Dec. 1, 1964 G. H. LOCKWOOD ETAL 3,158,965

APPARATUS FOR GRINDING

Original Filed Nov. 25, 1959 3 Sheets-Sheet 1

FIG. 1.

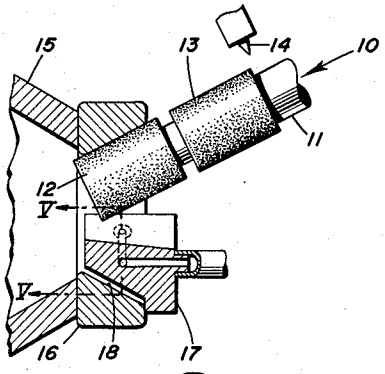


FIG. 5.



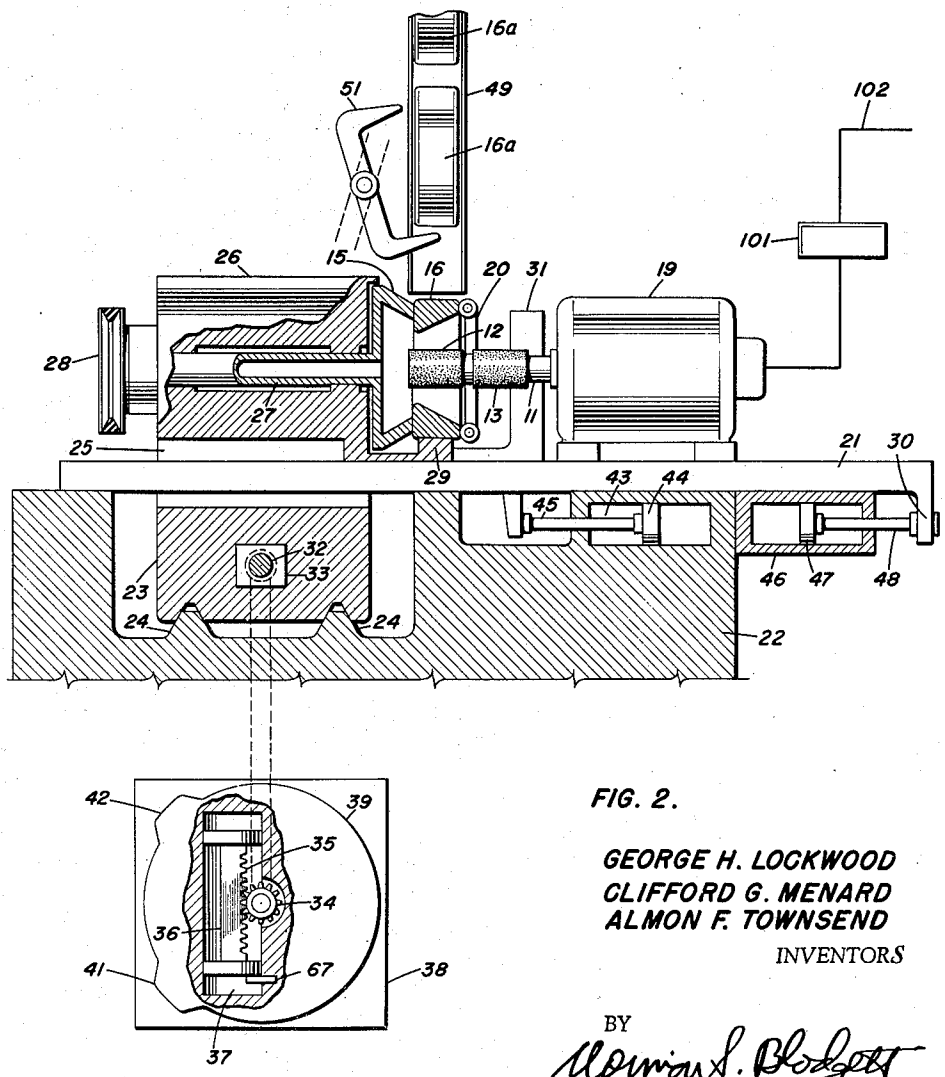


FIG. 2.

