

Dec. 24, 1968

E. G. ROBILLARD ET AL

3,417,512

GRINDING MACHINE

Filed Aug. 17, 1966

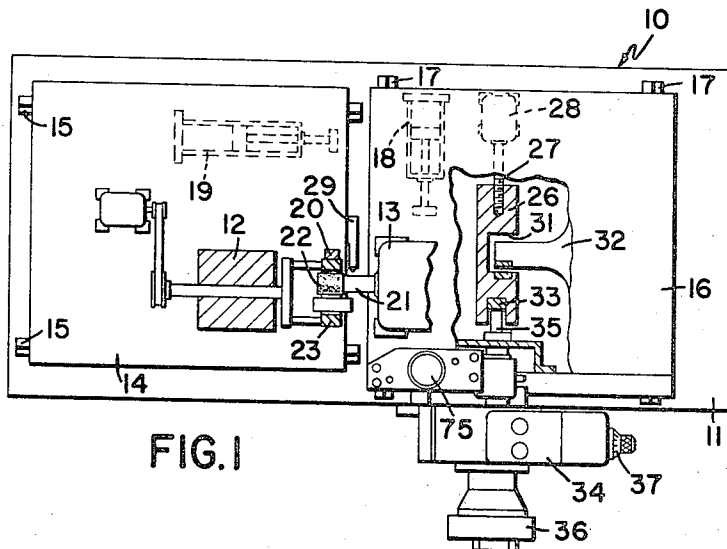


FIG. 1

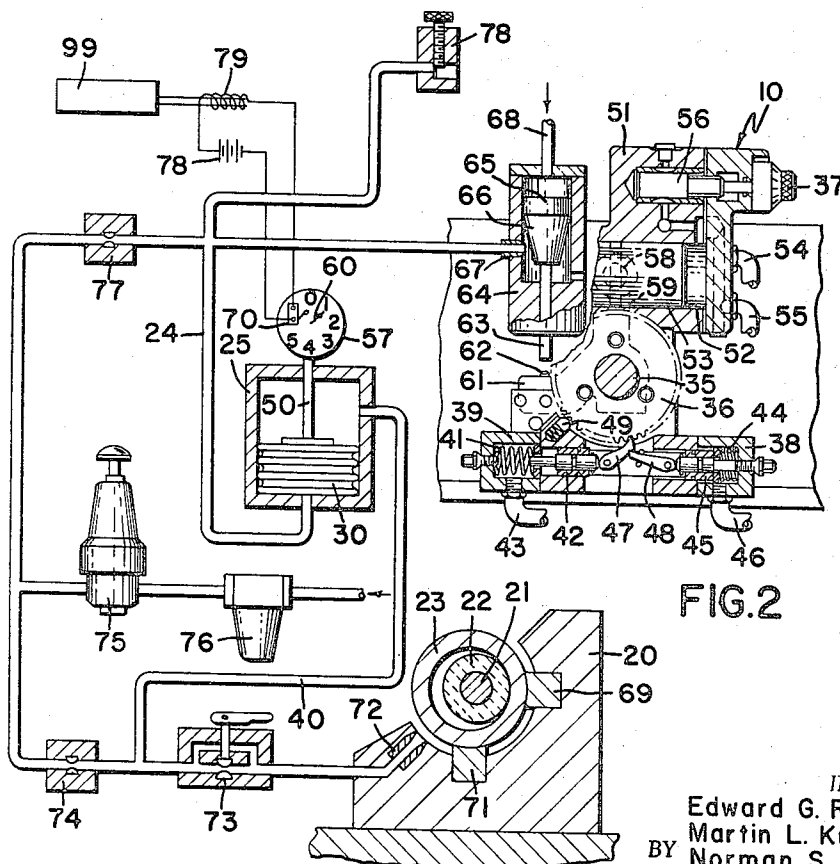


FIG. 2

INVENTORS
Edward G. Robillard
Martin L. Kuniholm
BY Norman S. Humes
Norman S. Humes
ATTORNEY

1

2

3,417,512

GRINDING MACHINE

Edward G. Robillard, Leicester, and Martin L. Kuniholm and Norman S. Humes, Worcester, Mass., assignors to The Heald Machine Company, Worcester, Mass., a corporation of Delaware

Filed Aug. 17, 1966, Ser. No. 573,010

7 Claims. (Cl. 51—165)

ABSTRACT OF THE DISCLOSURE

This invention relates to a grinding machine and, more particularly, to apparatus arranged to finish surfaces of revolution by the abrasive process wherein two gages are provided one proportional to the diameter of the surface of revolution being formed and the other one gaging the relative positions of the workhead and the wheelhead and wherein control means is provided for receiving these signals and changing the mode of operation when a predetermined relationship exists between the two signals.

