May 2, 1939. A. P. BURNS 2,156,970

GRINDING MACHINE

Filed July 3, 1937 4 Sheets-Sheet 1

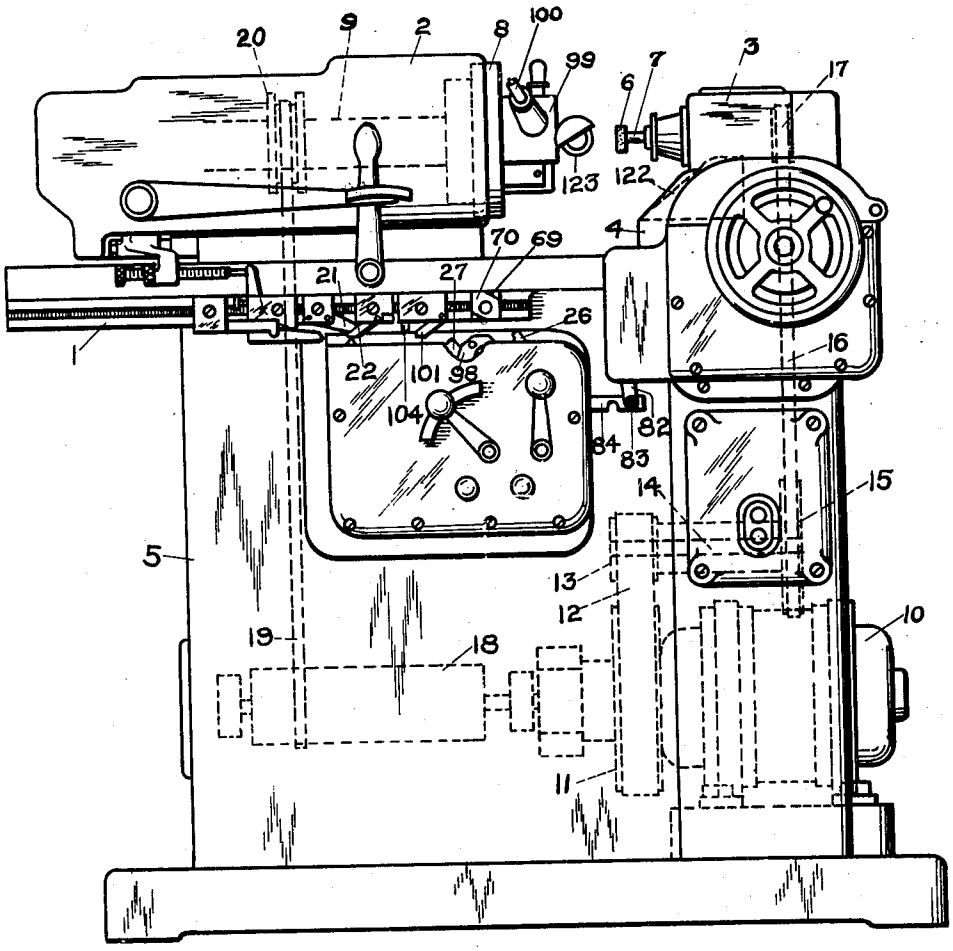


Fig. 1

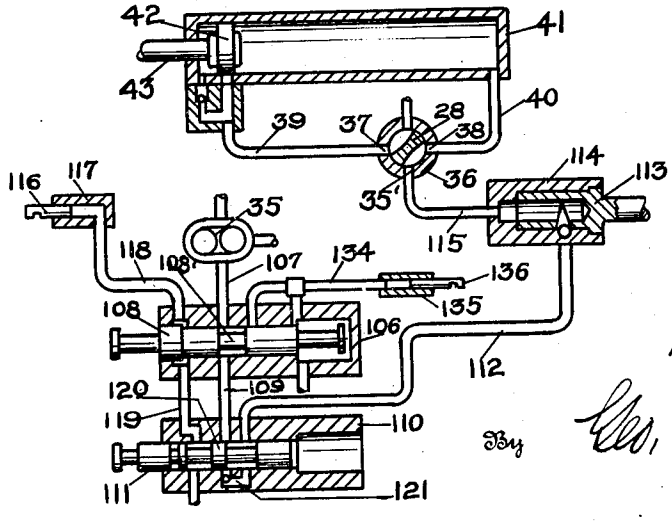


Fig. 5

Inventor

Alfred P. Burns

By Geo. H. Kennedy Jr.

Attorney

May 2, 1939. A. P. BURNS 2,156,970

GRINDING MACHINE

Filed July 3, 1937 4 Sheets-Sheet 2

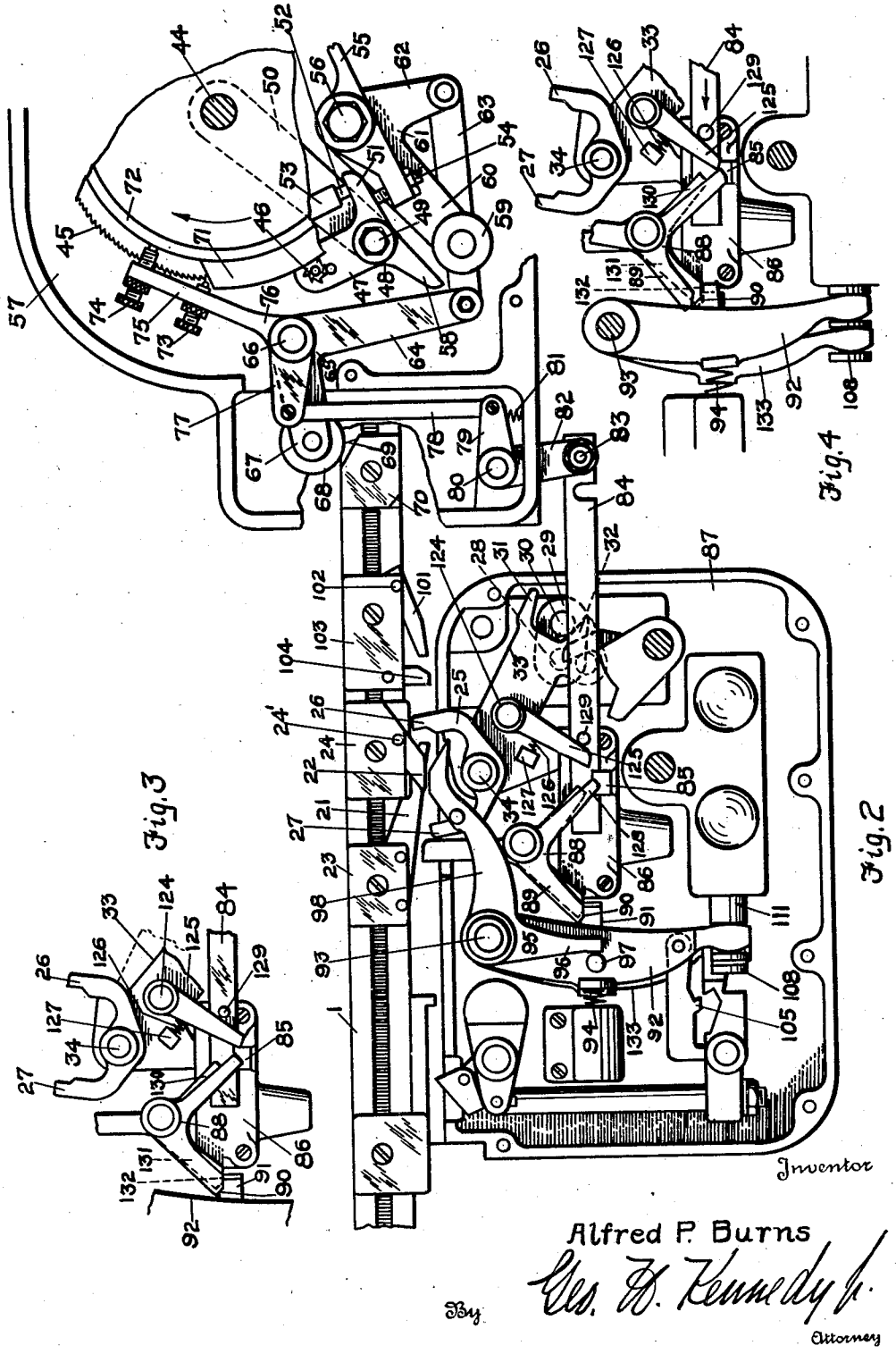


Fig. 2

Fig. 3

Fig. 4

Inventor

Alfred P. Burns

By Geo. W. Kennedy Jr.

