

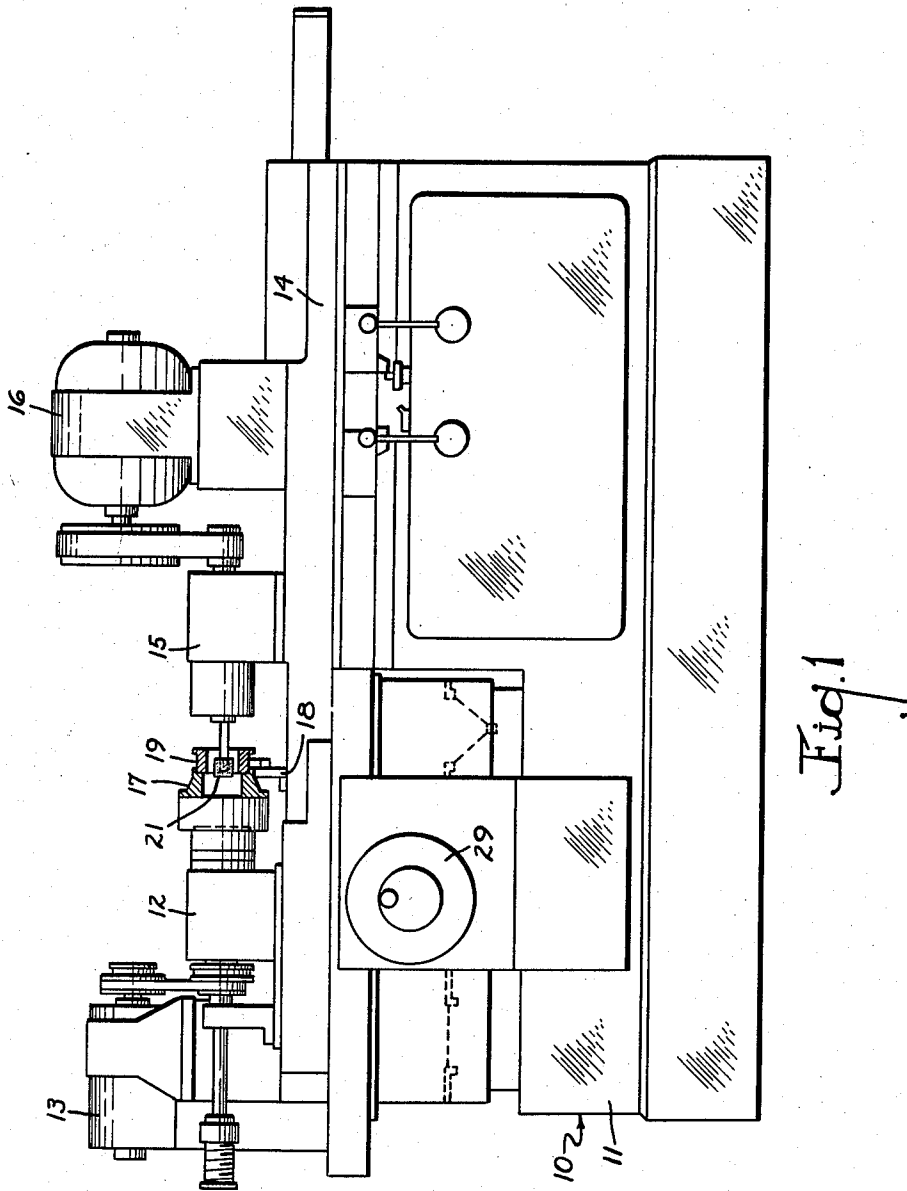
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J. KLAR ET AL
GRINDING MACHINE