GEORGE H. LOCKWOOD
CLIFFORD G. MENARD
ALMON F. TOWNSEND
INVENTORS

BY

Marion L. Blodgett

ATTORNEY

Dec. 1, 1964 G. H. LOCKWOOD ETAL 3,158,965

APPARATUS FOR GRINDING

Original Filed Nov. 25, 1959 3 Sheets-Sheet 2

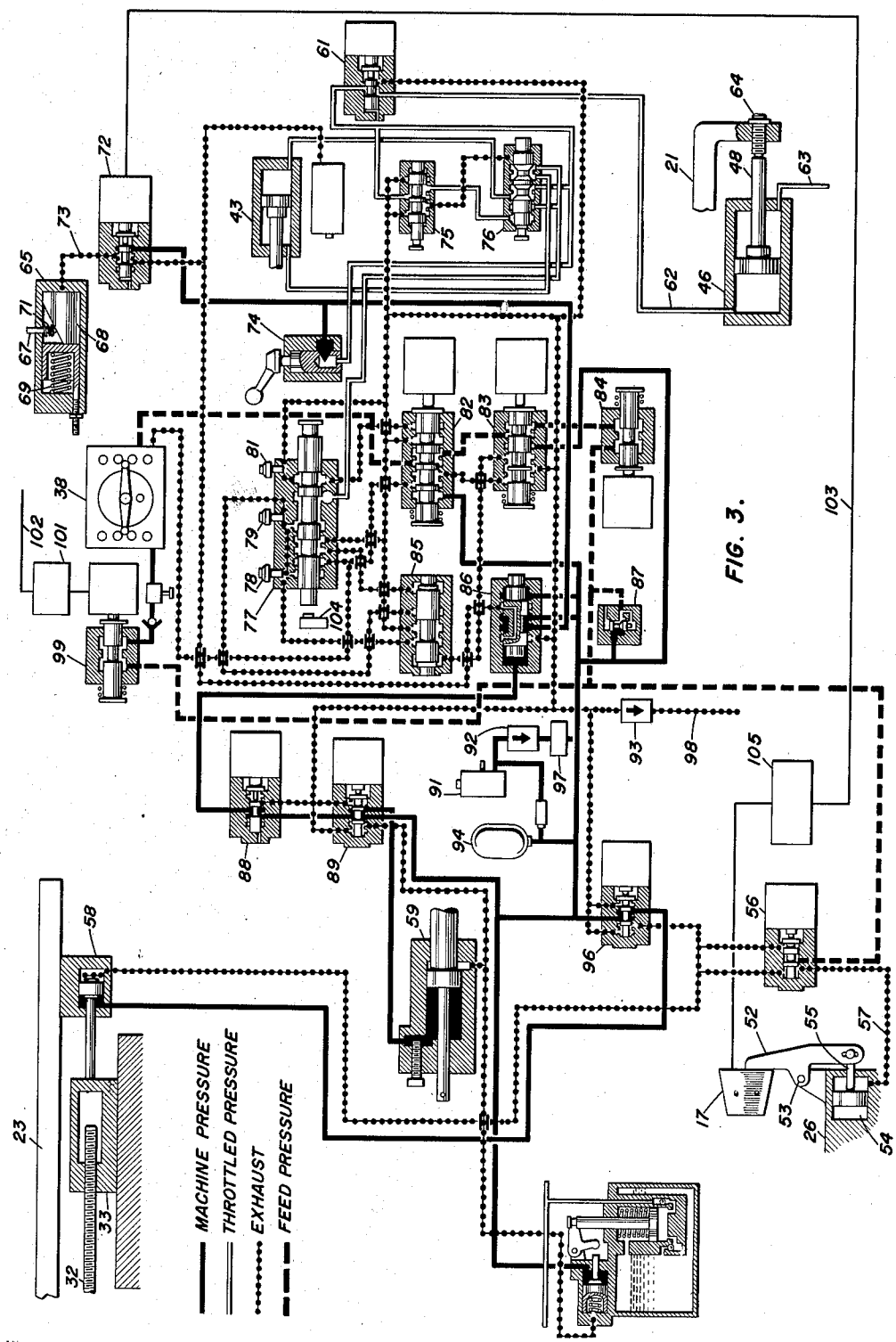


FIG. 3.

