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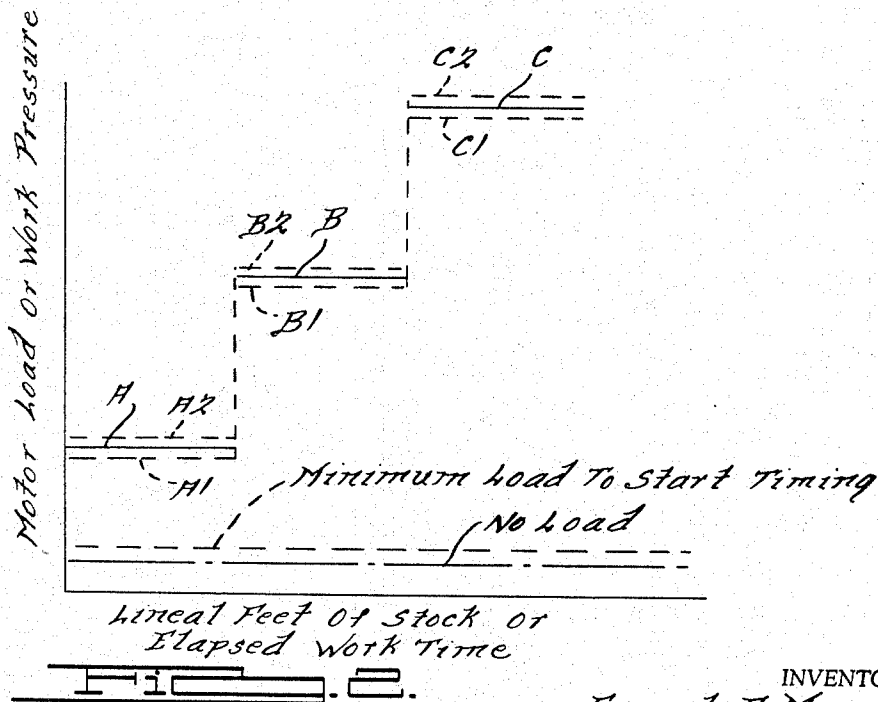
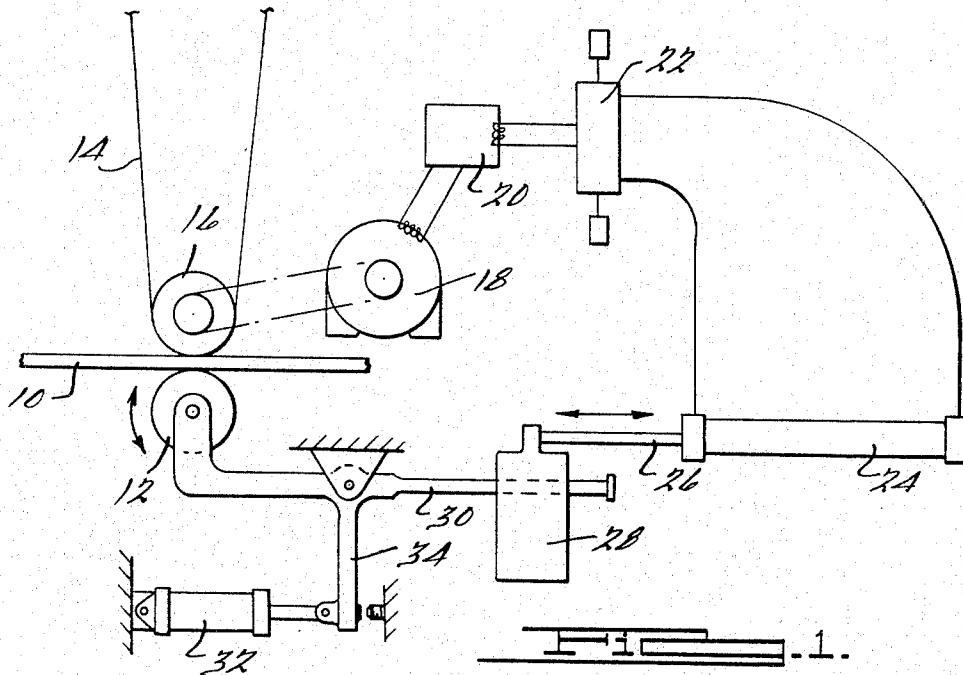
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3,415,017