2,924,913

Filed May 27, 1958

3 Sheets-Sheet 1



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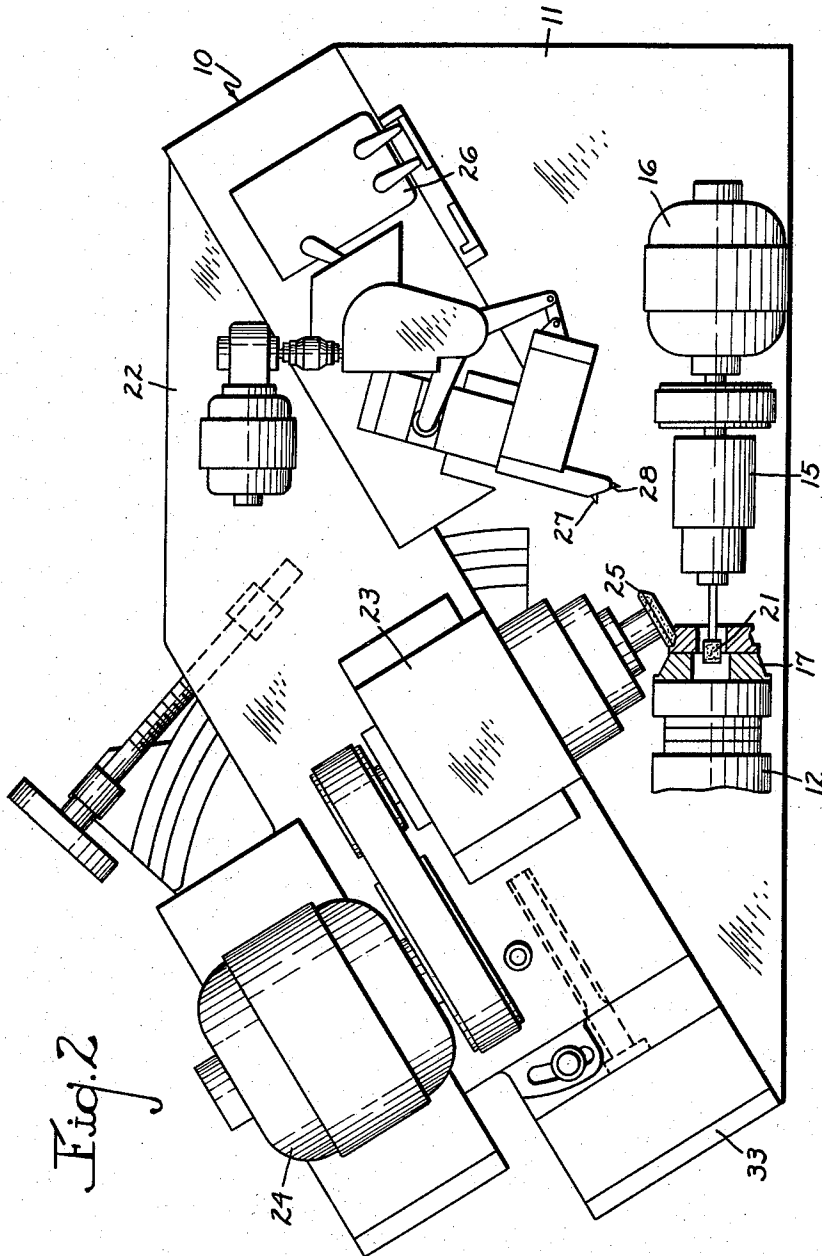
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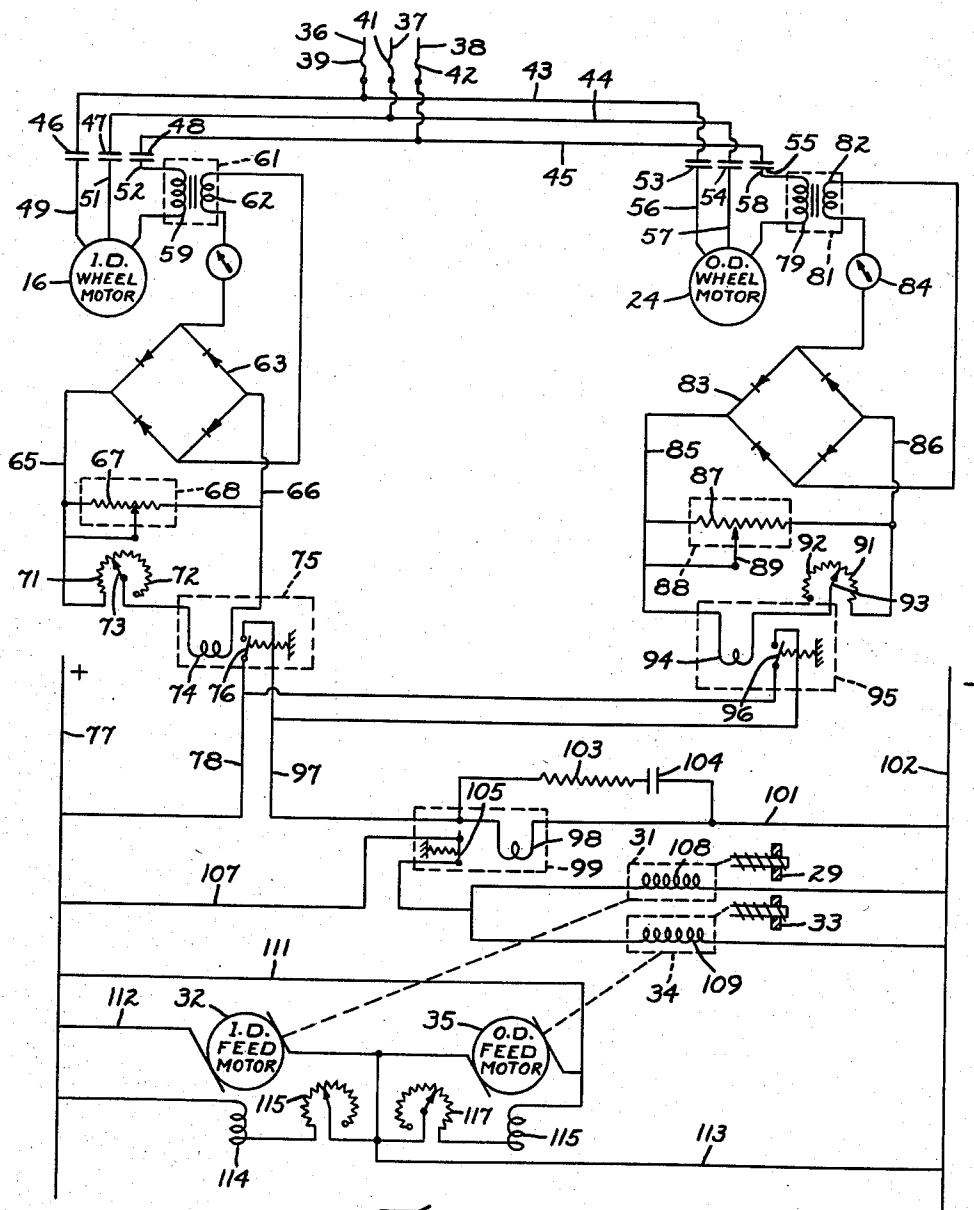