	WHEEL 12	WHEEL 13	VALVE 56	VALVE 99	VALVE 72	VALVE 61
1 LOAD WORKPIECE AND DRESS BOTH WHEELS	NO CONTACT WITH WORKPIECE	NO CONTACT WITH WORKPIECE	GAGE CYL. CONNECTED TO EXHAUST	CLOSED	CONNECTS STOP CYL. TO EXHAUST	JACK CONNECTED TO PRESSURE
2 RAPID IN-FEED	CONTACT WITH WORKPIECE	"	"	OPEN	"	"
3 PLUNGE FOR ROUGH GRIND	"	"	"	CLOSED	"	"
4 SPARKOUT (NO FEED)	"	"	"	"	PRESSURE OIL TO STOP CYL.	"
5 BACKOFF	NO CONTACT WITH WORKPIECE	"	"	"	STOP CYL. TO EXHAUST	EXHAUST OIL TO JACK
6 FINISH GRIND WITH RECIPROCATION	"	CONTACT WITH WORKPIECE	PRESSURE OIL TO GAGE CYL.	"	"	"

FIG. 4.

GEORGE H. LOCKWOOD
CLIFFORD G. MENARD
ALMON F. TOWNSEND
INVENTOR.

BY Norman L. Blodgett
ATTORNEY

United States Patent Office 3,158,965 Patented Dec. 1, 1964

3,158,965

APPARATUS FOR GRINDING

George H. Lockwood, Worcester, Clifford G. Menard, Shrewsbury, and Almon F. Townsend, Worcester, Mass., assignors to The Heald Machine Company, Worcester, Mass., a corporation of Delaware

Continuation of application Ser. No. 855,361, Nov. 25, 1959. This application Oct. 8, 1962, Ser. No. 230,787
3 Claims. (Cl. 51—5)

This invention relates to an apparatus for grinding and more particularly to machine for removing metal from a workpiece by abrasion. This is a continuation of patent application Serial Number 855,361, filed Nov. 25, 1959, now abandoned.

In the grinding of workpieces it is quite important that the cycle of operation be completed as quickly as possible on each individual workpiece. This is because the grinding machine presents a considerable capital investment; the more work flowing through it, the more efficiently the capital is being used. In the past, a fairly fast cycle has been evolved in grinding machines by providing for automatic loading and automatic feeding of the abrasive wheel through its cycle. Since it is necessary in the final finish grinding portion of the cycle to have a freshly-dressed wheel, attempts to shorten the cycle have always been limited by the necessity of removing the wheel from the workpiece and moving it past the dressing diamond before returning it to the workpiece for the final operation. This drawbar of the prior art has been obviated in a novel manner by the present invention.

Another object of this invention is the provision of a grinding machine capable of operation with a very short cycle.

A further object of the present invention is the provision of a grinding cycle in which it is not necessary to provide time for the dressing of the wheel.

It is another object of the instant invention to provide apparatus wherein rough grinding may take place by a plunge grinding operation immediately followed by a finish grinding operation with longitudinal wheel reciprocation without loss of quality and without the necessity for dressing the wheel between the two operations.

It is a further object of the invention to provide an internal grinding machine having a gauge which need not be removed from the bore of a workpiece during the entire cycle of operations.

A still further object of this invention is the provision of an air gauging head capable of higher accuracy and accurate operation, which may occupy the bore of a workpiece upon which an internal grinding operation is being performed at the same time that the abrasive wheel resides in the same bore.

It is a still further object of the present invention to provide a grinding machine in which gauging takes place without interruption during the entire cycle and in which the entire cycle of grinding operations takes place without the necessity of interruption for a dressing operation.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

FIG. 1 is a horizontal sectional view through the axis of the workpiece of a grinding machine incorporating the principles of the apparatus of the present invention,

FIG. 2 is a somewhat schematic vertical sectional view of the grinding machine,

FIG. 3 is a schematic diagram of the hydraulic system and associated equipment of the machine,

FIG. 4 is a chart showing the condition of the important elements of the machine at certain points in the grinding cycle, and

FIG. 5 is a sectional view of a gage forming part of the invention taken on the line V—V of FIG. 1.

