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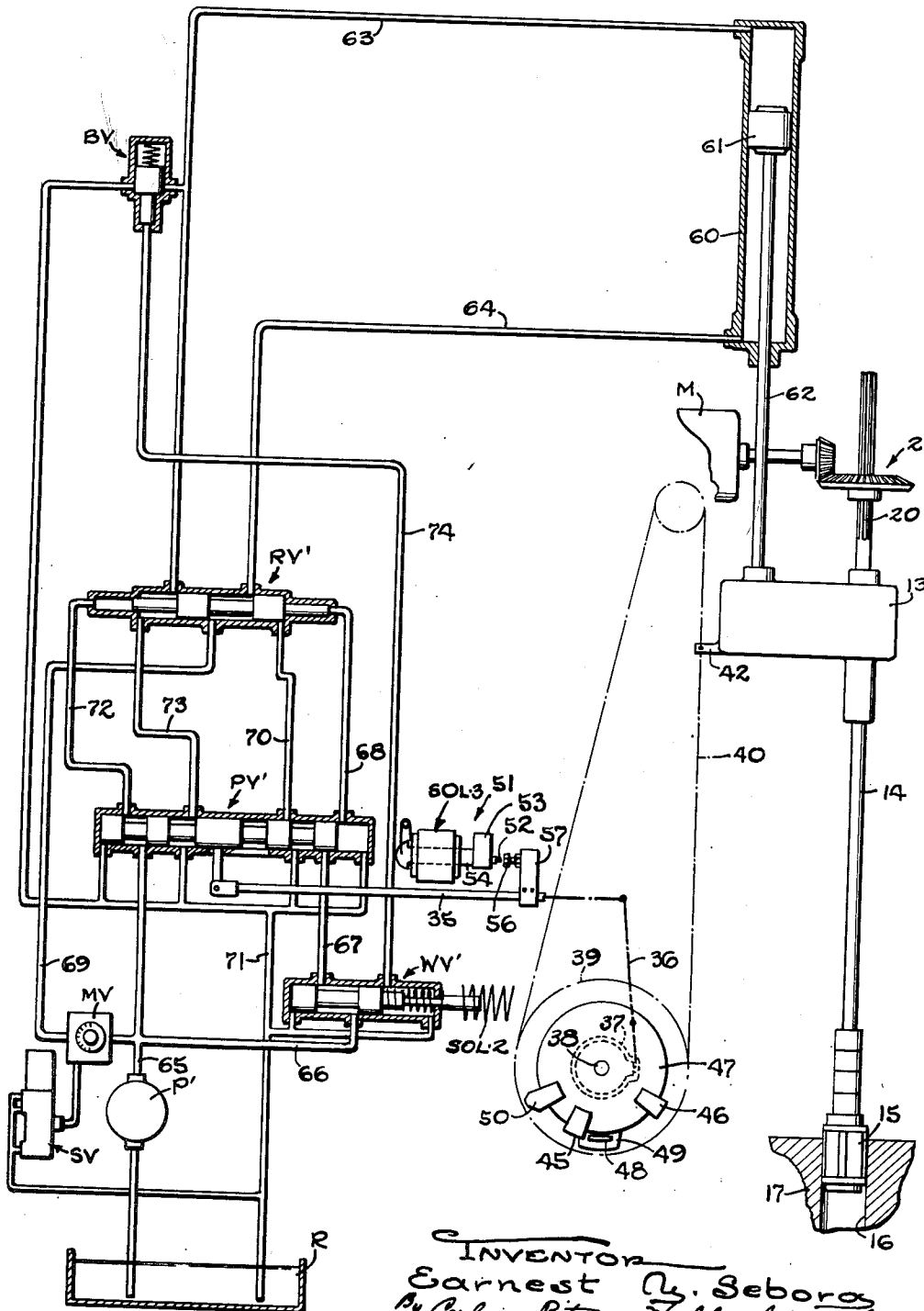
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CONTROL MECHANISM FOR HONING MACHINES

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4 Sheets-Sheet 4

Fig. 7



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CONTROL MECHANISM FOR HONING MACHINES

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1

The invention relates to machines for honing or lapping cylindrical surfaces and more particularly to improved controls for such machines.