Fig. 3

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GRINDING MACHINE

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Application May 27, 1958, Serial No. 738,137

11 Claims. (Cl. 51—88)

This invention relates to a grinding machine, and more particularly to automatic grinding machines having means for controlling the feed rate thereof.

Internal grinding machines employ various methods for holding the workpieces. The workpiece may be chucked or, in the simplest type of grinder, it may be supported between rollers or on shoe-type supports. The object is to support the work while it rotates about a fixed center line. The maintenance of a fixed rotational center line is essential with certain size-holding methods. For example, the machine may be arranged repetitively to advance the abrading surface of the wheel to a fixed position relative to the center of rotation of the workpiece, thereby producing consecutive workpieces of like internal diameter. In centerless external grinding machines there is a shifting of the work-center in relation to the parts of the machine. As stock is ground from the external surface, the work center is caused to approach the support shoes or rolls. If, then, external and internal grinding be carried on simultaneously, the internal operation need not complicate the external operation, but it is obvious that the external operation does affect the internal operation; this is because of the fact that, if the workpiece is supported on rolls or shoes, this causes a change in the position of the work center-line and, therefore, complicates the problem of holding size on the internal surface.

The problem is resolved if means be provided for guaranteeing that the work center line arrive at a constant position in relation to the work supports at the same time or before the internal abrading means arrives at its size-holding position. The problem is complicated, however, when the grinding stock allowance fluctuates, as it normally does, resulting in a variation in the rate of stock removal due to the resultant variations in spindle work and machine deflections which, in turn, are caused by the abrading means becoming dull or glazed to differing degrees.

