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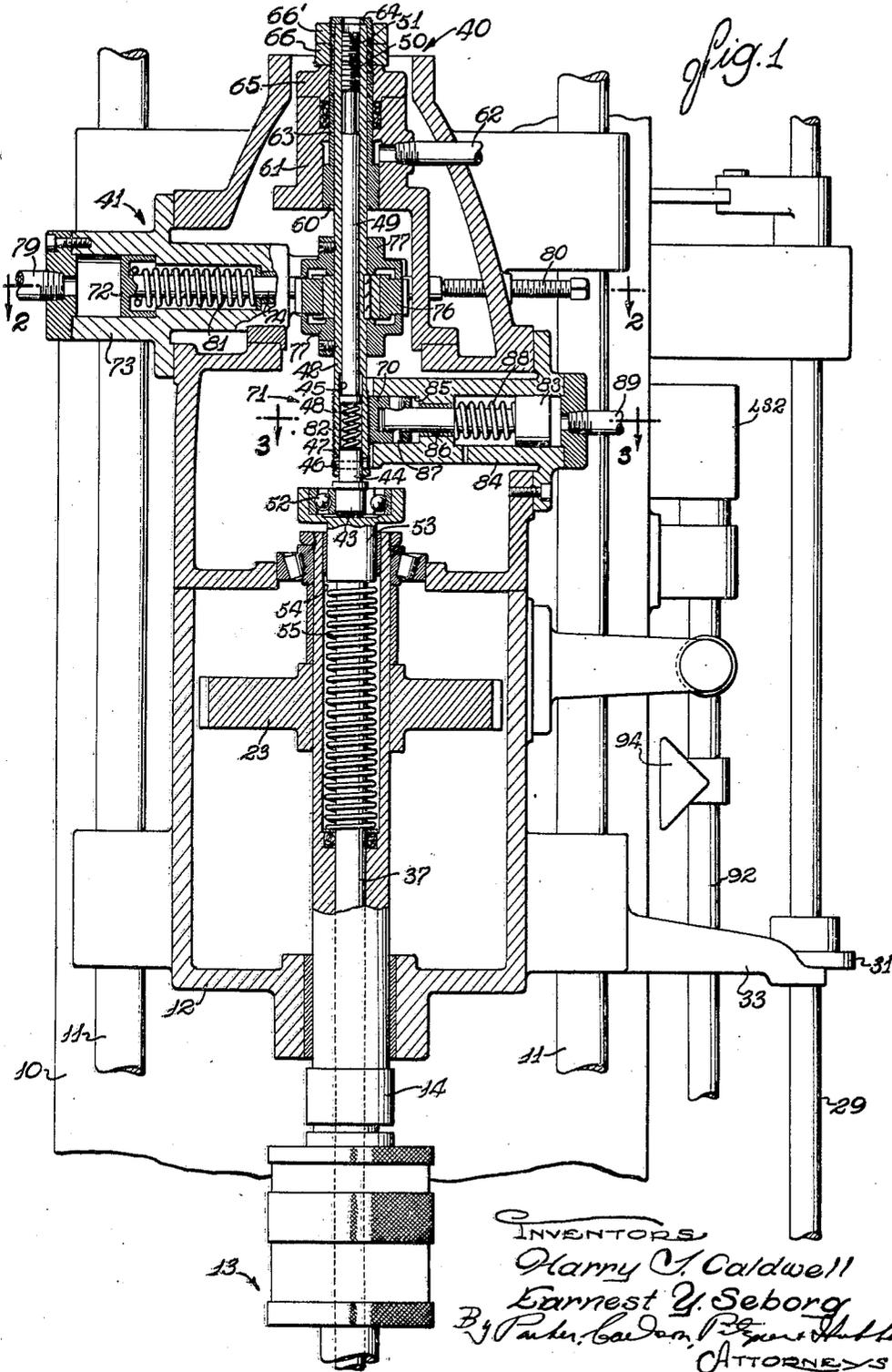
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2,343,275

