Sept. 15, 1959 H. L. BLOOD 2,903,827

GRINDING MACHINE

Filed April 25, 1957 2 Sheets-Sheet 1

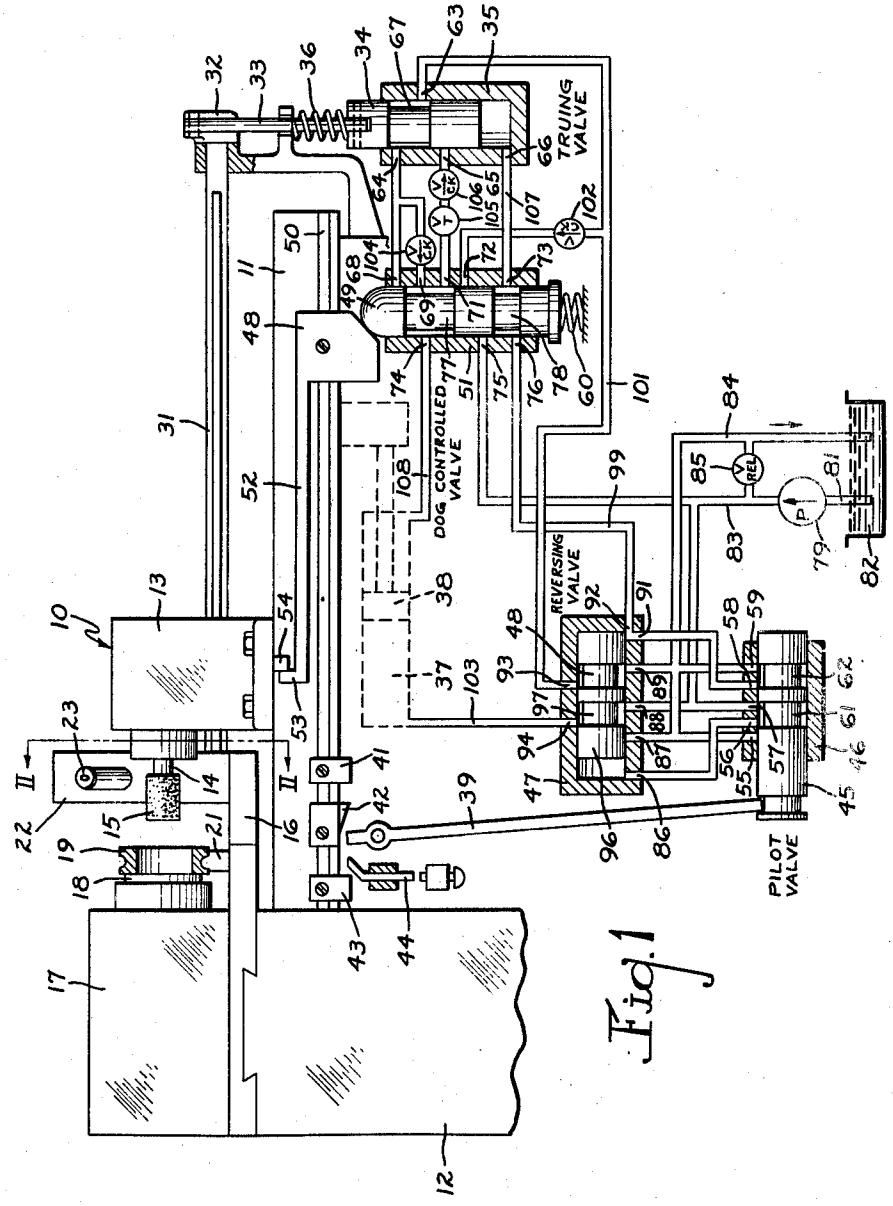


Fig. 1

INVENTOR.
Harold L. Blood
BY
Norman S. Blodgett
Attorney

Sept. 15, 1959 H. L. BLOOD 2,903,827

GRINDING MACHINE

Filed April 25, 1957 2 Sheets-Sheet 2

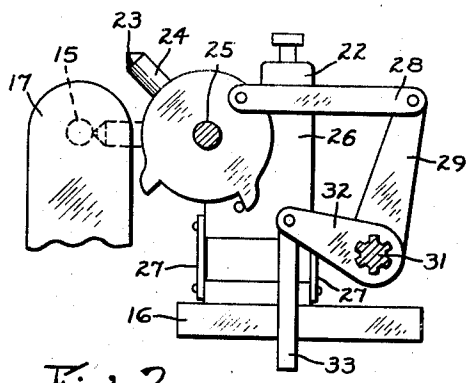


Fig. 2

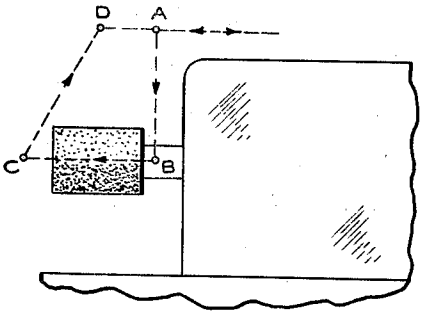


Fig. 3

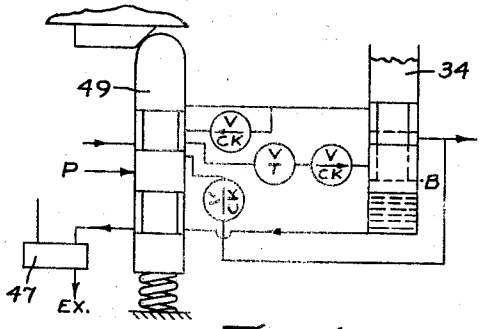


Fig. 4

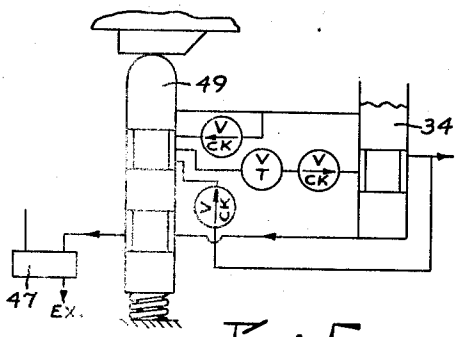


Fig. 5

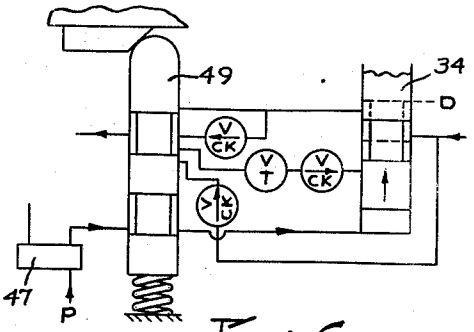


Fig. 6

INVENTOR.
Harold L. Blood

BY
Norman S. Blodgett
Attorney

United States Patent Office 2,903,827 Patented Sept. 15, 1959

2,903,827

GRINDING MACHINE

Harold L. Blood, Worcester, Mass., assignor to The Heald Machine Company, Worcester, Mass., a corporation of Delaware

Application April 25, 1957, Serial No. 655,156

9 Claims. (Cl. 51—48)

This invention relates to a grinding machine and more particularly to an internal grinding machine in which the grinding wheel is carried on a cantilever spindle of a wheelhead.

In the operation of grinding machines, it is usual practice to interrupt the grinding cycle before the grinding is completed and to move the wheel axially away from the work and then repeatedly back and forth across a truing tool, such as a diamond. Because the wheel head is so much larger than the wheel, the diamond is usually mounted on a holder which is swingable toward and away from the wheel, this motion being actuated by a table cam. Before this truing operation, it is customary to slow the motion of the table carrying the wheel by means of a table dog. After the wheel has traversed the diamond, so that a fresh, accurate surface is laid bare, a table cam swings the diamond away from the wheel and the wheel is moved axially into contact with the work again. One objectionable feature of this practice is that, after the wheel has passed the diamond, the wheel head table must move a considerable distance before the table cam is able to swing the diamond out of the way. This distance is, of course, dependent on the slope of the table cam, but the result is that, in many cases, the wheel spindle must be very long, which is undesirable because of the flexibility of a long cantilever. In many instances, it is desirable to true the wheel by one passage of the wheel across the diamond and the removal of a considerable amount of material in that one passage; conventional machines do not permit this practice. These and other difficulties experienced with the prior art machines have been obviated in a novel way by the present invention.