In the accurate generation of surfaces of revolution as, for instance, in the finishing of the surfaces of a bearing race, one of the commonly used methods of accurately sizing the workpiece is by terminating the cross-feed by bringing the cross-feed table or some portion thereof against a stop. Suitable means is provided to assure that this stop takes into consideration such matters as the dressing of the wheel and deflection in the wheel spindle. Most apparatus of this kind is expensive when it is able to operate accurately and, when one attempts to accomplish the same effect with simple constructions, the results are seldom accurate. These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide a grinding machine in which the size of the workpiece is maintained at a high level of accuracy.

Another object of this invention is the provision of a grinding machine having a simple means of maintaining an accurate finish size for the workpiece, despite variations in the size of a reference surface.

A further object of the present invention is the provision of an internal grinding machine for finishing an internal surface of revolution with accuracy, despite variations in the outside diameter of the workpiece.

It is another object of the instant invention to provide a grinding machine in which the finish size of the workpiece is maintained, despite variations in outside diameter.

It is another object of the instant invention to provide a grinding machine having a simple and rugged mechanism for compensating for O.D. variation.

It is a further object of the invention to provide a grinding machine having size control apparatus which is inexpensive to manufacture but which is rugged and which is capable of a long life of useful service with a minimum of maintenance.

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 one of its structural forms as illustrated by the accompanying drawings in which:

FIG. 1 is a plan view of a grinding machine embodying the principles of the present invention, and

FIG. 2 is a somewhat schematic view of certain portions of the apparatus.

In FIG. 1, it can be seen that the grinding machine, indicated generally by the reference numeral 10, is of the

type shown and described in the patent application of Robert G. Hatstat et al., Ser. No. 451,552, filed Apr. 28, 1965. This consists of a base 11 having a flat horizontal upper surface on which are mounted a workhead 12 and a wheelhead 13. The workhead is carried on a workhead table 14 which is mounted for longitudinal motion on the base 11 by means of ways 15. Similarly, the wheelhead 13 is carried on a wheelhead table 16 which is mounted for transverse sliding motion on the base 11 by means of ways 17. Extending between the workhead table 16 and the base 11 is a feed cylinder 18 which is suitably provided with fluid pressure to bring about movement of the table 16 transversely of the base. Similarly, a hydraulic cylinder 19 connects the table 14 to the base 11 and brings about longitudinal movement of the table 14 over the ways 15.

Extending from the wheelhead 13 is a rotatable spindle 21 carrying on its outer end an abrasive wheel 22. Carried by the workhead 12 and rotated thereby is a workpiece 23 which, for the purposes of illustration, is shown as the race of a ball bearing. The inner bore is being ground by the abrasive wheel 22 and the workpiece is supported on its outer cylindrical surface by a support 20.

Slidable on the upper surface of the base 11 is a block 26 which, at its rearward end, is threadedly attached to a threaded shaft 27 which, in turn, is driven by a motor 28 fastened to the base 11. The motor is of the type capable of small discrete rotary increments in response to pulses received from an electrical control. By regulating the nature and number of the pulses from the electrical control, it is possible to rotate the shaft of the motor quickly or slowly in an exact amount to make the block 26 move transversely over the surface of the base 11. In the present apparatus, this motor is used to produce compensation after dress and to provide for retraction of the wheel at a suitable time in the grinding cycle, as is well known. A dressing diamond 29 is mounted on the workhead table 14 in position to engage the wheel 22 during a dressing traverse at a suitable portion of the grinding cycle.

The block 26 is provided with a transverse slot 31 and in this slot resides a horn 32 extending downwardly from the undersurface of the wheelhead table 16. The front of the block 26 is provided with a hardened metal insert 33. Mounted on the front portion of the wheelhead table 16 is a retractable stop 34 having a contact rod 35 extending toward the block 26 and toward the metal insert 33. Mounted at the front of the retractable stop is a gear 36 and mounted at the side of the retractable stop is an adjusting knob 37.

Referring now to FIG. 2, it can be seen that the gear 36 is attached to the outboard end of the rod 35 and that the gear is contacted by a feedback mechanism 38. This feedback mechanism consists of a housing 39 having a bore 41 in one of which is slidably carried a piston 42. A conduit 43 is connected to the extreme end. Similarly, the other end of the housing is provided with a bore 44 carrying a piston 45, the bore being connected to a conduit 46. Connected to the pistons 42 and 45 are pawls 47 and 48, respectively, arranged to contact the gear 36 on occasion. A spring-loaded plunger 49 is mounted in the housing 39 and engages the teeth of the gear to prevent rotation by vibration.

Forming part of the retractable stop 34 is a housing 51 through which extends a bore 52 slidably carrying a piston 53. Through the housing to the right end of the bore 52 is a conduit 54. Also connected to the housing is a conduit 55 connected into a passage leading through an adjustable throttle 56 which is controlled by the knob 37 to the right-hand end of the bore 52.

Extending rearwardly from the center portion of the

piston 53 is a rod 58. This rod is pivotally mounted in the top of a crankarm 59 whose other end is connected through a sleeve to the contact rod 35. The forward end of the slot 31 on the block 26 is provided with a hardened metal button adapted to engage on occasion a similar hardened metal button located on the forward surface of the horn 32. The crankarm 59 is provided with a laterally-extending finger 61 having a hardened metal button 62 adapted to contact a vertical stop shaft 63. The shaft 63 is mounted in a cylinder 64 and is provided with a piston 65 having a conical surface 66. Mounted in the side of the cylinder 64 is an air nozzle 67 and, at the upper end the cylinder is connected to a conduit 68 providing it with constant 10 p.s.i. air.

It can be seen that the workpiece support 20 is provided with hardened metal shoes 69 and 71 located, respectively, at 3 o'clock and 6 o'clock positions relative to the axis of the workpiece 23. At approximately the 7:30 o'clock position, an air nozzle 72 is mounted in the body of the support 20. The nozzle is connected to a control valve 73 which, in turn, is connected through a jet 74 to a 30 p.s.i. pressure regulator 75 and a filter 76 to unregulated shop pressure (not shown). The regulator 75 is also connected through a jet 77 to the air nozzle 67. A point in the conduit between the nozzle 67 and the jet 77 is connected to a zero setting valve 78. The same point is connected by a conduit 24 to a differential pressure meter 25 and, more specifically, to the interior of a bellows 30 mounted on the interior thereof. A point between the jet 74 and the valve 73 is connected by a conduit 40 to the meter 25 and, more specifically, to the exterior of the bellows 30. The bellows is provided at its movable portion with a vertical rod 50 which is connected to an indicator mechanism 57. The indicator mechanism is provided with a hand 60 which indicates the amount of the differential pressure between the exterior and interior of the bellows 30, but also on occasion to contact and close an electrical switch 70. This switch is connected in series with a source of electrical power and a coil 79 which operates a selector valve 99. The valve serves to terminate the cross-feed operation of the apparatus in the manner of the similar valve 77 in the aforementioned patent application of Hatstat et al., Ser. No. 451,552.

The operation of the apparatus will now be readily understood in view of the above description. During a typical grinding cycle, the wheel 22 would be moved into the bore of the workpiece 23 and moved out again on occasion by providing the cylinder 19 with oil, so that the table 14 slides longitudinally over the ways 15. In a similar way, the abrasive wheel 22 will be moved laterally into engagement with the surface of the workpiece by the lateral movement of the table 16 on its ways 17 under the impetus of the hydraulic cylinder 18. It can be seen that, as the table 16 moves rearwardly, it will do so with a pressure determined by the force produced in the cylinder 18 and grinding will take place in accordance with the so-called "controlled force" system rather than the "feed rate" system. In other words, the force will be maintained at a constant predetermined value and the rate of advancement may vary without control. This is true until the table advances toward the block 26 sufficiently for the control rod 35 to strike the button 33. At that time, the table and the wheel can advance rearwardly into the grinding operation with the workpiece at a rate determined by the retraction of the rod 35. The rod is retracted by the provision of oil to either end of the bore 52 to rotate the contact rod 35 and cause it to advance in its threaded sleeve. The piston 53 operates on the crankarm 59 through the rod 58. At the same time that the crankarm is rotated about the axis of the control rod 35, the finger 61 moves upwardly and pushes the shaft 63. Shaft 63 is constantly held in contact with button 62 by 10 p.s.i. air.