One type of grinding feed mechanism that is well known operates to bring the wheel and work into engagement and then to maintain a definite pre-set force between the wheel and the work. The cycle time is a variable which is dependent on the magnitude of this force, the amount of grinding stock, the speed of and condition of the abrading member, work speed, etc. An alternate feed method, also well known, consists in causing the wheel relatively to approach the work at a present rate. This method results in a cycle time which remains constant but must be longer than the average time of the first method. This is because of the fact that the retracted position of the feed member must be sufficiently far from the finish position to accommodate a workpiece with the maximum grinding stock and the fact that the feed rate cannot be set faster than the rate at which the abrading means and machine are able to remove stock. Hence, time is inevitably wasted on all workpieces with less than the maximum stock allowance. Now, in a combination automatic grinder where outer and inner surfaces are ground simul-

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taneously, it has been pointed out that a necessary condition to successful operation is that the internal and external feed be so synchronized that, irrespective of initial stock conditions, the arrival of the outer surface at a given size either earlier than or co-incidental with the arrival of the internal abrading means at its reference point is necessary in order to hold a uniform internal size. This requirement makes it necessary to use feeds having constant rate so that both rates, internal and external, can be preset to arrive at the size holding reference point simultaneously or in any desired relationship, continuously and repetitively. The disadvantage of this method has been shown to be a wastage of time on workpieces with less than the maximum possible stock but the present invention combines the advantages of the latter method with those of the former method by eliminating the time wasting feature of the latter methods. The system of control embodied in this invention is particularly well adapted to cope with the above problem and offers an easy solution whether the machine feed actuator be hydraulic, electrical or mechanical. The difficulties presented by the prior art have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide an improved means for controlling feed rates in a grinding machine as a function of the power absorbed by the grinding wheel or wheels.

Another object of this invention is the provision of a means in a grinding machine whereby the machine is able to sense the amount of grinding stock to be removed from each workpiece.

It is a further object of this invention to provide a grinding machine having means for governing the feed in accordance with workpiece stock allowance thus shortening the time cycle on every workpiece having less than the maximum stock to be removed.

It is a still further object of this invention to provide a means for controlling wheel forces and machine deflections and for holding them within definite predetermined limits in spite of rough stock variations.

It is another object of the instant invention to provide a grinding machine having means to control the feeds of wheels in the simultaneous grinding of outer and inner surfaces of revolution; the feeds are so controlled that, however unequally the grinding stock may be distributed between outer and inner surfaces and however many times the feeds are halted and started as a consequence of maintaining the preset horsepower level, the arrivals of both inner and outer abrading surfaces at their terminal points relative to the workpiece center line will be co-incidental.

Another object of this invention is to provide a grinding machine having an electrical horsepower level control system of simple design with inherent dependability and long life expectancy.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself as to its objects and advantages, the mode of its operation and the manner of its organization, may be better understood by referring to the following description, taken in connection with the accompanying drawings forming a part thereof, and in which:

Figure 1 is a front elevational view of a grinding machine embodying the principles of the present invention;

Figure 2 is a plan view of the machine; and

Figure 3 is a schematic view of certain electrical and drive apparatus incorporated in the machine.

Referring first to Figures 1 and 2, wherein are best shown the general features of the invention, the grinding machine, indicated generally by the reference numeral 10, is shown as being of the type shown and described

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in the co-pending patent application of William D. Schmidt and Almon F. Townsend, Serial Number 445,152. A base 11 has mounted at one end a workhead 12 driven by a motor 13. Mounted on the base 11 for movement parallel to the axis of the wheelhead is a table 14 on which is mounted a wheelhead 15 driven by a motor 16. A drive piston 17 is associated with the wheelhead 12 and a work support 18 of the shoe type extends upwardly from the base 11, to support a workpiece 19 which, for the purposes of description, is shown as being an inner race of a bearing. An internal abrasive wheel 21 is associated with the wheelhead 15. Also mounted on the base 11 is a secondary table 22 mounted for pivotal adjustment and carrying an external wheelhead 23 driven by a motor 24 and adapted to carry an external abrasive wheel 25. A suitable wheel dressing apparatus 26 is mounted on the base and is provided with a diamond 27 adapted to dress the external wheel 25 and a diamond 28 adapted to dress the internal wheel 21. A feed mechanism 29 feeds the internal grinding wheel 21 relatively to the work and is driven through a magnetic clutch 31 (see Figure 3) by a motor 32. A feed mechanism 33 feeds the external grinding wheel 25 relative to the work and is driven through a magnetic clutch 34 by a motor 35. The machine is otherwise as described in the above-mentioned patent application of Schmidt and Townsend.