It is, therefore, an outstanding object of the present invention to provide a grinding machine having a wheel spindle of minimum length, the said machine having a mechanism which will stop the table, move the tool to the wheel in a plane normal to the axis of the wheel, move the wheel across the tool, move the tool out of the path of the wheel head, and only then move the wheel head past the tool.

Another object of the invention is the replacement in a grinding machine of the table dog and table cam usually used to slow the table motion for truing and to prevent interference between the wheel head and the truing device with a single table cam which combines these two functions and which can easily be adjusted along the table when the position of the wheel head or the length of the wheel spindle is changed.

A still further object of this invention is the provision of a grinding machine having means to move the tool into and out of truing position while the wheel head is substantially stationary relative to the work holder, combined with means to interlock the table cam with the wheel head to prevent the cam from being moved into a position which would allow the wheel head to strike the truing device.

It is another object of the present invention to provide a grinding machine having means for truing the wheel in one direction only, thus resulting in a saving of time and an improvement in the finish of the ground surface.

It is a further object of the instant invention to provide in an internal grinding machine of the type using a diamond for truing the wheel of a means permitting the use of a very short wheel spindle.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

In said annexed drawings:

Figure 1 is a somewhat schematic view of an internal grinding machine embodying the principles of the invention,

Figure 2 is a sectional view of the machine taken on the line II—II of Figure 1,

Figure 3 is a schematic view of the relationship of certain portions of the machine, and

Figures 4, 5 and 6 are schematic views of a portion of the machine showing the relative positions of the elements at different parts of the cycle of operation of the machine.

Referring first to Figure 1, wherein are best shown the general features of the invention, the internal grinding machine, designated generally by the reference numeral **10**, is shown as having a table **11** slidably mounted on a base **12**. The table carries a motorized wheel head **13** from which extends a cantilever spindle **14** having an abrasive wheel **15** mounted thereon. Also mounted on the base **12** is a conventional bridge-type cross slide **16** carrying a work head **17** which includes a work-holding means such as a magnetic chuck **18** adapted to rotate a workpiece **19** on a shoe-type support **21** also carried by the cross slide **16**. A truing device **22** is also mounted on the cross slide.

As is best shown in Figure 2, a diamond **23** is mounted on a holder **24** connected for hinged movement about a pivot shaft **25** to a housing **26**, all forming part of the truing device **22**. The housing **26** is connected to and supported by the cross slide **16** through resilient leaf springs or reeds **27**. In the drawing, the holder **24** is in its inoperative, raised position clear of the wheel head **13** and may be swung to the operative, lowered position indicated by the dotted line showing. It is moved into this last position for engagement with the wheel **15** by link **28**, a crank arm **29**, a splined shaft **31**, a crank arm **32** and a vertical link **33**. Returning to Figure 1, the lower end of the link **33** is fastened to the plunger **34** of a valve **35**; a coil spring **36** surrounds the link and maintains it normally in its lowermost position.

Between the table **11** and the base **12** extends a hydraulic linear actuator consisting of a cylinder **37** and a piston **38**. Flow of hydraulic fluid to and from the cylinder **37** is controlled by a lever **39** which is pivotally mounted on the base **12** and which is straddled by a table dog **41** and a dog latch **42** when the wheel **15** is coextensive with the work piece **19**. The upper end of the lever lies between the dog latch **42** and a table dog **43** when the wheel head **13** is retracted for the truing operation, as shown. A latch lifter **44** is operated by a solenoid, in the conventional manner, when an extended traverse of the table **11** is desired. The lower end of the lever **39** engages and operates the plunger **45** of a pilot valve **46** which controls a reversing valve **47**. A cam **48** is mounted on the table **11** in position to engage, on occasion, the plunger **49** of a valve **51** which plunger is nor-

mally biased to an upper position by a coil spring 60. The dog has an elongated horizontal arm 52 having an upstanding abutment 53 at its outer end; a similar abutment 54 extends downwardly from the wheel head 13, so that the two abutments may engage on occasion. The dog 48 is mounted in a dovetail groove 50 in the table for adjustment therealong and the dogs 41, 42 and 43 are mounted in the same groove.