APPARATUS FOR FINISHING WORKPIECES UNDER CONTROLLED PRESSURES

Filed May 13, 1965

2 Sheets-Sheet 1



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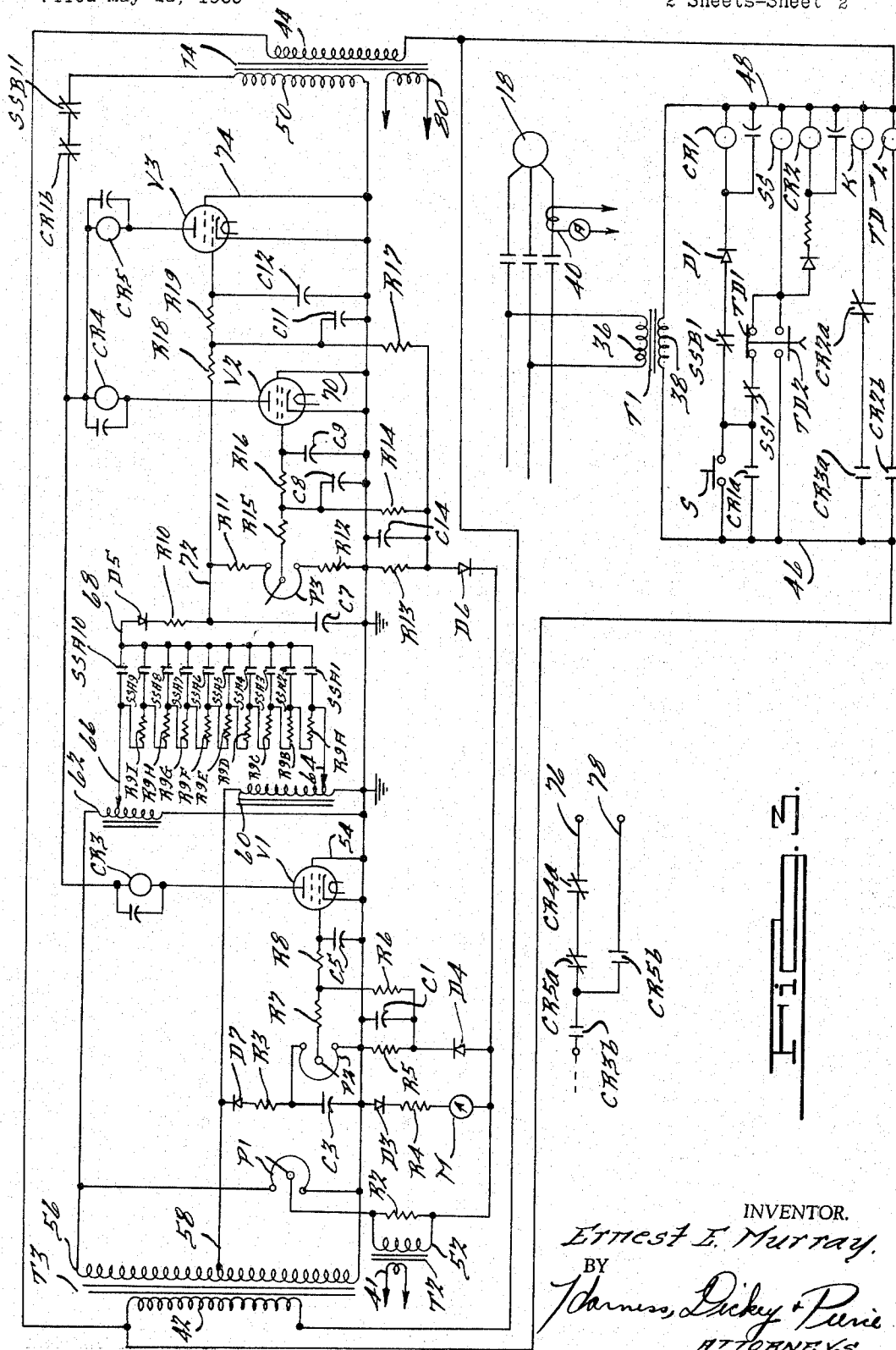
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ABSTRACT OF THE DISCLOSURE

Apparatus for finishing workpieces with an abrasive belt in which the pressure between the belt and workpiece is automatically varied to compensate for wear of the abrasive belt.

The present invention relates to apparatus for finishing workpieces and more specifically to apparatus for finishing workpieces by means of an abrasive belt.

In finishing or grinding flat steel stock by means of an abrasive belt, the grinding pressure normally is fixed at a selected pressure and remains at that pressure during the life of the belt. Since as a belt wears its capability to remove material under a given pressure will decrease, the pressure is normally set high enough to accommodate the belt in a worn condition. It has been found, however, that when initially grinding with a new belt the grits on the belt are sharp and an adequate amount of material can be removed at pressures which are substantially lower than the pressures required by the same belt after it is worn and the grits are dulled. It has also been found that when a new belt is worked under the pressure required for a worn belt the new belt wears rapidly. When the work pressure is varied such that it is low when the belt is new and is increased as the belt wears, the desired amount of material is removed at all times during the life of the belt and it has been found that the life of the belt is increased by a substantial margin. This increase in belt life results in savings in the cost for belts and in the decrease in the frequency of downtime of the grinding apparatus. Thus in the present invention apparatus is provided whereby the work pressure on the belt is initially a minimum for a new belt and is gradually increased to the maximum pressure as the belt is worn.