For the purposes of this description, the expression "longitudinal" will be used to indicate a direction in the direction of the axis of the abrasive wheel, while the expression "transverse" will be used to indicate a direction at a right angle to the axis of the wheel.

Referring first to FIG. 1, wherein is best shown the work area of the invention, the grinding machine, indicated generally by reference numeral 10, is shown as having a spindle 11 on which are mounted a first wheel 12 and a second wheel 13. The first wheel 12 is mounted at the outboard or free end of the spindle 11 while the second wheel 13 is mounted inwardly of the end in spaced relationship to the first wheel; the surfaces of the wheels are concentric and of the same diameter. A diamond 14 is mounted besides the path taken by the wheels as the spindle is moved axially. A drive platen 15 presses against one end of a workpiece 16, which is shown as consisting of the outer race of a tapered roller bearing. A crescent-shaped air gauge 17 resides within the tapered bore 18 of the workpiece at the same time that the wheel lies in the bore performing a grinding operation.

FIG. 2 is a vertical sectional view of the machine showing most of the important operating elements; the spindle 11 carrying the first wheel 12 and the second wheel 13 is mounted in and rotated by the wheelhead motor 19 which is mounted on a wheelhead table 21. The table is mounted on ways formed on the upper surface of a base 22, the slide motion being in the direction of the axis of the spindle 11. A workhead table 23 is mounted on ways 24 for movement transversely of the axis of the spindle. The table 23 is provided with a bridge 25 through which the wheel head table 21 is permitted to extend. On the upper part of the bridge is the wheelhead 26 in which is rotatably mounted a hollow drive spindle 27 having the drive platen 15 attached to one of its ends. On the other end of the drive spindle 27 is mounted a pulley 28 by which the spindle is rotated. Extending from the wheel head 26 is a supporting shoe 29 which contacts the outer cylindrical surface of the workpiece 16 in the manner commonly used in centerless grinding. A pressure member 20 is mounted to contact the end of the workpiece 16 opposite the end contacted by the drive platen 15; this pressure member consists of a yoke which carries pressure rolls adapted to contact the outer end of the workpiece. A dresser 31 carries the diamond 14 and is mounted on the workhead table 23. The workhead 26 is moved transversely of the axis of the spindle by means of a feed screw 32 which is indirectly connected to the base and which passes through a nut 33 mounted in the workhead table 23. The feed screw is connected (as indicated in the drawing by dotted lines) at its outer end to a gear 34 which, in turn, engages a rack 35 formed on the outer surface of a feed piston 36 which piston is slidable in a bore 37 formed in a feed box 38. Also connected to the outer end of the feed screw 32 is a disk 39 having cams 41 and 42 formed on its outer periphery. The motion of the wheel head 19 and its table 21 relative to the base 22 is brought about by a cylinder 43 having a piston 44 and a piston rod 45 connected to the table 21. A hydraulic jack 46 is also mounted on the base and is provided with a piston 47 and a piston rod 48 located for engagement on occasion with an ear 30 extending downwardly from the table 21. Overlying the work area is a loading chute 49 containing a number of

unfinished workpieces 16*a* which are released one at a time by means of an escapement mechanism 51.

FIG. 3 shows the general hydraulic arrangement of the machine. It can be seen that the crescent-shaped gauge 17 is mounted on the upper end of a crank arm 52 which is pivoted at its central part on a horizontal pivot pin 53 extending transversely of the axis of the workpiece. An actuating cylinder 54 located in the workhead holds a piston rod 55 which is attached at its outer end to the lower end of the crankarm 52. The cylinder 54 is provided with a solenoid valve 56 to which it is connected by a hydraulic line 57. The workhead table 23 is shown in connection with the feed screw 32; a back-off cylinder 58 connects the nut 33 to the table to provide an additional motion in the line of feed, as will be explained more fully hereinafter. A cylinder 59 is connected to the pressure member 20. It can be seen that a solenoid valve 61 is connected to the jack 46 by a hydraulic line 62. A drain line 63 is connected to the outboard end of the jack 46. It should also be noted that a screw adjustment 64 is provided to permit adjustment of the contact between the piston rod 48 and ear 30 of the wheelhead table 21.