In the hydraulic system shown in Figure 1, the pilot valve 46 is provided with five ports 55, 56, 57, 58 and 59, while its plunger 45 has two reduced portions 61 and 62. The valve 35 has four ports 63, 64, 65 and 66 and its plunger 34 has a single reduced portion 67. The valve 51 has eight ports 68, 69, 71, 72, 73, 74, 75 and 76, while its plunger 49 has two reduced portions 77 and 78. A pump 79 has an intake conduit 81 extending into an oil reservoir 82 and an output conduit 83 connected to an oil-return conduit 84 by a pressure relief valve 85. The reversing valve 47 has eight ports 86, 87, 88, 89, 91, 92, 93, and 94 and a free piston 96 with two reduced portions 97 and 98.

The output conduit 83 of the pump is connected to the port 57 of the pilot valve 46, the port 88 of the reversing valve 47, and the port 75 of the valve 51. The port 55 of the valve 46 is connected to the port 87 of the reversing valve 47 and both ports are connected through the oil-return conduit 84 to the reservoir. The port 56 of the valve 46 is connected to the port 86 of the valve 47 at the left end of the piston 96. The port 58 of the pilot valve 46 is connected to the port 91 of the reversing valve 47 at the right end of the piston. The port 59 of the pilot valve 46 is connected to the port 89 of the reversing valve and both ports are connected through the conduit 84 to the reservoir.

The port 92 located at the right end of the reversing valve 47 is connected by a conduit 99 to the port 76 of the dog-controlled valve 51. The port 93 of the reversing valve 47 is connected by a conduit 101 to the input port 63 of the truing valve 35, while the intermediate portion of the conduit 101 is connected through a check valve 102 to the port 72 of the dog-controlled valve 51, the check valve permitting flow only from the port 93 to the port 72. The port 94 of the reversing valve is connected through a conduit 103 to the left end of the table cylinder 37.

The port 64 of the truing valve 35 is connected directly to the port 68 of the dog-controlled valve 51 and also, through a check valve 104 to the port 69 of the valve 51, the check valve permitting flow only toward the port 69. The port 65 of the valve 35 is connected to the port 71 of the valve 51 through a throttling valve 105 and a check valve 106, these last two valves being in series and the check valve being oriented to permit flow of oil toward the port 65 only. A conduit 107 extends directly between the port 66 located below the piston 34 of the valve 35 and the port 73 of the valve 51. The port 74 of the valve 51 is connected by a conduit 108 to the right side of the table cylinder 37.

An examination of the hydraulic circuit shows that, whereas oil is supplied directly from the reversing valve 47 to the left side of the cylinder and is removed in the same manner, the branch extending between the reversing valve and the right side of the cylinder contains the truing valve 35 and the dog-controlled valve 51.

