United States Patent

[11] 3,590,534

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[21] Appl. No. **779,424**
[22] Filed **Nov. 27, 1968**
[45] Patented **July 6, 1971**
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[54] **WHEEL WEAR COMPENSATION**
6 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **51/165,** 51/5
[51] **Int. Cl.** **B24b 49/18**
[50] **Field of Search** 51/165, 165.01, 165.04, 165.09, 165.14, 165.15, 165.18, 5

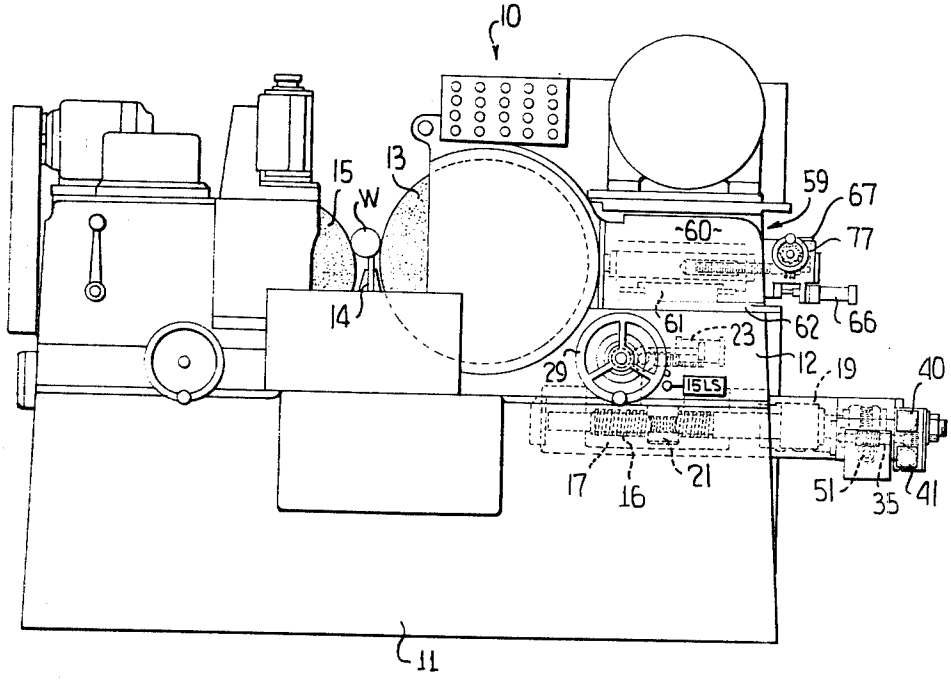
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ABSTRACT: A single compensating feed increment device advances the wheel to compensate first for wear and then for truing. A counter is set for a predetermined number of wheel feed increments, some of which are used to compensate for wheel wear, others to compensate for dressing. During grinding, a post process gauge actuates the increment feed to advance the wheel support each time work size reaches a predetermined oversize amount short of the oversize limit. Each increment of advance is equal to the amount of oversize correction for which the gauge is set. Each such advance is counted by the counter. A truing operation is performed after a predetermined number of pieces has been ground. In response to the truing signal, the increment feed is actuated to advance the wheel support by the remaining increments of the predetermined number for which the counter was set. The truing tool advances a predetermined number of increments equal to the total increment advance of the wheel, and reduces wheel radius by the amount equal to the wheel advance by said remaining increments.



