring now to the wiring diagram of Fig. 4, it will be seen that the electromagnet 47 will be energized as soon as the terminals 35 and 39 come together. This causes the amplified movement of the table 1, which has been described, and in consequence the dog 82 rocks the arm 84 twice, once as the table moves outwardly, and again as it moves inwardly. This action moves the finger 106 through two more stages bringing it to rest in contact with terminal 57, where the table will undergo another amplified movement when, and only when contact is made between the terminals

36 and 40 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 91.

Returning, however, to the specific embodiment of the invention shown in the drawings the second amplified movement of the table 1 moves the finger 106 into contact with terminal 58 (it being all the time in contact with plate 51) where the same circuit is ready for energization upon the making of contact at 37—41. This brings about a third amplified movement and as the table passes outwardly, the finger 106 is moved into the dotted line position of Fig. 4; subsequent movements of pawl 96 thereafter avail nothing since it has reached the right hand limit of teeth in segment 99. Magnet 47 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 38, which completes a circuit through magnet 48 (entirely unconnected with switch 52) thus raising the lever arm 79, whereupon the table 1 runs out to the position of Fig. 1. This final withdrawal carries the dog 83 past the arm 88, thus raising pawl 101 and returning all the elements attached to shaft 92 to the original position. This return movement occurs in response to the reaction of spring 93, since pawl 96, except when it is moved, is held away from segment 99 by the shield pin 98.

Referring now to Figs. 1, 9, 11 and 12, the dressing diamonds, and their accompanying mechanism are herein shown as mounted on the rear of the machine frame. They are designated by the numerals 107 and 108, respectively, and are carried by screw plugs 109 and 110 which fit in forwardly extending portions of oscillating members 111 and 112. The latter are rotatably mounted by means of bearings 113 and 114 on a stand 115 which is adjustably attached to a base 116, as by means of bolts 117—117 and a slot 118. In this manner coarse adjustments in the position of the diamonds can be readily made, the individual and fine adjustments being made by turning the screw plugs 109 and 110, binding screws 119 and 120 being provided to lock the plugs in any position of adjustment. The base 116 is itself adjustably attached to the machine frame by bolts 121—121 and a slot 122, said slot running in a direction at right angles to the aforesaid slot 118, whereby adjustments may be made in two directions.

The bearings 113 and 114 are designed to eliminate all play, and one construction which attains this end is shown in Fig. 9, but it is not deemed necessary to describe it in detail as this and many equivalent constructions for this purpose are well known in the machine tool arts. In said Fig. 9, the dresser devices 107, 108 are both shown in the down or operative positions, this being a position which, in this machine, they never assume together, but they have been so depicted to more clearly show the relationship of these parts, particularly how the diamonds 107 and 108 are brought to positions which, longitudinally considered, are close together, diamond 107 also having a position slightly in advance of 108, laterally considered. In the said operative positions, lugs on the oscillating members 111 and 112 strike lugs on the stand 115, or adjusting screws carried thereby, the construction being shown for the member 111 in Fig. 12, where 123 is the lug on said member, 124 is the lug on the stand and 125 is the adjusting screw.

Referring now to Figs. 12 and 13, the members 111 and 112 are moved to bring the dressing diamonds from inoperative position to operative position and back again by levers 126 and 127, said levers being both pivotally mounted on a shaft 128 which is journalled in the base 116. The upper ends of levers 126 and 127 are connected to link rods 129 and 130, the latter in turn being pivotally connected at 131 and 132 to the members 111 and 112. Suitable adjustment devices are provided at 133 and 134 and springs 135 take up any slack to the parts. The levers 126 and 127 are moved to bring the diamonds down by hydraulic means, and they are moved back again by mechanical means. In order to understand this action and also the manner in which the machine automatically shifts from the one dresser mechanism to the other, the fluid pressure control will now be explained, reference being first had to Fig. 8, which diagrammatically shows the connections.