Attorney

May 2, 1939. A. P. BURNS 2,156,970

GRINDING MACHINE

Filed July 3, 1937 4 Sheets-Sheet 3

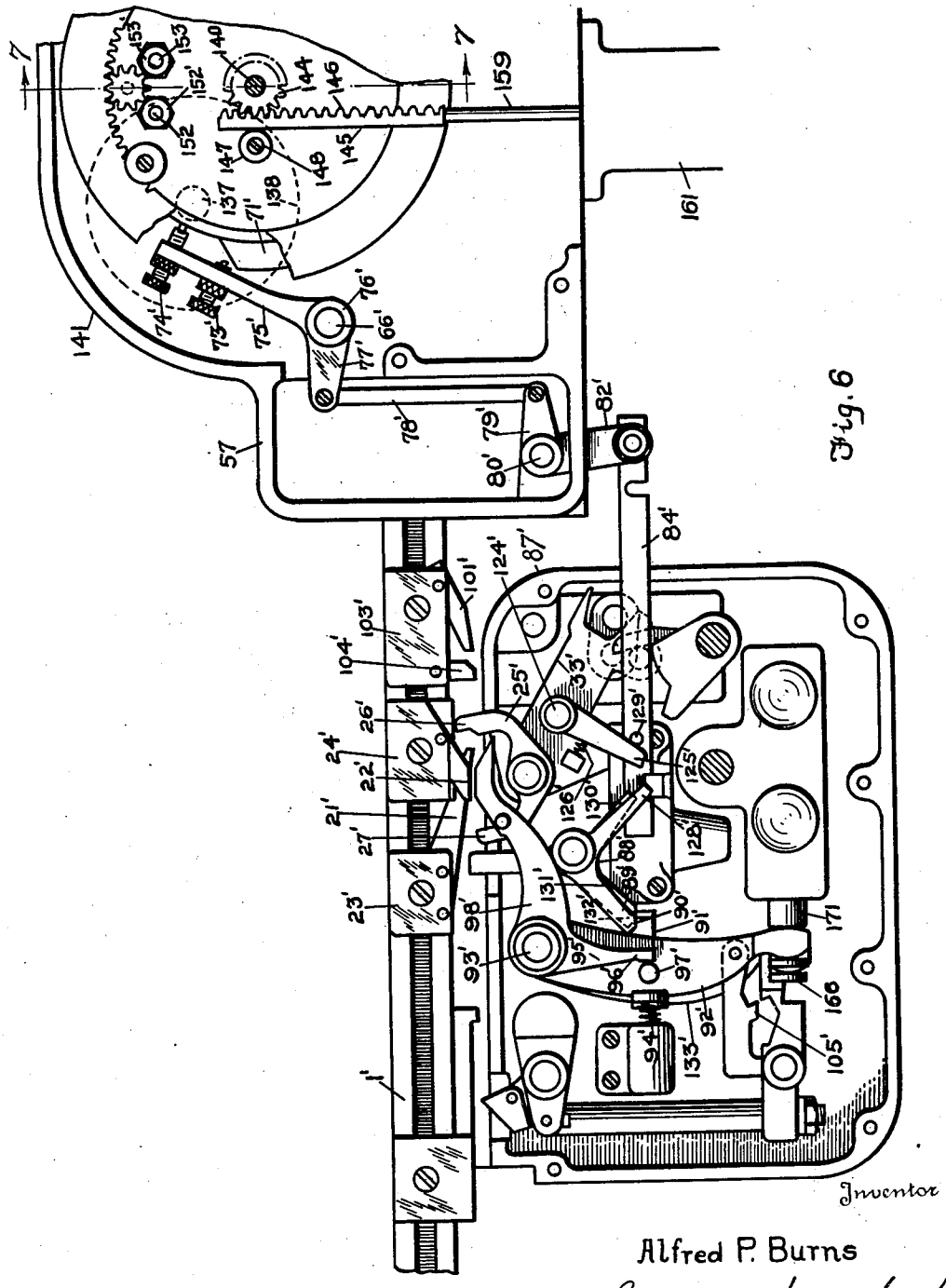


Fig. 6

Inventor

Alfred P. Burns

By Geo. W. Kennedy Jr.

Attorney

May 2, 1939. A. P. BURNS 2,156,970

GRINDING MACHINE

Filed July 3, 1937 4 Sheets-Sheet 4

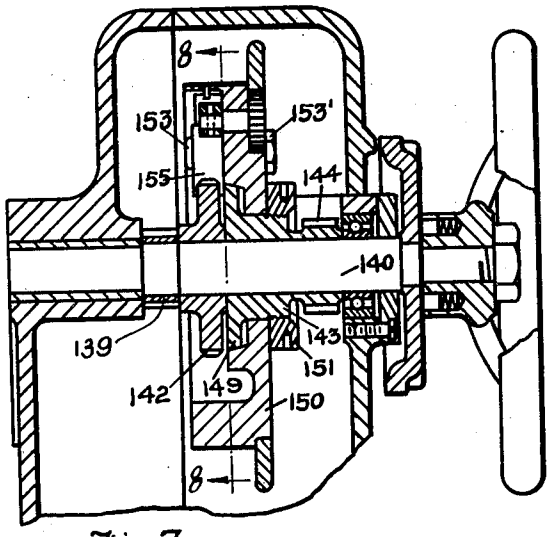


Fig. 7

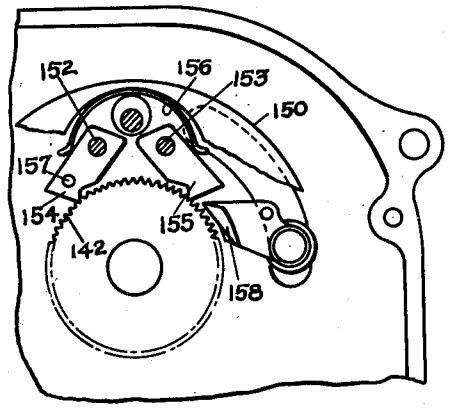


Fig. 8

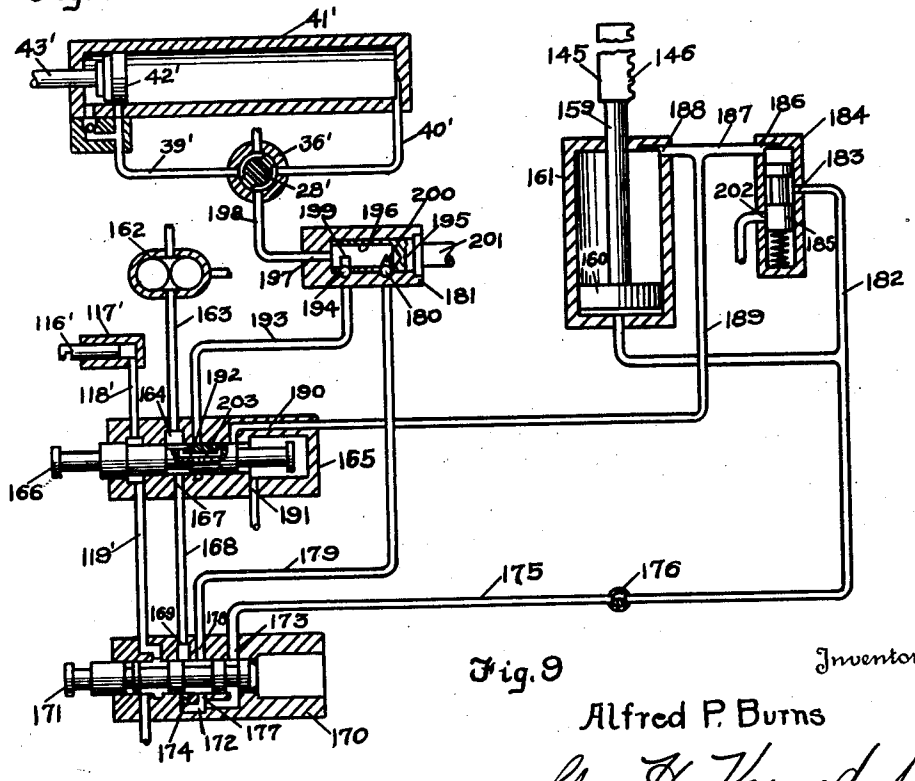


Fig. 9

Inventor

Alfred P. Burns

By Geo. D. Kennedy Jr.

