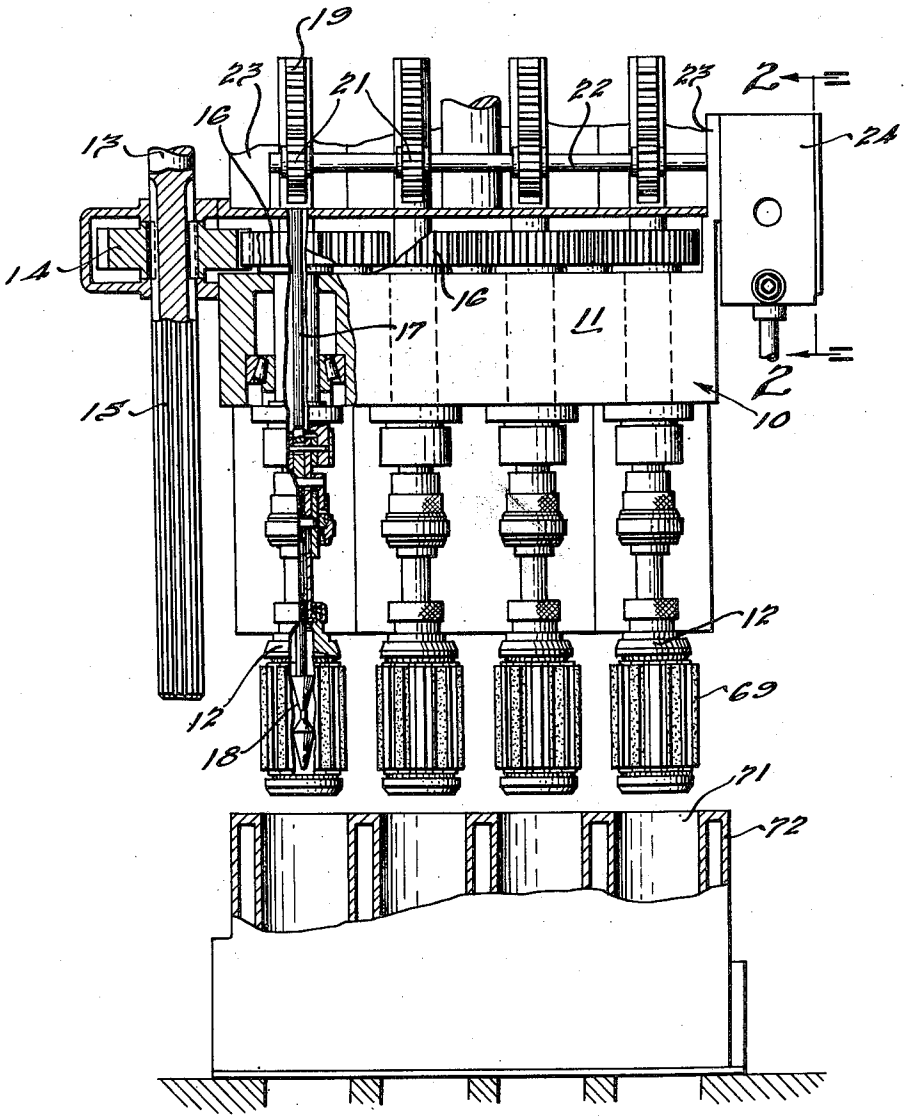
Oct. 16, 1945. J. E. KLINE 2,386,901

ADJUSTABLE FEED FOR TOOLS

Filed Nov. 16, 1940 3 Sheets-Sheet 1

Fig. 1.