The operation of the machine will be readily understood in view of the above description. With the table 11 situated so that the wheel 15 is coextensive with the workpiece 19 and the bridge 16 moving transversely of the bed 12 under the action of the conventional feed mechanism, the wheel contacts the surface to be ground and abrasion takes place. The table is reciprocated longitudinally of the base under the action of the cylinder 37 and its piston 38. Oil flow to the cylinder is reversed at a high frequency to produce the reciprocation, the reversal of flow being under the control of the reversing valve 47, which is controlled by the pilot valve 46, which, in turn, is reciprocated by the lever 39 as it is struck at the end of each stroke by the dog 41 or the latch 42. After sufficient metal has been removed from the workpiece, it is desirable to true the wheel before beginning the final finish grinding. The movement of the diamond relative to the wheel during the truing cycle is shown in Figure 3. This point in the cycle is initiated in the usual way by conventional means, as described more fully in the copending patent application of Quimby and Blood, S.N. 649,406, filed March 29, 1957 and the latch lifter 44 rises and presses the latch 42 upwardly so that the lever 39 can pass the latch without being struck. This permits the wheel head 13 to move to the right on an extended traverse, thus removing the wheel from the work. During the grinding period just described, oil flows to and from the reversing valve 47 and the right side of the cylinder 37 through the valve 35 from port 63 to port 64 through the reduced portion 67 of the plunger 34 and through the valve 51 from the port 68 to the port 74 through the reduced portion 77 of the plunger 49. At the same time positive pressure fluid presses against the lower end of the plunger 34 of the valve 35 and maintains it in its uppermost position, despite the downward pressure of the spring 36; this fluid reaches the valve from the pump 79 through the conduit 83, the port 75 of the valve 51, the reduced portion 78 of the plunger 49, the port 73, the conduit 107 and the port 66 of the truing valve 35.

When the table moves far enough to the right, so that diamond is at point A in Figure 3, the cam 48 strikes the upper end of the plunger 49 of the dog-controlled valve 51 and starts to press it downwardly. The situation shown in the drawing in Figure 1 is soon reached, the port 68 being closed to inhibit flow from the cylinder and the port 75 being closed to prevent pressure fluid from reaching the plunger 34 of the valve 35. At the same time, the port 76 is uncovered to permit release of the fluid trapped under the plunger 34, this fluid flowing to the oil reservoir by way of the port 66, the conduit 107, the port 73, the reduced portion 78, the port 76, the conduit 99, the port 92, the port 91, the port 58, the reduced portion 62, the port 59, and the conduit 84. This is the situation illustrated in Figure 4. With a return path thus provided, the fluid is squeezed from beneath the plunger 34 by the force of the spring 36 and the plunger moves downwardly. The downward movement of the plunger produces a similar movement of the link 33 and acts through the crank arm 32, the shaft 31, the crank arm 29 and the link 28 to rotate the holder 24 in a counterclockwise direction about its pivot shaft 25 to bring the diamond 23 from point A to point B of Figure 3 into line with the wheel 15. In other words, the holder is swung down past the wheel head into truing position with the diamond 23 at the spindle side of the wheel. At the time the diamond reaches the proper truing level, the plunger 34 of the valve 35 has been lowered to the point where the port 64 is closed off and the port 63 is connected by the reduced portion 67 to the port 65. This is the state of affairs illustrated in Figure 5. The conduit 101 is at this time connected through the reversing valve 47 to exhaust. Oil can now flow from the right side of the cylinder 37 through the conduit 108, the port 74, the reduced portion 77 of the plunger 49, the port 71, the throttling valve 105, the check valve 106, the port 65, and so on to exhaust. This permits the table 11 to resume its motion to the right at a reduced speed under the control of the throttling valve 105.

When the whell 15 has passed to the right of the diamond, i.e., so that the diamond is situated at point C of Figure 3, the table dog 43 strikes and reverses the lever 39, the pilot valve 46 and, hence, the table 11. The conduit 101 now contains pressure oil and, as the

table cam is now directly over the plunger **49** of the valve **51**, oil flows through the check valve **102**, the port **72**, the reduced portion **77** of the plunger **49**, the port **74**, and the conduit **108** to the right side of the cylinder **37**, the left side being connected to exhaust. The conduit **99** is also pressurized and oil flows from it through the port **76**, the reduced portion **78** of the plunger **49**, the port **73**, the conduit **107**, and the port **66** to the underside of the plunger **34** of the truing valve **35**. The elements are in the condition shown in Figure 6. The plunger, therefore, rises to the position D shown in broken lines and tilts the holder **21** upwardly. When the holder **24** clears the wheel head, the valve **35** unblocks the port **64** and oil passes through the check valve **104** to the right side of the cylinder. However, if the holder **24** fails to clear the wheel head when the table reaches the position shown in the drawings, the ports **64** and **72** are blocked and the table stops until the holder clears the wheel head. Thus, the holder is positively prevented from striking the wheel head by the same table cam and valve which determine the position of the table when its speed is reduced for truing. It is, therefore, necessary to adjust only this one cam along the table when the wheel head is moved along the table.

The abutment **53** may, on occasion, engage the abutment **54** on the wheel head making it impossible to move the cam **48** inadvertently into a position which would permit the holder **21** to strike the wheel head.

Because the table is stationary while the holder **24** is swinging downward, the overhung portion of the spindle **14** can be constructed with a minimum length. Because the table is moving while the holder **24** is swinging upwardly, there is a saving of time in the grinding cycle. Furthermore, the apparatus described makes it possible to true the wheel in a single pass, which saves time and which in many cases improves the finish of the ground surface.

It should be observed that by making the shaft **31** and the link **33** very long, as shown in Figure 1, it is possible to keep heat transfer from the hydraulic circuit to the truing device to a minimum, so that inaccuracies are not introduced due to thermal expansion and contraction of the elements.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in the following claims, or the equivalent of such, be employed. For example, the valves may be arranged to cause the diamond to true the wheel in the opposite direction from the one shown, or in both directions. In either case, if the diamond holder did not rise far enough to clear the wheel head, the table would be stopped before the wheel head could strike the diamond holder.

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

1. In a grinding machine, a base, a wheel head, an abrasive wheel, a diamond, a holder for the diamond movable between an inoperative and an operative position, a table movable on the base to move the wheel axially relative to the diamond, means responsive to the position of the table to stop its motion and while the table is stopped to move the diamond holder from its inoperative position to its operative position, means operable when the holder reaches its operative position with the diamond in the path of the wheel to move the table and the wheel relatively across the diamond at slow speed for a truing operation, means operable thereafter and responsive to the position of the table to move the holder from its operative position to an inoperative position, and means operable only when the holder is in an inoperative position out of the path of the wheel head to move the table to carry the wheel head relatively past the diamond holder.

2. A grinding machine comprising a work head for holding a workpiece, an abrasive wheel, a wheel head having a downwardly-extending abutment, a diamond, a holder for the diamond movable between a truing position and an inoperative position, a table on which the wheel head is mounted adjustably to move the wheel relatively into and out of overlapping relation with the workpiece in the work head and across the diamond, a cam movable with the table and adjustable therealong, a first control means actuated by the cam, a second control means connected to the diamond holder, said first and second control means being interlocked and adapted to interrupt the motion of the table when the table is moving the wheel away from the workpiece and when the wheel head reaches a predetermined position relative to the diamond, thereupon to move the diamond holder from an inoperative position to its operative position, and thereupon to restart the motion of the table at a reduced speed to carry the wheel across the diamond in a truing operation, an abutment extending upwardly from the cam and engageable on occasion with the wheel head abutment to prevent the cam from being positioned on the table greater than a predetermined distance from the wheel head.

3. A grinding machine comprising a work head for holding a workpiece, an abrasive wheel, a wheel head having a downwardly, extending abutment, a diamond, a holder for the diamond movable between a truing position and an inoperative position, a table on which the wheel head is mounted adjustably to move the wheel relatively into and out of overlapping relation with the workpiece in the work head and across the diamond, a cam movable with the table and adjustable therealong in a track formed thereon, a control means actuated by the cam, a hydraulic cylinder and valve combinaton connected to the diamond holder for the actuation thereof, said control means and combination being interlocked and adapted to interrupt the motion of the table when the table is moving the wheel away from the workpiece and when the wheel head reaches a predetermined position relative to the diamond, thereupon to move the diamond holder from an inoperative position to its operative position, and thereupon to restart the motion of the table at a reduced speed to carry the wheel across the diamond in a truing operation, an abutment extending upwardly from the cam and engageable on occasion with the wheel head abutment to prevent the cam from being positioned on the table a distance greater than a predetermined amount from the wheel head.