Attorney

Patented May 2, 1939

2,156,970

UNITED STATES PATENT OFFICE

2,156,970

GRINDING MACHINE

Alfred P. Burns, Worcester, Mass., assignor to The Heald Machine Company, Worcester, Mass., a corporation of Massachusetts

Application July 3, 1937, Serial No. 151,885

18 Claims. (Cl. 51—95)

The present invention relates to a grinding machine for the successive reduction of a plurality of workpieces all to a predetermined size, and is particularly applicable to machines for grinding the internal surfaces of sleeves, bushings and like articles. This application is a continuation-in-part of applicant's copending application Serial No. 50,777.

In grinding machines of the type disclosed in the Blood Patent No. 2,011,705, dated August 20, 1935, the progress of the grinding operation is selectively under the control of the cross-feed mechanism or under the control of gages which successively enter the bore of the workpiece as the latter approaches and reaches the desired size. When the grinding operation is under the control of the cross-feed mechanism an axial separation between the grinding wheel and a workpiece in the work-supporting structure is provided prior to completion of the grinding operation, during which axial separation the grinding wheel is dressed. The dressing tool, which is normally in an inoperative position, is moved downwardly, preferably by fluid under pressure, into alinement with the periphery of the grinding wheel, the movement of the tool occurring during the extended movement of the table which procures the relative axial movement between the grinding wheel and workpiece. The cross-feed mechanism is also frequently used for controlling other machine movements, such as a "back-off" of the wheel relative to the workpiece prior to the withdrawal of the wheel from within the workpiece bore at the completion of the grinding operation.

In the Blood Patent No. 2,011,705, the cross-feed mechanism is actuated by a cam which is mounted on the reciprocatory table and is adjusted to engage with a roller forming part of the crossfeed mechanism so that the roller is rocked during each reciprocation of the table. The cam and roller arrangement provides for a step-by-step crossfeed movement of the grinding wheel relative to the workpiece and this step-by-step advance may occur at any point of the table travel during the normal reciprocation thereof. Although the cam is preferably adjusted on the table so that the step-by-step advance of the wheel may occur at one end of the normal reciprocatory movement of the table, but this adjustment is frequently carelessly made so that the step-by-step advance does not occur at the desired point. Since the control mechanism which procures a runout of the table, either for the dressing operation during the grinding operation, or for a final separation between the wheel and the workpiece at the completion of the grinding, is actuated by the crossfeed mechanism, it would be apparent that the control mechanism is set in operation substantially at the same time that the cam on the table engages with the roller during one of the table reciprocations. The control mechanism may thus be actuated at any point in the normal reciprocation of the table, dependent upon the position of the table at the time that the feed cam engages and shifts the roller by which the cross-feed mechanism is actuated. If the grinding wheel is at the inner end of the workpiece, when the mechanism for shifting the tool is set in operation, the downward movement of the dressing tool is controlled by a cam on the machine which is located in a position to engage with a roller carried by the dressing tool support, thereby causing the dressing tool to move smoothly into operative position.

This cam, which controls the dressing tool movement, also cooperates with the roller in returning the dressing tool support to inoperative position when the grinding wheel and workpiece are returned to operative position, and is thus movable relative to the dressing tool support. Thus when the table carries the dressing tool, as in the Blood patent aforesaid, the cam is carried by the base of the machine. The cam is thus in a position to cooperate with the roller if the dressing tool begins its downward movement while the wheel is still within the bore of the workpiece.

If the grinding wheel is adjacent the outer end of the workpiece when the mechanism for moving the dressing tool is set in operation, the roller on the dressing tool support cannot engage with the cam since the latter is already longitudinally spaced therefrom. The dressing tool is thus moved rapidly down into operative position, where it is suddenly brought to rest, with the result that the machine or the tool is jarred and the tool is not properly located. By the sudden stopping of the swinging tool, the latter does not always remain in its lowermost position and thus does not produce a smooth periphery on the grinding wheel. This inaccuracy is particularly objectionable when the workpieces must be ground to very close tolerances. One of the principal objects of the present invention is to avoid the above noted objection by having the dressing tool always guided into operative position by the cam which cooperates with the dressing tool structure and which sub-

sequently moves the dressing tool upwardly into inoperative position.

Similarly, if the control mechanism by which the back-off is procured is actuated by the crossfeed mechanism, this back-off may occur at any point in the normal reciprocation of the table. If the back-off occurs when the wheel is at the inner end of the workpiece the wheel is backed away from the work while substantially the entire length of the wheel is in contact with the workpiece surface and no damage is done to the wheel or work. On the other hand, if the back-off is initiated at a time when the wheel is adjacent to the outer end of the workpiece, the wheel is not always backed away until the axial separation between the wheel and the workpiece has carried the wheel to such a position that only a relatively small portion of the entire length of the wheel is in engagement with the workpiece surface. When this occurs, the workpiece is ground unevenly with the so-called "bell mouthing" which obviously affects the salability and frequently the utility of the workpiece. This "bell mouthing" results from the increased grinding action of the wheel on the workpiece as the length of the line of contact between the wheel and the workpiece is diminished. One of the features of the present invention is to avoid this objectionable "bell mouthing" by causing the control mechanism, which procures the radial back-off, to be actuated while the grinding wheel is at the inner end of the workpiece so that the wheel will be radially withdrawn from the workpiece before the axial separation between the wheel and the workpiece has started.

The crossfeed mechanism of the Blood & Burns application Serial No. 684,210, now Patent No. 2,027,627, is actuated by a hydraulic mechanism so that the transverse movement of the grinding wheel relative to the workpiece is continuous rather than by a step-by-step motion, as in the patent above referred to, and the crossfeed movement is therefore independent of the table reciprocation. In order to avoid the objections above noted in the downward movement of the dressing tool into operative position and in the radial back-off of the grinding wheel, it is essential that the control mechanism, by which the dressing tool is shifted and by which the back-off is procured, be set in operation when the grinding wheel is at the inner end of the workpiece. To this end, the present invention involves the provision of a structure which, in association with the crossfeed mechanism, will set the control mechanism in operation at the end of the table reciprocation when the wheel is at the inner end of the workpiece. By this arrangement the control mechanism may be actuated by the crossfeed mechanism in the desired manner, but a suitable interconnection between the control mechanism and the table reversing mechanism assures that the control mechanism will function at one end of the table stroke.

According to the present invention the machine is so arranged that the mechanism which procures the runout of the table for the dressing operation is set in motion when the grinding wheel is at the inner end of the workpiece. With the mechanism set in operation at this point, as by mechanism controlled by the table reversing means, the dressing tool is moved downwardly and engages with the cam when the wheel begins its withdrawal movement relative to the work-support.

Other and further objects and advantages of the invention will more fully appear from the following detailed description taken in connection with the accompanying drawings, in which—

Fig. 1 is a front elevation of the mchine embodying the invention.

Fig. 2 is a front elevation on a larger scale of the mechanism within the control box and a portion of the crossfeed mechanism, parts broken away to show the construction more fully.

Fig. 3 is an elevation of a portion of the mechanism of Fig. 2 before the beginning of the dressing operation.

Fig. 4 is a view corresponding to Fig. 3, showing the position of the parts at the beginning of the dressing operation.

Fig. 5 is a fluid pressure diagram.

Fig. 6 is a front elevation corresponding to Fig. 2, showing a modified type of grinding machine to which the present invention is applied.

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

Fig. 8 is a sectional view along the line 8—8 of Fig. 7.

Fig. 9 is a fluid pressure diagram for the machine of Fig. 6.