In machines of the above general character the tool or hone and the work are carried on separate supports, one of which is mounted for reciprocation relative to the other. The reciprocable support is normally held in a retracted relation when the machine is idle and the tool and work are initially brought into operative association by an advancing movement of that support. Thereafter the support is reciprocated through a plurality of working strokes in which the relative movements of the tool and work are confined within a predetermined working stroke range such as to traverse the tool repeatedly from one end of the work to the other. The abrasive elements of the tool, of course, are adjusted radially into operative engagement with the surface of the work during such reciprocation and the tool may be rotated either continuously or intermittently. When the work is finished to the desired dimensions, the tool is adjusted out of operative engagement with the work and the reciprocatory support is moved through a withdrawal stroke substantially longer than the working stroke to separate the tool and work and return the reciprocatory support to its normal retracted position.

For production use it is customary to provide some type of control means for automatically terminating the working cycle of the machine and for initiating withdrawal of the tool from the work. The control means may be arranged to count the working strokes of the tool or alternatively may comprise a simple timing device or a gauging device arranged for measuring the work. With either of the latter two devices, the cycle terminating action occurs at random with respect to the reciprocation of the tool and work and the withdrawal stroke may be initiated with the tool at any position in the work. When this occurs during an inward or advancing stroke, the portion of the work surface ahead of the tool receives less abrading action than the remainder of the surface and is therefore not finished to precisely the same dimensions. While this difference is very minute, it is nevertheless important in precision finishing operations of the type for which honing and lapping machines are employed.

With the above in view, one object of the invention is to provide improved controls for machines of the above general character which insure precisely uniform finishing of the entire

2

work surface in each operating cycle of the machine.

Another object is to provide controls whereby a full advancing stroke of the tool is assured before the tool is withdrawn from the work at the end of each operating cycle and irrespective of the position of the tool at the instant the cycle terminating action takes place.

Still another object is to provide a control system in which the electrical control switches are operated only once in each cycle instead of each end of the tool stroke thereby permitting the use of switches of simple, relatively inexpensive construction.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a honing machine embodying the features of the invention.

Fig. 2 is a fragmentary front elevational view of a part of the reciprocation controlling mechanism of the machine.

Fig. 3 is a fragmentary view of another part of the control mechanism showing the relative position of certain of the control elements during an upstroke of the tool.

Fig. 4 shows the relative positioning of the control elements on the downstroke of the tool.

Fig. 5 is a diagram of the electrical circuit of the machine shown in Fig. 1.

Fig. 6 is a schematic diagram of the hydraulic circuit of the machine illustrated in Fig. 1, showing the relationship of the operating and control elements of the machine.

Fig. 7 is a schematic diagram of a modified form of the hydraulic circuit.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

For purposes of illustration, the invention has been shown as incorporated in a vertical honing machine equipped with control mechanism of the general type disclosed in the Caldwell Patent No. 2,381,572, granted August 7, 1945. This machine comprises a frame structure including an upright column 10 mounted on a base 11 and having on its front face a pair of parallel guide mem-

3
 bers 12 forming a guideway for a vertically reciprocable tool support or head 13. The head, in this instance, is equipped with a single rotatable spindle 14 which carries at its lower end an abrasive tool or hone 15 (Fig. 6). The tool 5 shown is a conventional expansible tool of the type used for honing internal surfaces such as the wall of a cylinder bore 16 in a cylinder block or other workpiece 17. As the tool is rotated and reciprocated while the workpiece is held 10 stationary in the exemplary machine, a suitable support 18 for the work is provided on the base 11.

A motor M (Figs. 1 and 5) mounted on the column 10 is arranged to rotatably drive the spindle 14 through the medium of a splined shaft 20 and suitable gearing 21 (Fig. 6), a part of which is enclosed in the upper portion of the column 10 and another part within the head 13. Reciprocation of the spindle to traverse the tool 20 axially of the work is effected by power-actuated means herein shown as a pressure fluid operated actuator including a pair of cylinders 22 (Figs. 1 and 6) supported in upright position adjacent the upper end of the column 10. Each cylinder 25 is fitted with a piston 23 having a downwardly extending piston rod 24 operatively connected with the head 13.

Pressure fluid for reciprocating the head 13 is supplied by a pump P (Fig. 6) driven by a motor M-1 (Figs. 1 and 5). In the exemplary machine the pressure fluid operated actuator is of the differential pressure type and accordingly the lower or rod ends of the cylinders 22 are connected to receive fluid under pressure in both 30 the up and down strokes of the head and the upper ends of the cylinders are arranged for connection alternately by a reversing valve RV to the source of pressure fluid and to a drain. To this end the pump is arranged to draw fluid, such as oil, from a sump or reservoir R and to discharge it under pressure into a main pressure conduit 25. A stop valve SV biased to a position to by-pass the fluid from the pump back to the sump R is arranged to be operated by a 40 solenoid SOL-1 to close the by-pass at the beginning of an operating cycle, as will appear presently. The conduit 25 has one branch 26 extending to the reversing valve RV and a second branch 27 extending to the lower ends of the cylinders 22. A conventional resistance or foot 50 valve FV interposed in the branch 27 prevents the pistons from creeping downwardly when the machine is idle.