4. In a grinding machine, a base, a wheel head, an abrasive wheel, a diamond, a holder for the diamond movable between an inoperative and an operative position, a table movable on the base to move the wheel axially relative to the diamond, means responsive to the position of the table to stop its motion and while the table is so stopped to move the diamond holder from one to another of said positions to an operative position, means operable when the holder reaches its operative position with the diamond in the path of the wheel to move the table and the wheel relatively across the diamond at slow speed for a truing operation, means operable thereafter and responsive to the position of the table to move the holder from its operative position to an inoperative position, and means to stop the motion of the table if it reaches a predetermined point before the diamond holder has reached one of said positions.

5. In a grinding machine, a base, a rotary wheel holder, a wheel, a truing tool, a holder for the tool movable between an inoperative and an operative position, a table movable on the base to move one of said holders relative to the other, means to connect the moving means to a source of power, means responsive to the position of the table to move the truing tool from an inoperative position to an operative position in the path of the wheel, means responsive to the position of the

tool holder to disconnect the moving means from the source of power, means to move the table and thereby to move the wheel relatively across the tool for a truing operation, means operative thereafter and responsive to the position of the table to move the tool from its operative position to an inoperative, means operative only when the tool is in an inoperative position out of the path of the wheel holder to move the table to carry the wheel holder relatively past the tool holder.

6. In a grinding machine, a base, a rotary wheel holder, a wheel, a truing tool, a holder for the tool movable between an inoperative and operative position, a table movable on the base to move one of said holders relative to the other, means responsive to the position of the table to move the tool from an inoperative position to an operative position in the path of the wheel, means to move the table and thereby to move the wheel relatively across the tool for a truing operation, means operable thereafter and responsive to a position of the table to move the tool from its operative position to an inoperative position, means operative only when the tool is in an inoperative position out of the path of the wheel holder to move the table to carry the wheel holder relatively past the truing tool holder, and means operative, if the table reaches a preselected position before the tool holder is out of the path of the wheel holder, to render the table substantially immovable while the tool holder is moving out of the path of the wheel holder.

7. In a grinding machine, a base, a rotary wheel, a wheel, a truing tool, a holder for the tool movable between an inoperative and an operative position, a table movable on the base to move one of said holders relative to the other, means responsive to the position of the table to apply power to move the tool from an inoperative position to an operative position in the path of the wheel, means to move the table and thereby to move the wheel relatively across the tool for a truing operation, means operable thereafter and responsive to the position of the table to move the tool from its operative position to an inoperative, and means operable only when the tool is in an inoperative position out of the path of the wheel holder to move the table to carry the wheel holder relatively past the tool holder, and a cam timed with the motion of the table and having a single follower to control

the application of power to the tool holder and to prevent interference between the tool holder and the wheel holder.

8. In a grinding machine, a base, a rotary wheel holder, a wheel, a truing tool, a holder for the tool movable between an inoperative and an operative position, a table movable on the base to move one of said holders relative to the other, means responsive to the position of the table to move the tool from an inoperative position to an operative position in the path of the wheel, means to move the table and thereby to move the wheel relatively across the tool for a truing operation, means operable thereafter and responsive to the position of the table to move the tool from its operative position to an inoperative position, and means operative only when the tool is in an inoperative position out of the path of the wheel holder to move the table to carry the wheel holder relatively past the tool holder, a first means to control the application of a force to the tool holder, a second means to interlock the motion of the tool holder with that of the table, a third means to change the speed of the table, and a single adjusting means to determine the positions of the table at which said first, second and third means are operable.

9. In a grinding machine, a base, a rotary wheel holder, a wheel, a truing tool, a holder for the tool movable between an inoperative and operative position, a table movable on the base to move one of said holders relative to the other, means responsive to the position of the table to move the tool from an inoperative position to an operative in the path of the wheel, means to prevent substantial movement of the table while the tool holder is moving between its operative and its inoperative positions, means to move the table and thereby to move the wheel relatively across the tool for a truing operation, means operable thereafter and responsive to the position of the table to move the tool from its operative to an inoperative position, and means operable only when the tool is in an inoperative position out of the path of the wheel holder to move the table to carry the wheel holder relatively past the tool holder.

References Cited in the file of this patent

UNITED STATES PATENTS

2,176,249	Cramer	Oct. 17, 1939
2,780,036	Townsend	Feb. 5, 1957