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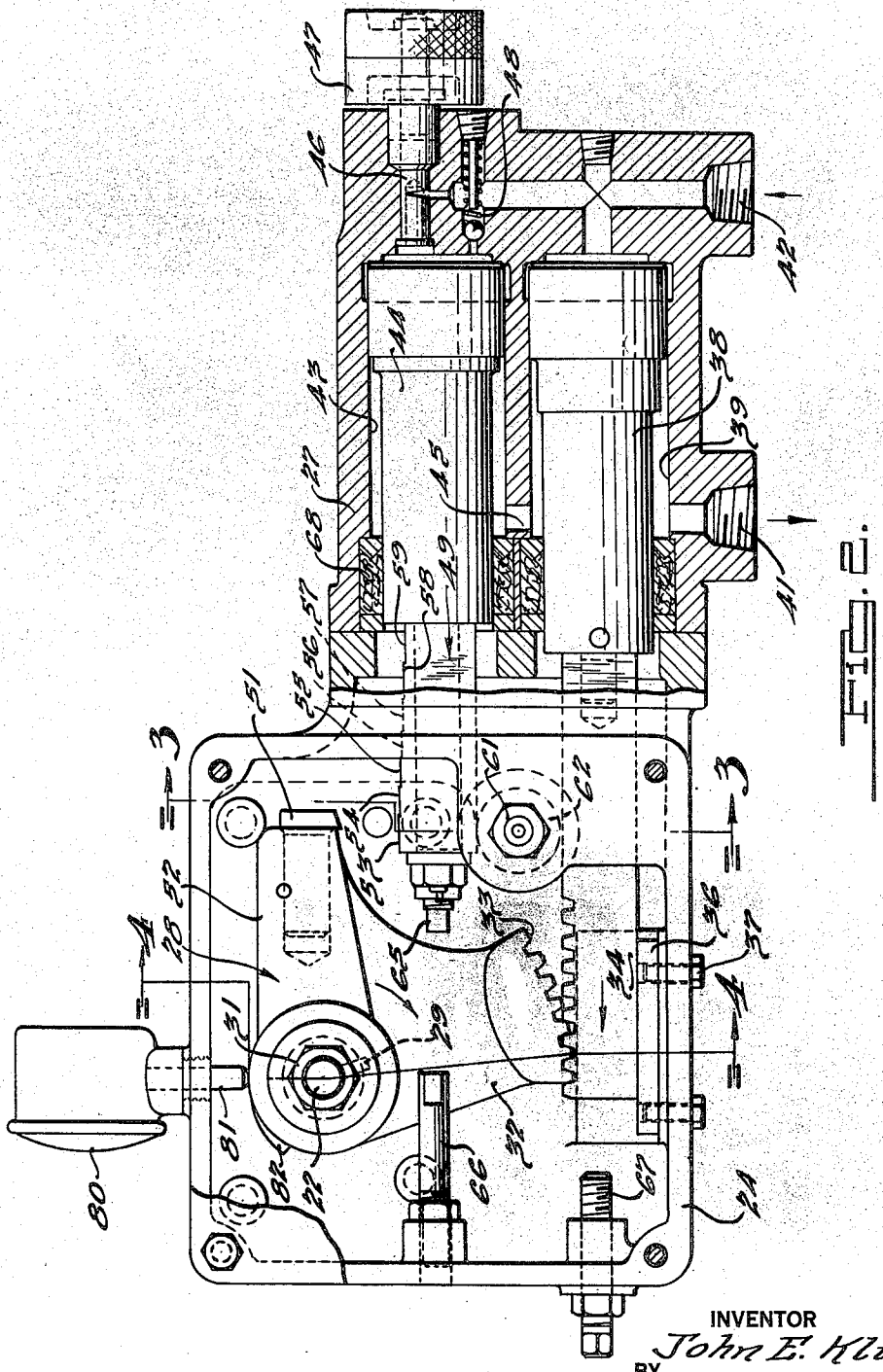


Fig. 2.

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Fig. 3.

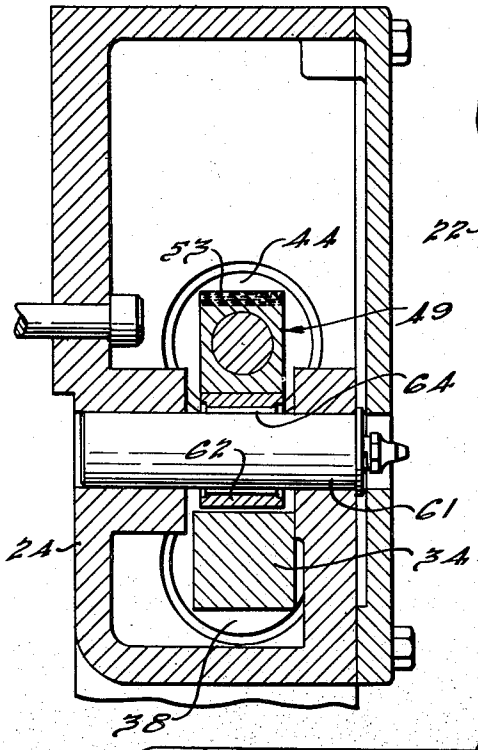
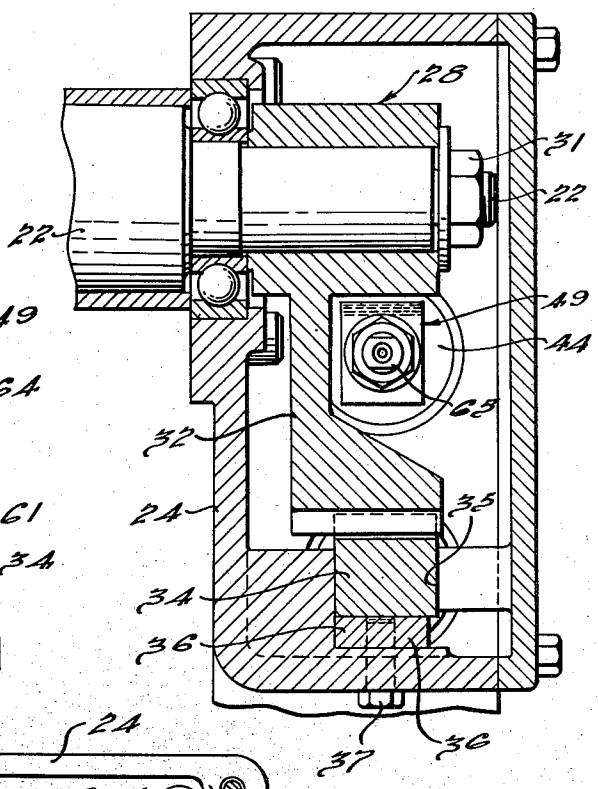