A stop feed mechanism 65 is provided within the feed box 38 and has a retractable peg 67 which extends into the bore 37 in position to be engaged by the end of the feed piston 36; this peg is also shown in FIG. 2. The mechanism 65 is provided with a piston 68 having an inclined surface in engagement with the inner end of the peg 67 to move it outwardly. A suitable coil spring 69 tends to keep the piston 68 at the end of the mechanism which will permit the peg 67 to be moved inwardly. A coil spring 71 surrounds the peg 67 and causes it to be retracted within the cylinder at all times except when it is pressed outwardly by the piston 68. A solenoid valve 72 is provided for the control of fluid to the mechanism 65 and the two are connected by a hydraulic line 73. The table cylinder 43 is shown in place, as are many of the other usual elements of an internal grinding machine. For instance, a hand throttle 74 is shown. A pilot valve 75 is associated with a reverse valve 76. A sequence valve 77 is provided with a rough adjusting knob 78, a finish adjusting knob 79, and a dress adjusting knob 81, each serving to throttle a particular hydraulic line. A runout solenoid valve 82 is provided, as is a dresser solenoid valve 83 along with a sparkout solenoid valve 84. Also forming part of the hydraulic system is a transfer valve 85, a stop valve 86, and a feed pressure regulating valve 87. A table stop-and-start solenoid valve 88 is provided along with a loading solenoid valve 89, a relief valve 91, and check valves 92 and 93. An accumulator 94 is connected into the hydraulic circuit as well as a solenoid valve 96. A pump 97 is connected to the check valve 92 and supplies the system with pressure fluid; the check valve 93 is connected by a line 98 to a sump tank or the like (not shown). A solenoid valve 99 is connected to regulate the flow of oil from the feed box 38, the energization of the valve coil being under the supervision of a load control 101. All of these elements are connected in the usual way by hydraulic lines. The exact nature of the valves and their connections is not part of the present invention but constitutes the usual apparatus for accomplishing a conventional cycle in an internal grinding machine.

The manner of operating the apparatus will now be readily understood in view of the above description. First of all, the chart in FIG. 4 indicates rather clearly the general nature of the cycle used in this machine. At Step #1 on the chart, the workpiece is loaded into the machine and both wheels are dressed by the diamond. Both abrasive wheels 12 and 13 are, of course, out of contact with the workpiece; the gauge cylinder 54 is connected to exhaust by the solenoid valve 56; the solenoid valve 99, which is a by-pass to the feed side of the feed piston 36 during the rapid in-feed portion of the cycle, is closed; the feed stop solenoid valve 72 connects the cylinder 65 to exhaust, and the jack solenoid valve 61 connects the cylinder 46 to pressure. Then the machine enters a rapid in-feed portion of the cycle, Step #2, in which the valve 99 is open permitting a very fast rate of feed. In this portion of the cycle the wheels are out of contact with the workpiece. This second portion of the cycle is terminated when the wheel 12 contacts the workpiece, the feeding having taken place, of course, transversely of the spindle axis; this is the condition shown in FIG. 1. As the wheel 12 strikes the workpiece, the current builds up in the wheelhead motor 19 which current is measured by the load control 101 connected by an electrical line 102 to the valve, shutting it off. This load control 101 is similar to the one shown in Patent No. 2,722,648, issued on November 1, 1955. With the rapid in-feed terminated in this manner, Step #3 of the cycle begins. This is a plunge for rough grind and, in this condition, wheel 12 is in contact with the work and the metering valve associated with the dial 78 of the sequence valve 77 regulates the speed of feed. A gauging control 105 associated with the air gauge 17 determines when the proper point in the plunge has been completed and, through an electrical line 103, energizes the solenoid valve 72 thus causing the peg 67 to extend into the path of the feed cylinder 36 and stop feed at that point while permitting a sparkout. During this sparkout period, designated as Step #4 in the chart in FIG. 4, there is no feed of wheel 12 toward the workpiece, but continued rotation and grinding under the influence of the deflection forces permits the deflection in spindle to be relieved. This, of course, means that the bore will become larger and the gauge 17 will indicate this fact to the control 105 which, in turn, will de-activate the solenoid valve 72 at a predetermined bore size, retracting the peg 67; feed does not continue, however, because the stop valve 86 prevents it. At the same time, Step #5, the workhead is retracted until the wheel clears the surface of the workpiece and the solenoid valve 61 is actuated, thus connecting the jack 46 to exhaust and causing the spindle to move longitudinally so that the wheel 13 enters the bore of the workpiece. Then, during Step #6, feed is continued under control of the finish metering knob 79 along with reciprocation of the table cylinder 43 until the gauge 17 indicates that the workpiece has reached the finished size. At that time, the back-out cylinder 58 will be energized thus withdrawing the workpiece from the wheel and the table cylinder will be energized on a long stroke to move the spindle and abrasive wheels out of the workpiece. Step #1 begins again with the removal of the finished workpiece and the insertion of a new unfinished workpiece into the machine.