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

Referring first to Fig. 1, the machine has the usual reciprocatory table 1 provided in an internal grinding machine. Either the grinding wheel or the work to be ground is carried on said table, the reciproactions of the latter operating in either case to procure a relative reciprocatory movement between said grinding wheel and the workpiece. In the construction shown the table supports and carries a workhead 2 and a wheelhead 3 is mounted on a bridge 4 which spans the guideways, not shown, provided by the base 5 of the machine for the movements of the table 1. The grinding wheel 6 is carried on a spindle 7 journaled in the wheelhead 3, and the workpiece not shown is mounted in a suitable work-supporting member in the form of a chuck 8 carried on the end of a spindle 9 journaled in the workhead.

Both the grinding wheel and the workpiece are positively rotated as from a driving motor 10 mounted on the base of the machine. In the construction shown, the drive shaft of said motor carries a large diameter pulley 11 connected by a belt 12 to a pulley 13 on a countershaft 14 journaled within the base. A second pulley 15 on the countershaft 14 is connected by a belt 16 to a small diameter pulley 17 on the grinding wheel spindle 7, thereby driving the grinding wheel at a high rate of speed. The drive shaft of the motor is also connected to a drum 18 journaled within the base of the machine and connected by a belt 19 to a pulley 20 on the spindle 9. The arrangement of belts and pulleys preferably provides for a rotation of the grinding wheel at a much higher rate of speed than that of the work-supporting member.

The reciprocations of the table 1, which cause the rotating grinding wheel to make the desired traverse over the surface of a workpiece mounted in the chuck, are imparted in any well known manner, as by the use of the fluid pressure controlling reversing mechanism described in the Heald & Guild Patent No. 1,582,468, dated April 27, 1926. It is sufficient to note for the purpose of the present application that reversal of the table movement at each end of the normal working stroke is procured by the use of spaced reversing dogs 21 and 22 carried by blocks 23 and 24 adjustably secured to the table and adapted al-

ternately to engage and move a reversing member 25. The latter has spaced upwardly projecting lugs 26 and 27 which are in a position to be engaged alternately by the dogs 21 and 22 respectively, while the grinding wheel is located within and reciprocated relative to the workpiece.

The reversing member 25 is connected to a reversing valve 28, Fig. 5, by which the table is reversed. The forward end of the reversing valve 28 has secured thereto an arm 29 which supports a pin 30, the latter being positioned between spaced projecting lugs 31 and 32 on the end of an arm 33 secured against turning movement on the same shaft 34 to which the reversing member 25 is secured. Movement of the member 25 accordingly shifts the position of the valve 28 and reverses the table movement.

Referring now to Fig. 5, fluid under pressure from a pump 35 enters the inlet port 35' of a casing 36 for the reversing valve 28 through suitable throttle and control valve mechanisms hereinafter described. Outlet ports 37 and 38 in the casing 36 are connected by pipes 39 and 40 to the left and right hand ends respectively of a cylinder 41 mounted in the base of the machine. The cylinder has a piston 42 having a projecting rod 43 which is secured to the table, the reciprocatory movements of the piston in the cylinder procuring corresponding movements of the table.

The relative crossfeed movement between the workpiece in the chuck and the grinding wheel is obtained by movement of the wheelhead 3 transversely on the bridge 4, this movement being procured in any suitable manner, as by mechanism actuated by the reciprocatory movements of the table, one form of such mechanism being fully described in the above cited Blood et al. Patent No. 2,011,705. As best shown in Fig. 2, the wheelhead is mounted on a cross-slide, not shown, movement thereof being procured by rotation of a crossfeed screw 44 which engages an internally threaded portion, not shown, of the cross-slide. The crossfeed screw, which is held against longitudinal movement in the bridge, is turned through a ratchet 45 suitably connected to said crossfeed screw. Rotation of the ratchet is procured by means of a pawl 46 which is carried by one arm 47 of a lever 48 journaled on a stud 49 on the end of an arm 50 turnable on the crossfeed screw 44. A second arm 51 of the lever 48 is engageable with an adjustable stop 52 carried by a lug 53 on the arm 50, said stop supporting the lever 48 against counterclockwise movement beyond the position shown. The arm 51 also engages an abutment 54 in a lever 55 normally held against turning movement on a stud 56 in the casing 57 which forms a housing for the crossfeed mechanism.

A third arm 58 on the lever 48 is in a position for engagement with a roller 59 on the end of one arm 60 of a bell crank lever 61 pivotally mounted on the stud 56. The other arm 62 of the bell crank lever 61 is connected by a link 63 to the end of one arm 64 of a bell crank lever 65 journaled on a stud 66 in the casing 57. The opposite arm 67 of the lever 65 carries a roller 68 which is in a position for engagement with a cam 69 on a block 70 adjustably secured to the table. During each reciprocation of the table, while the grinding wheel and workpiece are in operative position, the cam engages beneath said roller and procures an oscillation of the arm 65 and a corresponding upward movement of the pawl 46 for advancing the ratchet 45 clockwise. A step-by-step crossfeed movement of the grinding wheel relative to the workpiece is thus assured.

The ratchet wheel 45 and the crossfeed screw 44 are preferably connected by mechanism of the type disclosed in the Guild Patent No. 1,971,138, dated August 21, 1934. By this mechanism, which forms no essential feature of the present invention, the reduction in diameter of the grinding wheel, as a result of wear and the dressing operations performed thereon, is automatically compensated for so that each successively ground workpiece will be reduced to the predetermined diameter independently of variations in the diameter of the grinding wheel. For the purpose of the present invention, it will be sufficient to note that a cam 71 is carried by a ring 72 which is movable relative to the crossfeed screw and is arranged to be shifted relative thereto, as by the mechanism of the Guild patent, so that when the workpiece reaches a predetermined size said cam will always be at a predetermined point relative to the casing 57. During each grinding operation said cam advances as a unit with the ratchet wheel and crossfeed screw, the relative movement therebetween being procured during the retraction of the crossfeed movement between successive grinding operations.

As above stated, the grinding operation is under the control of the crossfeed movement and to this end the cam 71, which, during the grinding operation, is advanced clockwise in unison with the ratchet wheel, moves into engagement successively with the ends of adjustable screws 73 and 74 carried by an arm 75 of a bell crank lever 76 which is journaled on the stud 66. The screws 73 and 74 are locked in adjusted position within the arm 75. The other arm 77 of the bell crank lever 76 is connected by a link 78 to an arm 79 secured to a shaft 80 journaled in the casing 57. A spring 81, which engages the arm 79, urges the bell crank lever 76 clockwise into the position of Figs. 2 in readiness for rocking movement of said lever by the cam 71.

The shaft 80 projects beyond the casing 57 and has on the end thereof a depending arm 82 which carries a bolt 83 by which a horizontally slidable bar 84 is secured to said arm. The left hand end of the bar 84 projects into the control box and is supported at the left hand end by a lug 85 on a bracket 86 within the control box 87. Engagement of the cam 71 with the screw 73, and subsequently with the screw 74, procures two successive movements of the horizontal bar 84 to the left, thereby procuring changes in the grinding operation through actuation of the control mechanism, hereinafter described.

The first change in the grinding operation involves an extended movement of the table to the left to withdraw the grinding wheel from the bore of the workpiece, at which time a dressing operation is performed on the grinding wheel. This change is procured by the control mechanism when the first shifting movement of the bar 84 occurs.

The control mechanism, which corresponds substantially to the control mechanism of the Blood et al. Patent No. 2,011,705, comprises a bell crank lever 88, Fig. 2, one arm 89 of which engages a notch 90 in a lug 91 carried by a depending arm 92. The later is journaled on a shaft 93 in the box 87 and is urged counterclockwise by a spring 94. A bell crank lever 95 also journaled on the shaft 93 has a depending arm 96 which engages with a pin 97 on the arm 92. The

opposite arm 98 of the lever 95 projects upwardly between the lugs 26 and 27 and has a cam surface on its upper end for engagement with the reversing dog 22. Said dog is pivotally connected to the block 24 by a pin 24', and the arm 98, when in raised position, elevates the free end of said dog, thereby avoiding engagement between said dog and the lug 27 to permit the table to move to the left beyond its normal reciprocatory position to carry the grinding wheel past the dressing tool. The arm 98 is normally in its lower position shown, with the free end of said arm located below the dog 22 and out of engagement therewith, being moved upwardly only when the dressing operation is to take place.