While the grinding operation is taking place, the nozzle

72 provides a pneumatic signal indicative of the outside diameter of the workpiece 23 and transmits it through the valve 73 and the conduit 40 to the meter 25. In a similar manner, the nozzle 67 allows air to escape in an amount indicated by the space between the nozzle and the conical surface 66 of the piston 65, so that it, in turn, transmits a signal indicative of the position of the rod 63 back through the conduit 24 to the interior of the bellows 30 in the meter 25. The bellows 30 is, therefore, subjected to two air pressure signals, i.e., one indicative of the outside diameter of the workpiece 23 and the other indicative of the position of the shaft 63. The difference in pressure is shown on the indicator 57 by the position of the hand 60. Presumably, the pressure originating in the nozzle 67 will start at a higher value. As the shaft 63 moves upwardly, the pressure goes down, because the nozzle 67 lies adjacent a narrower portion of the conical surface 68. Thus, the differential pressure will drop until, eventually, it reaches zero at a predetermined point. When it does reach zero, the hand 60 contacts the switch 70 and operates the valve 99 to cut off flow of oil to the bore 52 and its piston 53. This stops the grinding machine feed.

Let us suppose that the outside diameter of the workpiece 23 is larger than average. This means that, as the workpiece resides in the shoes 69 and 71, the center of the workpiece is further to the left (in FIG. 2) than would be normal. This also means that the surface of the bore is further to the left, that is to say, the surface of the bore at the point where it is contacted and ground by the abrasive wheel 22. This means that, normally, in a grinding machine of this type, by the time the cycle is finished the bore will be larger than average and, in many cases, be beyond the permissible limits of variation from a predetermined size. By use of the present invention, the nozzle 72 senses that the outside diameter is larger and tells the machine that it should not go as far in its cross-feed operation. In the present case, if the outside diameter is larger than average, the pressure at the nozzle 72 transmitted back to the meter 25 will be high because of the smaller air escape gap. This means that the nozzle 67 will have to have its pressure drop at a lesser amount than usual in order for the meter 25 to read zero and terminate the grinding cycle. This means that the shaft 63 will not move upwardly quite as far and the control rod 35, therefore, will not retract quite as far, so that the table 16 will not be able to move as far rearwardly. Finally, the wheel 22 will not advance as far into the workpiece surface, so that the effect of the variation of the outside diameter of the workpiece 23 will be compensated for.

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 include 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, comprising
 - (a) a base,
 - (b) a workhead for holding a workpiece having an external and an internal surface of revolution,
 - (c) a wheelhead having an abrasive wheel for finishing the said internal surface of revolution,
 - (d) feed means for bringing about relative movement between the workhead and the wheelhead,
 - (e) a first gage associated with the workhead and generating a first signal proportional to the diameter of the said external surface of revolution,
 - (f) a second gage associated with the feed means and generating a second signal proportional to the relative position of the workhead and the wheelhead, and
 - (g) control means receiving the said first and second signals and operative to change the mode of opera-

5

tion of the said feed means when a predetermined relationship exists between the two signals.

2. A grinding machine as recited in claim 1, wherein the workhead includes shoes located to support the workpiece on its external diameter at 3:00 and 6:00 o'clock and the first gage is an air nozzle located at approximately 7:30 o'clock.

3. A grinding machine as recited in claim 1, wherein the second gage includes an inclined surface movable in a housing in proportion to the operation of the feed means and an air nozzle mounted on the housing to define an air escape gap with the said inclined surface.

4. A grinding machine as recited in claim 1, wherein the gages both include air nozzles and the control means is a meter which receives air pressure signals from the air nozzles and indicates the differential between the air pressure signals.

5. A grinding machine as recited in claim 1, wherein the feed means consists of a cylinder operating between the wheelhead and the base to produce movement and a retractable stop also operating between the wheelhead and the base to resist movement, the stop being movable relative to the wheelhead at a controlled rate to control the abrasive process, the second gage reading the position of an element which moves with the stop.

6

6. A grinding machine as recited in claim 3, wherein the inclined surface is a conical surface on a piston slidable in a bore in the said housing and wherein a piston rod extends from the piston to the exterior of the housing.

7. A grinding machine as recited in claim 1, wherein the first gage is mounted on a shoe-type support for the workpiece and constitutes an air nozzle located a substantial distance from the support points to indicate variations in the external diameter of the workpiece, wherein the second gage includes an air nozzle located adjacent a tapered surface of an element which moves in proportion to the said relative movement, and wherein the said feed means includes a retractable stop whose rate of retraction determines the rate of the said relative movement.

References Cited

UNITED STATES PATENTS

2,647,347	8/1953	Blanchette	51—103 X
2,793,479	5/1957	Arms et al.	51—165 X
3,157,007	11/1964	Lockwood	51—165

LESTER M. SWINGLE, *Primary Examiner.*

U.S. Cl. X.R.

25 51—48