Fig. 4.



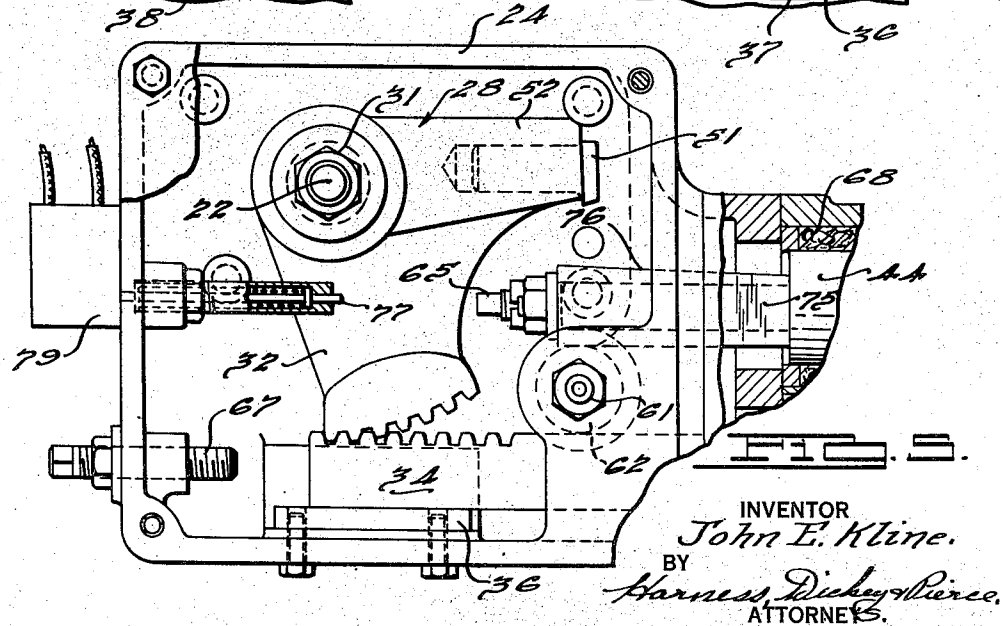


Fig. 5.

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Patented Oct. 16, 1945

2,386,901

UNITED STATES PATENT OFFICE

2,386,901

ADJUSTABLE FEED FOR TOOLS

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Application November 16, 1940, Serial No. 365,893

21 Claims. (Cl. 51—34)

My invention relates to honing devices and particularly to a control means for honing tools which accurately regulate the feeding of abrasive stones of the tools radially during the machining operation.

Various means have been employed for controlling the expansion of the abrasive stone of a honing tool. Springs were used for initially loading the stones a predetermined amount which decreased in applied pressure, due to diminution of spring force, as the abrasive operation progressed. Fluid means were employed for applying pressure to abrasive elements, usually by maintaining a constant, predetermined pressure thereon, or by changing the pressure during various phases of the machining operation. The method of applying pressure to urge the abrasive stones outwardly was objectionable as there was no balance or control provided between the machining to be accomplished, the applied pressure and the time of performing the operation.