As the table moves to the left beyond its normal reciprocatory position, the pivotally mounted carrier 99, having mounted thereon a dressing tool 100, is swung downwardly to move the dressing tool into alinement with the grinding wheel 6. The dressing tool and the supporting structure are of any suitable construction, as for example, the construction described in the Blood Patent No. 1,971,848, dated Aug. 28, 1934, in which the dressing tool is moved downwardly into operative position by fluid under pressure. The fluid connection by which the carrier 99 is oscillated will be hereinafter described in connection with the remaining fluid pressure mechanism. The dressing tool and supporting structure are located on the table to provide for a relative movement between the tool and the grinding wheel.

After the dressing tool has passed the grinding wheel during the extended movement of the table to the left, a reversing dog 101 pivotally mounted on a pin 102 in a block 103 on the table engages the lug 27 and oscillates the valve 28 to reverse the table movement and restore the grinding wheel to operative position relative to the workpiece. During the movement of the table to bring the grinding wheel and workpiece into operative position after the dressing operation, the arm 98 is moved downwardly into inoperative position by a dog 104 carried by the block 103 on the table. The dog depresses the arm 98 and rocks the arm 92 clockwise, the latter being held against subsequent counterclockwise movement by a latch 105, the operation of which is fully described in the aforesaid Blood & Burns Patent No. 2,011,705.

Referring now to Fig. 5, fluid under pressure from the pump 35 enters a valve casing 106 through a conduit 107, passes around a reduced portion 108' of valve 108 and through a conduit 109 to a valve casing 110. A valve 111 in the casing 110 normally provides fluid connection between the conduit 109 and a second conduit 112 by which fluid is directed to a throttle valve 113 in a casing 114. The throttle valve casing 114 is connected by a conduit 115 to the reversing valve 28. Fluid under pressure is thus directed to the reversing valve through the throttle valve 113.

The dressing tool is moved downwardly into operative position by a piston 116 slidable in a casing 117, connected by a conduit 118 to the valve casing 106. A conduit 119 which provides connection between the casings 106 and 110 provides fluid connection to the casing 117. The valve 111 has a full-size portion 120 which normally cuts off the flow of fluid from the conduit 109 to the conduit 119. The valve 111 is however, in engagement with the lower end of the arm 92, Fig. 2, and movement of said arm to the right shifts said valve therewith and establishes fluid connection between the conduits 109 and 119 to allow fluid under pressure from the pump to pass directly to the casing 117 and move the dressing tool into operative position. The connection between the piston 116 and the dressing tool carrier is by any suitable mechanism, as by the arrangement fully described in the aforesaid Blood Patent No. 1,971,848. The shifting movement of the valve 111 also directs fluid under pressure through a throttled by-pass 121 to the main throttle valve 113 for reducing the rate of travel of the table during the dressing operation.

The return of the arm 92 substantially to original position after the dressing operation and during the return of the table to normal reciprocatory position restores the valve 111 substantially to the position of Fig. 5, thereby cutting off the flow of fluid under pressure to the casing 117 to allow the dressing tool support to be moved upwardly into the inoperative position of Fig. 1. This return movement is positively procured by engagement between a cam 122 on the bridge 4 and a roller 123 on the dressing tool carrier. The cam 122 is so located as to move the carrier upwardly as soon as the dressing tool passes the wheel during the return movement of the table to normal reciprocatory position. The complete arrangements shown in Fig. 5 are fully described in the aforesaid Blood et al. Patent No. 2,011,705, and not being essential to the present invention, are not further described.

The above described mechanism is fully disclosed in prior patents or copending applications and is not of itself a part of the present invention. The latter involves the attainment, in connection with the above, or similar machine instrumentalities, of the novel and useful results herein set forth. According to the present invention the movement of the arm 92 by which the mechanism controlling the dressing operation is started, occurs only when the grinding wheel is at the inner end of the workpiece. To this end the bell crank lever 33, forming part of the table reversing mechanism, has a stud 124 on which is pivotally mounted an arm 125, the latter being normally urged counterclockwise by a spring 126 positioned between said arm and a lug 127 on the lever 33. In the normal position of the arm 125 it is out of engagement with a depending arm 128 of the bell crank lever 88, as shown in Fig. 3, the arm 125 being held against a pin 129 on the bar 84. The oscillation of the lever 33 thus has no effect on the lever 88 while the bar 84 remains in the position of Figs. 2 and 3. When the screw 73 is elevated by the cam 71, however, the bar 84 is moved to the left, as above pointed out, moving the pin 129 on said bar to the left and thereby swinging the free end of the arm 125 to the left into the position of Fig. 4. When this occurs, as shown in Fig. 4, the end of the arm 125 engages with the arm 128 and procures a clockwise turning movement of the bell crank lever 88 into the position shown to release the depending arm 92.

The bell crank lever 88 is turned by the arm 125 during the clockwise turning movement of the arm 33 which occurs when the grinding wheel reaches the inner end of the workpiece, at which time the reversing dog 21 engages the lug 26 and procures a turning movement of the arm 33. The control mechanism is thus set in operation when the grinding wheel is at the inner end of the workpiece and in response to the movement of the table reversing means. Since the arm 92 moves counterclockwise only when the grinding wheel is at the inner end of the workpiece, and

since the movement of the arm 92 procures a downward movement of the dressing tool into operative position, the cam 122 is in a proper position to engage with the roller 123 during the downward movement of the tool carrier and cause the dressing tool and its carrier to move downwardly slowly, guided by the cam 122, until the carrier and tool reach operative position. During the remainder of the grinding operation, after the grinding wheel is dressed, the bell crank lever 88 no longer engages with the notch 90 and the contact between the arm 125 and the arm 128 of the bell crank lever has no effect on the grinding operation.

After the grinding wheel and workpiece have been returned to operative position, following the dressing operation, the grinding continues with the grinding wheel given a cross-feed movement until the cam 71 engages and elevates the screw 74 to procure a second extended movement of the table to the left to separate the grinding wheel from the workpiece, thereby bringing the grinding operation to a close. This second extended movement of the table is procured through a further movement of the bar 84 to the left, swinging the arm 125 even more to the left into engagement with the depending arm 130, Fig. 4, of a bell crank lever 131 located directly in back of the bell crank lever 88. This bell crank lever, as fully described in the above mentioned Blood et al. Patent No. 2,011,705, has an integral latch corresponding to the arm 89 of the lever 88 which normally engages in a notch 132 provided by a depending arm 133 corresponding to the arm 92. Said arm 133 is urged counterclockwise by a spring corresponding to the spring 94 and carries a pin, not shown, which engages with a depending arm, also not shown, integral with the lever 95 so that swinging movement of said arm 133 elevates the arm 98. The free end of the arm 98 is moved higher than it was moved by the previous swinging of the arm 92 to elevate the dog 101, thereby rendering both the dogs 22 and 101 inoperative for a movement of the table to the left beyond its normal operative position, said table being brought to rest by any suitable mechanism, as for example, that disclosed in the Blood et al. patent above referred to.

The lower end of the arm 133 engages with the valve 108 to shift said valve to the right, Fig. 5, thereby establishing fluid connection from the pump through a conduit 134 to a casing 135 in which a plunger 136 is slidable. This plunger is connected to a back-off mechanism by which the grinding wheel is given a slight radial movement away from the workpiece surface to prevent engagement between the grinding wheel and the workpiece during the axial separation thereof. This mechanism may be of any suitable type, as for example, that disclosed in Kempton & Gallimore No. 1,826,178, dated Oct. 6, 1931, or the Heald et al. Patent No. 1,816,082, dated July 28, 1931. In the structure of either of these patents the movement of a plunger by fluid under pressure procures a temporary radial separation between the grinding wheel and the workpiece at the beginning of the axial separation, thereby avoiding the objectionable "bell mouthing", otherwise resulting. Since the lever 131 is rocked by the turning movement of the member 33, which occurs while the grinding wheel is at the inner end of the workpiece, this back-off of the grinding wheel will occur before the grinding wheel begins its withdrawal movement from the workpiece bore.