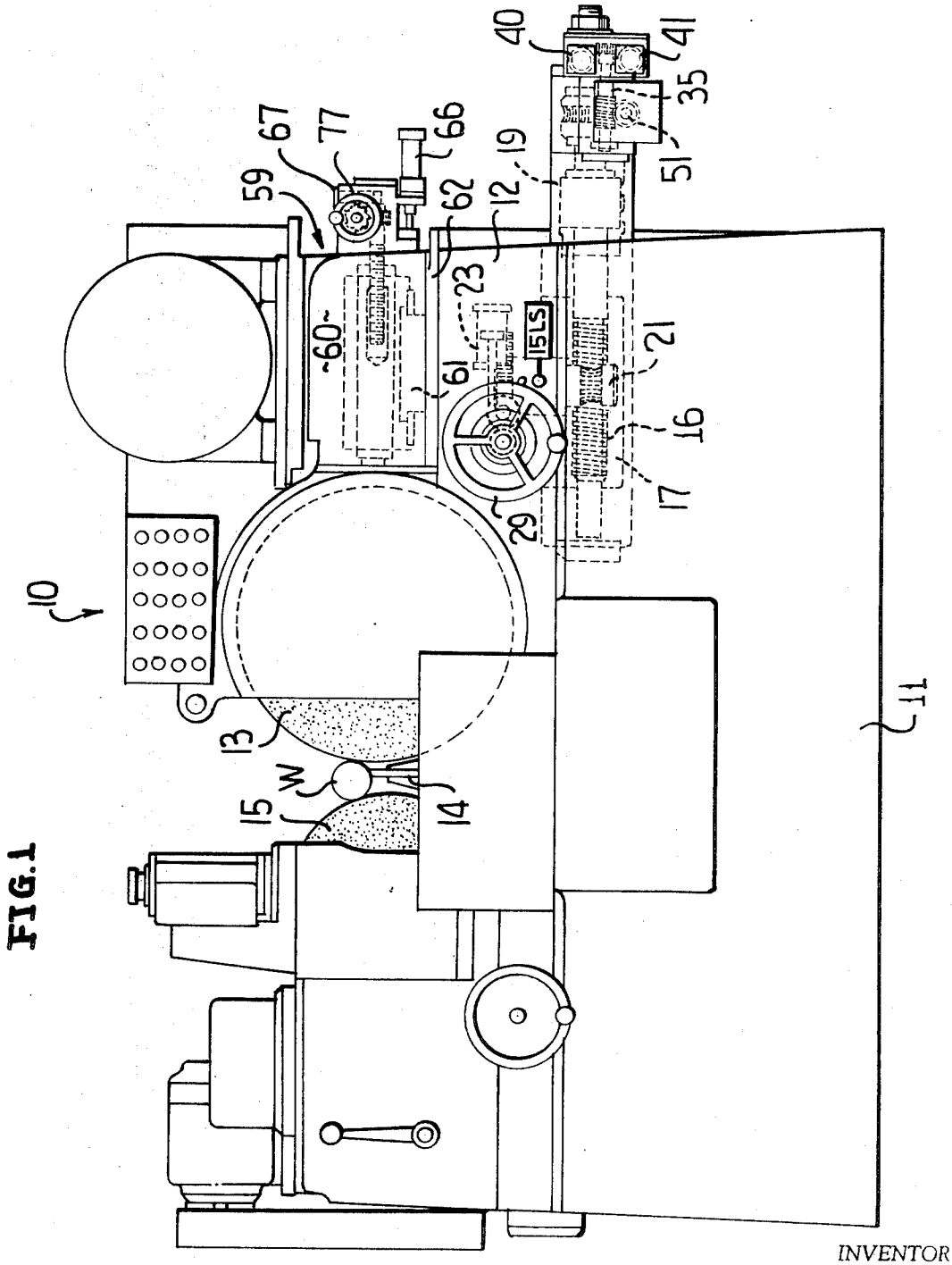
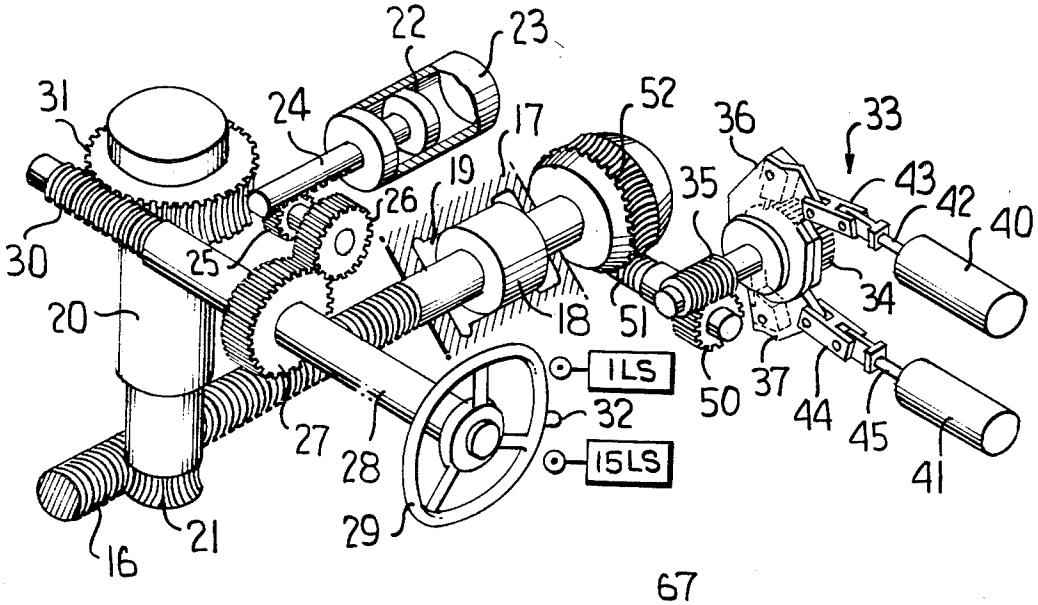