Any suitable pump 136 is provided to supply pressure fluid, desirably oil, to the dresser operating mechanisms. 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 the piping 137. The discharge end of the pump is indicated at 138 and it has been found desirable to connect a relief valve 139 of any usual sort at this point, the discharge of said relief valve leading by piping 139* to the supply source. Line piping 140 connects to the discharge end of the pump, and connected to said line piping is a branch 141 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 our invention, but Fig. 8

shows the relationship between such and the hydraulic means to selectively move the different dressers, since a common source of fluid under pressure suffices to actuate both the table 1 and the dressers. In the branch piping 141 is a slow-down or table speed reducing valve 142, which is shown in section in Fig. 8, and the operation of which will be described hereinafter.

The supply line 140 leads to an entrance port 143 of a valve which is generally designated by the numeral 144, and which is shown in true horizontal section in Fig. 8. It is shown in vertical section in Fig. 7. A valve member 145 is adapted, in one position, to connect the port 143 with a port 146 which leads the pressure fluid to the diamond moving mechanisms. In the other, or inoperative position, which is illustrated by Figs. 7 and 8, the port 143 is entirely closed, the port 146 being connected to an exhaust port 147 which communicates by piping 147^a with the source of fluid supply. The valve member 145 is moved to the operative position whenever the electromagnet 47 is energized, and to this end a depending arm 148 is attached to the hub portion 149 which holds the armature 73 and lever arm 74, these parts, of course, being conveniently made in a single piece. The manner in which magnet 47 is successively energized to bring about the several dressing operations has been already described. Each separate energization thereof attracts the armature 73, and by means of the arm 148 and a suitable connection 150, draws the valve member 145 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 151, Fig. 1, is carried either by the block 59, the block 61, or some member attached to either of these. As actually shown herein, this cam portion forms a part of the latch lever 64. At all events it is in the path of the roller 75 on arm 74, and is so located that when the table 1 has reached approximately the extreme outer limit of its amplified dressing stroke, said cam portion 151 engages the roller 75 and forcibly turns the parts 73, 74 and 148 in a clockwise direction to their original position. It will be remembered that prior to such return movement, the said roller 75 was in engagement with the latch lever 64, the latter being raised, and therefore a stop 152 is provided to back up said latch lever 64 when the cam portion 151 comes into action. This positive means of returning the valve 145 to the position of Fig. 8 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 pressure moving cylinders have been relieved of fluid pressure.

The port 146 is connected, by means of piping 153, to the entrance port 154 of a two-way or selective valve 155. The position of the movable member 156 of this valve determines which of the several dresser moving mechanisms will be operated. As is the case with valve 144, this valve 155 is shown in vertical section in Fig. 7 and horizontal section in Fig. 8. However, Fig. 7 shows it in one position, while Fig. 8 shows it in the other extreme position. In the position of Fig. 7 the entrance port 154 is connected to a port 157 which leads the pressure fluid by means of piping 158 and 159 to a cylinder 160, (see also Fig. 13) in which is a piston 161. This piston 161 is shown as having been moved to operative position in Figs. 8 and 13;—when fluid under pressure is forced into cylinder 160, the valve member 156 being in the position of Fig. 7, said piston is moved to the possition shown in these figures, thus pushing outwardly a pin 162 on lever 126, which action lowers the diamond 107. In similar fashion, when the valve member 156 is in the position of Fig. 8, the fluid under pressure entering valve 155 by way of the single entrance port 154, leaves it by distributing port 163, thence by piping 164 and 165 to the other cylinder 166, moving a piston 167 outwardly, (which is shown in its initial position in Figs. 8 and 13), thus moving a pin 168 attached to lever 127. This, of course, lowers the diamond 108.