In the operation of the machine, which will be apparent from the foregoing description, the grinding operation having been started and the grinding wheel being located within the bore of the workpiece, the grinding operation continues with the wheel reciprocating relative to the workpiece and with the cam 71 advanced clockwise for each reciprocation of the table until the screw 73 is engaged and moved upwardly by the cam 71 for procuring an extended movement of the table for the dressing operation on the grinding wheel. Movement of the screw 73 procures a shifting movement of the bar 84 to the left, thereby bringing the end of the arm 125 into a position for engagement with the end of the arm 128. When the reversing members 25 and 33 are next moved clockwise by the reversing dog 21, this movement occurring when the grinding wheel is at the inner end of the workpiece, the downward movement of the arm 125 on the member 33 rocks the bell crank lever 88 clockwise and withdraws the arm 89 from the notch 90. This permits the arm 92 to move to the right, elevating the dog 22 to permit the table to move beyond its normal reciprocatory position and, at the same time shifting the valve 111 to the right to provide fluid connection from the pump 34 to the cylinder 117 for procuring a downward swinging movement of the dressing tool support. Fluid connection to the cylinder 117 thus occurs when the grinding wheel reaches the inner end of the workpiece and, as the dressing tool support swings downwardly, the roller 123 engages with the cam 122 and the dressing tool is accordingly moved slowly into operative position, being guided by said cam. The dressing tool is carried over the periphery of the grinding wheel and the movement of the table is then reversed by the dog 101 for restoring the grinding wheel and workpiece to operative position for completion of the grinding operation.

After the grinding wheel and workpiece are restored to operative position after the dressing operation, the grinding continues with the grinding wheel given a further crossfeed movement until the screw 74 is engaged and elevated by the cam 71, thereby shifting the bar 84 further to the left to bring the end of the arm 125 into alinement with the end of the arm 130 for turning movement of the latter when the reversing member 33 is given its next clockwise turning movement. This clockwise turning movement of the arm 33 occurs when the table is at the right hand end of its reciprocatory movement with the grinding wheel at the inner end of the workpiece and this shifting movement of the member 33 allows the depending arm 133 to swing to the right, thereby elevating the arm 98 to render the dogs 22 and 101 inoperative for a runout of the table to the left to rest position. The swinging movement of the arm 133 also shifts the valve 108 to render the fluid pressure back-off mechanism operative, thereby avoiding contact between the wheel and the work during the runout. The back-off is accordingly procured when the grinding wheel is at the inner end of the workpiece by the arm 125 which is rendered operative by mechanism under the control of the crossfeed movement.

With reference now to Fig. 6, the crossfeed mechanism, instead of being actuated by the table reciprocations as above stated, is hydraulically actuated, as by mechanism of the type shown in the Blood & Burns Patent No. 2,027,627. To this end the transverse movement of the cross-slide is obtained by rotation of the crossfeed screw 137

(see also Fig. 7) which engages an internally threaded portion, not shown, of the cross-slide, the latter being mounted on a bridge similar to the bridge 4 above described, which spans the guideways on which the table is reciprocated. The crossfeed screw has a gear 138 on the forward end thereof which meshes with a pinion 139 secured against turning movement on a shaft 140 journalled in a casing 141 in which the crossfeed mechanism is positioned, the casing being mounted on the forward end of the bridge. The pinion 139 during the crossfeed movement of the table is rotated in unison with a ratchet wheel 142 which is positively rotated by fluid under pressure, as hereinafter described. The rotation of the pinion 139 procures, through rotation of the crossfeed screw, a transverse movement of the grinding wheel relative to the work-supporting structure to cause a cutting action on the workpiece.

As shown in Fig. 7, the shaft 140 has journalled thereon an annular member 143 having an integral pinion 144, and a vertically extending rod 145, Fig. 6, has rack teeth 146 which are held in engagement with the pinion 144 by a roller 147 journalled on a pin 148 secured in the casing 141. The rod 145 is reciprocated vertically by fluid under pressure for procuring, during its upward movement, a lateral or crossfeed movement of the wheelhead 3, and during its downward movement a retraction of the crossfeed movement. Again referring to Fig. 7, the sleeve 143 has a flange 149, against which an annular member 150 is clamped by a threaded nut 151 engaging a portion of the member 143. The member 150 thus rotates with the member 143 during a crossfeed movement of the wheelhead or a retraction thereof.

The annular member 150 has spaced studs 152 and 153, Figs. 6 and 8, secured by nuts 152' and 153' to said member. Said studs provide pivotal suports for pawls 154 and 155 normally maintained resiliently in engagement with the ratchet wheel 142 by a spring 156. The pawl 155 procures clockwise turning movement of the ratchet wheel in response to a corresponding clockwise rotation of the pinion 144 and the pawl 154 procures counterclockwise turning of the ratchet wheel when the pinion 144 is turned counterclockwise.

During the crossfeed movement of the grinding wheel a pin 157 on the pawl 154 is brought into engagement with a shield 158 adjustably positioned in the casing 141. Said shield withdraws the pawl from engagement with the ratchet wheel 142 without affecting the crossfeed movement of the wheelhead. During the subsequent retraction of the crossfeed movement by counterclockwise rotation of the pinion 144 the annular member 150 is allowed to turn counterclockwise relative to the ratchet wheel, the pawl 154 being inoperative until the pin 157 has been moved out of engagement with the shield 158. During the remainder of the retracting movement the ratchet 142 and member 150 rotate in unison and thus procure a retraction of the grinding wheel from operative position. The relative movement between the member 150 and the ratchet 142 provides for a compensation for the reduction in size of the grinding wheel, as will be apparent.

The rod 145, by which the pinion 144 is rotated, is actuated as above stated by fluid under pressure. Referring to Fig. 9, the rod 145 is a continuation of a piston rod 159 secured to a piston 160 in a cylinder 161, the latter being mounted, as shown in Fig. 6, on the base of the machine. Fluid under pressure from a pump 162 is directed through a conduit 163 to a channel 164 in a casing 165 which has a longitudinal bore in which a valve member 166 is slidable, this valve member corresponding in general to the valve 108 above described. The channel 164 is substantially diametrically opposite to a channel 167 which is connected by a conduit 168 to a port 169 in a casing 170. This casing has a bore in which a valve 171, corresponding in general to the valve 111 above described is slidable.

A channel 172 in the casing 170 is open at one end to the bore at a point substantialy opposite to the port 169 and at the opposite end opens into the bore at a point opposite to the port 173. A throttle valve 174 is provided in the channel 172. The port 173 is connected by a conduit 175 to the lower end of the cylinder 161, an adjustable throttle 176 being positioned in the conduit 175, if desired, for controlling the rate of crossfeed movement. A port 177 intersects the channel 172 substantially midway between the opposite ends of the channel and this port is directly opposite port 178 which is connected by a conduit 179 to a port 180 in a casing 181.

With the valves 166 and 171 in the position shown, these being the positions of the valves at the beginning of the grinding operation, fluid under pressure is admitted to the conduit 175 from the pump for actuating the crossfeed mechanism, the fluid passing around a reduced portion of the valve 166 and a reduced portion of the valve 171. A second reduced portion of the valve 171 provides fluid connection between the channel 172 and the port 173.

The conduit 175 has a branch conduit 182 communicating with a port 183 in a casing 184 having a plunger 185 slidable therein. A port 186 in the casing 184 is longitudinally spaced from the port 183 and is connected by a conduit 187 to a port 188 in the upper end of the cylinder 161. A conduit 189 provides connection between the conduit 187 and a channel 190 in the casing 165. The inner end of the channel 190 intersects the bore in the casing 165 and fluid connection through this channel to an exhaust port 191 in the casing 165 is normally provided by a reduced portion of the valve 166. The valves 166 and 171 being in the position shown, an upward movement of the piston 160 is caused by fluid under pressure entering the lower end of the cylinder 161, thereby procuring a crossfeed movement of the grinding wheel.