The reversing valve RV as shown is operated 55 to its alternate positions by pressure fluid under control of a two-position pilot valve PV. As the head 13 reaches the upper end of the working stroke, the pilot valve PV is rocked from the "up" position in which it is shown in Fig. 6 to a "down" position. Pressure fluid from the branch 28 of the main pressure conduit is then directed through a conduit 29, a normally open pull-out or withdrawal valve WV and a conduit 30 to one end of the housing of the valve RV so as to shift its plunger 31 from the "up" position shown to its other or "down" position. With the valve plunger 31 thus positioned, the upper 60 ends of the cylinders 22 are connected by way of a conduit 32 and branch conduit 26 to the main pressure conduit 25. Accordingly, fluid supplied to the upper ends of the cylinders 22 is effective to shift the pistons 23 and head 13 downwardly against the force exerted by the fluid against the smaller effective areas at the

lower ends of the pistons. Fluid is discharged from the lower ends of the cylinders and returned to the main pressure line 25. A metering valve MV of any preferred character may be interposed in the conduit 25 to regulate the rate of movement of the pistons.

Upon operation of the pilot valve PV to its alternate position, pressure fluid from the main conduit 25 is directed by way of a conduit 33 to the other end of the housing of the reversing valve RV. The valve plunger 31 of the reversing valve is then shifted to its alternate or "up" position so as to connect conduit 32 with a drain conduit 34 leading back to the sump R. The piston 23 and head 13 are therefore moved upwardly until the pilot valve is operated at the upper end of the working stroke or until the head 13 reaches its fully retracted position. This latter movement of the head beyond the working stroke range is initiated by operation of the valve WV which establishes a by-pass to the drain for both the conduit 29 and the conduit 30. Valve WV is arranged to be operated by a solenoid SOL-2 at the end of an operating cycle as will be described presently.

In the exemplary machine, the shifting of the pilot valve PV from one position to the other is effected by control mechanism including a shifter rod 35 connected at one end to a pivoted rocker arm 36 cooperating with a control cam 37. This control cam is rotatably mounted on a shaft 38 which has keyed thereon a sprocket wheel 39. An endless chain 40 running over the sprocket wheel 39 and a companion sprocket wheel 41 is supported on the column 10 with one run of the chain disposed parallel to the reciprocatory path of the head 13. This chain run is operatively connected with an arm 42 projecting from the head 13 whereby the sprocket wheel 39 and shaft 38 are rocked or oscillated in timed relation to the reciprocation of the head and through an arc corresponding to the range of travel of the head.

Valve shifting movements are imparted to the cam 37 at the upper and lower limits of the working stroke through the medium of a pair of dogs 45 and 46 carried by a disk member 47 rigid with the shaft 38. The dogs are mounted on the disk in circumferentially spaced relation and extend radially therefrom for engagement alternately 50 with a finger piece 48 projecting from an arm 49 rigid with the cam. The arrangement is such that either dog on engaging the finger piece shifts the arm and cam through an angle effective to reposition the pilot valve and reverse the direction of movement of the head 13. The arm, the cam and the shifter rod remain in their set position of course until the head approaches the opposite end of its working stroke, whereupon the shifting again takes place but in the opposite 60 direction.

Having in mind the construction and relation of the mechanical and hydraulic elements of the control system above explained, the automatic cycling of the machine will be readily understood upon reference to the control circuit diagram of Fig. 5. In the electrical control system shown the operating elements of the system are supplied with low voltage current through a transformer TF connected to a power line L which 70 supplies current to the motors M and M-1.

It will be appreciated that at the beginning of a cycle the toolhead 13 is in the fully retracted position and the pilot valve PV and reversing valve RV are in the "down" position. Upon manipulation of a cycle starting control device, in 75

this instance a pushbutton actuated switch S (Fig. 5), relays R1, R2 and R3 are energized. Relay R1 closes switches R1-1 and R1-2 to complete a holding circuit for itself, which circuit includes a normally closed manually operable "inching" switch S-1, a limit switch LS-1 and a normally closed manually operable stop switch S-2. The limit switch LS-1 is open when the head 13 is in its upper or retracted position and is closed upon movement of the head from that position. Opening and closing of the switch is effected in this instance by means of a dog 50 (Figs. 2 and 6) mounted on and rotatable with the control disk 47.