Referring to Figs. 6 and 7, the member 94, already referred to as fastened to the shaft 92, is a cam member, the contour of which can be plainly seen in Fig. 7. Pivotally mounted at 169 is a lever 170, which provides a roller 171 engaging the periphery of said cam member 94. A coil spring 170^a surrounds the hub of lever 170, one end of the spring being looped around the lever and the other end being attached to the box 91; thus the lever 170 is urged in a counterclockwise direction, Fig. 7, and the roller 171 is held against the periphery of the said cam member 94. The upper end of lever 170 connects at 172 to the valve member 156. Thus, in the position of parts shown by Fig. 7, the valve member 156 is in its left hand position, ready to connect the pressure fluid line 140 to the diamond operating cylinder 160 by way of port 157. When the metal finger 106 has moved to the position where it connects the terminals 51 and 57, the cam member 94 has moved the lever 170 to shift the valve member 156 to the position shown in Fig. 8, in which position, in the particular arrangement of the invention shown by the drawings, it is held after the first dressing has been completed and until the workpiece being operated upon is finished. As previously described, this valve acts

simply as a distributing valve, while the actual functioning of the particular diamond which is to be operated is controlled by the operation of upper valve member 145.

As aforesaid, the dresser points are raised, and the pitsons 161 and 167 are replaced by mechanical means. Referring to Figs. 11, 12, 13 and 14, a cam member 173 is suitably fastened to the table 1 at the rear thereof, as by bolts 174, 174, provision being made for longitudinal adjustment of said cam member, as by providing slots 175, 175, through which the said bolts pass, and an adjustment rod 176 which also takes the end thrust, said rod 176 being anchored to the table 1 by means of a a lug 177 and nuts 178—178. This adjustable cam member 173 has surfaces 179 and 180 which, when the table has completed the return half of the amplified or wheel dressing stroke and is reentering its normal grinding stroke, bear the relation shown in Fig. 14 to rollers 181 and 182,—the latter being carried, respectively, by forward extensions 183 and 184 of levers 126 and 127. The roller 181 is shown in the up position in this figure, which corresponds to Figs. 12 and 13. Movement of the table 1 to carry the grinding wheel 5 back into the work piece 6, forces the roller 181 downwardly, thus rocking the lever 126 in a counterclockwise direction (Fig. 12). This action restores the diamond 107 to the inoperative position, and forces back the piston 161. Fluid is consequently ejected from the cylinder 160. The valve member 145 having already been repositioned in the manner described, the normal exhaust port 147 is opened up, but at this stage in the operation of the machine, the valve member 156 has just been shifted to make ready for the operation of the other diamond, so exhaust port 147 is cut off from cylinder 160. See Fig. 8. Consequently auxiliary exhaust ports 185 and 186 are provided in the valve 155, said ports leading to a chamber 187 (see Fig. 7) which exhausts by piping 188 to the main fluid supply. Thus the fluid from the cylinder 160 exhausts by way of port 185.

It will be readily understood that in exactly similar fashion, the diamond 108 and piston 167 are mechanically repositioned by contact of surface 180 with roller 182,—when this happens, either subsequent to the first or second dressing of the grinding wheel 5 by the diamond 108, the valve members 145 and 156 are in the position shown in Fig. 8, the former having been moved by subsequent electrical contacts in the control mechanism since the stage at which the cylinder 160 was exhausted, but the latter having remained stationary, and consequently the fluid from cylinder 166 exhausts, by the normal exhaust port 147 in valve 144. Auxiliary port 186 serves no direct function in the present arrangement of the invention, but acts as a safety port, and allows the dresser moving operations to be reversed, as by simply crossing pipes 158 and 164.

Still referring to Fig. 8, the table speed reducing valve a slow down valve 142, hereinbefore referred to, comprises a rotatable valve member 189 having a hole 190 therethrough. Said valve member is actuated by a shaft 189^a. Turning of the valve member offsets said hole 190 to entrance and exit ports 191 and 192, and thus restricts the passage of the pressure fluid to the table operating cylinder, not shown. To the shaft 189^a of member 189 is fastened a member 193 as shown in Fig. 12, having a long arm 194 and a short arm 195. Connected to the said long arm 194 is a link 196, which also connects to a depending lever arm 197 keyed to shaft 128. Thus it will be seen that the valve 142 is controlled from shaft 128, the angular position of the latter being in turn controlled from the levers 126 and 127, as follows.

Refering to Fig. 10, a collar 198 is also splined to said shaft 128. This collar provides an upwardly extending pair of lugs 199 and 200. Each diamond operating lever 126 and 127 has a pair of spaced lugs; 201 and 202 in the case of lever 126; 203 and 204 in the case of lever 127. Adjustment screws 201^a, 202^a, 203^a and 204^a, respectively, are carried by said lugs. Collar 198 is controlled in longitudinal position by a pin 205 attached to an arm 206, the latter being fastened to a short shaft 207 which extends upwardly from a casing 208. In the inside of said casing is a flap valve member 209, which is likewise attached to said short shaft 207.

Ports 210 and 211 in this casing connect to piping 158 and 164, respectively, and another pair of ports 212 and 213 (in the top part of the casing) connect to piping 159 and 165. When fluid flows through piping 158, it enters the casing 208 at port 210 and forces the flap valve 209 to the position shown in Fig. 10, thus allowing fluid to exit by port 212, thence through piping 159 to cylinder 160. The flap valve is likewise held in this position when the fluid exhausts by way of piping 159. When fluid comes in by way of piping 164, the valve member 209 is forced to an opposite position and likewise is held there by the exhaust of such fluid. From Fig. 10 it will be seen that the upper ports 212 and 213 are elongated in shape so that neither of them can ever be entirely closed. This prevents locking of fluid in the diamond operating cylinders, which might otherwise occur in case flap valve 209 should be manually moved to the wrong position. The arm 206 is, of course, moved in accordance with the position of flap valve 209, and so the collar 198 is also moved, and the lugs 199 and 200 fit, respectively, between screws 201^a and 202^a, or 203^a, 204^a, as the case may be. So any desired control can be automatically exercised on the valve 142, since turning of shaft 128 is

bound to result when one of the above screws strikes a corresponding lug, said screws being carried, as stated, by the lever arms 126 and 127, and shaft 128 being operatively connected to the valve member, through the arm 197.

It will readily be seen that any range of speed of the table 1 can be worked out for the different dressing strokes, the intermediate cutting strokes on the workpiece between said dressing strokes and the final and finishing cutting strokes on the workpiece, merely by properly adjusting the screws 201^a, 202^a, 203^a and 204^a. The possible combinations are too numerous to recite—suffice it to say that adjustments of screws 202^a and 201^a will control, respectively, the speed to which the table reciprocation is reduced during the wheel dressing by the diamond 107, and the speed to which the table returns during the working reciprocations immediately following this dressing. Likewise, the adjustments of screws 204^a and 203^a control, respectively, the corresponding speeds during and after the dressing operation by the diamond 108.

However, it is desirable that after a given workpiece is finished, the valve member 189 should be returned to the original position of free flow of the pressure fluid, irrespective of the setting of the adjustment screws. So, referring to Figs. 12 and 14, a third cam surface 214 is provided on bar 173, said surface facing in the opposite direction from the other surfaces 179 and 180. In the path of surface 214 is a roller 215 on a rod 216 which passes down through a bearing in the machine frame. A link 217 is connected to the bottom of this rod, and the other end of the link 217 connects to the short arm 195 already referred to. When the table withdraws to the position of Fig. 1, after a workpiece is finished, the surface 214 strikes and depresses the roller 215, moving downwardly the rod 216 and link 217, and thus the valve member 189 is restored to the position of free flow.

