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 and initially loading the stones a predetermined amount was 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 through-out 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 positions 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 workplace

at the time this incremental advancement occurs;

to provide a shaft for expanding the abrasive

elements operated by a gear element which is

activated by a cam, limited by the advance-

ment of a cam; to provide means whereby the op-

erating 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

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

conditioning of the stone during 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 un-
derstanding of my invention, to the following
description taken in conjunction with the ac-

companying drawings, wherein:

Figure 1 is a view in elevation with parts in

section, illustrating a honing machine embody-
ing features of my invention.

Figure 2 is a sectional view of the structure il-

lustrated in Fig. 1, taken on the line 2—2 thereof;

Figure 3 is a sectional view of the structure il-

lustrated in Fig. 2, taken on the line 3—3 thereof;

Figure 4 is a sectional view of the structure il-

lustrated in Fig. 2, taken on the line 4—4 thereof;

Figure 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 con-

ventional honing machine 18 which embodies a

reciprocating head 14 supporting a plurality of

honing tools 12. A driven shaft 13 operates to

rotate a gear 15 through a spline connection 19

for rotating a plurality of gears 16 and drive the

honing tools 12 in rotation. Rods 17 extend

through the head 14 and the tools 12 for operat-
ing 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 sliding within a slot 35, as illustr-

ated 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 recipro-
cated within a cylinder 40 by the application of

springing 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 be-
tween 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 adjust-
ing knob 47 permits the adjustment of a meter-

ing valve 48 to accurately meter the fluid passing

in the righthand end of the cylinder 43. A ball

check valve 49 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 or without a dwell por-
tions 55, 56, 57, 58 and 59, which are offset from

each other a predetermined amount. While I have

illustrated the cam as having stepped sur-

faces in Fig. 2, it is to be understood that a con-

tinuous sloping surface could be employed in some

instances, as illustrated in Fig. 5. A shaft 51

carries a roller 52 which tangentially guides the

back of a cam 48 provided to the head 51 to

back up the cam and prevent it from being de-

fected. Needle bearings 54 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 55, driven in relation with an

adjustable plug 60 for the pur-

pose of limiting the advancement of the cam 49

and therefore the expansion of the abrasive tool.

A stop element 61, which is adjustable, may

be aligned with the rack 34 to limit its forward

travel. Suitable packing 65 is provided around

the left hand end of the piston, as viewed in the

figure, to prevent the leakage of oil therefrom.

Suitable devices, not herein illustrated, regu-
late 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

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 move-

ment.

The rotation of the shaft 31 produces the ro-
tation 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 en-
geine, having four cylinders 11, 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 cylin-
der 43 to move the piston 44 at a predetermined

speed, regulated by the adjustment of the valve

48. As the honing operation proceeds under a

predetermined pressure between the stones and

the wall of the cylinder 71, the cam 45 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
provided the adjustment of the plug 63, 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 action.

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 therein. 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 the 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 vibration 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 38 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 cam 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 45, 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 been advanced to a predetermined depth as determined 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 71 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 83. During the initial rotation of sector 82, or until finger 81 comes into contact with cam 83, the portion of cam 82 which contacts plunger 81 is concentric and cylindrical relative to the axis of shaft 22. Thereafter, as sector 82 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 82 is finally stopped by the cessation of movement of cam 83. 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 co-pending application Serial No. 297,868, filed February 18, 1938, which matured as Patent No. 2,315,662, 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 advancement of the operating means for 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 expandable 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 expandable 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 expandable 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 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 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 expandable 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 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 expandable 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 contractible 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 journeled at one end in said head and adapted to carry on the other end an expandable 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 position 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 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 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 wedge having steps of progressively varying height adapted to be interposed in the path of the plunger.

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, 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.

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 positioned 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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