In practicing my invention, I automatically proportion the application of pressure during the time of operation so that amount of effort required to perform variable amounts of work in given units of time will conform to the amount of machining which is to be accomplished. The time cycle of the machine is adjustably fixed and the feeding of the abrasive stone occurs in periodic intervals or at a predetermined rate relative to the time so that the loading of the abrasive stones is completely controlled. In an oversized bore having little material to be removed, the initial pressure between the work surface and abrasive will be relatively low but will increase towards the end of the operation in proportion to the resistance or response of the work surface to the work done upon it. At intervals (or at a predetermined rate), outward movement of the stones occurs and produces incremental pressure on the stones, thereby increasing the abrasive action a predetermined amount at the beginning of each increment of advancement. In workpieces requiring a great amount of material to be removed, the abrasive pressure reaches a maximum amount immediately upon expanding the abrasive stones into contact with the wall of the bore. Pressure begins to drop as the amount of material removed gains on the rate at which the abrasives are permitted to expand. After a balance between the rate of stock removal and the rate of radial movement of the abrasives has been attained, the feeding of the stones occurs progressively to maintain, within narrow limits, this condition of balance throughout the entire phase of the stock removal portion of the operation.

The structure herein illustrated for producing the incremental control of the radial advancement of the stones embodies a cylinder which is advanced under pressure to operate a rack, which drives a gear sector to rotate a shaft upon which the sector is mounted. The shaft is geared through pinions to racks attached to the longitudinally moving element of the honing tool, which operates cams for controlling the expansion of the abrasive stones. The initial movement of the shaft produces an expansion to normal rough bore size, so that the abrasive operation may immediately begin in bores of normal diameter, or may commence later during the subsequent incremental expansion of the abrasive stones in bores of greater than normal.

The rotation of the shaft is limited by a projecting finger of the sector which engages a stepped cam, each step of which forms a dwell for maintaining each degree of expansion a predetermined time. The cam is mounted on the end of a piston which is advanced by a fluid metered by a volume regulating valve, to advance the dwell surface along the finger. The fingers will drop from one surface to another as the cam is advanced, urged by the piston and rack, resulting in the rotation of the sector and shaft slight amounts. This advances the camming members for the abrasive stones which incrementally moves the stone radially in the bore. Any number of the steps or dwell portions may be provided on the cam and their heights may be uniform or varied, as desired. At the end of the operation an adjustable stop limits the movement of the cam to prevent any further advancement of the abrasive stones radially towards the bore wall. A switch may be operated by the plunger which is engaged by the end of the cam, to interrupt the operation and reverse the flow of the fluid in the device, so as to immediately contract the abrasive stone which may thereafter be withdrawn from the bore. It is within the purview of my invention to use an inclined plane on the cam face to obtain continuous advancement of the abrasive stones toward the bore wall.

Accordingly, the main objects of my invention are: to provide a method of honing, which controls the advancement of the abrasive element into the surface of the work at timed intervals relative to the time of producing the abrasive operation; to provide a method of honing the cylinder walls to the incremental advancement of the stones towards the wall accurately controlled

by cam means which advances relatively to the time cycle of the operation without respect to the position of the honing tool on the workpiece at the time this incremental advancement occurs; to provide a shaft for expanding the abrasive elements operated by a gear element which is actuated by a cylinder, limited by the advancement of a cam; to provide means whereby the operating pressures between the abrasives and the workpiece are varied proportionately to the amount of work effort required to remove varying amounts of material from successive workpieces, as required, in a given unit of time; to provide a device for rotating a shaft for expanding a plurality of honing tools a predetermined amount, and thereafter incrementally rotating the shaft a predetermined small amount by a cam; to provide a switch actuated by the advancement of the cam which controls the expansion of the abrasive stone; to interrupt the circuit when a predetermined degree of advancement has been attained; and in general to provide control means for expanding the abrasive element to control the loading of the stone during an abrasive operation, which is simple in construction and positive in operation.

Other objects and features of novelty of my invention will be specifically pointed out, or will become apparent when referring, for a better understanding of my invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a view in elevation with parts in section, illustrating a honing machine embodying features of my invention;

Fig. 2 is a sectional view of the structure illustrated in Fig. 1, taken on the line 2—2 thereof;

Fig. 3 is a sectional view of the structure illustrated in Fig. 2, taken on the line 3—3 thereof;

Fig. 4 is a sectional view of the structure illustrated in Fig. 2, taken on the line 4—4 thereof;

Fig. 5 is a view of structure, similar to that illustrated in Fig. 2, showing a modified form thereof;