Referring now to Figure 3, power lines 36, 37, and 38 are connected to a source of 3-phase electrical power, not shown, and are connected through fuses 39, 41, and 42 to leads 43, 44, and 45. These leads are connected through starter contactors 46, 47, and 48 to leads 49, 51, and 52 connected to the internal diameter wheel motor 24. The leads 43, 44, and 45 are also connected respectively through starter contactors 53, 54, and 55 to leads 56, 57, and 58 connected to the outside diameter wheel motor 24.

Connected in the lead 52 is the primary 59 of a current transformer 61, having a secondary coil 62. The ends of the secondary coil 62 are connected to opposite sides of a rectifier 63, one of the leads having inserted therein an A.C. ammeter 64. The output side of the rectifier 63 is connected to leads 65, and 66 across which is connected the resistance element 67 of a rheostat 68. The contact arm 69 of the rheostat is connected back to the line 65. The line 65 is also connected to one end of the resistance element 71 of a variable resistor 72, the contact arm 73 thereof being connected to one side of the coil 74 of a normally-open sensitive relay 75. One side of the switch element 76 of the relay 75 is connected to a line 77 by means of a lead 78.

Inserted in the lead 58 associated with the motor 24 is the primary coil 79 of a current transformer 81. The secondary coil 82 is connected by leads to the input sides of a rectifier 83, one of the leads having an A.C. ammeter 84. To the output side of the rectifier 83 are connected leads 85 and 86 across which is connected the resistance element 87 of a variable resistor 88. The contact arm 89 is connected back to the line 85. The line 86 is connected to one end of the resistance element 91 of a variable resistor 92. The contact arm 93 of the resistor 92 is connected to one side of the actuating coil 94 of a sensitive relay 95 and the other side of the coil is connected to the lead 85. The switch elements 96 are connected across the switch element 76 associated with the relay 75, so that one of the leads from the switch element 96, is connected by the lead 78 to the line 77. The other sides of the switch elements 76 and 96 are connected through a lead 97 to one side of the coil 98 forming part of a normally-closed relay 99. The other side of the coil 98 is connected by a lead 101 to a line 102. The lines 77 and 102 are connected to opposite-polarities of a source of direct current electricity, not shown; the polarity is, of course, immaterial to the operation of the apparatus. Across the coil 98 is connected a resistor 103 in series with a capacitor 104. One side of the

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contactor 105 associated with the relay 99 is connected to the line 77 by a lead 107. The other side of the contactor 105 is connected to the coil 108 of the magnetic clutch 31. The actuating coil 109 associated with the magnetic clutch 34 is also connected to the same side of the contactor 105 as is the coil 108. The other sides of the coils 108 and 109 are connected to the line 102.

The line 77 is connected by a lead 111 to one side of the rotor of the outside diameter feed motor 35. The line 77 is also connected by a lead 112 to one side of the internal diameter feed motor 32. The other sides of each of these motors are connected together and through a lead 113 to the line 102. The field coil 114 associated with the motor 32 is connected on one end to the line 77 and on the other end to a variable resistor 115, the contact arm of which is connected through the lead 113 to the line 102. In the same manner, one end of the field coil 115 associated with the outside diameter feed motor 35 is connected to the lead 111 connecting it to the line 77. The other side of the field coil 116 is connected to one side of a variable resistor 117, the contact arm of which is connected through the lead 113 to the line 102.