Therefore it is an object of the present invention to provide improved grinding apparatus for removing material from workpieces.

It is another object of the present invention to provide improved apparatus for removing material from workpieces by means of an abrasive belt and in which the grinding pressure is varied in accordance with the condition of the belt.

It is another object of the present invention to provide improved apparatus for removing material from workpieces by means of an abrasive belt and in which the grinding pressure is varied from a minimum pressure when the belt is new to a maximum pressure when the belt is worn.

With certain grinding apparatus, the apparatus is set to grind workpieces of a given thickness at a given pressure; if the thickness varies the pressure varies; it is an object of the present invention to provide grinding apparatus in which grinding is performed at selected pressures unaffected by variations in stock thickness.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a pictorial and diagrammatical representation of a preferred form of grinding apparatus of the

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present invention, and includes an abrasive belt and a control circuit, which is shown in block form;

FIGURE 2 is a graphical representation depicting a selected relationship between work pressure on the abrasive belt and lineal feet of stock to be finished; and

FIGURE 3 is an electrical schematic diagram of the control circuit for controlling the work pressure on the abrasive belt.

Looking now to FIGURE 1, grinding apparatus is shown for grinding flat stock such as workpiece 10 (partially shown) as it is passed between a pressure or billy roll 12 and an endless abrasive belt 14. The belt 14 is driven by a spindle 16 located at its lower end, with the spindle 16 in turn being driven, via a drive belt, by an electric motor 18. The motor 18 is fixed to drive at a given speed and as the pressure applied against the abrasive belt 14 is increased the power output requirement of motor 18 increases and the power input via the armature current for the motor 18 increases. Since the amplitude of the armature current then is a function of the work pressure of the abrasive belt 14 against the workpiece 10, the magnitude of the work pressure can be determined by sensing the amplitude of the armature current. This is done by the electrical control circuit 20.

The specific construction of the control circuit 20 is to be described; in general the circuit provides an output signal which varies in accordance with two factors: (1) the magnitude of the work pressure on the belt 14 and (2) the time for which the belt 14 is working at selected work pressures. The significance of these two factors will be presently understood.

The amount of wear on the belt 14 is a function of the work pressure and the amount of time the belt 14 is operated at a work pressure. In operation, the belt 14 will be continuously moving; however, the belt 14 will wear only when it is performing work on the workpiece 10. Therefore in the practice of the present invention the work pressure is varied as a function of actual working time of the belt. The work pressure can be varied with respect to working time in many different ways and benefits of the present invention can still be obtained. In the preferred embodiment presented here a simple, effective mode of variation was selected, i.e., a plurality of step functions; this is depicted in FIGURE 2. In FIGURE 2 a minimum value A of work pressure for a new belt is selected and a maximum value C for the same belt in a worn condition is selected. At the same time a number of intermediate values such as B are selected between the minimum A and maximum C. In operation a new belt is initially operated at the minimum pressure A. This pressure level is maintained for a selected working time for the belt after which the working pressure is automatically increased to the next pressure level. This continues until the maximum work pressure C is reached. After operation for a given interval at this pressure level, the belt is changed. While only one intermediate working pressure B is shown in FIGURE 2, this is exemplary only and in the preferred form a total of ten steps is shown. To effectuate the above mode of operation the control circuit 20 senses the actual work time of the belt 14 at each work pressure level and after operation at that level for a selected time provides a signal whereby the work pressure is increased to the next selected level.

Looking again to FIGURE 1, the control circuit 20 transmits its signal to a solenoid actuated four-way, directional hydraulic valve 22 which can be connected to a source of hydraulic pressure (not shown). Upon actuation of the valve 22 fluid under pressure is transmitted to a counterweight adjustment cylinder 24 which has a reciprocally mounted piston rod 26 connected to a counterweight 28. The rod 26 can be moved in either direction

whereby the effect of the counterweight 28 can be lessened or increased, depending upon the character of the signal from the control circuit 20.

The counterweight 28 is movably mounted on one end of a pivot bar 30 which is fulcrumed at a point intermediate its ends and which supports the billy roll 12 at its end opposite the counterweight 28. As can be seen, the location of counterweight 28 determines the pressure with which the workpiece 10 will be held against the belt 14.

A pressure release cylinder 32 is connected to an arm 34 of the pivot bar 30 and extends from its fulcrum point. The cylinder 32 acts as a shock absorber and resists shock loads, i.e., when the end of the workpiece 10 leaves the billy roll 12 and the billy roll 12 wants to move upwardly.