The function and shifting movements of the valves 166 and 171, so far as they control the movements of the table, are fully described in the Blood & Burns application Serial No. 631,334, filed July 20, 1933, now Patent No. 2,011,705. For the purposes of the present application it will be sufficient to note that the casing 165, Fig. 9, has a port 192 spaced from the port 164 and connected by a conduit 193 to a port 194 in the casing 181. This casing has a longitudinal bore in which the main throttle valve 195 is positioned and this valve has a longitudinal recess 196 which is open at the inner end of the bore in which the valve is located to communicate with a port 197 in the end of the casing. This port is connected by a conduit 198 to the inlet port of the casing 36' for the reversing valve 28'. The throttle valve has a rectangular notch 199 in line with the port 194. The throttle valve is also provided with a V-shaped notch 200 adjacent the port 180, thereby providing for adjustment of the flow

of fluid from the conduit 179 to the reversing valve. The throttle valve 195 has a forwardly projecting valve stem 201 which projects through the cover plate of the control box on the front of the machine and has a lever, not shown, on the front end thereof, for manual adjustment of the valve. During the operative reciprocation of the table with the grinding wheel reciprocating relative to the surface of the workpiece, fluid is directed through the notch 200 by passing around the reduced portion of the valve 171 which provided fluid connection between the ports 169 and 178.

In this modification the grinding operation is under the control of the crossfeed movement and to this end the annular member has mounted thereon a cam 71' which, during grinding operation, is advanced clockwise with the member and moves into engagement successively with the ends of adjustable screws 73' and 74' carried by an arm 75' of a bell crank lever 76' which is journalled on the stud 66'. The other arm 77' of the bell crank lever 76' is connected by a link 78' to an arm 79' secured to a shaft 80' journalled in the casing 57. The shaft 80' has mounted thereon a depending arm 82' which is connected to a horizontally slidable bar 84'. The left hand end of this bar projects into the control box and is shifted to the left, upon engagement between the cam 71' and either of the screws 73' or 74', for actuating the control mechanism.

The control mechanism of this modification is similar to that above described. It is sufficient to note for purposes of this modification that the lever 88', Fig. 6, has one end 89' thereof in a position for engagement with a notch 90' in a lug 91' carried by a depending arm 92'. The latter is journalled on a shaft 93' in the box 87' and is urged counterclockwise by a spring 94'. A bell crank lever 95', also journalled on a shaft 93', in the box 87' is urged counterclockwise by a spring 94'. A bell crank lever 95' also journalled on the shaft 93' has a depending arm 96' which engages with a pin 97' on the arm 92'. The opposite arm 98' of the lever 95' projects upwardly between the lugs 26' and 27' of the reversing lever and has a cam surface on its upper end for engagement with the reversing dog 22'.

The reciprocating table 1' is shifted by fluid under pressure, as hereinafter described, and the reciprocation is under the control of reversing dogs 21' and 22' carried by blocks 23' and 24' on the table. The dogs alternately engage and shift a reversing lever 25' having an integral arm 33'. The reversing lever is suitably connected to the reversing valve 28' for shifting the latter, thereby directing fluid under pressure to alternate ends of the cylinder 41' which is mounted within the base of the machine. A piston 42' within the cylinder has a projecting piston rod 43' suitably connected to the table and fluid connection from the reversing valve to opposite ends of the cylinder is provided by conduits 39' and 40'.

In accordance with the present invention the arm 33' has a stud 124' on which is pivotally mounted an arm 125', the latter being normally urged counterclockwise by a spring 126'. In the normal position of the arm 125' it is out of engagement with the depending arm 128' of the bell crank lever 88', the arm 125' resting against a pin 129, on the bar 84'. When the screw 73' is elevated by the cam 71' causing movement of the bar 84' to the left, the end of the arm 125' is in a position for engagement with the arm 128' when the reversing lever 25' is next shifted clockwise. Clockwise shifting movement occurs when the table is at the right hand end of its normal reciprocatory movement at which time the grinding wheel is at the inner end of the workpiece bore.

When the arm 125' engages the arm 128' the elver 88' is rocked to remove the end 89' from engagement with the notch 90' to allow the depending arm 92' to move to the right, thereby elevating the arm 98' to render the reversing dog 22' inoperative and simultaneously to shift the valve 171 to the right for causing a movement of the dressing tool into operative position and for discontinuing temporarily the hydraulic crossfeed movement.

For discontinuing the crossfeed movement during the dressing operation, the valve 171 has a full-sized portion, which, when the valve is shifted to the right, closes the port 173, thereby preventing the entry of fluid under pressure to the cylinder 161 below the piston 160 while the valve 171 is in its right hand position. When the valve 171 is restored to its original position, during the return of the grinding wheel and workpiece to operative relation, fluid connection is again established through the port 173 to the cylinder 161 for procuring a further crossfeed movement.

The dressing tool is moved downwardly into operative position by a piston 116' slidable in a casing 117' connected by a conduit 118' to a port in the valve casing 165 and a similar port directly opposite is connected by a conduit 119' to the valve casing 170. The valve 171 has a full sized portion which normally cuts off the flow of fluid from the conduit 168 to the conduit 119', but when the valve 171 is shifted to the right, fluid connection between these two conduits is established to allow fluid under pressure to enter the casing 117' for moving the dressing tool into operative position. The connection between the piston 116' and the dressing tool carrier may be, for example, that shown in the above mentioned Blood Patent No. 1,971,848. The shifting of the valve 171 also directs fluid under pressure through the throttled channel 172 for reducing the rate of travel of the table during the dressing operation.

After the dressing tool has been carried past the grinding wheel during the extended movement of the table to the left, the reversing dog 101' carried by the block 103' on the table engages and shifts the reversing lever 25' for reversing the table movement. During the subsequent movement of the table to the right to restore the grinding wheel and workpiece to operative relation, the arm 98' is moved downwardly into inoperative position by a pivotally mounted dog 104' carried by the block 103'. Downward movement of the arm 98' involves a corresponding movement of the arm 92' to the left substantially to its original position, where it is held by a latch 105' fully described in the Blood & Burns Patent No. 2,011,705, above referred to.

The return of the arm 92' to its original position following the dressing operation returns the valve 171 substantially to the position of Fig. 9, thereby cutting off the flow of fluid to the casing 117' for permitting the dressing tool support to be returned to its inoperative position by the cam and roller arrangement similar to that described in Fig. 1.

After the grinding wheel and workpiece have

been returned to operative relation following the dressing operation the grinding action continues with the crossfeed movement again being hydraulically procured until the cam 71' engages and elevates the screw 74' to procure a second extended movement of the table for axially separating the grinding wheel and workpiece. This second extended movement of the table results from a further movement of the bar 84' to the left, thereby moving the arm 125' into a position for engagement with the depending arm 130' of a bell crank lever 131' located directly in back of the bell crank lever 88'. This bell crank lever, as above described, has an integral latch corresponding to the arm 89' of the lever 88' which normally engages in a notch 132' provided by a depending arm 133' corresponding to the arm 92'. The arm 133' is urged counterclockwise by a spring corresponding to the spring 94' and upon swinging movement to the right procures a corresponding upward movement of the arm 98', this elevating movement being higher than during the previous upward movement of the lever, thereby rendering both dogs 22' and 101' inoperative to allow the table to move to its extreme right hand position, where it is brought to rest.

The lower end of the arm 133' engages with the valve 166 to shift said valve to the right, thereby establishing fluid connection from the pump through the conduit 189 to the upper end of the cylinder 161 for a retraction of the crossfeed movement. When fluid enters the upper end of the cylinder 116, fluid under pressure is also directed to the upper end of the casing 184 to shift the plunger 185 downwardly, establishing fluid connection between the port 183 and an exhaust port 202 for the exhaust of fluid under pressure from the underside of the piston 160. Fluid connection from the pump to the conduit 189 is provided by a channel 203 provided in the valve 166.

Although the operation of the modified machine disclosed in Figs. 6 to 9 inclusive, will be apparent from the foregoing description, it will be briefly summarized. After the grinding operation has been started with the grinding wheel positioned in the bore of the workpiece, the grinding continues in the usual manner until the cam 71' has engaged and elevated the screw 73', thereby shifting the bar 84' to the left, Fig. 6, carrying therewith the lower end of the arm 125'. During the subsequent clockwise movement of the reversing lever 25' when the table is at the right hand end of its movement, the arm 125' rocks the lever 88, thereby procuring an extended movement of the table to the left by rendering inoperative the reversing dog 22'. The valve 171 is simultaneously shifted to the right, procuring movement of the dressing tool into operative position, and also temporarily interrupting the hydraulically actuated crossfeed movement.