The operation of the apparatus will now be readily understood in view of the above description. The power drawn by the internal diameter wheel motor 16 is indicated to the current transformer by the passage of one phase of the current through the primary coil 59 thereof. The voltage appears across the output coil 62 which is proportional to the current in the lead 52 and therefore is approximately indicative of the H.P. drawn by the motor. The output signal of the current transformer 61 is alternating but, after treatment by the rectifier 63, emerges as a series of direct current pulses of a magnitude indicative of the power drawn by the motor. The relay 75 is so constructed that, when the size of the pulses reaching it is great enough, the switch element 76 will close. In the same way, the current drawn by the motor 24 is felt by the primary coil 79 of the current transformer 81. An alternating voltage appears on the output leads of the coil 82 indicative of the power drawn by the motor 24. This alternating signal is rectified by the rectifier 83 and is impressed on the coil 94 of the relay 95. When a given pulse is large enough, the switch 96 closes. The closure of either or both of the switch elements 76 and 96 causes a flow of current through the coil 98 of the relay 99. The current passes from the line 77 through the lead 78, through one of the two switches 76 and 96, and through the lead 97, the coil 98 and the lead 101 to the line 102. A similar current passes through the resistor 103 and the capacitor 104. A sufficient flow of current through the coil 98 causes an opening of the contactor 105 thus cutting off the flow of current to the coils 108 and 109 associated with the clutches 31 and 34 respectively. As is evident from a study of Figure 3, the motors 32 and 35 operate continuously but the de-activation of the clutches 108 and 109 causes the cutting off of power transmittal from these motors to the feed mechanisms 29 and 33. It will be understood that the relays 75 and 95 are very sensitive. The variable resistance 68 acts as a means of adjusting the sensitivity of the relay 75 and a variable resistance 88 performs a similar function in connection with the relay 95. An additional adjustment of sensitivity is provided by the variable resistances 72 and 92. Suppose that the control be set at 3 hp. As the wheel feeds into the work the power loading increases from its free-running value towards the 3 hp. value. The contact-carrying armature of the sensitive relay or solenoid-actuated switch 75 is subject to two opposing forces; the relay spring tries to maintain the relay contact open while the increasing magnetic field from the coil 74 opposes the spring and attempts to close the contact. It is obvious at this point that the force acting on the switch element 76 is not substantial, particularly since the magnetic force is

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pulsing at twice the supply current frequency, and only the difference between the magnetic force and the spring force is available to effect closure. If this switch element be used to control the feed through an on-off device such as a magnetic clutch, a rapid functioning results. This becomes especially true if two clutches (as for an internal feed and external feed, such as we have in the present case) be operated from one ordinary sensitive relay. At the threshold of operation the switch element 76 (and the switch element 96, for that matter) behaves like a faulty rheostat with a large voltage drop across the contact. This, in turn, results in feeding of the clutch which operates at the slightly lower energy level, while the other clutch fails to drive. This situation could not be tolerated on a machine for simultaneously grinding outer and inner surfaces for the previously-described reason that a necessary condition of the operation of such a machine is accurate synchronization of the internal and external feeds. To avoid this difficulty the operation of the sensitive relay is converted from an erratic to a positive action by providing the relay 99 which is shunted by an integrating capacitor 104 and resistor 103. The function of the integrating capacitor is to accumulate the pulse energy delivered by the switch elements 76 and 96 and, when the energy level reaches that required by the resistor 103 and the relay 99, it causes a sustained (unpulsed) actuation of the relay 99. The positive action on the relay 99 efficiently and cleanly interrupts both feeds, whereupon the power loading of the spindle motors diminishes until the switch elements 76 and 96 are both open. The energy accumulated in the capacitor 104 dissipates meanwhile through the resistor 103 and the coil 98 of the relay 99 until it reaches the level where release of the contactor 105 occurs. The contactor then closes with a positive action and the energization of the coils 108 and 109 and the operation of the feed mechanisms 29 and 33, respectively, are again actuated.

The power differential between pull-in and drop-out of the relay 99 is related to the values of the capacitor 104 and the resistor 103 which are in parallel with the relay, and related as well as to the internal resistance of the relay itself. These elements can be so chosen that the feed advances by small or large increments, each type of performance having its own advantages in specific cases. In the preferred embodiment a relay 99 is used having a high internal resistance and a resistance is placed in series with the capacitor to reduce the current flowing through the sensitive relays 75 and 95. The switch element 76 and 96, because of the low pressure vibratory type of operation (with consequent arching) would not otherwise have a long nor dependable life expectancy. In a specific example the relays 75 and 95 have an internal resistance of one ohm, the resistor 103, a resistance of 10,000 ohms, the capacitor 104, a capacity of 4 microfarads, and the relay 99 an internal resistance of 10,000 ohms. Suppose that it is desired to set up the grinding machine to simultaneously grind the outer and inner surfaces of a ring where the maximum stock found on the outer surface is .030" on the diameter and .025" on the inner diameter. Suppose further that it is possible to remove .028" from the outer surface in 28 seconds and .026" on the inner surface in 26 seconds, these rates being close to, but safely under the critical point where the abrading surface might be severely crushed or damaged. This would allow .002" for further finishing of each surface. Instead of setting the rates on internal and external feeds to a 28th second cycle (the slower of the two) the present invention makes it possible to set the feed rates of each at a much faster rate, say, 4 times faster or 7 seconds. At the same time the danger of exceeding the critical wheel pressure is overcome by setting the external and internal power load adjustments to values which are consistent with that face value produced by the 28 second cycle on the outer surface and 26 second cycle on the internal surface. A