As noted, the rod 26 can be moved in directions either to increase or decrease the effect of counterweight 28 on billy roll 12. If the workpiece 10 is irregular in thickness, then as a thicker portion moves between the billy roll 12 and the belt 14 the work pressure will increase somewhat. The control circuit 20 will sense this increase and will provide a signal to actuate the valve 22 whereby the rod 26 will be moved to change the position of counterweight 28 whereby the proper work pressure will be reinstated. The reverse occurs if the thickness of the workpiece 10 decreases and the work pressure decreases. Note that normally the pivoted relationship between the counterweight 28 and billy roll 12 should automatically compensate for these changes in stock thickness. However, the friction of the system can prevent such compensation and, hence, the apparatus noted above will positively insure such compensation. The details of the control circuit 20 are shown in FIGURE 3.

In FIGURE 3 the motor 18 is shown to be energized by a 220 volt three wire system with power for the control circuit taken from two if the wires via a transformer T1 having a primary 36 and a secondary 38. At the same time the amplitude of the current to motor 18 is sensed via a current sensing winding 40 which is connected to the primary 41 of transformer T2. The primaries 42 and 44 of transformers T3 and T4, respectively, are connected across secondary 38 via conductors 46 and 48.

Considering now some other of the components of FIGURE 3, a relay CR1 when energized closes normally opened contacts CR1b. A relay CR2 when energized opens normally closed contacts CR2a and closes normally opened contacts CR2b. The relays CR1 and CR2 are associated with the resetting portion of the control circuit.

A relay CR3 when energized closes normally opened contacts CR3a and is connected with the timing portion of the control circuit. A relay CR4 when energized opens normally closed contacts CR4a and a relay CR5 when energized opens normally closed contacts CR5a and opens normally closed contacts CR5b; relays CR4 and CR5 are operative for actuating circuits to the solenoids which actuate valve 22 to thereby control its actuation and hence to control the flow of hydraulic fluid under pressure to the adjustment cylinder 24. Each of the relays CR1-CR5 is shunted by a capacitor to provide a preselected time delay in actuation.

A stepping switch SS will sequentially close normally opened contacts SSA1 through SSA10 in positions one through ten, respectively; it will open normally closed contacts SSB1 and SSB11 in its first and eleventh positions, respectively; and it will open normally closed contacts SSI in its first position. A timer TD has a clock or timer section K and a pair of contacts TD1 and TD2, with contacts TD1 being normally closed and contacts TD2 being normally opened and with the clock K opening contacts TD1 and closing contacts TD2 after a preselected timed interval. The timer TD has a return section L which, when energized, returns the clock K to zero.

In order to reset the control circuit of FIGURE 3 a normally opened reset switch S is closed whereby a series circuit between conductors 46 and 48 is completed via the closed contacts SSB1, a diode or rectifier D1 and relay

CR1. This results in contacts CR1A closing whereby a series circuit between conductors 46 and 48 is completed via contacts SSI, contacts TD1 and stepping switch SS. Note that at this point switch S1 can be released and relay CR1 is maintained self-energized through its now closed contacts CR1a and conductor 50. When stepping switch SS is energized relay CR2 is also energized since it is located in a series circuit with a rectifier D2 and resistor R1 which circuit parallels switch SS. Energization of relay CR2 closes contacts CR2b whereby a series circuit is completed from conductors 46 and 48 through the return section L of timer TD. Return section L upon energization returns the clock section K to its zero or initial condition. The stepping switch SS will be energized until it steps back to its original or primary position at which contacts SSI and SSB1 are opened; the de-energizes the circuits of relays CR1 and CR2 and stepping switch SS. Thus contacts CR1a and CR2b are again opened and stepping switch SS is in its first position, closing contacts SSA1. Note that the clock section K is located in a series circuit including contacts CR3a and CR2a between conductors 46 and 48. Thus during resetting as previously noted contacts CR2a will be opened.

With the control circuit in the condition noted the clock section K is now ready to begin its timing function. Note that the clock section K can be set to any preselected time interval such that the clock section K will reverse the conditions of contacts TD1 and TD2 after this selected interval has elapsed. When this occurs a circuit is closed to stepping switch SS and also to relay CR2 through closed contacts TD2. This results in stepping switch SS being pulsed to its next position, i.e., closing contacts SSA2 and opening contacts SSA1, SSI and SSB1, and energizing return section L whereby the clock section K is again returned to zero and the next timed operation is ready to commence. The above sequence of operation is repeated with the stepping switch SS moving through all of its positions, i.e., through eleven positions. As will be seen, further pulsing of switch SS is prevented upon attainment of the eleventh position whereby the control circuit is then maintained in that condition until it is again reset by closing the reset switch S1. The significance of the previous detailed description of the control circuit will be further understood from the discussion which follows.