FIG. 1

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FIG.2



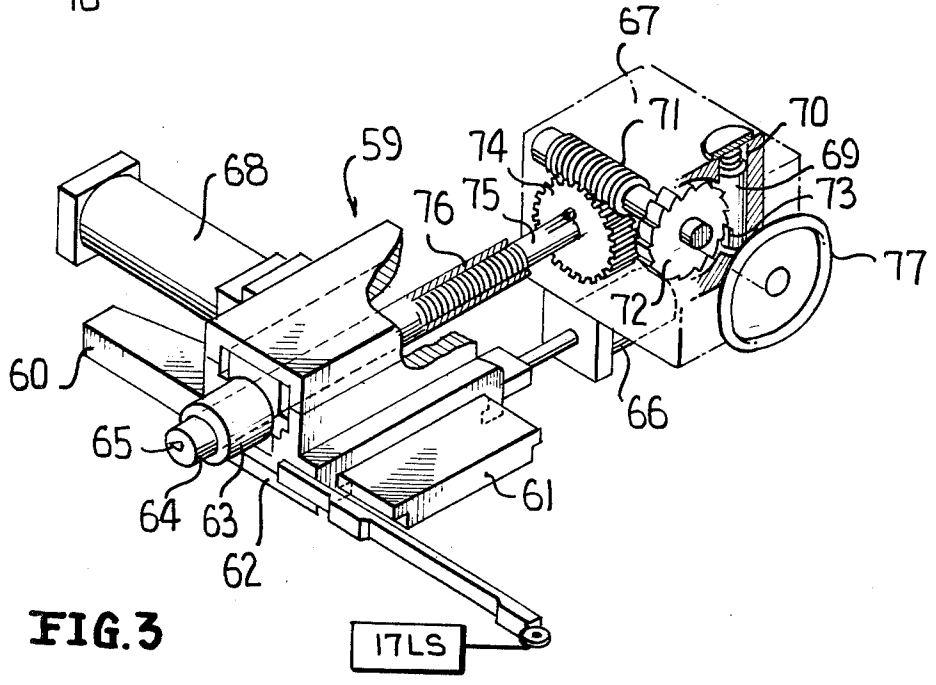


FIG.3

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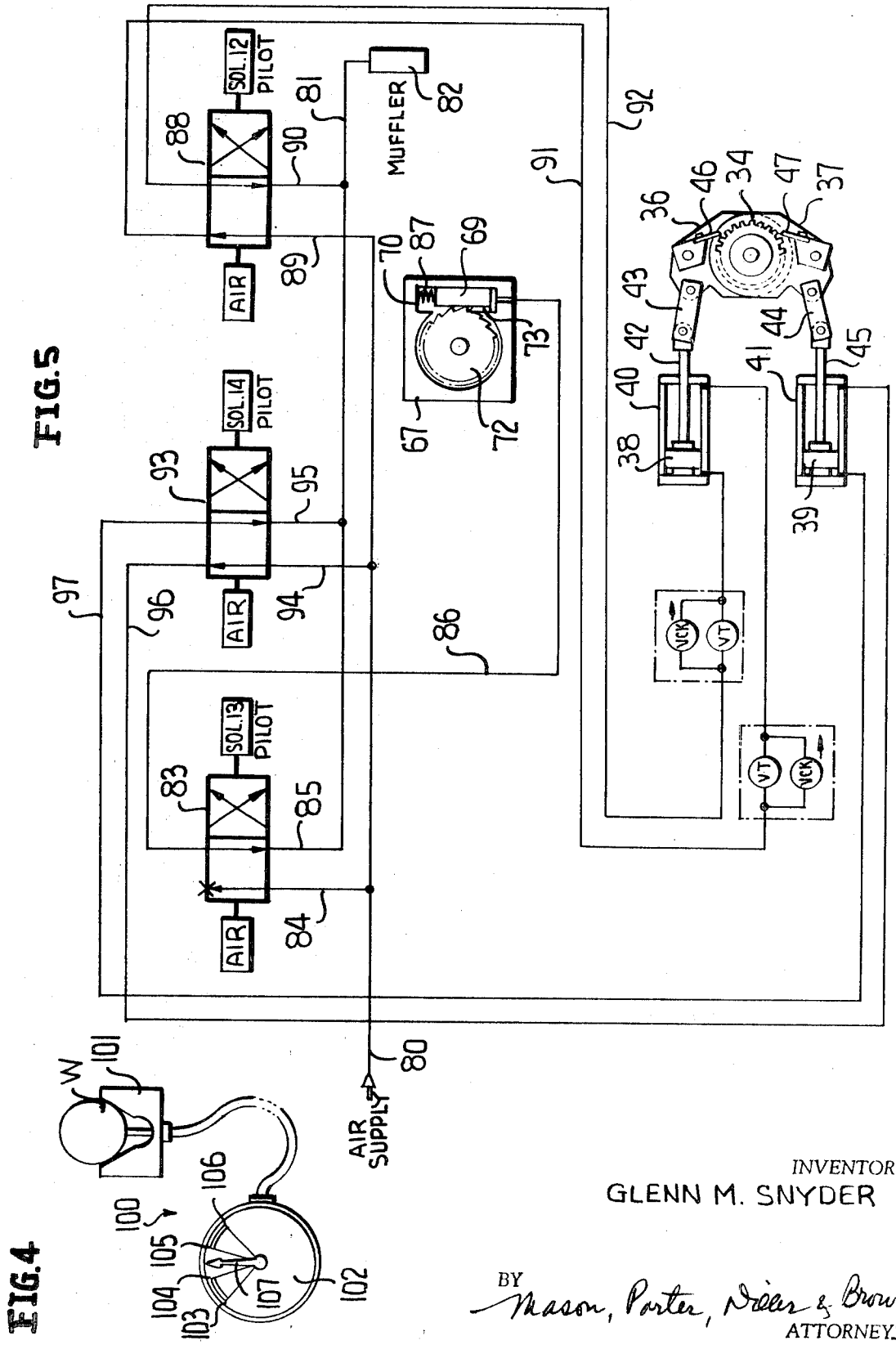


FIG.5

FIG.4

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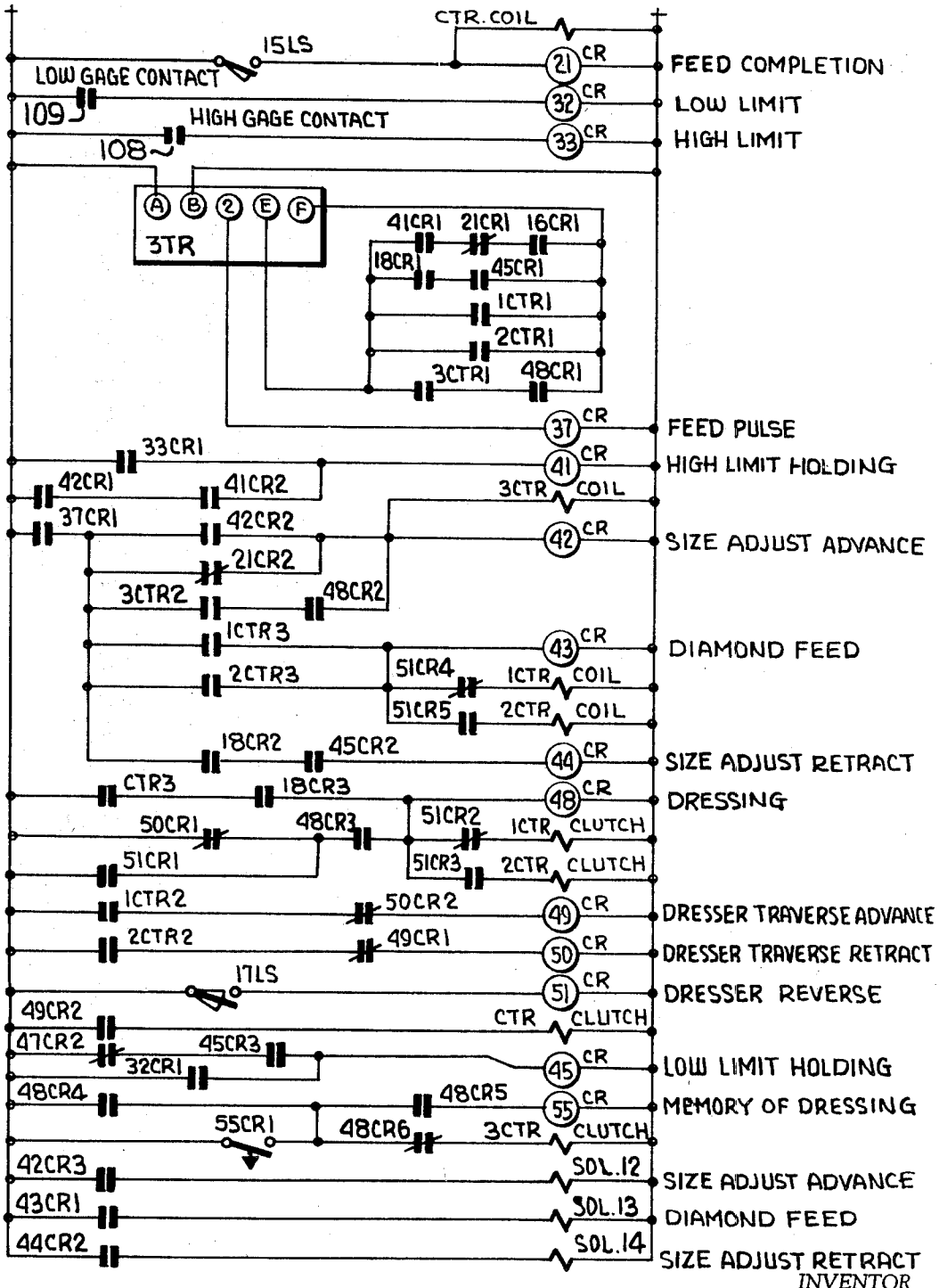