The operation of the machine has been set forth with the description of parts, but briefly recapitulating, the operator finds the machine with the table 1 in the position of Fig. 1. Assuming that all necessary adjustments have been made, he places an unground workpiece in the chuck 6^a, sets the latter in rotation, and likewise causes the spindle 10 to be rapidly rotated. By movement of the lever 90, the table is started to carry the grinding wheel 5 toward the workpiece 6, the reversing member 9 automatically assuming its position between dogs 7 and 8. The caliper control box 22 swings inwardly, carrying the point 16 into contact with the internal surface of the workpiece. The preliminary cuts are now taken on the workpiece, but before the wheel 5 has a chance to get dull, the terminal 35 reaches the terminal 39 and the table moves outwardly in an amplified stroke, carrying the wheel 5 past the diamond 107, which has been lowered as set forth. The cutting operation is resumed, at reduced speed of table traverse, if desired, in accordance with the automatic setting of the valve 142. Later in the operation on this workpiece, and desirably after a substantial advance has been given to the feed screw shaft 11, the table undergoes a second amplification, and the wheel is dressed again, this time by the diamond 108. Thereafter the cutting operation is again resumed, but only for a few strokes, since the wheel is again to be dressed by the same diamond 108 when contacts 37 and 41 in the box 22 come together. This double dressing from a single diamond which reaches a given operative position is possible because a slight "spring" always exists in the spindle 10 subsequent to a comparatively great number of workpiece reducing strokes. Subsequent to a second dressing of the wheel 5 by a given diamond, however, practically no "spring" is present in the spindle 10, and the workpiece is finished, desirably at reduced speed of table traverse, whereupon the contacts 34 and 38 come together and the table again runs out to the position of Fig. 1.

Thus the grinding wheel 5 is kept sharp and free cutting during the entire operation of reducing the workpiece, and therefore extremely hard workpieces can be accurately ground. It is obvious that by simply substituting a different cam 94, the wheel 5 can be dressed twice on the first diamond 107, or indeed it could be dressed all three times on any given diamond. Also, by merely providing more contacts in the progressive switch mechanism and in the box 22, any number of dressing operations could be brought about. Many other changes in the arrangement and form of the invention can be made, the scope of the invention being set forth in the following claims.

We claim:

1. In a grinding machine, a plurality of wheel dressing devices, hydraulic means automatically brought into action to severally move said devices into operative position at different stages in the reduction of a workpiece, and mechanical means also automatically brought into action to reposition said devices.

2. In a grinding machine, a plurality of hydraulically operated dresser moving mechanisms, a selective valve device to determine which of said mechanisms will be operated, and a progressive mechanism to actuate said selective valve.

3. In a grinding machine, means for bringing a dressing point to a given operative position, means for bringing a second dressing point to another operative position, and selective means automatically bringing said first or second named means into operation.

4. In a grinding machine, the combination

with a plurality of movable dresser devices, separate means to actuate said dresser devices, a reciprocating table and a speed control for said table, of means actuated severally by the separate means to actuate said dresser devices, for operating said speed control.

5. In a grinding machine, a reciprocatory table, a plurality of dressers, and separate means to control the speed of said table responsive severally to movement of said dressers.

6. In a grinding machine, a plurality of dressing devices, hydraulic means for severally actuating said devices to move them to operative position, and mechanical means to replace them in inoperative position.

7. In a grinding machine, a pair of hydraulically operated dressers, a reciprocatory table, a control device to govern the speed of said table, and means for shifting said control device from one to the other of said dressers, said control being shifted by the flow of pressure fluid to operate a given dresser.

8. In a grinding machine, a pair of movable dresser devices, actuating means for said dressers, a work-sizing mechanism, and selective means under the control of said work-sizing mechanism to cause one or the other of said dressers to be actuated.

9. 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, further means for dressing said wheel by a dressing device located substantially 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 which of said dressing means shall be brought into operation.

10. 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, further means for dressing said wheel by a dressing device located substantially in the same plane but at a different position in the line of feed, a progressive control mechanism which determines which of said dressing means shall be brought into operation, and means for moving said progressive control mechanism to a different stage for each dressing.

11. In a grinding machine, a plurality of dresser moving mechanisms, selective means to determine which of said mechanisms will be operated, and a progressive mechanism to actuate said selective means.

12. In a grinding machine, a pair of dressing devices, separate means to operate said dressers, a reciprocatory table, a control device to govern the speed of said table, and means for shifting said control device from one to the other of said dressers, said control being shifted automatically to the dresser operating means that is made active at the initiation of its action.

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