The clock section K will perform its timing function only during those intervals when contacts CR3a are closed. These contacts are closed when relay CR3 is energized by current flow through the plate-cathode circuit of a thyatron V1 which serially connects the relay CR3 with the secondary winding 50 of transformer T4 via normally closed contacts CR1b and SSB11. One side of secondary 50 is grounded. As will be described in detail, the circuit controlling the firing of thyatron V1 senses the presence of a workpiece 10 between the billy roll 12 and the belt 14 and only during that occurrence fires thyatron V1. The latter sensing can be done by means of the armature current to motor 18 since the amplitude of current will be a known no load value when no workpiece is being finished and will increase to at least a known minimum load value when a workpiece is being finished. This armature current is sensed by coil 40 with a resultant load signal being induced in a secondary 52 from primary 41 of transformer T2.

The thyatron V1 has its cathode connected to ground and its shield grid connected to ground via conductor 54. The input circuit for the control grid of tube V1 includes a potentiometer P1 having its winding connected across the secondary 56 of transformer T3 and having its movable wiper arm connected to one end of a resistor R2 which is connected across the secondary 52 of transformer T2. One end of secondary 56 is grounded. The opposite end of resistor R2 and hence the corresponding end of secondary 52 is connected to ground via three circuits to be described; these three circuits are a null balance circuit and two bias circuits.

The null balance circuit includes a null meter M serially connected with a resistor R4, and a rectifier D3. Note that the potential between the wiper and ground side of potentiometer P1 opposes the potential developed at secondary 52 and across resistor R2. This provides a means for initially zero balancing the signal from sensing coil 40 when the motor 18 is running under no load. Thus initially with no workpiece being finished the potentiometer P1 is adjusted until a null is indicated at null meter M.

The first of the bias circuits mentioned includes a rectifier D4 serially connected with the parallel combination of a resistor R5 and capacitor C1. The latter circuit is utilized to provide a D.C. bias for the control grid of tube V1 and for this purpose is connected to that grid via a resistor R6, connected between the high potential side of resistor R5 and capacitor C1 and to one side of a resistor R8 which is connected at its other side to the control grid and also to ground via a capacitor C5. The polarity of the bias from this circuit is such as to fire tube V1 upon attainment of the proper magnitude. This bias, however, is opposed by a variably selectable bias circuit. The latter circuit is connected from an intermediate tap 58 of secondary 56 to ground. This variable bias circuit includes a diode D7 which has one end connected to tap 58 and which is in series with a resistor R3 and capacitor C3, which is connected to ground. A potentiometer P2 is connected from the juncture between resistor R3 and capacitor C3 and ground and has its movable wiper connected to resistor R8 via a resistor R7. With this circuit arrangement thyatron V1 will not be fired until the D.C. bias provided from the armature current sensing circuit via resistor R6 exceeds the critical grid bias and that provided from the variable bias circuit via resistor R7. In operation the potentiometer P2 is adjusted to a minimum load level such that tube V1 will fire only when the current amplitude in the armature of motor 18 exceeds the no load value by a selected amount thereby positively indicating that a workpiece 10 is located between belt 14 and billy roll 12 and is being worked on. When this occurs the signal at resistor R2 and hence the bias circuit connected thereto will provide a bias signal sufficient to fire tube V1; this energizes relay CR3 closing the opened contacts CR1a permitting current to flow to the clock section K of timer TD whereby the timing is initiated. Assuming now that the entire sequence of operations has just been commenced, i.e., reset switch S has been actuated and released, it is important that the load on the workpiece 10 be brought to and maintained at the first selected low load level being level A of FIGURE 2. This load level is set by the circuitry to be described.

A winding 60 is inductively coupled with secondary 56 and is electrically connected from the tap 58 to ground. Another winding 62 is inductively coupled with secondary 56 and is electrically connected from the high voltage side of secondary 56 to ground. Both windings 60 and 62 are provided with selectively movable taps 64 and 66 respectively, whereby the voltage secured therefrom can be varied. The winding 62 and its wiper 66 are used to select the maximum voltage level and hence the maximum work pressure level C while the winding 60 and its wiper 62 are used to select the minimum voltage level and hence the minimum work pressure level A. A plurality of resistors R9A-R9I are connected in series between wipers 64 and 66 and are a part of a ten level voltage dividing network. The voltage across the network is the difference in potential between wipers 64 and 66. One side of individual ones of the ten normally opened contacts SSA1-SSA10 is connected at the opposite ends of the series of resistors R9A-R9I and also at each juncture between adjacent resistors. The opposite side of each of the contacts SSA1-SSA10 is connected to a common conductor 68. The resistors R9A-R9I are shown fixed but could be provided to be variable; in the preferred form the

resistors R9A-R9I were all of equal magnitude resulting in equal incremental potential steps from the minimum to the maximum level; however, these values could be varied to provide a different desired relationship. Of course, more or less increments could be provided by changing the number of resistors. In operation, at the beginning SSA1 will be closed and hence the minimum potential at wiper 64 will be imposed at conductor 68. When the selected time of timer K is reached and stepping switch SS is pulsed to its second position, SSA1 will again be opened and SSA2 will be closed whereby the potential at the juncture of resistors R9A and R9B will be imposed at conductor 68. This timing and pulsing sequence will continue until contacts SSA10 are closed.