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comparison can now be made between the time taken by two machines, one equipped with this invention and one without. The average grinding stock will be assumed to be .014" on the outer surface and .013" on the inner surface. Without this power control the cycle time would be an unvarying 28 seconds. With this control the 7 seconds pre-set rate would accomplish the first .014" of feed (where no stock is encountered) in one half the 7 seconds or 3½ seconds. The second half of the feed would require 14 seconds. The total average time with the use of this invention would be 14 plus 3½ or 17½ seconds, compared to the 28 seconds for the machine without it. This is a large saving in time and the machine is rendered 60% more productive in rough grinding.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions, and changes in the forms and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

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

1. A grinding machine, comprising an internal grinding wheel, an internal wheel motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means for driving the internal feed mechanism, a second means for driving the external feed mechanism, and means operative when the power consumed by either motor exceeds a predetermined value to render both the first and the second means inoperative.

2. A grinding machine, comprising an internal grinding wheel, an internal wheel motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means for driving the internal feed mechanism, a second means for driving the external feed mechanism, a third means giving a signal proportional to the power consumed by the internal wheel motor, a fourth means giving a signal proportional to the power consumed by the external wheel motor, and means operative when the signals from either the third or the fourth means exceeds a predetermined value to render both the first and the second means inoperative.

3. A grinding machine for use in simultaneously abrading external and internal surfaces of a workpiece, comprising an internal grinding wheel, internal wheel motor, and external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first motor for driving the internal feed mechanism, a second motor for driving the external feed mechanism, a first means giving a signal proportional to the power consumed by the external wheel motor, and a relay operative when the signal from either first or the second means exceeds a predetermined value to render both the first and second motors inoperative.

4. A grinding machine, comprising an internal grinding wheel, an internal wheel motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means including a motor and clutch for driving the internal feed mechanism, a second means including a motor and clutch for driving the external feed mechanism, a third means giving the signal proportional to the power consumed by the internal wheel motor, a fourth means giving a signal proportional to the power consumed by the external wheel motor, and means operative when the signals from either the third or the fourth means exceed a predetermined value to render both clutches associated with the first and second means inoperative.

5. A grinding machine for use in simultaneously abrading external and internal surfaces of a workpiece, comprising an internal grinding wheel, an internal wheel

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motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means for driving the internal feed mechanism, a second means for driving the external feed mechanism, a third means giving a signal proportional to the power consumed by the internal wheel motor, a first relay operated when the signal from the third means exceeds a predetermined value, a fourth means giving a signal proportional to the power consumed by the external wheel motor, a second relay operated when the signal from the fourth means exceeds a predetermined value, and a third relay actuated by the operation of either the first or the second relay to render both the first and second means inoperative to drive their respective feed mechanisms.

6. A grinding machine for use in simultaneously abrading external and internal surfaces of a workpiece comprising an internal grinding wheel, an internal wheel motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means including a motor and clutch for driving the internal feed mechanism, a second means including a motor and clutch for driving the external feed mechanism, the third means giving a signal proportional to the power consumed by the internal wheel motor, a first relay operated when the signal from the third means exceeds a predetermined value, a fourth means giving a signal proportional to the power consumed by the external wheel motor, a second relay operated when the signal from the fourth means exceeds a predetermined value, and a third relay actuated by the operation of either the first or the second relay to render both the clutches of the first and second means inoperative to connect their respective motors to their respective feed mechanisms.

7. A grinding machine for use in simultaneously abrading external and internal surfaces of a workpiece, comprising an internal grinding wheel, an internal wheel motor, an external grinding wheel, an external wheel motor, an internal feed mechanism, an external feed mechanism, a first means including a motor and clutch for driving the internal feed mechanism, a second means including the motor and clutch for driving the external feed mechanism, a first current transformer connected in a lead to the internal wheel motor giving a signal proportional to the power consumed thereby, a first relay operated when the signals from the first current transformer exceeds a predetermined value, a second current transformer connected in a lead to the external wheel motor giving a signal proportional to the power consumed thereby, a second relay operated when the signal from the second current transformer exceeds a predetermined value, and a third relay actuated by the operation of either the first or second relay to render both clutches of the first and second means inoperative to connect their respective motors to their respective feed mechanisms.

8. A grinding machine for use in simultaneously abrading external and internal surfaces of a workpiece, an internal grinding wheel, an internal wheel motor of the alternating current type, an external grinding wheel, an external wheel motor of the alternating current type, an internal feed mechanism, an external feed mechanism, a first means including a motor and clutch for driving the internal feed mechanism, a second means including a motor and clutch for driving the external feed mechanism, a third means giving a signal proportional to the power consumed by the internal wheel motor, a first sensitive relay operated when the signal from the third means exceeds a predetermined value, a fourth means giving a signal proportional to the power consumed by the external wheel motor, a second sensitive relay operated when the signal from the fourth means exceeds a predetermined value, a third relay actuated by the operation of either the

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first or the second relay to render both clutches of the first and second means inoperative to connect their respective motors to their respective feed mechanisms, and a capacitor connected across the third relay to render it insensitive to high frequency opening and closing of the first and second relays.

9. A grinding machine for use in simultaneously abrading internal and external surfaces of a workpiece, comprising an internal grinding wheel, an internal wheel motor of the alternating current type, an external grinding wheel, an external wheel motor of the alternating current type, an internal feed mechanism, an external feed mechanism, a first means including a motor and clutch for driving the internal feed mechanism, a second means including a motor and clutch for driving the external feed mechanism, a first current transformer connected in a lead to the internal wheel motor giving a signal proportional to the power consumed thereby, a first sensitive relay operated when the signal from the first current transformer exceeds a predetermined value, a second current transformer connected in a lead to the external wheel motor giving a signal proportional to the power consumed thereby, a second sensitive relay operated when the signal from the second current transformer exceeds a predetermined value, a third relay actuated by the operation of either the first or second relay to render both clutches of the first and second means inoperative to connect their respective motors to their respective feed mechanisms, and a capacitor connected across the coil of the third relay to render it insensitive to high frequency opening and closing of the first and second relays.

10. A grinding machine, comprising a grinding wheel, a wheel motor of the alternating current type, a feed mechanism, a first means for driving the feed mechanism, a second means giving a signal proportional to the power consumed by the wheel motor, a sensitive relay operated when the signal from the second means exceeds a predetermined value, a second relay actuated by the operation of the sensitive relay to render the first means inoperative to drive the feed mechanism, and a capacitor connected across the coil of the second relay to render it insensitive to high frequency opening and closing of the first and second relays.

11. A grinding machine for use in simultaneously finishing external and internal surfaces of revolution of a workpiece, comprising an internal grinding wheel, an internal wheel motor for carrying on the finishing operation on the internal surface, an external grinding wheel, an external wheel motor for carrying on the finishing operation on the external surface, an internal feed mechanism, an external feed mechanism, the feed mechanisms being arranged to bring the internal and external finishing operations to a conclusion at approximately the same time, a first means for driving the internal feed mechanism, a second means for driving the external feed mechanism, a third means giving a signal proportional to the power consumed by the internal wheel motor in carrying on the finishing operation of the internal surface, a fourth means giving a signal proportional to the power consumed by the external wheel motor in carrying on the finishing operation on the external surface, the feed rates being substantially greater than the rate which will maintain the power consumed by the wheel motors below the said predetermined values during the finishing cycle, the predetermined values being those above which operation is destructive of the wheel, and means operative when the signals from either the third or the fourth means exceed a predetermined value to render both the first and second means inoperative.

References Cited in the file of this patent

UNITED STATES PATENTS

2,694,883	Balsiger	Nov. 23, 1954
2,807,916	Squire	Oct. 1, 1957