In general, then, the steps of the cycle involve (1) a load and dress, (2) a rapid in-feed, (3) a plunge-grind with the first wheel, (4) feed stop and sparkout to a predetermined minimum power value, determined by measuring the motor current, (5) a back-off sufficient to separate wheel 12 from the work, and (6) advancement of the wheel 13 longitudinally and the completion of the finish grind with the reciprocation of wheel 13. A new cycle begins with the removal of the finished workpiece and the introduction of an unfinished workpiece while the dressing of the wheels takes place.

More specifically, as the loading is completed, the table stop valve shifts to let the table come in toward the workhead and the workpiece. At that time, the runout solenoid valve 82 is de-energized and drops out. The table jack 46, operated by the solenoid valve 61 which is energized, stops the table with the first wheel in plunge-grinding position. Reciprocation cannot take place because the conventional reversing dogs on the grinding machine table are to the right of the reversing lever on the control box, this being the usual way of actuating the reverse valve 76. The transfer valve 85 has been shifted by the table stop valve thus putting the table into rapid

traverse. The table comes in against the extended table jack 46 and stops. Although the table has shifted the table speed or selector valve 77, there is no motion because the jack 46 serves to stall the table cylinder 43. With the shifting of the table speed control valve 77, a limit switch 104 is struck by the end of the plunger. This releases the back-off valve 96 and releases oil to the feed box 66. The power control box 101 permits the feed to enter rapidly because of oil by-passing through the solenoid 99 until the wheel begins to strike the workpieces. At this point the valve 99 is deenergized by the control 101 permitting normal rough plunge feed to start. The positive termination of this rough plunge grind is introduced by energization of the solenoid valve 72. The attainment of a predetermined size is relayed to the air gauge control 102 and this de-energizes the solenoid 72, stopping the feed. The load meter 101 senses the power decline and, when a predetermined lower limit of load is reached, it causes the workhead table to back off. The table backs off and pressure is released from the jack 46 so that the table moves into the second position by means of the table cylinder 43 and wheel 13 is within the bore. A back-off timer set for a tenth of a second is started and the back-off is released. At the end of the tenth of a second the finish feed starts. As the table moves into the second position (at which position the second wheel lies within the bore), the feed box 38 shifts to finish feed. When the final size is reached, as determined by the gauge 17, the stop feed solenoid valve 88 is de-energized, thus stopping the feed and starting a second timer. Grinding continues through a sparkout cycle and, after the spindle deflection has been relieved, the second timer times out and a third timer starts while the solenoid valve 88 is energized to resume feed. Fine feed continues until the air gauge 17 signals that the final size has been reached, although this finish point may have been reached during the timer operation. When this is done, the workhead slide 23 is backed off by the cylinder 58 and the solenoid valve 56 is energized, withdrawing the gauge from the workpiece. The dresser solenoid valve 83 is energized, thus stopping the feed and shifting the transfer valve 85. The table moves to the right for dress and, at the end of the dress, the table speed valve 77 is shifted and the limit switch 104 operated by the plunger of the valve 77 releases the table start valve 88 and shifts the valve stopping the table beyond the dress point. This energizes the runout solenoid valve 82 which retracts the hand wheel of the machine and energizes the loading solenoid valve 89. This starts the loading operation by energizing the cylinder 59 which is connected to the escapement mechanism 51, thus permitting an unfinished workpiece to drop into place and ejecting the finished workpiece. This also energizes the solenoid valve 61 to reset the jack 46 in the position shown in FIG. 3. At the end of the loading operation a limit switch associated with the loading apparatus signals the start of a new grinding cycle.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to complete all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent, is:

1. A grinding machine for finishing the surface of a tapered bore of a workpiece, comprising a workhead for supporting the workpiece and rotating it about the axis of the bore, a wheelhead having a rotatable spindle, a first and a second abrasive wheel mounted on the spindle in spaced relation, each wheel being longer than the bore, means for feeding the spindle transversely to bring the first wheel into contact with the surface of the bore for a plunge grind, means for terminating the feeding but continuing grinding by the first wheel to relieve spindle deflection, means for advancing the spindle longitudinally to bring the second wheel into contact with the surface of the bore, means for feeding the second wheel transversely for a finish grind, means for continuously gaging the bore during the finish grind, means responsive to the gaging for removing the wheels from the workpiece, a loading mechanism operative to replace the workpiece with another workpiece, a dresser, and a control apparatus for rendering the dresser operative to dress the wheels only while the loading mechanism is operative.

2. An internal grinding machine for finishing a bore, comprising a workhead for holding the workpiece, a wheelhead having a rotatable spindle, first and second abrasive wheels mounted at spaced points on the spindle, means for advancing the wheelhead and the workhead relative to one another to bring the first wheel into contact with the workpiece for a rough grind, means for moving the spindle to bring the second wheel into contact with the workpiece for a finish grind, a pneumatic gage fixedly mounted relative to the workhead and occupying the bore for continuous measurement during the finish grind, the gage having an outer surface adapted to lie adjacent the surface of the bore with air openings located thereon and an inner surface with a configuration to allow the entry of the spindle and wheels and to allow the engagement of the wheels with substantially the entire length of the surface of the bore, means responsive to the gage for removing the spindle and wheels from the workpiece, a loading mechanism operative after the last-named removing to replace the finished workpiece with an unfinished workpiece, a dresser, and a control apparatus for rendering the dresser operative to dress the wheels only while the loading mechanism is operative.

3. A grinding machine for finishing the surface of an internal surface of revolution in a workpiece, comprising a workhead for supporting the workpiece and rotating it about the axis of the surface of revolution, a wheelhead having a rotatable spindle, a first and a second abrasive wheel mounted on the spindle in spaced relation, means feeding the spindle transversely to bring the first wheel into contact with the surface of the bore for a plunge grind, means for advancing the spindle longitudinally to bring the second wheel into contact with the surface of the bore, means for feeding the second wheel transversely for a finish grind, means for continuously gaging the bore during the finish grind, means responsive to the gaging for removing the wheels from the workpiece, a loading mechanism operative to replace the workpiece with another workpiece, a dresser, and a control apparatus for rendering the dresser operative to dress the wheels only while the loading mechanism is operative.

References Cited in the file of this patent

UNITED STATES PATENTS

1,949,552	Taylor et al.	Mar. 6, 1934
1,952,458	Page	Mar. 27, 1934
2,585,533	Bryant et al.	Feb. 12, 1952
2,636,380	Van Dorn	Apr. 28, 1953
2,646,652	Blood	July 28, 1953
2,826,909	Schmidt et al.	Mar. 18, 1958
2,915,855	Thompson	Dec. 8, 1959
2,927,406	Terp	Mar. 8, 1960
2,932,130	Blood et al.	Apr. 12, 1960
2,963,829	Werth	Dec. 13, 1960

FOREIGN PATENTS

669,887	France	Aug. 12, 1929
794,127	Great Britain	Apr. 30, 1958