As will be seen, the potential at conductor 68 will determine the work pressure applied by the billy roll 12. This is done by comparing the potential at conductor 68, which represents the selected work pressure, with the potential at resistor R2 which represents the actual work pressure and, depending upon the result, transmitting an appropriate signal to the solenoids operating the four-way hydraulic valve 22 whereby the rod 26 and hence counterweight 28 are moved in the proper direction to bring the actual work pressure applied by the billy roll 12 to equal that which was selected. It can be appreciated that the load can be too high or too low. To compensate for a level which is too low a circuit including a thyatron V2 is provided while to compensate for a level which is too high a circuit including a thyatron V3 is provided. With regard to tube V2, it has its plate-cathode circuit connected in series with relay CR4, normally closed contacts CR1b and SSB11 and across secondary 50 of transformer T4. Tube V2 has a shield grid connected to ground via a conductor 70. The control grid is biased by potentials from the voltage divider network or load selecting circuit, i.e., across wipers 64, 66, and from the potential across R2 or the load sensing circuit. Note that the latter circuit is the second bias circuit associated with resistor R2 previously referred to. Conductor 68 is connected to ground via a series circuit composed of a rectifier D5, a resistor R10, and a capacitor C7. A potentiometer P3 via a resistor R11 is connected to a conductor 72 which is connected at the juncture of resistor R10 and capacitor C7; P3 is connected to ground via resistor R12. The potentiometer P3 has a wiper connected to the control grid of tube V2 via serially connected resistors R15 and R16. The control grid is connected to ground via capacitor C9. The bias applied to the control grid thereby, if unopposed, would maintain tube V2 off. Here relay CR4 would be de-energized whereby the solenoid would be actuated to open valve 22 such as to cause the counterweight 28 to be moved by rod 26 in a direction to increase the load by the billy roll 12. The potentiometer P3 provides adjustable means whereby the latter bias level can be selected. Note that the bias at the control grid of V2 is substantially determined by the potential at conductor 68 and that the potentiometer P3 allows for moderate variations in the resulting bias.

Considering the opposing bias from the load sensing circuit, resistor R2 is connected to ground via a rectifier D6 which is in series with a resistor R13. A capacitor C14 is connected to ground from the juncture of rectifier D6 and resistor R13 and a resistor R14 is connected from this same juncture to the control grid of tube V2 via resistor R16. The resistors R14, 15 and 16 which are all connected together are connected to ground from their common connection via capacitor C8. Thus the bias from resistor R2 as applied to the control grid of tube V2 opposes the bias as applied by the voltage divider network from conductor 72. If the load on billy roll 12 is low, i.e., below the selected level, the bias from resistor R2 will not be sufficient to overcome the bias from conductor 72 and the load on the billy roll will be increased; when the bias from resistor R2 is sufficient to overcome the bias from conductor 72 and to turn tube V2 off the

load on billy roll 12 will be equal to or greater than the selected load. As will be seen the thyatron V3 operates in much the same manner to control overload.

The tube V3 has its plate-cathode circuit in series with relay CR5, normally closed contacts CR1b and SSB11 and across the secondary 50 of transformer T4. Tube V3 has its shield grid connected to ground via conductor 74. The control grid of tube V3 is normally biased off by the potential from the voltage divider network including wipers 64 and 66 and to this end is connected to conductor 72 via resistors R18 and R19. A capacitor C12 connects the control grid of tube V3 to ground. The control grid of tube V3 is connected to the bias from the load sensing circuit, i.e., resistor R2, via a resistor R17 which is connected between the juncture of rectifier D6 and resistor R13 and the juncture of resistors R18 and R19. The resistors R17, 18 and 19 at their common connection are connected to ground by capacitor C11. As long as the load on the billy roll 12 is equal to or below the selected load the bias from resistor R2 will not be sufficient to turn tube V3 on. However, once the selected load is exceeded the tube V3 will be fired and the solenoid energized to actuate the four-way valve 22 whereby the counterweight 28 will be moved in a direction to decrease the load on the billy roll 12.