FIG.6

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WHEEL WEAR COMPENSATION

This invention relates to grinding machines, and more particularly, to an apparatus for controlling the compensating feed movement of the grinding wheel support between truing operations which are customarily performed. The wheel support is advanced or retracted an increment of feed following a signal from a post process gauge when a workpiece approaches the high or low limits of the gauge during the grinding cycle to correct for wheel wear.

Also, in accordance with this invention during the truing operation, the amount of compensating feed for the wheel support will be a preselected number of increments minus the number of increments deducted for each advance of the wheel support, to realign the preset amount of truing tool feed with the total amount of wheel advance.

Prior to this invention, a truing operation was controlled by a truing interval counter to effect the occurrence of the truing operation after a predetermined number of workpieces were ground. During this operation, the grinding wheel was advanced a predetermined amount to compensate for the advance of the truing tool and for the reduction in diameter of the grinding wheel due to the truing operation.

Since the above-described truing method does not compensate for wheel wear, the advance of the diamond tool by a specific amount does not change the size of the grinding wheel by the same amount. The grinding wheel is actually advanced more than its radius is reduced by turning. Therefore, workpieces would be ground undersize following the truing operation.

In accordance with the present invention, means are provided to automatically compensate for wheel wear during the grinding cycle. A post process gauge provides a signal to advance the wheel support to compensate for wheel wear when a workpiece approaches the oversize gauge limit. This wheel feed increment will deduct a count from the preselected number of counts on the compensating feed counter.

During the dressing operation, the grinding wheel will be advanced the remaining number of the preselected increments. The truing tool will be advanced an amount equal to the total number of increments preset on the dresser advance counter, which realigns the truing tool with the face of the grinding wheel.

Compensating feed can also be furnished on manual machines by providing a hand operated switch to effect compensation for wheel wear. Means to advance the wheel support would be effected in a similar manner previously described. However, the frequency of wheel wear correction would be determined when the measured workpieces approached the oversize limits.

From the foregoing, it will be readily apparent that the primary object of this invention is to maintain uniform workpiece size automatically through repetitive wheel truing operations.

Another object of this invention is to provide means to advance or retract the wheel support and increment of feed automatically between truing operations to improve size control limits.

Still another object of this invention is to eliminate overcompensation for wheel wear resulting in undersize workpieces following a truing operation.

Yet another object of this is to cancel the effect of grinding variables such as wheel wear, changes in machine temperature, wheel action and variations in workpieces which effect size tolerances, roundness and finish.

A further object of this invention is to increase production by eliminating manual adjustments of the wheel feed handwheel to maintain constant tolerances.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims and the several views illustrated in the accompanying drawings:

IN THE DRAWINGS:

FIG. 1 is a front view of a centerless grinder incorporating the compensating feed and automatic wheel truing mechanism of this invention.

FIG. 2 is a schematic perspective view showing the specific details of the feed mechanism for the wheel support.

FIG. 3 is a schematic perspective view of the specific details of the dresser and the feed for the truing tool thereof.

FIG. 4 is a schematic view showing basically the details of a post process gauge utilized in accordance with this invention.

FIG. 5 is a combined fluid and mechanical diagrammatic view showing the relationship of various elements of the grinder.

FIG. 6 is a wiring diagram for the grinder.

Referring now to the drawings in detail, it will be seen that there is illustrated in FIG. 1 the overall details of the grinder in which this invention is incorporated, the grinder being generally identified by the numeral 10. Basically, the grinder 10 includes a bed 11 on which there is mounted for transverse movement a wheel support 12 which has mounted thereon a removable grinding wheel 13. The grinding wheel 13 is carried by a rotatable spindle (not shown) in a conventional manner.

There is mounted on the bed 11 in a conventional manner an upstanding and longitudinally extending work support 14. It is to be noted that the general axis of the work support 14 is parallel to the axis of the grinding wheel 13.

There is also associated with the work support 14 and the grinding wheel 13 a regulating wheel 15. It is to be understood that the support for the regulating wheel 15 of a centerless grinder is normally tilted to form a helix angle with the grinding wheel to direct workpieces through the machine. The specifically illustrated centerless grinder 10 is of a type having a conventional feed for workpieces wherein workpieces are fed into the front of the machine and are removed from the front of the machine with the longitudinal position of workpieces being in part controlled by the feed mechanism. As a result, the regulating wheel 15 has the support thereof tilted so as to urge workpieces, such as the workpiece W, towards the front of the grinder 10.

It is to be understood that the feed mechanism or loader for the workpiece W, which may be of the ram type, will advance an unground workpiece into grinding position between the regulating wheel 15 and the grinding wheel 13 with the workpiece W being supported by the work support 14. The loader will also cooperate with the regulating wheel 15 to longitudinally position the workpiece W. After the grinding operation has been completed the ground workpiece will be moved by the loader into a gauging position and an unground workpiece received thereby.

It will be readily apparent from FIG. 1 that movement of the grinding wheel 13 towards and away from the work support 14 and the regulating wheel 15 controls the diameter of the workpiece being ground. It will also be readily apparent that the diameter of the grinding wheel 13 will control the diameter of the workpiece being ground with wheel wear resulting in an increase in diameter of the workpiece.

The mechanism for adjusting the position of the wheel support 12 relative to the bed 11 is shown in FIGS. 1 and 2. With particular reference to FIG. 2 at this time, it will be seen that the feed mechanism for the wheel support includes a feed screw 16 which is rotatably and slidably mounted in a feed shaft housing 17 which is attached to or forms a part of the bed 11. The feed screw 16 is secured to the rapid feed piston 18 which is mounted in a rapid feed cylinder 19 formed in the feed shaft housing 17.

The feed screw 16 is advanced or retracted by the piston 18 to effect rapid movement of the wheel support 12. The feed screw 16 is connected to the wheel support 12 through a vertical shaft 20 with is journaled in the wheel support 12 for rotation relative thereto and for transverse movement therewith. The vertical shaft 20 is provided at its lower end with a worm wheel 21 which is in operative engagement with the threads of the feed screw 16.

It will be readily apparent that when the feed screw 16 is axially reciprocated, the interlock between the worm wheel 21

and the feed screw 16 will provide an interlock of the wheel support 12 with the feed screw 16 whereby a like movement of the wheel support 12 will be effected.

The wheel support 12 is advanced at a fast rate by the movement of the piston 18 until a conventional limit switch (not shown) discontinues fluid flow into the cylinder 19 and transfers the feed of the wheel support 12 to a piston 22 and a cylinder 23. The piston 22 is secured to the feed rack 24 which, in turn, is in mesh with a pinion 25 which, in turn, is coupled to a driving gear 26. It is to be understood that the pinion 25 and the driving gear 26 are suitably rotatably mounted within the wheel support 12.

The driving gear 26 is in mesh with a driven gear 27 which may be directly mounted or connected through suitably gearing to a shaft 28 for a handwheel 29.

A wormshaft 30 is coupled to the hand wheel shaft 28 in a suitable manner, including a clutch (not shown) if desired, with the wormshaft 30 being meshed with a worm gear 31 coupled to the upper end of the vertical shaft 20.

It is to be understood that when the vertical shaft 20 is rotated by means of the worm gear 31, the wheel support 12 will move relative to the feed screw 16 and the bed 11. Thus, when feed of the wheel support 12 is shifted from the piston 18 and the cylinder 19 to the piston 22 and the cylinder 23, fast grinding feed continues. This fast grinding feed by means of the piston 22 and the cylinder 23 continues until the grinding wheel 13 contacts the workpiece W which results in the operation of a load control relay (not shown) or a limit switch 1LS is actuated by a pin 32 on the hand wheel 29 to reduce the flow of fluid to the cylinder 23. The piston 22 and the feedrack 24 continue to advance under the reduced flow of fluid which effect a slow grinding feed. The wheel support 12 continues to advance with the slow grinding feed continuing until a feed completion limit switch 15LS is actuated by the pin 32.

At this time it is pointed out that the handwheel 29, which is connected to the worm shaft 30, may be actuated manually or by power means (not shown) to move the wheel support 12 relative to the feed screw 16 and the bed 11.

The feed mechanism for the wheel support also includes a compensating feed mechanism which is generally identified by the numeral 33. The feed mechanism 33 includes a ratchet wheel 34 which is secured to an end of a worm shaft 35. Suitable detent means (not shown) releaseably engage the ratchet wheel 34 to hold it stationary. The ratchet wheel 34 has pivotally mounted thereon a pair of ratchet arms 36 and 37. As is best shown in FIG. 5, the ratchet arms 36 and 37 are positioned by means of pistons 38 and 39, respectively, of pneumatic cylinders 40 and 41. The piston 38 has a piston rod 42 thereof connected to the ratchet arm 36 by means of an intermediate link 43. A similar link 44 connects the piston rod 45 of the piston 39 to the ratchet arm 37.

The ratchet arm 36 is provided with a pawl 46 which is engaged with the ratchet wheel 34 to effect a clockwise rotation thereof, as viewed in FIG. 5 when the cylinder 40 is energized. In a like manner, the ratchet arm 37 is provided with a pawl 47 which engages the ratchet wheel 34 to rotate the same in a counterclockwise direction when the piston 41 associated therewith is energized. It is to be understood that the respective cylinders, ratchet arms and pawls, are so associated with the ratchet wheel 34 so as to rotate the ratchet wheel a predetermined increment upon each actuation or energization of the associated cylinder.

In order that the incremental rotation of the worm shaft 35 may result in the incremental advancement of the wheel support 12, the worm shaft 35 is meshed with a worm gear 50 (FIG. 2) which is carried by a wormshaft 51. The worm shaft 51 is, in turn, meshed with a worm gear 52 which is mounted on the feed screw 16 for rotation therewith but for relative sliding with respect thereto. At this time, it is pointed out that the worm shafts 35 and 51 are suitably rotatably journaled within the housing 17.

It will be readily apparent from FIG. 2 that when the ratchet wheel 34 is rotated, the feed screw 16 will be rotated a minute amount with the result that the reaction of the feed screw 16 relative to the vertical shaft 20 will effect a minute movement or adjustment of the wheel support 12. It is understood that the piston 38 will advance the wheel support and the piston 39 will retract the wheel support.