In Fig. 1, I have illustrated a portion of a conventional honing machine 10 which embodies a reciprocating head 11, supporting a plurality of honing tools 12. A driven shaft 13 operates to rotate a gear 14 through a spline connection 15 for rotating a plurality of gears 16 and drive the honing tools 12 in rotation. Rods 17 extend through the head 11 and the tools 12 for operating a cam 18 of the tools which expands the abrasive elements. The rods 17 are supported at the upper end on reciprocable racks 19, which are in mesh with a plurality of pinion gears 21. The gears 21 are mounted on a shaft 22 supported in suitable bearings 23 and extend within a housing 24 which contains mechanism for operating the shaft 22 in rotation. The housing 24 in which the shaft 22 projects encompasses a bell crank 28, which is secured to the shaft by a key 29 and nut 31. The arm 32 of the bell crank has a gear segment 33 attached to, or formed thereon, which meshes with a rack 34 slidable within a slot 35, as illustrated more clearly in Figs. 3 and 4. A bearing block 36 is secured by screws 37 for positioning the rack relative to the gear segment 33. The rack is attached to a piston 38, which is reciprocated within a cylinder 39 by the application of fluid pressure to one or the other orifice 41 or 42. A cylinder 43 is provided adjacent the cylinder 39, in which a piston 44 likewise is movable in reciprocation by a fluid. In one instance, the fluid passes through an orifice 45 in the wall between the cylinders 43 and 39 for moving the pistons simultaneously to the right, as viewed in the figures. A bleeding valve 46 meters the flow of fluid to the righthand end of the piston 44, and regulates its advancement to the left. An adjusting knob 47 permits the adjustment of the metering valve 46 to accurately meter the fluid passing in the righthand end of the cylinder 43. A ball check valve 48 is provided in parallel with the valve 46 to permit the rapid discharge of fluid from the righthand end of the cylinder when the piston 44 is moved to the right.

A stepped cam 49 is carried by the end of the piston 44 in the path of movement of the head 51 carried by the arm 52 of the bellcrank 28. The cam 49 is provided with cam or dwell portions 53, 54, 55, 56, 57, 58 and 59, which are offset from each other a predetermined amount. While I have illustrated the cam as having stepped surfaces in Fig. 2, it is to be understood that a continuous sloping surface could be employed in some instances, as illustrated in Fig. 5. A shaft 61 carries a roller 62 which tangentially contacts the back of cam 49 directly opposite to the head 51 to back up the cam and prevent it from being deflected. Needle bearings 64 are disposed between the roller and shaft to minimize friction between said shaft and rollers. The end of the cam 49 has an adjustable plug 65, disposed in abuttable relation with an adjustable plug 66 for the purpose of limiting the advancement of the cam 49 and therefore the expansion of the abrasive tool. A stop element 67, which is also adjustable, may be aligned with the rack 34 to limit its forward travel. Suitable packing 68 is provided around the lefthand end of the piston, as viewed in the figure, to prevent the leakage of oil therefrom.

Suitable devices, not herein illustrated, regulate the driving of the head 11 in reciprocation, as well as the flow of fluid to the orifices 41 and 42, in the adjusting mechanism. After the tools 69 have been inserted into the cylinder 71, fluid is introduced through the orifice 42 into the cylinder 39 to move the piston 38 and therefore the rack 34 to the left, as viewed in Figs. 2 and 5. This rotates the bellcrank 28 and shaft 31 clockwise until the head 51 strikes the cam or dwell surface 53, which prevents further movement.

The rotation of the shaft 31 produces the rotation of the pinion gears 21, which operate the racks 19 downwardly to move the rods 17 and cams 18 downwardly therewith and force the abrasive stones 69 of the tool outwardly against the surface 71 of the bores of the workpiece 72. As herein illustrated, the workpiece 72 comprises a cylinder block of an internal combustion engine, having four cylinders 71, which are aligned with four tools 12 carried by the head 11 of the honing machine.

As fluid is introduced into the cylinder 39, it is also by-passed by the valve 46 into the cylinder 43 to move the piston 44 at a predetermined speed, regulated by the adjustment of the valve 46. As the honing operation proceeds under a predetermined pressure between the stones and the wall of the cylinder 71, the cam 49 is slowly advanced to the left until the head 51 passes from the surface 53 onto the surface 54. This permits the cylinder 38 to advance the rack 34 and therefore the bellcrank 28 to rotate the shaft 22 a slight additional amount. This application of increments of additional rotation continues as the cam 49 is advanced to advance the dwell surfaces 54, 55, 56, 57, 58 and 59 under the head

51, provided the adjustment of the plugs 65, 66 and 67 is such as to permit this amount of advancement during the machining operation. Any number of the dwell surfaces may be employed, depending upon the number of increments of advancement required for the particular honing operation.