The control circuit for the solenoids for valve 22 is shown in FIGURE 3. The solenoid for actuating the valve 22 to increase the load is energized via a conductor 76 while the solenoid for actuating the valve 22 to decrease the load is energized via conductor 79. Conductor 76 is in a series circuit with normally closed contacts CR4a and CR5a of relays CR4 and CR5, respectively, which series circuit is in parallel with conductor 78 in series with normally opened contacts CR5b of relay CR5. The two circuits are connected together to a source of potential (not shown) via normally opened contacts CR3b of relay CR3. In operation assuming a workpiece 10 is being machined relay CR3 is energized and contacts CR3b are closed. If the load is too low both tubes V2 and V3 will be off and relays CR4 and CR5 will be de-energized; thus a circuit will be completed through contacts CR3b, CR5a and CR4a whereby the solenoid will be energized to actuate valve 22 to increase the load on the billy roll. If the load is at or above the selected level the tube V2 will be fired and relay CR4 energized opening contacts CR4a to interrupt the circuit connected to the conductor 76. If the load is too high then tube V3 will be fired and relay CR5 will be energized opening contacts CR5a and closing CR5b whereby the solenoid connected to conductor 78 will be energized resulting in the load being decreased. The contacts CR5a are in the circuit as a safety measure; if tube V2 fails then CR4 remains unenergized and contacts CR4a would remain closed and the load could become excessive. Contacts CR5a prevent this, since when the load reaches the value to fire V3, contacts CR5a are opened breaking the circuit to the load-increasing solenoid.

Note the biases on tubes V2 and V3 are selected such that tube V2 fires at a minimum value below the preselected level and tube V3 fires at a maximum value above the preselected level. The spread between this minimum and maximum is selected to be sufficient to minimize hunting. Looking at FIGURE 2 the minimum, maximum for level A would be A1, A2, for level B would be B1, B2, and for C would be C1, C2.

Looking at the control circuit of FIGURE 3 filament voltage for the tubes V1, V2 and V3 is provided by a secondary winding 80 of transformer T4.

In operation the desired high and low pressure levels are selected via the wipers 64 and 66 and a null via load balance for the armature current to motor 18 is made via potentiometer P1. Operation is initiated by actuating switch S and stepping switch SS resets to its number one position and clock section K is reset. In this position contacts SSA1 are closed and the system is set to operate at the minimum

selected pressure level. As soon as workpiece 10 is introduced between belt 14 and billy roll 12 the armature current to motor 18 increases and this signal is sensed to fire tube V1 and the timing by clock section K is commenced.

At the same time this current amplitude is used as bias to tubes V2 and V3 whereby if the load is too low or too high automatic correction will be made. Timing will continue as long as work is performed and after the selected time interval for the minimum load has elapsed, stepping switch SS is actuated to move to its second position, the timer section K is reset and the load is brought up to the next level. This continues until at the tenth position of switch SS the maximum load is attained. After passage of the preselected time at the maximum load level switch SS steps to its eleventh position at which contacts SSB11 are opened. As can be seen this prevents further timing and load control since tubes V1, V2 and V3 are all de-energized. From FIGURE 3A it can be seen that no energy can be delivered to the solenoids of valve 22 since contacts CR3b are opened. While not shown an alarm or visual indication could be provided to warn the operator that the maximum load has been reached and the time therefor has passed and the belt should be changed.

Note that with the above circuitry load variations at any selected level due to variations in stock thickness will be accommodated.

With the system as described, belt life will be substantially increased and the frequency of downtime of the apparatus will be reduced.

With the apparatus shown and described the work pressure is varied by varying the force of the billy roll 12 against the workpiece 10. In some apparatus the depth of cut is preselected and fixed; in such a case the billy roll 12 would be a fixed distance from the abrasive belt 14. The work pressure would be varied by varying the speed with which the workpiece 10 is fed between the billy roll 12 and belt 14. In the application of the present invention to such a structure the feed speed of the workpiece would be varied in accordance with the wear condition of belt 14 either in accordance with preselected steps as shown in FIGURE 2 or in accordance with some other suitable function.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In apparatus for finishing flat metal stock with an abrasive belt in which the abrasive belt is supported upon a spindle which is driven by an electric motor and in which the flat stock is fed between the abrasive belt and a pressure roll and work pressure applied to the flat stock by the belt via the relative pressure between the pressure roll and spindle; the improvement comprising: means for sensing the amplitude of the power to the motor and for providing a first signal having a magnitude varying in accordance with the amplitude of the power utilized by the motor; means for providing a second signal varying in magnitude in accordance with the wear condition of the belt, and means for varying the relative pressure between the pressure roll and spindle in accordance with the difference in magnitudes between said first and second signals whereby the work pressure on the flat stock is varied in accordance with the wear condition of the belt.

2. The apparatus of claim 1 in which said second signal varies in amplitude as a preselected function of time.

3. The apparatus of claim 1 in which said second signal increases in amplitude in a series of timed, sequential steps.

4. The apparatus of claim 1 in which said second signal increases in amplitude in a series of sequential

steps from a preselected minimum to a preselected maximum.