Referring once again to FIG. 1 in particular, it will be seen that there is mounted on the wheel support 12 adjacent the grinding wheel 13 a wheel truing device which is generally identified by the numeral 59. The wheel truing device 59, as is best shown in FIG. 3 includes a cross slide carriage 60 and is slidably mounted on a swivel base 61 which, in turn, is secured to a plate 62. The plate 62 is suitably mounted on the wheel support 12.

The carriage 60 supports a slidably mounted bar slide 63 which, in turn, houses a diamond bar 64. The diamond bar 64 supports a truing tool 65 which is preferably in the from of a diamond. The diamond bar 64 provides means for advancing and retracting the truing tool 65 relative to the grinding wheel 13 by means of a piston and cylinder assembly 66 secured to the underside of a housing 67 which is suitably mounted on the carriage 60.

Traverse movement of the truing tool 65 is effected through a traverse cylinder 68 which is fixedly mounted on the swivel base 61. It is to be understood that the cylinder 68 will effect movement of the truing tool 65 parallel to the axis of the grinding wheel 13 so as to dress the face thereof.

At this time, it is pointed out that the piston and cylinder assembly 66 is utilized for the purpose of advancing the truing tool 65 from a retracted position to an operative position prior to the operation of the cylinder 68 to traverse the truing tool 65 across the grinding wheel 13, and after the grinding wheel truing operation has been completed, the piston and cylinder assembly 66 is utilized to retract the truing tool 65 to an out of the way inoperative position.

Means are also provided for advancing the truing tool 65 and the diamond bar 64 a minute definite amount automatically at the start of a truing cycle and at the end of the first truing stroke of the truing tool 65 across the grinding wheel 13 for the return pass to true the grinding wheel 13.

The preset increment of feed of the truing tool 65 is obtained by means of a piston 69 which is mounted vertically within a cylinder 70 formed within the housing 67. The housing 67 also has rotatably journaled therein a wormshaft 71 which has mounted thereon a ratchet wheel 72. The piston 69 carries a pawl 73 which on each stroke of the piston 69 engages the ratchet wheel 72 and rotates or advances the ratchet wheel 72 a predetermined amount.

The wormshaft 71 is meshed with a feed gear 74 which is slidably secured on a diamond bar feed screw 75 for effecting the rotation thereof. The feed screw 75 is in threaded engagement with a nut 76 which is secured to the diamond bar 64 to incrementally advance the truing toll 65. The worm shaft 71 may also be rotated by a handwheel 77.

At this time it is pointed out that the design of the incremental feed for the truing tool 65 will be such so as to correlate the feeding of the truing tool 65 with the advance of the wheel support 12 by the compensating feed mechanism 33 so that the wheel support 12 may be automatically advanced to compensate for the amount dressed from the face of the grinding wheel 13 to thereby realign the wheel support 12 with the workpiece W at each truing operation, to maintain uniform workpiece size.

PNEUMATIC CONTROL SYSTEM

Referring now to FIG. 5, it will be seen that the pneumatic control system includes a main air supply line 80 to which there are coupled the cylinders 40, 41 and 70 for the purpose of actuating the pistons 38, 39 and 69, respectively thereof. It is also to be noted that the system includes a return line 81 which is connected to a muffler 82.

Reciprocation of the piston 69 is controlled by means of a valve 83 to which there is connected a supply line 84 leading

from the supply line 80. The valve 83 is also connected to the return line 81 by means of a line 85. A line 86 extends from the valve 83 to the lower end of the cylinder 70. At this time, it is pointed out that the piston 69 is always urged to a retracted lower position by means of a spring 87.

It is to be noted that the valve 83 is constantly urged by air pressure to a position wherein the line 86 is in communication with the return line 81. Normally the supply of air within the valve 83 is blocked off as indicated. The valve 83 is actuated by a solenoid SOL 13 which when energized, shifts the valve 83 to a position wherein the cylinder 70 is connected to the air supply line 80 and the piston 69 is urged upwardly through a predetermined stroke to advance the turning tool 65.

The actuation of the piston 38 to advance the wheel support 12 is controlled by means of a control valve 88. The control valve 88 is connected to the air supply line 80 by means of an air line 89 and to the return line 81 by means of a line 90. The valve 88 is also connected to the opposite ends of the cylinder 40 by means of lines 91 and 92.

It will be seen that the valve 88 is normally held by air pressure in a position wherein air under pressure is directed into the right-hand end of the cylinder 40 and the left-hand end of the cylinder 40 is connected to exhaust whereby the piston 38 is held in a retracted position. The valve 88 is provided with a control solenoid SOL 12 which, when energized, effects the shifting of the valve 88 so as to direct air under pressure to the left-hand end of the cylinder while exhausting the right-hand end of the cylinder so as to effect the movement of the piston 38 to the right and the rotation of the ratchet wheel 34 in a clockwise direction.

The movement of the piston 39 within the cylinder 41 is controlled by means of a valve 93. The valve 93 is connected to the air supply line 80 by means of a line 94 and to the return line 81 by means of a line 95. The valve 93 is also connected to the right-hand end of the cylinder 41 by means of a line 96 and to the left-hand end of the cylinder 41 by means of a line 97.

It is to be noted that the valve 93 is normally held by air pressure in the position wherein the right-hand end of the cylinder 41 is connected to the air supply line 80 so that the piston 39 is held in its retracted position. The valve 93 is provided with a control device in the form of a solenoid SOL 14. The solenoid SOL 14, when energized, serves to shift the valve 93 so as to communicate the left end of the cylinder 41 with the air supply line 80 while connecting the right-hand end of the cylinder 41 to exhaust. This results in the shifting of the piston 39 to the right end of the cylinder 41 and a controlled rotation of the ratchet wheel 34 to retract the wheel support 12 a predetermined increment.

POST PROCESS GUAGE

Referring now to FIG. 4, it will be seen that there is schematically illustrated a post process gauge assembly which is generally identified by the numeral 100. The gauge 100 includes a caliper 101 of a conventional construction for automatically gauging a workpiece W when it is positioned relative to the caliper 101 by the loader of the grinder 10. The caliper 101 is electrically connected to a combination indicator and contact unit which is identified by the numeral 102 and which is also conventional. It is also to be understood that the indicator 102 has four control points thereon, the control points being identified by the numerals 103, 104, 105 and 106. When a pointer 107 of the indicator 102 is positioned between the control points 103 and 106, the gauged workpiece W is within the tolerable limits for the workpiece. However, it is preferred to retain the pointer 107 between the points 104 and 105. In accordance with this invention, when the pointer 107, during the gauging of a workpiece, moves outside of the limits of the indicator points 104 and 105, the compensating feed mechanism 33 will be actuated so as to advance or retract the wheel support 12 accordingly.

ELECTRICAL CONTROLS AND OPERATION

It is first pointed out that in the normal operation of the grinder 10, after each workpiece is ground, the grinding wheel 13 is automatically retracted, a next workpiece is positioned relative to the work support 14 and the regulating wheel. The grinding wheel 13 is fed in the workpiece in a plunge grinding operation.

When wheel wear has progressed to the point where a workpiece has reached the high limit 105 of the indicator during a post process gauging thereof, a high guage contact 108 of the guage 100 closes to energize a high limit relay 33CR before the wheel support 12 is retracted. As a result, contact 33CR1 closes to complete a circuit to energize high limit holding relay 41CR which, in turn, effects the closing of contacts 41CR1 and 41CR2. It is to be understood that the relay 41CR retains the high limit signal until the wheel support 12 is again advanced, in a manner to be described hereinafter.

The wheel support 12 retracts automatically in a manner not a part of this invention, the finished ground workpiece is unloaded, an unground workpiece is loaded into the machine, and the wheel support 12 automatically is advanced towards the workpiece when an infeed relay (not shown) is energized in a conventional manner.

An infeed relay contact 16CR1 closes to complete a circuit through contact 41CR1 and normally closed contact 21CR1 to energize a pulsing timer 3TR. The pulsing timer 3TR energizes a feed pulse relay 37CR for a predetermined interval.

Contact 37CR1 closes to complete a circuit through normally closed contact 21CR2 to energize a size adjust advance relay 42CR and a compensating feed counter coil 3CTR.

The counter 3CTR is preset for a number of anticipated compensating feed increments to correct for wheel wear during the grinding cycle. Included are one or more feed increments for the reduction of the wheel diameter of the truing operation. The feed increments are effected through the pulsing of contact 37CR1 until pulsing timer 3TR is deenergized. Contact 42CR2, in parallel with normally closed contact 21CR2, closes to hold relay 42CR energized.

Contact 42CR3 closes to complete a circuit to energize the size adjust advance solenoid SOL 12 which, when energized, shifts the valve 88 to the left to direct fluid pressure from air supply line 80 to the left end of the feed pulse advance cylinder 40. The piston 38 is shifted to the right in the cylinder 40 to effect the wheel support movement through the ratchet wheel 34. The ratchet wheel 34 rotates the feed screw 16 to advance the wheel support 12 an increment of feed.

Each time a workpiece is ground, the feed completion limit switch 15LS is tripped by the pin 32 to effect retraction of the wheel support 12 after a timed sparkout interval. After a predetermined number of workpieces have been ground, the dressing interval count coil CTR counts out and contact CTR 3 closes to complete a circuit through contact 18CR3 which closes when wheel support 12 is retracted to energize a dressing relay 48CR.

The relay 37CR is energized when contact 48CR1 closes in the circuit with counter contact 3CTR1 which was closed from completion of the previous dressing cycle. Contacts 37CR1 and 48CR2 are closed in a circuit with previously closed contact 3CTR2 to energize relay 42CR which advances wheel support 12 by whatever counts are remaining of the total number of counts from which the counter coil 3CTR was set.

Contact 48CR3 closes to complete a circuit through normally closed contact 50CR1 and 51CR2 to energize a dresser advance feed pulse clutch 1CTR. Contact 1CTR1 closes to complete a circuit through pulsing timer 3TR which energizes relay 37CR.

Contact 37CR1 pulses and energizes the diamond feed relay 34CR and dresser advance feed pulse coil 1CTR. Contact 43CR1 closes to complete a circuit to energize diamond feed solenoid SOL 13, which as previously described shifts the valve 83 to the left to direct fluid from the air supply line 80

into the lower end of the cylinder 70 to advance the diamond feed piston 69 which operates the ratchet wheel 72.

It is to be understood that the dresser advance feed pulse coil 1CTR pulses until a preselected number of counts are obtained, after which contact 1CTR2 is closed to complete a circuit through normally closed contact 50CR2 to energize dresser traverse advance relay 49CR to effect dresser traverse.

Contact 49CR2 is closed to energize CTR clutch to reset the dressing integral count coil CTR. Contact 1CTR1 will now open to deenergize relay 37CR.

The truing tool 65 continues to traverse across the grinding wheel face until a dresser reverse limit switch 17LS (FIG. 3) closes to energize dresser reverse relay 51CR. Contact 51CR2 opens to deenergize 1CTR clutch and to reset the dresser advance pulse count coil 1CTR. Contact 51CR3 closes to energize dresser retract feed pulse clutch 2CTR.

Contact 2CTR1 closes to energize pulsing timer 3TR and relay 37CR. Contact 37CR1 will pulse to energize relay 43CR and dresser and retract feed pulse coil 2CTR. The diamond or truing tool 65 advances until feed pulse coil 2CTR counts out. Contact 2CTR1 will open to deenergize pulsing timer 3TR and relay 37CR.

Contact 2CTR2 closes to complete a circuit through normally closed contact 49CR1 to energize the dresser traverse retract relay 50CR.

Contact 2CTR3 will open to deenergize the diamond feed relay 43CR to prevent additional feeding of the truing tool 65.

Contact 43CR1 is opened to deenergize solenoid SOL 13 which returns the diamond feed solenoid valve 85 to its normal position, after which the truing tool 65 will be traversed across the face of the grinding wheel in the reverse direction until it reaches the rest position, at which time, the limit switch 17LS will again shift to deenergize relay 51CR. Contact 51CR1 will then open to deenergize dressing relay 48CR to complete the dressing cycle.

When relay 48CR was energized at the start of a dressing cycle, contacts 48CR4 and 48CR5 closed to complete a circuit to timing relay 55CR which provides a memory of the dressing cycle.

Normally closed contact 48CR6 was opened to prevent the compensating feed clutch 3CTR from being energized until the dressing relay 48CR is deenergized when the timed relay contact 55CR1 is closed. Contact 55CR1 is opened following a timed delay after relay 55CR is deenergized at the completion of the dressing cycle to energize compensating feed clutch 3CTR which resets the count coil 3CTR. Contacts 3CTR1 and 3CTR2 are closed in preparation for the next dressing cycle.

At the completion of the dressing cycle, the advance increments of wheel support 12 and truing tool 65 have compensated for both wheel wear and dressing.

It is also pointed out here that provision are made to retract the wheel support 12 if a workpiece should reach a low limit as indicated by the indicator 102 of the post process gauge 100. When the pointer 107 moves beyond the point 104 on the indicator 102, a low limit gauge contact 109 is closed to energize low limit relay 32CR before the wheel support 12 is retracted.

Contact 32CR1 closes to complete a circuit to energize low limit holding relay 45CR which retains the low limit signal until wheel support 12 is retracted. Contact 45CR3 closes to hold relay 45CR energized through normally closed contact 47CR2.

Wheel support retract contact 18CR1 closes to energize pulsing timer 3TR through contact 45CR1 when the wheel support 12 is retracted.

Relay 37CR is energized for a predetermined interval to provide a pulse signal to energize relay 44CR when contacts 18CR2 and 45CR2 are closed. Contact 44CR3 closes to complete a circuit to energize the feed retract solenoid SOL 14.

The wheel support 12 is retracted with each pulse of the solenoid SOL 14, as the valve 93 is shifted to the left to direct fluid under pressure into the left-hand end of the cylinder 41. The position 39 in the cylinder 41A is shifted to the right to effect the wheel support movement through the ratchet wheel 34.

AT this time it is pointed out that a relay (not shown), which relay is identified as relay 47CR, was energized to provide a holding signal of wheel support retraction when relay 44CR was energized to retract wheel support 12. At the completion of the low limit retraction correction, normally closed contact 47CR opens to deenergize relay 45CR. Contact 45CR1 is opened to deenergize the pulsing timer 3TR.

Contact 45CR2 is opened to deenergize relay 44CR, and contact 44CR2 is opened to deenergize solenoid SOL 14 so that the valve 93 may return to its normal position to direct pressure to the right-hand end of the cylinder 41 to retract the piston 39.

At this time it is pointed out that although this invention has been specifically illustrated and described in conjunction with a centerless grinder, it is to be understood that it is immaterial as to how the work is supported during the grinding operation. For example, the workpiece may be supported by suitable centers, a chuck, etc. during the grinding operation.

It is also pointed out here that although the invention has been specifically described and illustrated in conjunction with a plunger grinding operation, it is also feasible to utilize the same basic principles of this invention in conjunction with a grinder wherein there is no plunge grinding operation. It is merely necessary that the position of the wheel support be adjusted at a time when there is no workpiece in engagement with the grinder wheel.

Although only a preferred embodiment of the invention has been specifically illustrated and described herein, it is to be understood that minor variations may be made in the grinder construction without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. A grinding machine comprising
   a. a grinding wheel and grinding wheel support,
   b. a work support,
   c. means for moving said grinding wheel support toward and from said work support including
   d. a feed mechanism,
   e. a dressing device including
   f. a truing tool,
   g. means for effecting relative transverse and longitudinal movements between said truing tool and said grinding wheel to perform a dressing operation,
   h. a guage for measuring workpieces,
   i. wheel adjusting means for actuating said feed mechanism for adjusting said grinding wheel relative to said workpiece,
   j. said wheel adjusting means being operable in response to said gauge each time said gauge shows a predetermined approach to an off-size limit of a workpiece,
   k. means for incrementally actuating said wheel adjusting means to effect a predetermined compensation for wear of the grinding wheel as indicated by said gauge,
   l. an adjustment counter set for a predetermined number of increments of adjustment of said wheel support,
   m. and a work counter operable after a predetermined number of workpieces have been ground to advance said grinding wheel by the used number of said predetermined number of increments and for effecting transverse movement of said truing tool to adjust said truing tool by an amount equal to the adjustment of said grinding wheel by said predetermined number of increments.

2. The grinding machine of claim 1 having means operable after the advance of said truing tool to initiate said longitudinal movement to dress said grinding wheel by an amount corresponding to the adjustment of said grinding wheel by said remaining increments, whereby when said grinding wheel is advanced for the next grinding operation, it will be in position to grind a workpiece to nominal size.

3. The grinding machine of claim 1 wherein said means for effecting incremental feeding of said grinding wheel and said means for effecting transverse adjustment of said truing tool are both accomplished by ratchet type drive mechanisms.

4. The grinding machine of claim 1 wherein

a. said means for effecting incremental feeding of said grinding wheel and said means for effecting transverse adjustment of said truing tool are both fluid actuated means controlled by electrically positioned valves,

b. said adjustment counter and said work counters have electrical control components,

c. and there is an electrical control circuit coupling said

counters and said valves.

5. The grinding machine of claim 1 wherein said feed mechanism is operable to retract said grinding wheel after each grinding operation and to progressively feed said grinding wheel towards a next positioned workpiece.

6. The grinding machine of claim 1 wherein said feed mechanism is operable to retract said grinding wheel after each grinding operation and to progressively feed said grinding wheel towards a next positioned workpiece to a predetermined position to automatically grind a workpiece to a predetermined size.