After the dressing tool has been carried past the grinding wheel the reversing dog 101' shifts the reversing lever and causes the table to return to operative position, the arm 98' and the valve 171 being restored to original position during the return movement of the table. The return of the valve 171 allows the dressing tool to be returned to inoperative position and again sets the crossfeed mechanism in operation.

Grinding continues subsequent to the dressing operation until the cam 71' elevates the screw 74', thereby shifting the arm 125' still further to the left into a position for engagement with the arm 130' when the reversing lever 25' is subsequently rocked clockwise at the right hand end of the table travel. The arm 130' is a part of the lever 131' and movement of this lever releases the depending arm 133' for again elevating the arm 98' and for shifting the valve 166 to the right. Elevation of the arm 98' causes the table to move to the left to inoperative position and movement of the valve 166 procures a retraction of the crossfeed movement.

From the foregoing it will be apparent that the present invention provides for setting in operation the mechanism which procures the movement of the dressing tool into operative position only when the grinding wheel is at the inner end of the workpiece, so that the dressing tool during its movement into operative position will be guided by the same cam which subsequently returns the dressing tool to inoperative position. The mechanism which actuates the dressing tool is set in operation by the reversing member through which the table movements are procured, and is actuated when the reversing member is shifted at one end of the table movement. The same mechanism which procures the movement of the dressing tool at the desired point, also may be used for setting other mechanism in operation when the grinding wheel is at the inner end of the workpiece. Such other mechanism may be the structure by which the back-off of the grinding wheel is obtained. Where the crossfeed movement is independent of the reciprocations of the table the present invention provides for causing the changes in the grinding operation to take place at one end of the normal reciprocation of the table rather than independently thereof, as would occur if the changes in the grinding operation were under the control of the crossfeed mechanism without any interconnection between the control mechanism and the reversing means for the table movement.

I claim:

1. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, actuating means for said control means automatically operative at a predetermined point in the grinding operation and independently of the position of the table, and cooperating means between said actuating means and said reversing means for procuring actuation of said control means by said actuating means only at one end of the table movement.

2. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, actuating means for said control means automatically operative at a predetermined point in the grinding operation and independently of the position of the table, and means associated with the reversing means and providing a connection between said actuating means and said control means for actuating said control means only in response to movement of said reversing means.

3. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for pro-

curing a change in the grinding operation, actuating means associated with said reversing means for rendering said control means operative in response to shifting of said reversing means, means for procuring a crossfeed movement between said members, and means under the control of the crossfeed movement for shifting said actuating means into operative position.

4. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, actuating means associated with said reversing means for rendering said control means operative in response to shifting of said reversing means, means independent of the table reciprocations for procuring a crossfeed movement between said members, and means under the control of the crossfeed movement for shifting said actuating means into operative position.

5. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, means for procuring a crossfeed movement between said members, means responsive to said crossfeed movement for actuating said control means, and means associated with the reversing means and providing a connection between said actuating means and said control means whereby said actuating means procures actuation of said control means only in response to movement of said reversing means.

6. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, means independent of the table reciprocations for procuring a crossfeed movement between said members, means responsive to said crossfeed movement for actuating said control means, and means associated with the reversing means and providing a connection between said actuating means and said control means whereby said actuating means procures actuation of said control means only in response to movement of said reversing means.

7. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, a latch for holding said control means in inoperative position, and means automatically operative during the grinding operation and actuated in response to movement of the reversing means at one end of the table movement for tripping said latch.

8. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, a latch for holding said control means in inoperative position, means for procuring a crossfeed movement between said members, and means rendered operative in response to said crossfeed movement and actuated by movement of said reversing means at one end of the table movement for tripping said latch.

9. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, a latch for holding said control means in inoperative position, actuating means for said latch carried by said reversing means, and means automatically operative during the grinding operation for shifting the actuating means into latch engaging position.

10. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table on which one of said members is mounted for procuring a relative movement therebetween, reversing means for said table, control means for procuring a change in the grinding operation, a latch for holding said control means in inoperative position, actuating means for said latch carried by said reversing means, means for procuring a crossfeed movement between said members, and means responsive to said crossfeed movement for shifting the actuating means into latch engaging position.

11. In a grinding machine, a grinding member, a work-supporting member, a reciprocatory table for one of said members for procuring a relative movement therebetween, a dressing member mounted for movement relative to the grinding member in response to the table movement, said dressing member having an inoperative and an operative position in alinement with the position of the grinding member, reversing means for said table, control means for procuring movement of the dressing member into operative position, means for procuring a crossfeed movement between the grinding member and the work-supporting member, means on said reversing means for rendering said control means operative, and means responsive to the crossfeed movement for shifting said last means into operative position.

12. In a grinding machine, a grinding member, a dressing member having an inoperative and operative position in alinement with the periphery of the grinding member, a reciprocatory table for one of said members for procuring a relative movement therebetween, reversing means for said table, control means for procuring movement of the dressing member into operative position, a cam in fixed relation to the grinding member for moving the dressing member out of operative position, and means on the reversing means for rendering said control means operative to procure movement of the dressing member into operative position at one end of the table movement, whereby said cam will guide the dressing member into operative position.

13. In a grinding machine, a grinding member, a work-supporting member, a table on which one of said members is mounted and whose movement procures a relative axial movement between said members, reversing means for reversing the direction of movement of the table, automatic control means for interrupting the normal reciprocatory movements of said table, a latch for normally retaining said control means in an inoperative position, means for procuring a crossfeed movement between said members, means on said reversing means for actuating said

latch, and mechanical elements adapted to be shifted in response to the crossfeed movement for rendering said last means operative.

14. In a grinding machine, a grinding member, a dressing tool member having an inoperative and an operative position, a table on which one of said members is mounted for procuring a relative movement therebetween to carry the dressing tool past the grinding wheel, cam means moving the dressing tool out of operative position, other means for moving the dressing tool into operative position, reversing means for reversing the direction of movement of said table, and means on said reversing means for rendering said other means operative.

15. In a grinding machine, the combination with a grinding wheel, a dressing tool having an operative and an inoperative position, a table for procuring a relative movement between said parts, means including a reversing member and reversing dogs for reversing the direction of movement of said table, cam means for moving the dressing tool out of operative position, actuating means for shifting the tool into operative position, and control means for said actuating means, of means associated with said control means and forming a part of the reversing means to provide for actuation of said control means only at one end of the table movement, said cam being positioned to guide the tool into operative position.

16. In a grinding machine, the combination with a grinding member, a work-supporting member, a table on which one of said members is mounted for procuring a relative movement therebetween, a dressing tool having an operative and an inoperative position and mounted for movement relative to the grinding member in response to the table movement, means including a reversing member for reversing the direction of movement of said table, cam means for moving the dressing tool out of operative position, actuating means for shifting the tool into operative position, and control means for said actuating means, of means associated with said control means and forming a part of the reversing means to provide for actuation of said control means only at one end of the table movement, and means automatically operative during the grinding operation for rendering said last means operative.

17. In a grinding machine, the combination with a grinding member, a work-supporting member, a table on which one of said members is mounted for procuring a relative movement therebetween, a dressing tool having an operative and an inoperative position and mounted for movement relative to the grinding member in response to the table movement, means including a reversing member for reversing the direction of movement of said table, cam means for moving the dressing tool out of operative position, actuating means for shifting the tool into operative position, control means for said actuating means, and means for procuring a crossfeed movement between said members, of means associated with said control means and forming a part of the reversing means to provide for actuation of said control means only at one end of the table movement, and means responsive to the crossfeed movement to render said last means operative.

18. In a grinding machine, a grinding member, a work-supporting member, a reciprocating table on which one of said members is mounted for procuring a relative movement between said members, reversing means for the table, control means for procuring a radial separation between said members and simultaneously an axial separation therebetween by an extended movement of the table, actuating means associated with said reversing means for rendering said control means operative in response to shifting of said reversing means, means for procuring a crossfeed movement between said members, and means responsive to said crossfeed movement for shifting said actuating means into operative position.

ALFRED P. BURNS.