Relay R2 when energized closes switch contacts R2-1 to start the pump motor M-1 and relay R3 closes switch contacts R3-1 to start the spindle motor M. Closure of the switch contacts R1-2 completes a circuit for energizing a control relay R4 which closes contacts R4-1 to energize the solenoid SOL-1 and thus interrupt the by-passing of the pump P so that fluid under pressure is supplied to the operating elements of the machine.

After starting the machine in the above manner the head 13 is advanced to associate the tool with the work, such advance continuing until the tool is traversed through the work, at which time the pilot valve PV is actuated in the manner heretofore explained to reverse the direction of movement of the head. The head is accordingly given a return movement which is reversed at the upper end of the working stroke as above explained. Such reciprocation continues within the working range until the cycle is interrupted either by closure of a normally open manually operable cycle stop switch S-3 or by the operation of a cycle stop device SD which may be in the nature of a timer, gauge, or the like. In the particular machine illustrated, the stop device comprises an electrically driven timer started in operation by closure of a limit switch LS-2 coincidentally with the entry of the tool into the work. Closure of this limit switch is effected by the arm portion 49 of the cam member 37 which has a cam surface at its lower end adapted to hold the switch closed as long as the reciprocation is confined within the working range. Control device SD when energized closes a switch SD-1 after a suitable timing cycle.

The cycle stop switch S-3 and the control device SD are operable, of course, at random with respect to the reciprocation of the head. In accordance with the invention, provision is made for coordinating their cycle terminating action with the reciprocation of the head 13 so that when either is operated during an advancing stroke of the head, the effectiveness of such operation is delayed until the advancing stroke is completed. This insures uniform tool action over the entire work surface in each operating cycle since a full stroke of the tool through the work is insured at the end of the cycle. Such coordination is effected in the present instance by an auxiliary control device 51 (Figs. 3, 4 and 6) arranged for operation in synchronism with the reciprocation of the head 13, that is, during a particular phase of the reciprocation. Such coordination is effected in the present instance in cooperation with a mechanical element of the control system, such as the shifter rod 35 to prevent completion of the control circuit prepared by the switches S-3 and SD-1 while the head is advancing.

Referring to Figs. 3 and 4, the auxiliary control device 51 in its preferred form comprises a nor-

mally open switch S-4 (Fig. 5) adapted to be closed by inward movement of an operating member or plunger 52. Switch S-4 is enclosed in a housing 53 supported on the movable core 54 of a solenoid SOL-3 which when energized shifts the switch bodily from the position shown in full lines in Figs. 3 and 4 to the position shown in broken lines in those figures. A spring 55 acting on the core 54 returns the switch to normal rest position when the solenoid is deenergized.

For operating the switch S-4, abutment means 56 is provided on the shifter rod for engagement by the switch plunger 52 incident to the shifting of the switch from rest position. The abutment means as herein shown comprises a stop screw adjustably threaded into a bracket 57 rigidly mounted on the shifter rod 35. The arrangement is such that when the shifter rod occupies its left-hand position (see Fig. 3) as it does during the upward stroke of the head, abutment 56 is positioned for operative engagement by the plunger 52 upon energization of the solenoid SOL-3 whereby the switch S-4 is operated to closed position. Conversely, when the shifter rod occupies its right-hand position (see Fig. 4) during the downward or advancing stroke of the head, the abutment 56 is moved beyond the range of the plunger 52. Energization of the solenoid SOL-3 is therefore ineffective to operate or close the switch until the shifter rod is again moved to the left as the head reaches the end of its advancing stroke.

Referring now to Fig. 5 of the drawings, solenoid SOL-3 is energized upon closure of either switch S-3 or switch SD-1. When switch S-4 is closed, a circuit is completed by way of closed switch contacts R4-2 of control relay R4 for energizing control relay R5. This relay upon energization completes a holding circuit for itself by closing switch contacts R5-1 and additionally completes a holding circuit for solenoid SOL-3 by closing contacts R5-2. By closing contacts R5-3 relay R5 completes a circuit for solenoid SOL-2, which as previously explained, shifts the with drawal valve WV to its alternate position so as to prevent operation of the reversing valve RV as the head reaches the upper end of its working stroke. Consequently, movement of the head continues until the head reaches retracted position whereupon limit switch LS-1 is opened by control dog 50.

Opening of limit switch LS-1 results in the deenergization of all of the control relays and the various solenoids. Solenoid SOL-1 permits stop valve SV to open and by-pass the fluid from the pump P. Relay R2 stops the pump motor M-1 and relay R3 opens the running circuit for the motor M. To provide for quickly stopping this motor, a conventional plugging switch PS is provided which is closed when the motor is running in the normal forward direction. When this switch is closed, the deenergization of relay R3 and closure of switch contacts R3-2 complete a circuit for a reversing relay R6 which closes switch contacts R6-1 to reverse the motor M. Such reversal brings the motor to a quick stop and the concurrent opening of the plugging switch brings about the immediate deenergization of the relay R6 and consequent interruption of the reversing circuit. Relay R6 when energized also opens switch contacts R6-2 to prevent accidental energization of relay R3 before the motor M is brought to a complete stop.

The application of the improved full stroke control arrangement to a honing machine

7
equipped with pressure fluid operated head reciprocating means of the double-acting type is shown in Fig. 7 of the drawings. In this case the pressure fluid actuated means includes a cylinder 60 with a working piston 61 operatively connected with the head 13 by a piston rod 62. The upper and lower ends of the cylinder 60 are connected respectively with a reversing valve RV' by conduits 63 and 64. Reversing valve RV' is shiftable between two positions under control of a pilot valve PV' which in turn is shifted in synchronism with the movements of the head by control mechanism similar to that heretofore described, including the shifter rod 35.

In the normal operation of the machine the plunger of the pilot valve PV' is positioned as shown in Fig. 7 as the head moves upwardly during a working stroke. When the dog 45 engages the finger 48, the valve PV' is shifted to the right. Pressure fluid from a pump P' is thereupon directed by way of a conduit 65, branch conduit 66, withdrawal valve WV', conduit 67, pilot valve PV' and conduit 68 to the housing of the reversing valve to shift the plunger of that valve to the "down" position. The valve accordingly is set to direct pressure fluid by way of the conduit 65 and conduit 69 through conduit 63 to the upper end of the cylinder 60. Fluid is exhausted from the lower end of the cylinder 60 by way of the conduit 64, reversing valve RV' conduit 70, pilot valve PV' and drain conduit 71.

At the lower end of the working stroke of the head the pilot valve plunger is shifted to its alternate position, thereby directing pressure fluid by way of the conduit 72 to the left end of the reversing valve housing to shift the plunger to the "up" position. Pressure fluid is now supplied to the lower end of the cylinder 60 by way of the conduit 69, reversing valve and conduit 64 while fluid is exhausted from the upper end of the cylinder by way of conduit 63, reversing valve, conduit 73, pilot valve and drain 71.

When the tool is to be withdrawn from the work at the end of an operating cycle, the withdrawal valve WV' is operated by energization of its solenoid SOL-2. Consequently, when the pilot valve PV' is reversed at the upper end of the working stroke no corresponding reversal of the valve RV' occurs since the pressure conduit 67 is closed by the withdrawal valve. The upward movement of the head therefore continues until the head reaches its fully retracted position and the machine is stopped by the control mechanism, as explained heretofore.

In each shift of the pilot valve PV' which is effected mechanically in timed relation to the movements of the head as heretofore described, the exhaust for the cylinder 60 through either of conduits 70 or 73 and the pilot valve is closed immediately, thus instantaneously interrupting the movement of the head irrespective of any controlling action by the reversing valve. This permits of very accurate determination of the limit position of the working stroke regardless of any lag in the response of the reversing valve. When the withdrawal valve is operated, a new exhaust circuit is provided for the actuator cylinder by a by-pass valve BV operated through the diversion of pressure fluid thereto by way of conduit 74.

In the modified form of the machine, the auxiliary controlling device 51 is associated with the shifter rod 35 in precisely the same manner as in the previously described machine. Furthermore,

its action in delaying energization of the withdrawal solenoid SOL-2 is the same.

It will be apparent from the foregoing that the invention provides improved controls for honing machines whereby a full stroke of the tool is obtained at the end of each cycle regardless of the honing of the withdrawal initiating action with reference to the reciprocation of the toolhead. Uniform finishing of the entire area of the workpiece is therefore insured. The mechanism for effecting such control is efficient and dependable. Since it utilizes switch means operable only once in each cycle, the switch means may be of relatively simple and inexpensive construction.

I claim as my invention:

1. In a honing machine having a reciprocable support, in combination, power-actuated means operable to reciprocate said support through a working range and to shift the support beyond said working range to a retracted position, control mechanism operatively connected with said power-actuated means including a control member shiftable alternately between two positions as the support approaches opposite ends of its working range, abutment means mounted on and shiftable with said control member, a control switch mounted for bodily movement toward and from said abutment means and normally retained in a position remote from said abutment means, means operable to shift said control switch toward said abutment means and into a position to be actuated thereby when the control member occupies one of its two positions, and a control device operable responsive to the actuation of said control switch for initiating movement of the support to retracted position.

2. In a honing machine having a reciprocatory support, in combination, a main pressure fluid operated actuator operable to reciprocate the support, a source of pressure fluid, a reversing valve connected between said source and said actuator operative to control the supply of pressure fluid to and exhaust of spent pressure fluid from said actuator, a pair of pressure fluid operated actuators operatively associated with said reversing valve for shifting the valve between alternate positions, a pilot valve connected to control the supply of pressure fluid to said valve actuators and the exhaust of fluid from said main actuator, mechanism for operating said pilot valve in timed relation to the reciprocation of the head, a withdrawal valve effective when operated to block delivery of pressure fluid to and thus prevent operation of said reversing valve following an operation of said pilot valve whereby to initiate movement of the head to a retracted position, and a by-pass valve responsive to the operation of said withdrawal valve to establish an exhaust circuit for said main actuator during such movement of the head to retracted position.

3. In a honing machine, the combination of, a support movable to bring a honing tool into a work bore to be honed, a power actuator for reciprocating said support to hone said bore, mechanism controlling the operation of said actuator to advance the support from a withdrawn position into a predetermined honing range and then to reciprocate the support back and forth between limit forward and retracted positions within said range, a movable member, a motion transmitting connection between said member and said power actuator to move said member along a predetermined path and dispose the member in spaced first and second positions when

said support is at opposite limits of the forward and return strokes respectively, a second member normally maintained out of said path but movable into the path to a position for engagement by said first member when the latter is in said first position only, means operable at random and while said support is in different positions in different honing cycles to move said second member to said engaging position, and means responsive to the engagement between said two members to modify the action of said controlling mechanism and cause the ensuing return stroke of said actuator to be continued beyond the retracted position of said support and thereby return the support to said withdrawn position.

4. In a honing machine, the combination of, a support movable to bring a honing tool into a work bore to be honed, a power actuator for reciprocating said support to hone said bore, mechanism controlling the operation of said actuator to advance the support from a withdrawn position into a predetermined honing range and then to reciprocate the support back and forth between limit forward and retracted positions within said range, a movable element, a first control member mounted on said element for bodily movement therewith, a motion transmitting connection between said element and said power actuator to move said member along a predetermined path and dispose the member in spaced first and second positions when said support is at opposite limits of the forward and return strokes respectively, a stationary element, a second control member mounted on said stationary element and normally inoperatively disposed relative to said first member, one of said members being mounted on the corresponding element for shifting relative thereto to dispose said second member in operative relation to said first member when the latter is in said first position only, means operable at random and while said support is in different positions in different honing cycles to shift said one member relative to the corresponding element, and means responsive to said two members when operatively related to modify the action of said controlling mechanism and cause the ensuing return stroke of

said actuator to be continued beyond the retracted position of said support and thereby return the support to said withdrawn position.

5. In a honing machine, the combination of, a support movable to bring a honing tool into a work bore to be honed, a power actuator for reciprocating said support to hone the bore, mechanism controlling the operation of said actuator to advance the support from a withdrawn position into a predetermined honing range and then to reciprocate the support back and forth between limit forward and retracted positions within said range, a control device operable when actuated to modify the action of said mechanism and cause said actuator to move said support beyond said retracted position to said withdrawn position, means energized at random and while said support is in different positions in different honing cycles, a movable member, a motion transmitting connection between said member and said power actuator to move the member back and forth along a predetermined path in response to reciprocation of said support, and a second member disposed alongside said path to be operatively related to said movable member only upon full advance of said support and operable upon energization of said random means and when operatively related to said movable member to actuate said control device thereby to modify the action of said mechanism and cause said support to move beyond said retracted position to said withdrawn position after a complete advancing stroke.

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