When the cylinder 38 has advanced initially until it is stopped by the engagement of the head 51 with the dwell surface 53, the abrasive stones expand to engage the wall of the cylinder 71 during the time the honing tools 12 are reciprocated and rotated therewithin. In those cylinders in which only a small amount of stock is to be removed, very little, if any, contact will occur between the abrasive stone and the cylinder walls. In those cylinders having more stock to be removed, a greater pressure between the stones and wall occurs, so that a more rapid machining of such walls initially takes place. After a predetermined increment of time, the abrasive stones will be advanced an additional slight amount to engage the cylinder wall with the desired pressure. This slight increase in pressure during the machining operation will occur each time the head 51 engages an additional cam surface.

In those cylinders in which a greater amount of stock is to be removed a greater pressure between the stones and the wall will initially obtain and more rapid machining will occur. By the end of the abrasive operation, all of the cylinders will have been machined to a desired diameter and a slight additional honing time without an increase in pressure is preferably provided to more highly finish the cylinder walls. Thereafter, the timing device interrupts the reciprocation of the honing tools and reverses the flow of fluid in the orifices 41 and 42 to produce the contraction of the abrasive stones before they are withdrawn from the cylinder block 72. The tool is preferably provided with wiper guides which project beyond the abrasive stones when the stones are contracting to prevent the stones from contacting the wall because of the tool's gyration when being withdrawn from the cylinders.

As pointed out hereinabove, the fluid is reversed in the orifices 41 and 42 before the tools 12 are withdrawn from the cylinder block 72. The fluid introduced within the orifice 41 passes into the cylinder 39 and through aperture 45 into the cylinder 43. This moves the pistons to the right and rotates the shaft 22 in a counterclockwise direction which retracts the rods 17 and cams 18 which permit the stones 69 to retract.

In Fig. 5, I have illustrated a structure similar that illustrated in Fig. 2 and embodying a modified form thereof. The piston 44 has a cam 75 on its end, in place of the cam 49, which is advanced in the same manner as that above described. The cam 75 is provided with a sloping cam surface 76 which initially interrupts the movement of the head 51 and thereafter permits the continual rotation of the shaft 22 as the cam 75 is advanced. After the abrasive stones have expanded to a predetermined diameter limited by the engagement of the head 51 with the cam 75, the continuous advancement of the abrasive stones occurs as the cam 75 advances until the final diameter is reached. When the final diameter is reached, the plug 65 has advanced a plunger 77 in an adjustable body 78 to operate a switch 79. The switch operates a valve to reverse the flow of fluid in the orifices 41 and 42, and interrupts the reciprocation of the abrasive tools which are thereafter withdrawn from the engine block 72. A time delay device may be inserted in the circuit of the switch 79 to provide an additional time of operation of the honing tools on the cylinder walls after the roughing operation.

As an added feature and to afford the operator a visual indication of the progress of the honing operation, a dial indicator 80 may be provided as shown in Figs. 1 and 2. The plunger 81 of this device bears against a uniform rise annular cam 82 generated upon the hub of sector 32. During the initial rotation of sector 32, or until finger 51 comes into contact with cam 53, the portion of cam 82 which contacts plunger 81 is concentric and cylindrical relative to the axis of shaft 22. Thereafter, as sector 32 further rotates, the rise of cam 82 depresses plunger 81 causing the pointer of indicator 80 to move around its dial until rotation of the sector 32 is finally stopped by the cessation of movement of cam 53. Should the operator desire to stop the operation at any point intermediate of the total cycle of operation, he can do so at any time he desires as indicated by the traverse of the pointer.

In either construction a complete control of the honing operation is provided, the abrasive stones being expanded to a predetermined diameter, which may or may not contact the cylinder wall, and thereafter either progressively or by increments the expansion is continued until a desired diameter is reached. This prevents the "loading" or "glazing" of the abrasive stone of the tool as is desirable while producing cutting pressure between the stones and the cylinder wall which efficiently machines the wall throughout the entire time cycle of operation.

While the tools 12 herein illustrated have not been described in detail, the tools follow the conventional construction and reference may be had to my copending application Serial No. 257,088, filed February 18, 1939, which matured as Patent No. 2,315,062, March 30, 1943, and assigned to the assignee of the present application, for a full description and illustration thereof.

While I have described and illustrated but two embodiments of my invention, it will be apparent to those skilled in the art that various changes, omissions, additions, and substitutions may be made therein without departing from the spirit and scope of my invention, as set forth in the accompanying claims.

I claim as my invention:

1. In a honing machine, a honing tool having abrasive stones, means for advancing and contracting said stones, means for operating said advancing means, visual means for indicating the progress of said advancement, means movable into the path of advancement of said operating means for interrupting its movement, and means thereafter for moving said movable means to positively control the further advancement of said operating means.

2. In a honing machine, a honing tool having abrasive stones, means for advancing and contracting said stones, means for operating said advancing means, means movable into the path of movement of the operating means for initially interrupting its movement, and additional means for moving said movable means to permit further advancement of said operating means under the positive control of said movable means.

3. In a honing machine, a honing tool having abrasive stones, means for advancing and con-

tracting said stones, means for operating said advancing means, stepped means disposed in the path of movement of said operating means for initially interrupting its movement, and additional means for moving said stepped means to permit further advancement of said operating means by increments between predetermined time intervals.

4. In a honing machine, a plurality of honing tools having expansible and contractible abrasive stones, common means for advancing said stones, and movable means disposed in the path of movement of said common means for interrupting the expansion of the stones and thereafter permitting the continuous expansion of said stones to a predetermined diameter.

5. In a honing machine, a plurality of honing tools having expansible and contractible abrasive stones, common means for advancing said stones, means for limiting the movement of said common means for expanding said stones initially to a predetermined diameter, and means for continuously moving said limiting means for positively controlling the movement of said common means and the further advancement of said stones.

6. In a honing machine, a plurality of honing tools having expansible and contractible abrasive stones, common means for advancing said stones, stepped means for limiting the movement of said common means for expanding said stones to a predetermined diameter initially, and means for moving said stepped means for positively controlling the movement of said common means and the further periodical advancement of the stones of the tool to a plurality of greater diameters.

7. In a honing machine, a plurality of honing tools having abrasive stones, means for driving said tools in rotation and reciprocation, means for expanding the stones of said tools, a shaft common to said expanding means, means interconnecting said shaft and the tool expanding means, a piston, means interconnecting said shaft and said piston for producing the shaft rotation, means disposed in the path of movement of said interconnecting means for limiting the advancement of said piston, and additional means controlling the movement of said limiting means for positively controlling the movement of said interconnecting means.

8. In a honing machine, a plurality of honing tools having abrasive stones, means for driving said tools in rotation and reciprocation, means for expanding the stones of said tools, a shaft common to said expanding means, means interconnecting said shaft and the tool expanding means, a piston, means interconnecting the shaft and said piston for producing the shaft rotation, a cam for limiting the movement of said interconnecting means, and means for moving said cam for positively controlling the movement of said interconnecting means.

9. In a honing machine, a plurality of honing tools having abrasive stones, means for driving said tools in rotation and reciprocation, means for expanding the stones of said tools, a shaft common to said expanding means, means interconnecting said shaft and the tool expanding means, a piston, means interconnecting the shaft and said piston for producing the shaft rotation, a stepped cam in the path of movement of said interconnecting means for limiting the advancement of said piston, and means for moving said cam for permitting the advancement of said interconnecting means by increments.

10. In a honing machine, a plurality of honing tools having expansible abrasive stones, means for driving said tool in rotation and reciprocation, means for expanding the stones of said tools, a shaft common to all of said expanding means, means operatively interconnecting the shaft and said expanding means, a gear element on said shaft, a piston for operating said gear element, a limiting head on said shaft, a cam in the path of movement of said head, and a piston for advancing said cam for positively controlling the movement of said gear element by said first piston.

11. In a honing machine, a plurality of honing tools having expansible abrasive stones, means for driving said tool in rotation and reciprocation, means for expanding the stones of said tools, a shaft common to all of said expanding means, means operatively interconnecting the shaft and said expanding means, a gear element on said shaft, a piston for operating said gear element, a limiting head on said shaft, a cam in the path of movement of said head, a piston for advancing said cam, and valve means for regulating the movement of said cam piston for regulating the expansion of said abrasive elements by the movement of said gear as the head is permitted to advance by the movement of the cam.

12. The method of honing which includes the steps of inserting a tool within a cylinder to be honed, rotating and reciprocating said tool, expanding the tool to a predetermined diameter, and thereafter additionally expanding the tool to greater controlled diameters in time controlled intervals independently of the reciprocating motion.

13. The method of honing a plurality of cylinders which includes the steps of inserting a honing tool within each cylinder, of rotating and reciprocating said honing tools, of expanding all of said tools to a predetermined diameter, and thereafter expanding said tools to a number of predetermined greater diameters in predetermined time intervals independently of the reciprocating motion.

14. The method of honing a plurality of cylinders which includes the steps of inserting a honing tool within each cylinder, of rotating and reciprocating said honing tools, of expanding all of said tools to a predetermined diameter, of thereafter expanding said tools to a number of predetermined greater diameters in predetermined time intervals independently of the reciprocating cycle, and of continuing the operation a predetermined time interval after a predetermined diameter has been reached.

15. The method of honing a plurality of cylinders which includes the steps of inserting a honing tool within each cylinder, of rotating and reciprocating said honing tools, of expanding all of said tools to a predetermined diameter, of thereafter expanding said tools to a number of predetermined greater diameters in predetermined time intervals independently of the reciprocating cycle, of continuing the operation a predetermined time interval after a predetermined diameter has been reached, and interrupting the honing operation by contracting the abrasive elements and withdrawing the tools from the bore.

16. A honing machine having, in combination, a reciprocatory head, a plurality of hollow tool spindles each journaled at one end in said head and adapted to carry on the other end an expansible and contractible honing tool, a tool

actuator extending from each tool through its associated spindle and into the head, means yieldably holding the actuators in a withdrawn position to permit the tools to contract, means for shifting the actuators simultaneously to an operated position to expand the tools, said shifting means including a shaft journaled in the head and extending transversely across the same above the tool spindles, means providing an operative connection between the shaft and each actuator, a reciprocatory plunger for rocking said shaft, and adjustable stop means engageable by said plunger in its movement in one direction to determine the limit positions of said actuators.

17. A honing machine having, in combination, a reciprocatory head, a hollow tool spindle journaled at one end in said head and adapted to carry on the other end an expansible and contractible honing tool, a tool actuator extending from the tool through the spindle and into the head, means yieldably holding the actuator in a withdrawn position to permit the tool to contract, means for shifting the actuator to an operated position to expand the tool, said shifting means including a reciprocatory plunger, a stepped wedge positioned to block the movement of said plunger in one direction, and means for shifting said wedge to present different steps in the path of the plunger and thereby vary the range of movement of the actuator.

18. A honing machine having, in combination, a reciprocatory head, a hollow tool spindle journaled at one end in said head and adapted to carry on the other end an expansible and contractible honing tool, a tool actuator extending from the tool through the spindle and into the head, means yieldably holding the actuator in a withdrawn position to permit the tool to contract, means for shifting the actuator to an operated position to expand the tool, said shifting means including a reciprocatory plunger, a stepped wedge positioned to block the movement of said plunger in one direction, said wedge being normally positioned to limit the plunger to a minimum range of movement, and means for gradually withdrawing said wedge to increase the range of movement of the plunger.

19. A honing machine having, in combination, a reciprocatory head, a hollow tool spindle journaled at one end on said head and adapted to carry on the other end an expansible and contractible honing tool, a tool actuator extending from the tool through the spindle and into the head, means yieldably holding the actuator in a withdrawn position to permit the tool to contract, means for shifting the actuator to an operated position to expand the tool, said shifting means including a reciprocatory plunger, a wedge having steps of progressively varying height adapted to be interposed in the path of the plunger, said wedge being normally positioned to present its highest step in blocking relation to the plunger, pressure fluid operated means for gradually withdrawing said wedge to present the lower steps of the wedge in succession in the path of the plunger, and other pressure fluid operated means acting to force the plunger into engagement with each step of the wedge and thereby progressively advance said actuator.

20. A honing machine having, in combination, a reciprocatory head, a hollow tool spindle journaled at one end on said head and adapted to carry on the other end an expansible and contractible honing tool, a tool actuator extending from the tool through the spindle and into the head, means yieldably holding the actuator in a withdrawn position to permit the tool to contract, means for shifting the actuator to an operated position to expand the tool, said shifting means including a reciprocatory plunger, a wedge having steps of progressively varying height adapted to be interposed in the path of the plunger, said wedge being normally positioned to present its highest step in blocking relation to the plunger, pressure fluid operated means for gradually withdrawing said wedge to present the lower steps of the wedge in succession in the path of the plunger, other pressure fluid operated means acting to force the plunger into engagement with each step of the wedge and thereby progressively advance said actuator, and means for independently varying the speed of operation of said first pressure fluid operated means to regulate the rate at which the actuator is advanced.

21. 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, tool actuating means including a cylinder and a piston working therein, a rod operatively connecting the piston with the tool operated when the piston is shifted in one direction to expand the tool, a stepped wedge position to block the movement of the plunger in said one direction, wedge shifting means comprising a cylinder and a piston working therein, said piston being operatively connected with the wedge and acting to withdraw the same from the path of the rod when the piston is moved in one direction, a fluid pressure line connected to the corresponding ends of both cylinders for supplying pressure fluid thereto to expand the tool and withdraw said wedge, discharge lines connected to the opposite ends of said cylinders, and an adjustable valve interposed in the discharge line of said second cylinder for regulating the rate at which the piston is shifted to withdraw said wedge.

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