HONING MACHINE

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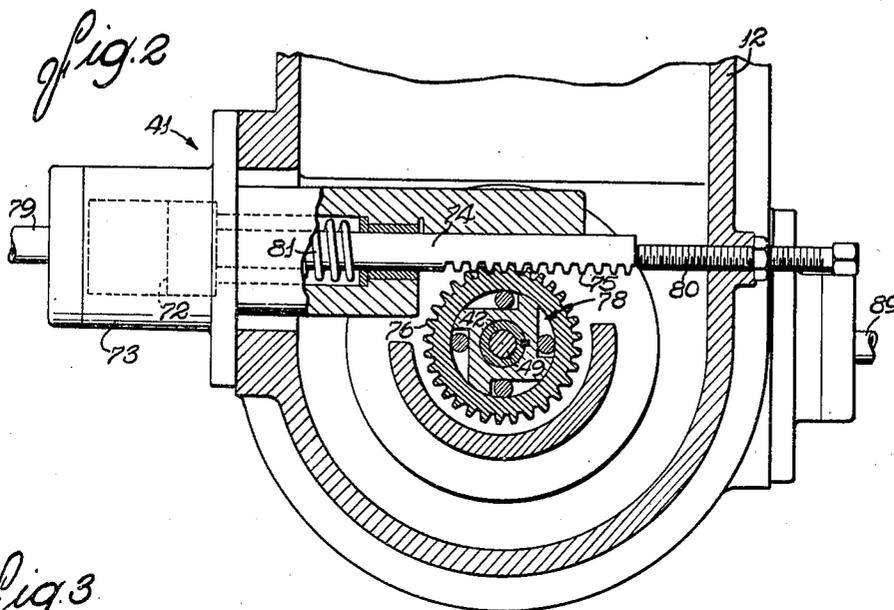
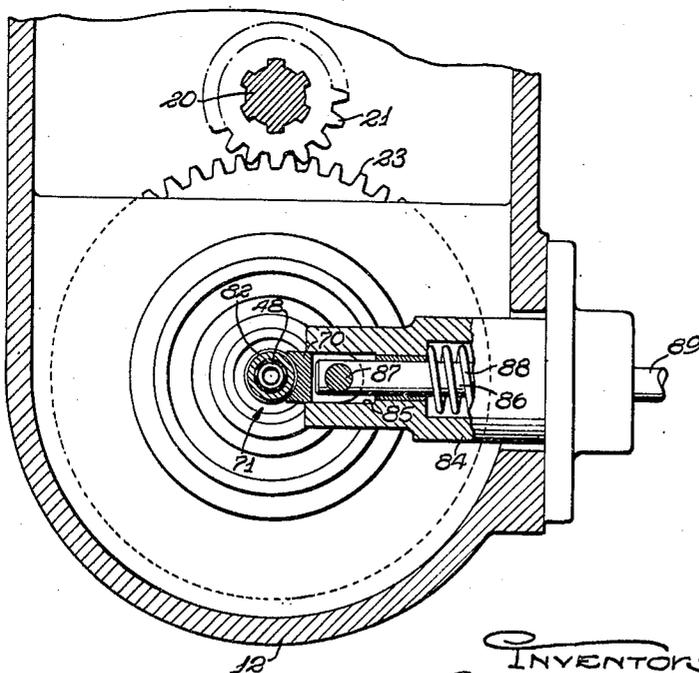


fig. 3



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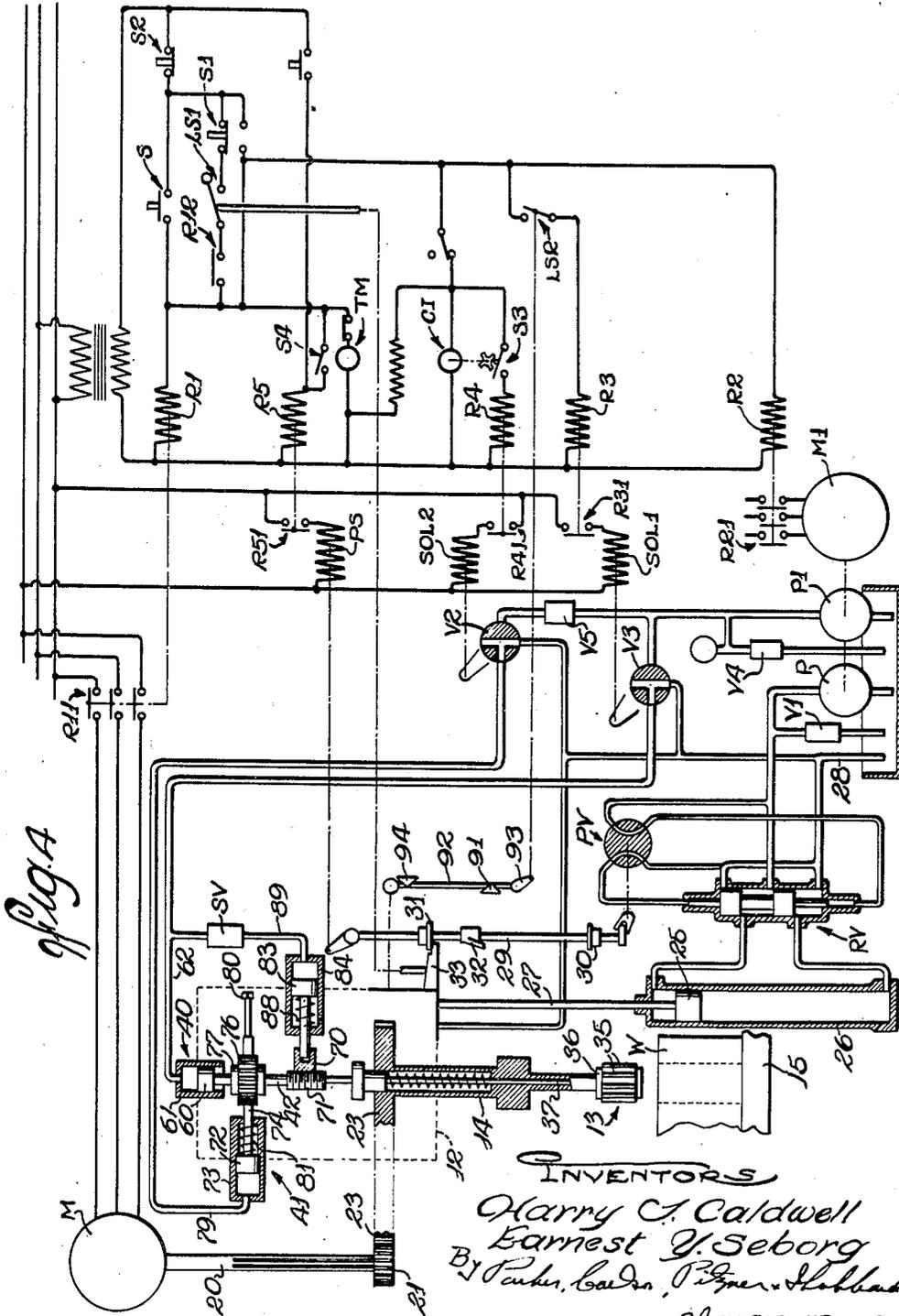
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UNITED STATES PATENT OFFICE

2,343,275

HONING MACHINE

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17 Claims. (Cl. 51—34)

The invention relates to honing machines generally and more particularly to improved power actuated means for expanding the honing tools used in such machines.

One object of the invention is to provide an improved tool expanding mechanism operative to effect a rapid initial expansion of a honing tool to operatively associate the abrasive element thereof with the work and thereafter to effect a positive and progressive expansion of the tool in intermittent steps while the abrasive elements are operating on the work.

Another object is to provide novel means for effecting expansion of a honing tool with either a uniform or a progressively increasing pressure in accordance with the resistance offered to the shifting of the tool adjusting member.

Still another object is to provide improved means for effecting positive stepped expansion of the honing tool during the working cycle of the machine and rapid contraction of the tool at the end of the cycle or at any point in the cycle at which the machine may be stopped.

It is also an object of the invention to provide novel safety mechanism operative to limit the expanding pressure on the hone and thereby prevent damage to the tool or work.

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 vertical sectional view of the tool spindle supporting head of a honing machine embodying the features of the invention.

Fig. 2 is a horizontal sectional view of the spindle head taken along the line 2—2 of Fig. 1.

Fig. 3 is a horizontal sectional view of the spindle head taken along the line 3—3 of Fig. 1.

Fig. 4 is a diagrammatic view showing the electrical and hydraulic circuits and their relationship to the operating and control elements of the machines.

For purposes of illustration the invention has been shown and will be described herein as embodied in a single spindle internal honing machine of the type in which the relative rotational and reciprocatory movements of the tool and work are effected by rotating and simultaneously reciprocating the tool while the work is held stationary. It is to be understood, however, that the invention is not limited to honing machines of this particular type but is readily applicable to other types of honing machines as well as to other of machine tools. It is also

to be understood that various modifications and adaptations may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention as expressed in the appended claims.

Referring now to Figs. 1 and 4 of the drawings, the machine selected to illustrate the invention comprises generally an upright frame or column 10 (Fig. 1) on the face of which are mounted a pair of spaced cylindrical guide bars 11 forming a vertical guideway for a reciprocatory head constituting, in this instance, a support for a conventional honing tool 13 (Fig. 4). The tool is carried in the usual manner by a tubular tool spindle 14 suitably journaled on the head 12. The work to be operated on by the tool such as workpiece W is stationarily supported on a suitable work support or table 15.

In order to obtain the relative rotational and reciprocatory movements of the tool and work required for the performance of the honing operation, suitable power driven means is provided for rotatably driving the spindle and for simultaneously reciprocating the head 12 which carries the spindle. As herein shown, the spindle is driven by an electric motor M (Fig. 4) through the medium of a splined drive shaft 20 and gears 21, and 23. These gears are rotatably supported on the head and are reciprocable therewith. The gear 21 has a splined driving connection with the shaft 20 while the gear 23 is keyed or otherwise fixed to the spindle 14 within the head 12.

The means for reciprocating the head 12 comprises, in this instance, a pressure fluid actuator herein shown as a piston 25 (Fig. 4) working in a vertical cylinder 26 suitably attached to the machine frame. A piston rod 27 connects the piston with the head. Pressure fluid is supplied to the cylinder 26 by a pump P driven by an electric motor M1. A conventional pressure fluid actuated reversing valve RV operated under control of a pilot valve PV connects the respective ends of the cylinder to the pump and to a drain 28 alternately to effect the reciprocation of the piston. The pilot valve is actuated in well known manner by a shiftable control rod 29 having spaced limit stops 30 and 31 and an intermediate stop 32 engageable by a dog or other suitable member 33 carried by the head 12 and reciprocable therewith. A pressure relief valve V1 limits the pressure in the fluid supply circuit to a safe value.

The conventional honing tool employed for honing internal cylindrical surfaces, of which the

tool 13 is an example, comprises a series of abrasive elements or honing stones 35 (Fig. 4) arranged around the periphery of a cylindrical carrier 36 for movement radially thereof. The abrasive elements are normally held in their inner or contracted position by suitable springs and are shifted outwardly or expanded by means of an adjusting rod 37 (Figs. 1 and 4) extending axially through the hollow shank of the tool and through the tubular spindle 14 on which the tool is carried.

In the operation of the machine the tool is inserted in the work with the abrasive elements contracted. It is then expanded, that is, the abrasive elements are shifted radially outwardly into operative engagement with the surface to be operated on. The expanding effort must be continued of course while the elements perform their metal removing functions. For some types of work it has been found that greater efficiency is attained if the expanding pressure is progressively increased in relatively small, graduated steps as the honing operation proceeds. The invention provides novel power actuated mechanism for effecting such stepped expansion of the honing tool during the working portion of the cycle and for reducing the non-working portion of the cycle to a minimum by providing rapid initial expansion and rapid contraction of the tool to bring the abrasive elements into engagement with the surface of the work and to return them to their inner positions to condition the tool for withdrawal from the work. Moreover the stepped expansion of the honing tool is effected in a positive manner without interfering in any way with the rapid contraction of the tool when desired at any point in the operating cycle of the machine.

The hone expanding mechanism in its preferred form comprises a pair of independently operable pressure fluid actuators 40 and 41 (Figs. 1 and 4) to which pressure fluid is supplied by a pump P herein shown as driven in tandem with the pump P by the motor M1. Valves V2 and V3 control the delivery of pressure fluid to the respective actuators as will appear presently. The pressure in the supply circuit is maintained at the desired level and the building up of excessive pressure in the system is prevented by a conventional relief valve V4. A pressure regulating valve V5 of any suitable type may be interposed in the branch line leading to the actuator 41 to permit independent regulation of the pressure of the fluid supplied thereto.

In the particular embodiment illustrated, the actuators are arranged to operate through an elongated tubular actuating member 42 to impart endwise movements to the tool adjusting rod 37 both to effect rapid initial expansion and progressive stepped expansion of the honing tool. The actuating member 42 as herein shown is arranged above and axially aligned with the tool adjusting rod 37. At its lower end the member is operatively connected to the adjusting rod so that endwise movements of the member are transferred to the rod.

The operative connection between the member 42 and the rod 37 is provided in the present instance by a yieldable safety release mechanism which effectually prevents the application of excessive pressure to the abrasive elements of the tool and thus protects the elements and the work from damage under abnormal working conditions. As shown in Fig. 1, the mechanism in its preferred form comprises a headed connect-

ing element 43 having a cylindrical shank 44 of reduced diameter slidably fitted in a chamber 45 formed by a counter bore in the lower end of the tubular member 42. A pin 46 extending transversely through the shank of the element and engaging in oppositely disposed longitudinal slots 47 in the member acts to hold the parts in assembled relation and to permit limited relative movement therebetween longitudinally of the member. The connecting member is yieldably urged outwardly with respect to the tubular member by suitable resilient means such as a spring 48 interposed between the end of the shank 44 and the adjacent end of an adjusting bar 49 disposed within the tubular member with its lower end projecting into the chamber 45. A screw plug 50 threaded into the upper end of the member 42 provides for adjusting the position of the bar 49 and thus for regulating the tension of the spring 48. A second plug 51 may be screwed into the end of the member 42 to lock the first mentioned plug and bar in adjusted position.

The connecting element 43 serves to transmit the endwise movements of the member 42 to the tool adjusting rod 37 with which it is operatively connected. This connection as herein shown is provided by an antifriction thrust bearing 52 carried in a recess in the enlarged end portion of a sleeve member 53 fixed to the upper end of the tool adjusting rod. The bearing thus permits relative rotation of the parts for purposes to be described presently. To permit the required movement of the rod and sleeve member longitudinally of the tool spindle 14, the sleeve is slidably received in a counter bore 54 in the upper end of the spindle as shown in Fig. 1. A coiled compression spring 55 interposed between the bottom of the counter bore and the lower end of the sleeve urges the adjusting rod upwardly or toward the tool contracting position.

With the arrangement above described the tool adjusting rod is shifted toward the tool expanding position by an endwise movement of the actuating member 42 downwardly as viewed in Fig. 1. However, due to the presence of the spring 48, the actuating member may continue its advance while the adjusting rod remains stationary in the event that the resistance offered to further expansion of the tool exceeds a predetermined value. This prevents the application of excessive pressure to the honing tool and effectually guards against damage to the tool or work when unexpected resistance to tool expansion is encountered.

Endwise tool expanding movements may be imparted to the actuating member 42 by either of the pressure fluid actuators 40 or 41. The actuator 40, in this instance, is arranged to effect a continuous rapid advance of the member to initially expand the tool into operative engagement with the work. To this end, the member 42 is provided at its upper end with a piston member 60 working in a cylinder 61 rigidly supported in the upper end of the tool head 12 concentric with the spindle 14. Pressure fluid may be introduced into the cylinder above the piston through a pipe 62 thus forcing the piston and associated parts downwardly or toward the tool expanding position. The piston, in this instance, is loosely mounted on the member and is formed with a sleeve-like extension 63 having at its outer end an internal flange 64 adapted to bear against the upper end of the member 42 and thus effect a one-way driving connection with the member. This extension projects

through a cap 65 which closes the upper end of the cylinder and is threaded for the reciprocation of a nut 66 adapted to act as an adjustable stop to limit the extent of movement of the piston toward the open end of the cylinder. A lock nut 66' threaded on the sleeve cooperates with the nut 66 to retain the latter in adjusted position.

The actuator 41 is arranged to advance the actuating member 42 in successive steps to effect a positive stepped expansion of the honing tool. For this purpose, the actuator is operated intermittently under the control of any suitable means, as for example a timer, as hereinafter set forth, and the actuating member 42 is rotated intermittently about its longitudinal axis while a stationary nut 70 engages a lead screw 71 rigid with the member. As shown in Figs. 1 and 2 the actuator 41 in its preferred form comprises a piston 72 working in a cylinder 73 mounted in a horizontal position on one side of the tool head 12. The piston is provided with a piston rod 74 extending into the head and having rack teeth 75 (Fig. 2) meshing with a pinion 76 rotatably supported between spaced collars 77 fixed to the actuating member 42. The teeth of the pinion are sufficiently wide to retain their meshing engagement with the rack teeth as the pinion moves axially with the member between tool expanding and contracting positions. Relative movements of the pinion 76 are transmitted to the actuating member through a one-way driving connection of any suitable type interposed between the pinion and the member. As herein shown, this connection comprises a ball type clutch 78 arranged to drive the actuating member when the pinion 76 is rotated in a clockwise direction as viewed in Fig. 2. When the pinion is rotated in the opposite direction, the driving connection is interrupted thus allowing the actuator to return to its normal rest position while the actuating member is retained in the position to which it was previously operated.

In the particular machine illustrated rotation of the pinion in the direction to drive the actuating member is effected by introducing pressure fluid into the outer end of the cylinder 73 through a pipe 79 thereby shifting the piston and its rod toward the right as viewed in the drawings. An adjustable stop screw 80 positioned for engagement by the inner end of the piston rod determines the length of the piston stroke and thus the angle through which the actuating member is rotated in each operating cycle of the actuator. When the pressure on the piston 72 is relieved by the action of the control mechanism in shifting the connection of the pipe 79 from the pressure fluid source to the drain, a spring 81 returns the piston to its normal rest position at the outer end of the cylinder. Ordinarily, no rotation is imparted to the actuating member in this return movement due to the release of the clutch 78.

The lead screw and nut mechanism by which the rotating movements of the actuating member are translated into intermittent endwise steps is shown in Figs. 1 and 3 of the drawings. In the exemplary machine the lead screw 71 is formed by threading an enlarged section 82 of the actuating member. The nut 70 in its preferred form comprises a generally rectangular block having an arcuate recess in one face threaded for engagement with the screw threads 71. Thus the nut may be moved into or out of engagement with the lead screw as required.

With the nut in the engaged position, positive longitudinal movement in steps of predetermined length will be imparted to the actuating member as the member is intermittently rotated by the actuator 41. When the nut is disengaged, the actuating member may be shifted rapidly to tool expanding position by the actuator 40 or returned to tool contracting position under the influence of the spring 55.

While any suitable means may be employed for shifting the nut 70 between engaged and disengaged positions, it is preferred to utilize pressure fluid operated means for this purpose because of the ease with which the operation of the nut may be synchronized with the various operations of the machine. The pressure fluid operated means as herein shown comprise a piston 83 (Figs. 1 and 4) working in a cylinder 84. The cylinder is rigidly supported on the frame work of the spindle head 12 as shown in Figs. 1 and 3 with its axis disposed in a horizontal position and substantially aligned with the axis of the actuating member 42. At its inner end the cylinder is formed with recess 85 of generally rectangular cross-section dimensioned to receive the nut 70 with a sliding fit. A piston rod 86 extends from the piston to the nut and is drivingly connected therewith as by a pin 87 which permits a limited vertical movement between the parts to eliminate any binding due to non-engagement of the lead screw and the nut. A spring 88 interposed between the piston and the inner end of the cylinder normally urges the piston to the right as viewed in Figs. 1 and 3 and thus tends to maintain the nut 70 in the disengaged position. Pressure fluid introduced into the outer end of the cylinder 84 through a pipe 89 shifts the piston to the left against the influence of the spring 88 and thus moves the nut into engaging relation with the lead screw thread 71.

The operations of the hone expanding actuators 40 and 41 are coordinated for most efficient operation by timing the action of the nut actuating mechanism in accordance with the operation of the actuator 40 to effect initial rapid expansion. More particularly the nut is maintained in its disengaged position to avoid interference with the operation of the actuator 40 until the piston 60 reaches the end of its operating stroke as determined by the setting of the stop nut 66. The nut 70 is then automatically shifted into engagement with the lead screw threads and the actuator 41 thus becomes effective to continue the advance of the actuator in intermittent steps and thereby expand the hone in successive positive steps.

Automatic control of the nut actuating mechanism is effected in the exemplary machine by connecting the cylinder 84 and the actuator cylinder 61 in parallel through a sequence or foot valve SV (Fig. 4). This valve may be of the conventional type arranged to open and allow pressure fluid to pass into the pipe 89 only when the fluid in the pipe 62 reaches the pressure for which the valve is adjusted. Thus the delivery of pressure fluid to the cylinder 84 is conditioned upon the building up of a predetermined pressure in the actuator cylinder and may be accurately timed to take place at the exact instant necessary for most efficient operation of the honing tool. The sequence valve, of course, is arranged to permit unrestricted fluid flow in the reverse direction when the pressure in the pipe 62 is relieved. The fluid may therefore be ex-

hausted from the cylinder 84 by the action of the spring 88 upon the piston 83.

The automatic control of the hone expanding mechanism eliminates the need for close supervision of the machine during its operating cycle and moreover insures operation of the honing tool in the most efficient manner. Through the medium of these controls and others shown in Fig. 4, the machine attendant is relieved of substantially all duties except that of loading the work on the work support and removing the finished work therefrom after the machine has been set up for a particular job. Thus an operating cycle of the machine is started by momentarily closing a starting switch S (Fig. 4) to energize a pair of motor control relays R1 and R2. Relay R1 closes switch R11 to start the spindle driving motor M. Relay R2 closes switch R21 to start the pump motor M1. As the pump P begins to function, pressure fluid is supplied through the reversing valve RV to the upper end of the head reciprocating cylinder 26 thus moving the tool head downwardly and entering the tool in the work.

The attendant may release the starting switch S as soon as the tool head leaves its normal rest position which results in the closure of a limit switch LS1 in well known manner. The limit switch completes a holding circuit for the relays R1 and R2 which circuit includes a switch R12, closed by the relay R1 when energized, and normally closed manually operable switches S1 and S2. Switch S1 is the "inching" switch commonly used in honing machines. Switch S2 is the "stop" switch by which the operation of the machine may be interrupted at any point in its cycle.

When the tool head advances sufficiently to enter the tool in the work, a suitable cam engaging member carried by the head engages a cam 91 on a vertical rock shaft 92 and through a linkage 93 closes a limit switch LS2. Closure of this limit switch energizes a control relay R3 which, in turn, closes a switch R31 to energize a solenoid SOL. 1. This solenoid is operatively associated with the valve V3 and is arranged when energized to set the valve in a position to connect the discharge line from the pump P1 to the actuator 40 and to the nut actuating cylinder 84. In its alternate position the valve V2 connects the actuator and the cylinder to the drain 28. Upon connection of the pump P1 to the actuator, the latter operates in the manner previously explained to rapidly expand the hone into engagement with the work. When the advance of the piston 60 is blocked by the stop nut 66, pressure is built up in the supply pipe 62 until the sequence valve SV opens and directs the fluid into the nut actuating cylinder 84. Piston 83 accordingly advances and shifts the nut 70 into engagement with the lead screw threads 71.

Concurrently with the actuation of the starting switch S to energize the motor relays R1 and R2, a running circuit is completed for a motor driven timer TM and for a motor driven current interrupter CI. The timer, in well known manner, determines the length of the operating cycle of the machine and acts to stop the same at the end of the cycle as will be explained presently. The interrupter intermittently closes and opens a switch S3 to energize and deenergize a control relay R4. The relay through its switch R41 controls the circuit for a solenoid SOL. 2 associated with the valve V2

whereby the valve alternately connects the actuator cylinder 73 to the pump P1 and to the drain 28. The piston 72 is accordingly reciprocated within the cylinder and, through the pinion 76 and the clutch 78, imparts successive rotative steps to the tool actuating member 42. When the nut is shifted into engagement with the lead screw threads as above explained, the actuating member and the tool expanding rod 37 are advanced step by step to progressively expand the honing tool.

Reciprocation of the head 12 through a succession of strokes effective to traverse the honing tool repeatedly from one end of the work piece to the other continues under control of the reversing valve RV and the associated pilot valve PV in the usual and well known manner. After a predetermined operating interval as determined by the timer TM, the latter closes its switch S4 to effect the energization of a control relay R5. The relay by closing switch R51 energizes a pull-out solenoid PS which, through a suitable mechanical linkage, rocks the control rod 29 to a position in which the intermediate stop 32 is ineffective for control purposes. The tool head is thus free to move beyond an upper limit of the working stroke to the withdrawn or normal rest position.

As the head passes the upper limit of the working stroke, the cam engaging member on the head engages a cam 94 on the control rod 91 and rocks the rod into a position to open the limit switch LS2. This interrupts the circuit for the control relay R3 which, in turn, interrupts the circuit for the solenoid SOL. 1. Valve V3 is thereupon returned to open position in which it connects the actuator cylinder 61 and the nut actuating cylinder 84 with the drain 28. The pistons operating in these cylinders are immediately returned to their normal rest positions by their associated springs. Disengagement of the nut 70 from the lead screw threads as a result of the return of the piston 83 permits rapid return of the actuating member 42 and tool expanding rod 37 with corresponding rapid contraction of the hone tool. The tool may therefore be withdrawn from the work without danger of injury to either the tool or work.

The tool head 12 upon reaching its normal rest position acts through the member 33 and upper limit stop 31 to condition the pilot valve PV for the next operating cycle, that is, it sets the valve in the position shown in Fig. 4. At the same instant the limit switch LS1 is opened to interrupt the holding circuit for the relays R1 and R2. The relays and their associated solenoids accordingly become deenergized and stop the machine. Operation of the interrupter CI and timer TM is also terminated, the latter being reset automatically in well known manner for the next operating cycle. Thus the head is stopped with the tool withdrawn from the work so that the attendant may remove the finished workpiece from the machine and replace it with the next workpiece to be operated on.

It will be apparent from the foregoing that the invention provides novel power actuated means for expanding a honing tool in a manner effective to attain the most efficient results. The improved mechanism operates to effect a rapid initial expansion of the honing tool to operatively associate the abrasive elements thereof with the work and thereafter to effect a positive and progressive stepped expansion of the tool while the abrasive elements are operating on the work.

Due to the rapid initial expansion of the tool, the non-working portion of the machine cycle is reduced to a minimum. Moreover the improved tool actuating mechanism provides for rapid contraction of the tool at the end of the working cycle thus further reducing non-productive time. The invention also provides a novel safety mechanism which effectually prevents the application of excessive pressure to the honing tool and thereby guards against damage to the tool or work under abnormal operating conditions.

We claim as our invention:

1. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, a first tool actuating means operable to effect a rapid initial expansion of the tool into operative engagement with the work, a second tool actuating means operable to effect positive expansion of the tool in intermittent steps while the tool is operating on the work, and control means operative to govern the operation of said tool actuating means selectively.
2. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, power actuated means operable to effect a rapid initial expansion of the tool into operative engagement with the work, other power actuated means operable to effect expansion of the tool in intermittent steps, and control means operative automatically to initiate the operation of said other power actuated means upon the completion of the operation of said first mentioned power actuated means.
3. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, a pair of independently operable power actuated mechanisms each operative to expand the hone, control means operative to initiate the operation of one of said mechanisms, and other control means actuated in response to a predetermined expansion of the tool by said one mechanism to initiate the operation of the other of said mechanisms.
4. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, power actuated mechanism operable to effect rapid continuous expansion of the tool, other power actuated mechanism operable to effect positive expansion of the tool in intermittent steps, control means operative to initiate the operation of said other mechanism upon engagement of the work by the tool, and timing means operative to determine the rate of expansion of the tool by said other mechanism while the tool is operating on the work.
5. The combination with a honing tool, of an elongated actuating member shiftable longitudinally to expand and contract the tool, a first power driven actuator acting directly on said member to shift the member to tool expanding position, and a second power driven actuator arranged to rotate said member about its longitudinal axis, said member having a threaded portion engageable with a stationary nut operative to impart longitudinal movement to the member in response to its rotation by said second actuator.
6. The combination with an expansible and contractible honing tool, of an elongated actuating member shiftable longitudinally to expand and contract the tool, screw threads formed on a section of said member, a power driven actuator directly coupled with said member and operable to shift the member in a direction to expand or contract the tool, a second power driven actuator operable to rotate said member in intermittent steps, and a threaded nut shiftable into engagement with the threaded section of said member in timed relation to the operation of said first mentioned actuator, said nut acting to shift said member in a direction effective to expand the tool incident to the rotation of the member.
7. The combination with an expansible and contractible honing tool, of an elongated actuating member shiftable longitudinally to expand and contract the tool, screw threads formed on a section of said member, a power driven actuator directly coupled with said member and operable to shift the member in a direction to expand the tool, a second power driven actuator operable to rotate said member, a threaded nut supported for movement only transversely of said member into and out of engagement with the threaded section of the member, and power actuated means operating in timed relation to the operation of the first mentioned actuator for moving said nut into and out of engagement with the threaded sections of said member, said nut when engaged acting to shift said member in a direction to expand the tool incident to the rotation of the member.
8. The combination with an expansible and contractible honing tool, of an elongated actuator member shiftable longitudinally to expand and contract the tool, screw threads formed on said member, a pressure fluid actuator directly coupled with said member operable to shift the member in a direction to expand the tool, power actuated means operable to rotate said member, a threaded nut supported for movement only transversely of said member into and out of engagement with the screw threads thereon and operative when engaged to shift the member longitudinally incident to the rotation of the member, a pressure fluid actuator operable to shift said nut between engaged and disengaged positions, and a circuit arranged to supply pressure fluid to said actuators in predetermined sequence.
9. The combination with a honing tool, of an elongated actuating member shiftable longitudinally to expand and contract the tool, screw threads formed on said member, a nut supported for movement only transversely of said member into or out of engagement with said screw threads, power driven means operable to rotate said member, said nut when engaged with the screw threads acting to impart longitudinal movement to the member in response to such rotation, and a power driven actuator coupled with said member operable to shift the member longitudinally when said nut is disengaged from the screw threads, said actuator having a one-way connection with the member to permit independent movement of the member in one direction.
10. The combination with a honing tool having an axially movable adjusting rod associated therewith, an elongated tubular member supported substantially in axial alignment with the tool

adjusting rod, power actuated means operable to shift said member toward the adjusting rod, a pair of cylindrical elements disposed in said tubular member, one of said elements being held in a fixed position in the member and the other of said elements projecting from the member to engage the adjacent end of the tool adjusting rod and to impart thereto the movements of the member, spring means interposed between said elements effective to permit limited relative movement between said other element and the member when the resistance of the adjusting rod to movement reaches a predetermined value, and means for adjusting the position of said one element with reference to said member to regulate the tension of said spring means.

11. The combination with a longitudinally shiftable tool adjusting member having a threaded section, of a first pressure fluid operated actuator coupled directly with the member and operative to impart rapid longitudinal movement thereto, means for imparting slower longitudinal movement to the member in successive positive steps including a second pressure fluid operated actuator operative to rotate the member in intermittent steps, a nut supported for movement transversely of the threaded section of the member between disengaged and thread engaging positions, means normally effective to hold said nut in the disengaged position, and means for shifting said nut to the engaged position in timed relation to the operation of said first actuator.

12. The combination with a longitudinally shiftable tool adjusting member having a threaded section, of a first pressure fluid operated actuator coupled directly with the member and operative to impart rapid longitudinal movement thereto, means for imparting slower longitudinal movement to the member in successive positive steps including a second pressure fluid operated actuator operative to rotate the member in intermittent steps, a nut supported for movement transversely of the threaded section of the member between disengaged and thread engaging positions, means normally effective to hold said nut in the disengaged position, pressure fluid operated means connected in parallel with said first actuator operative to shift said nut into the engaged position, and a control valve for timing the operation of said nut shifting means with respect to the operation of said first actuator.

13. The combination with a longitudinally shiftable tool adjusting member having a threaded section, of a first power actuated means operative to impart relatively rapid continuous longitudinal movement to the member, means for imparting slower longitudinal movement to the member in progressive steps including a second power actuated means operative to rotate the member about its longitudinal axis in intermittent steps, a nut movable transversely of the threaded section of the member into or out of engagement with the threads thereof, means normally effective to hold said nut in a disengaged position, and a third power actuated means operative to move said nut into engaged position to render said second power actuated means effective.

14. The combination with a longitudinally shiftable tool adjusting member having a threaded section, of a first power actuated means operative to impart relatively rapid continuous longitudinal movement to the member, means for imparting slower longitudinal movement to the member in progressive steps including a second power actuated means operative to rotate the member about its longitudinal axis in intermittent steps, a nut movable transversely of the threaded section of the member into or out of engagement with the threads thereof, means normally effective to hold said nut in a disengaged position, means operable to shift said nut into engaged position and thereby render said second power actuated means effective to impart longitudinal movement to the member, and control means for initiating the operation of said nut shifting means in timed relation to the operation of said first power actuated means.

15. The combination with a rotatable honing tool having a plurality of radially movable abrasive elements, of an adjusting mechanism including a member shiftable axially of the tool to impart said radial movements to the abrasive elements, power actuated means operable to shift said member at a rapid rate, other power actuated means operable to shift said member at a slower rate, and control means effective to initiate the operation of said other power actuated means in response to a predetermined increase in the resistance offered by said member to movement by said first power actuated means.

16. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, pressure fluid actuated means operable to effect a rapid expansion of the tool into engagement with the work, other pressure fluid actuated means operable to expand the tool at a slower rate while operating on the work, and valve means operative to initiate the operation of said other pressure fluid actuated means when expansion of the tool by the first mentioned pressure fluid actuated means is interrupted by the initial engagement of the tool with the work.

17. A honing machine having, in combination, a support for an expansible and contractible honing tool, a support for work to be operated on by the tool, means for effecting relative rotation and simultaneous relative reciprocation of the tool and work supports, pressure fluid actuated means operable to effect a continuous rapid expansion of the tool, other pressure fluid actuated means operable to expand the tool intermittently at a slower rate, and valve means operative to initiate the operation of said other pressure fluid actuated means when a predetermined resistance is offered to the expansion of the tool by the first mentioned pressure fluid actuated means.

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