5. In apparatus for finishing flat metal stock with an abrasive belt in which the belt is supported upon a spindle which is driven by an electric motor and in which the flat stock is fed between the abrasive belt and a pressure roll and work pressure applied to the flat stock by the belt via the relative pressure between the pressure roll and spindle, the improvement comprising: pressure means supporting the pressure roll and spindle for relative movement towards and away from each other, means for sensing the amplitude of the power to the motor and for providing a first signal having a magnitude varying in accordance with the amplitude of the power utilized by the motor, means for providing a second signal varying in magnitude as a function of time selected whereby the magnitude of said second signal varies in accordance with the wear condition of the belt, pressure varying means operatively connected to said pressure means for relative pressure between the pressure roll and spindle in accordance with the difference in magnitudes between said first and second signals whereby the work pressure on the flat stock is varied in accordance with the wear condition of the belt.

6. The apparatus of claim 5 with said pressure means comprising a pivot bar mounted for pivotal movement and supporting the pressure roll on one end and a counterweight on the other, and in which said pressure varying means comprises a movable member for moving the counterweight whereby the pressure exerted by the pressure roll can be varied.

7. Apparatus for finishing flat metal stock with an abrasive belt comprising: means for grinding material from the stock by applying work pressure between the belt and stock, means for automatically varying the work pressure between the belt and stock in accordance with a signal varying in magnitude indicative of the wear condition of the belt and at any one wear condition of the belt for automatically maintaining the work pressure at a selected magnitude for said one wear condition, and means for varying the magnitude of said signal in accordance with use of the belt for grinding and generally not varying the magnitude of said signal for non-grinding use of the belt, said last named means including means sensing the difference between grinding and non-grinding use of the belt whereby the magnitude of said signal will be varied solely in response to grinding operation.

8. Apparatus for finishing workpieces with an abrasive belt comprising: means for grinding material from the workpieces by applying work pressure between the belt and workpieces, and means for varying the work pressure between the belt and workpieces in accordance with variation in magnitude of a signal indicative of the time that the belt has been used for grinding and means for varying the magnitude of said signal in accordance with use of the belt for grinding and generally not varying the magnitude of said signal for non-grinding use of the belt, said last named means including means sensing the difference between grinding and non-grinding use of the belt whereby the magnitude of said signal will be varied solely in response to grinding operation.

9. Apparatus for finishing workpieces with an abrasive belt comprising: means for grinding material from the workpieces by applying work pressure between the belt

and the workpieces, means for sensing, out of the elapsed running time, the elapsed only grinding time during which the abrasive belt is used solely for grinding and means for varying the work pressure from a minimum work pressure when the belt is new to a maximum work pressure when the belt is worn in accordance with an increase in said elapsed grinding time.

10. Apparatus for finishing workpieces with an abrasive belt comprising: means for grinding material from the workpieces by applying work pressure between the belt and the workpieces, means for sensing, out of the elapsed running time, only the elapsed grinding time during which the abrasive belt is used solely for grinding and means for varying the work pressure from a minimum work pressure when the belt is new to a maximum work pressure when the belt is worn in accordance with an increase in said elapsed grinding time, said last named means varying the work pressure in a plurality of discrete steps from said minimum work pressure to said maximum work pressure.

11. Apparatus for finishing workpieces with an abrasive belt comprising: grinding means for grinding material from the workpieces by applying work pressure between the belt and the workpieces and for varying the magnitude of the work pressure in accordance with a work pressure signal, timing means for sensing the elapsed time during which the abrasive belt is used solely for grinding, and means for sensing the magnitude of the work pressure applied by said grinding means and for providing a sensed signal varying in magnitude in accordance with the variations in magnitude of the work pressure and means for providing said work pressure signal and for varying the magnitude of the work pressure in accordance with said elapsed time and in accordance with the magnitude of said sensed signal.

12. Apparatus for finishing workpieces with an abrasive belt comprising: grinding means for grinding material from the workpieces by applying pressure between the belt and the workpieces and for varying the magnitude of the work pressure in accordance with a work pressure signal, means for sensing the magnitude of the work pressure applied by said grinding means and for providing a sensed signal varying in magnitude in accordance with the variations in magnitude of the work pressure, means for providing a work pressure change signal varying in magnitude in accordance with a preselected function and means responsive to said sensed signal and to said work pressure change signal for providing said work pressure signal to said grinding means for varying the magnitude of the work pressure in accordance with the difference in magnitude between said sensed signal and said work pressure change signal.

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51—139

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,415,017

December 10, 1968

Ernest E. Murray

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 10, line 2, "the elapsed only grinding time" should read -- only the elapsed grinding time --; line 38, after "applying" insert -- work --.

Signed and sealed this 17th day of March 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents