

Dec. 9, 1941.

K. W. CONNOR ET AL

2,265,800

VARIABLE PRESSURE HONING TOOL AND METHOD

Filed Nov. 18, 1938

3 Sheets-Sheet 1

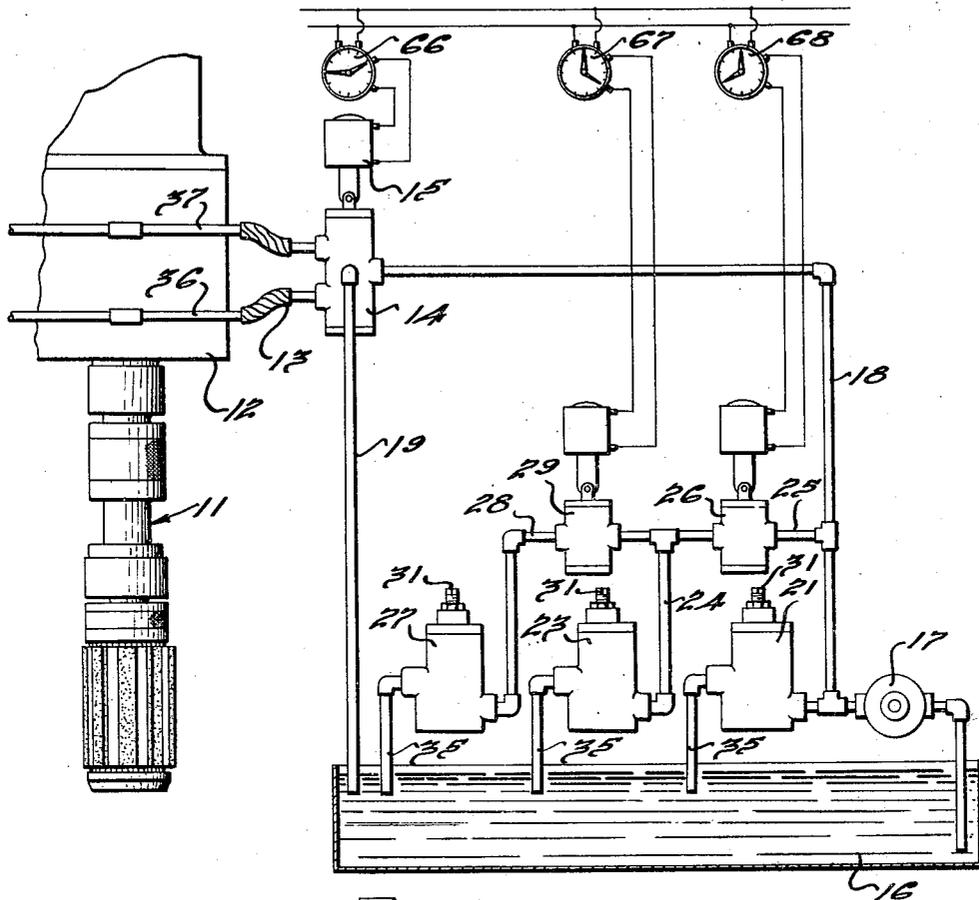


FIG. 1.

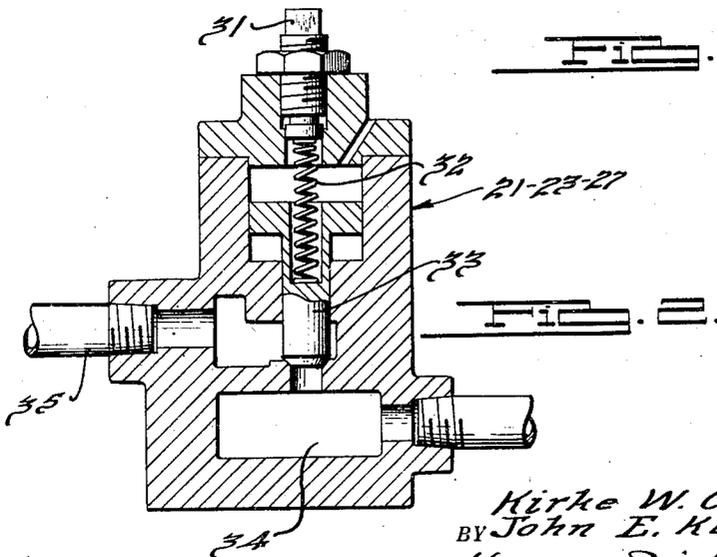


FIG. 2.

INVENTORS.
Kirk W. Connor,
BY John E. Kline.
Harnes, Dickey & Bier.
ATTORNEYS.

Dec. 9, 1941.

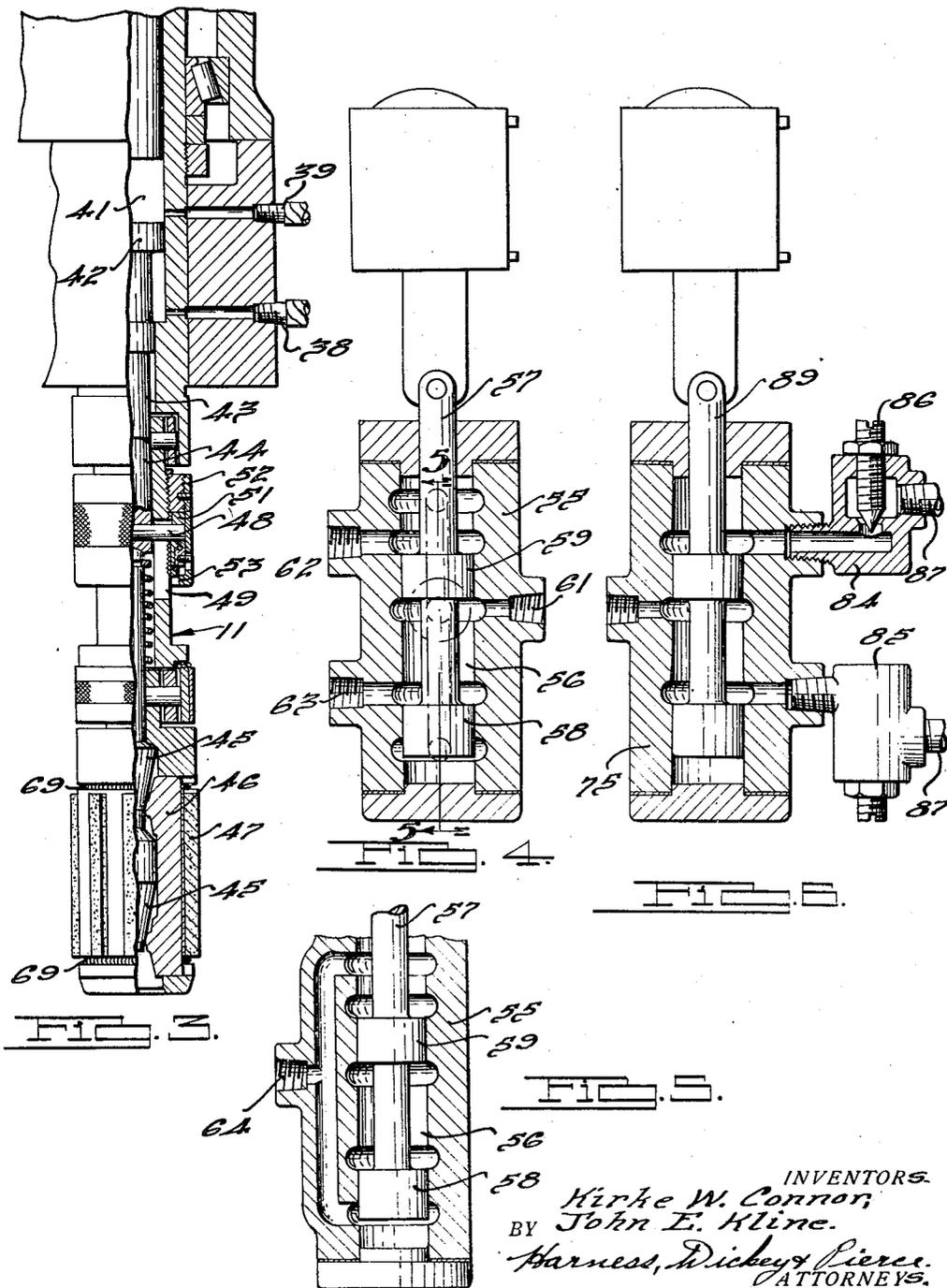
K. W. CONNOR ET AL.

2,265,800

VARIABLE PRESSURE HONING TOOL AND METHOD

Filed Nov. 18, 1938

3 Sheets-Sheet 2



INVENTORS
Kirk W. Connor,
John E. Kline.
Harness, Dickey & Pierce,
ATTORNEYS.

Dec. 9, 1941.

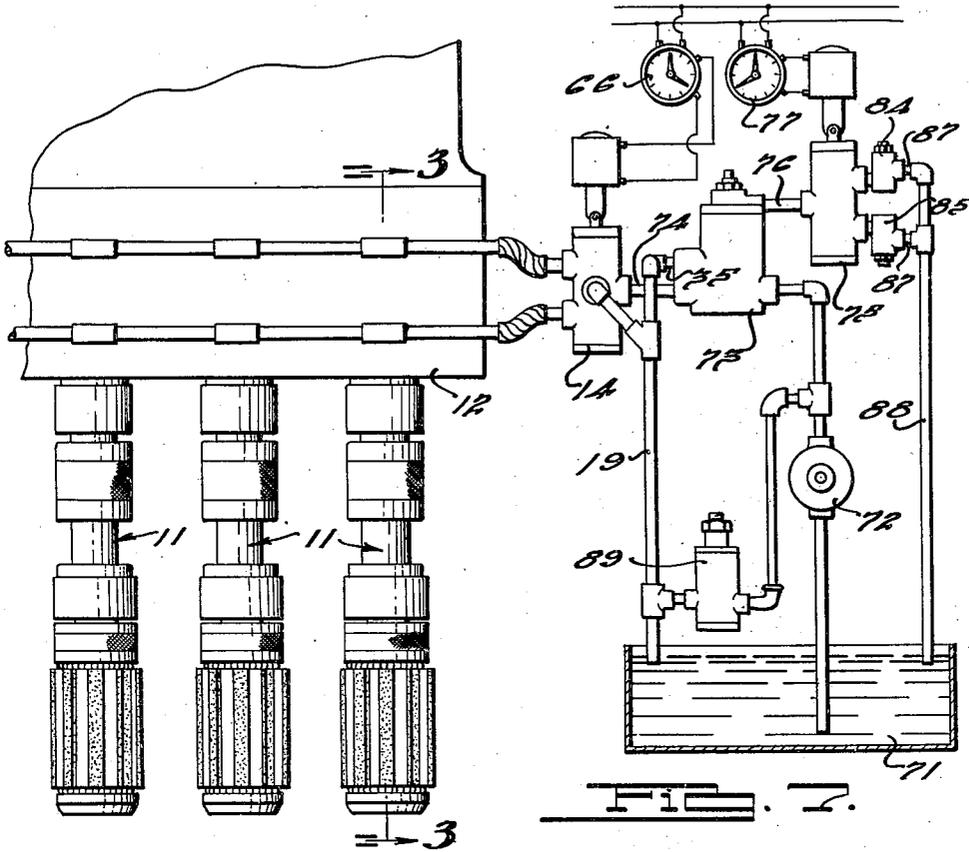
K. W. CONNOR ET AL

2,265,800

VARIABLE PRESSURE HONING TOOL AND METHOD

Filed Nov. 18, 1938

3 Sheets—Sheet 3



UNITED STATES PATENT OFFICE

2,265,800

VARIABLE PRESSURE HONING TOOL AND METHOD

Kirke W. Connor, Detroit, and John E. Kline,
Grosse Pointe Farms, Mich., assignors to Micro-
matic Hone Corporation, Detroit, Mich., a cor-
poration of Michigan

Application November 18, 1938, Serial No. 241,104

13 Claims. (Cl. 51—184.3)

Our invention relates to honing devices and methods, and particularly to a honing device having control means for accurately regulating and controlling the pressure between the abrading tool and the surface to be machined during various phases in the machining cycle.

Heretofore, it has been the practice to construct abrading tools with spring loading devices which produce a predetermined pressure on the abrading stones throughout the cycle of operation. In practicing our present invention, we provide a honing device having means for changing the pressure between the abrading members and the work member surfaces during the cycle of honing operation. Since the surface to be honed may be rough, very little area of surface engagement occurs between the stones and the projections on the surface. Initially, a light pressure is desirable to prevent the rapid wear of the stones which would occur when presented with high unit pressure against the rough surface. We have, therefore, provided means whereby initially a light pressure is employed to grind the projections from the surface being operated on and thereafter, when material surface engagement obtains between the stones and the surface, the pressure is materially increased and the roughing operation completed under such increased pressure. For the finishing operation, the original light pressure or a pressure greater or less than such initial pressure may be employed for honing a desired finish on the surface. The employment of this lighter pressure permits the abrading particles to become dulled and yet not be dislodged as would be the case if high operating pressures were continued. The "dulling" of the abrasive permits it to produce a surface on the work of a smoother character than the abrasive would produce if it remained sharp.

Various means may be provided for effecting the change in pressure. Sources of supply at variegated pressures may be provided which may be introduced selectively at various stages to produce the loading of the abrading stones. For the purpose of illustration, we have shown a pump for supplying a fluid to a line forming a rail system from which conductors may lead to a plurality of tools which are simultaneously operated. A relief valve is connected in the line to limit the rise in pressure to a predetermined amount. The valve is adjustable so that any desired maximum pressure may be obtained, which maximum pressure will be the pressure employed for the roughing operation. A second relief valve set to open at a pressure materially below that of the valve

providing the working pressure is also connected in the supply line, fluid to which is controlled preferably by a solenoid operated valve. When the latter valve is open, the supply line will have the fluid therein delivered at a pressure controlled by the relief valve of lower rating. This latter relief valve, determining the reduced pressure, may function initially to provide the initial pressure to the abrading stones. A third relief valve, controlled preferably by a second solenoid operated, or other remotely actuated, valve, may additionally be employed to provide a still lower pressure which may be utilized either for the initial pressure or for the finishing pressure near the end of the abrading operation.

Various devices may be employed for controlling the operation of the solenoids to render the low pressure valves effective. For the purpose of illustration, we have shown time switches which are set relative to each other and which control the entire cycle of honing operation and the cutting in and out of the relief valves to control the pressures during the various phases in the cycle of operation.

In a modified form of our invention, we have provided a valve which is automatically operated to increase the pressure on the abrading stones progressively and to progressively relieve such pressure during the cycle of operation. Cycle counters, time, relays, and the like may be employed for controlling the phases of building up and reducing the pressure of the system during the honing cycle. A valve is so constructed that initially the pressure is low and as the honing operation progresses the pressure progressively increases at a pre-set rate to a predetermined maximum during the roughing operation, after which the pressure diminishes to provide the dulling of the abrasive to produce the desired degree of surface finish on the work piece.

Accordingly, the main objects of our invention are: to provide a device and method for effecting an abrading operation under different pressures during different phases in the cycle of operation; to provide an initial pressure for the honing operation which is increased during the roughing cycle and diminished thereafter during the finishing phase of the honing operation; to provide a device and means for progressively increasing the pressure during the honing operation and for thereafter progressively decreasing the pressure through the finishing phase of the honing cycle; to provide a plurality of relief valves and means for rendering the relief valves effective and ineffective during the honing cycle; to provide a re-

relief valve which progressively increases and decreases the fluid pressure which is delivered to a honing tool; and, in general, to provide control means for the abrading element of a honing tool which varies the pressure during the various phases of the honing cycle, which is simple in construction and positive in operation.

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

Figure 1 is a diagrammatic view of a honing tool and the control therefor embodying features of one form of our invention;

Fig. 2 is a sectional view of a relief valve illustrated in Fig. 1;

Fig. 3 is an enlarged sectional view of the honing tool illustrated in Fig. 1, and the support therefor;

Fig. 4 is a sectional view of a valve controlling the direction of flow of the fluid to the honing tool;

Fig. 5 is a sectional view of the structure illustrated in Fig. 4, taken on the line 5-5 thereof;

Fig. 6 is a view of a valve similar to that illustrated in Fig. 4 having pressure regulating means thereon employed with the modified structure illustrated in Fig. 7;

Fig. 7 is a view of structure, similar to that illustrated in Fig. 1, showing a modified form thereof; and,

Fig. 8 is a sectional view of the pressure control valve illustrated in Fig. 7.

It has been pointed out hereinabove that the novel features of our invention embody the application of different pressures during the various phases of abrading occurring during an abrading cycle. In Fig. 1, we have illustrated a honing tool and control means therefor, which illustrates one form of structure and method which may practice our invention. One or more honing tools 11 are supported in the reciprocating head 12 for movement in rotation in a conventional manner. The tool is provided with a cylinder in which a piston is operated to apply pressure to the abrading stones for moving them radially of the tool axis. A fluid system supplies fluid under pressure to a valve 14 which may be shifted to direct the flow of fluid to the cylinders to one or the other side of the pistons therein. Suitable means, herein illustrated as a solenoid 15, is utilized for shifting the plunger of the valve 14.

Fluid is supplied from a reservoir 16 by a pump 17 to a supply line 18 which is connected to the valve 14. A return conductor 19 returns the fluid from the valve 14 to the reservoir 16. Directly connected in the line 18 is a relief valve 21 which is adjustable to by-pass to the reservoir the fluid circulated by the pump 17 after the pressure has reached a predetermined amount. A second relief valve 23 is connected to the line 18 through conduits 24 and 25, the latter of which contains a solenoid operated valve 26. The relief valve 23 is similar to the valve 21 and is adjusted to open at a materially lower pressure than the relief valve 21. When the solenoid valve 26 is open, the fluid in the supply line 18 is bypassed through the relief valve 23 and thereafter the pressure in the line 18 is that required to operate the latter relief valve.

A third relief valve 27 is herein illustrated as being connected in the line 18 in extension of the

line 25 by a conduit 28 in which a solenoid operated valve 29 is disposed. When the valves 26 and 29 are both open, the relief valve 27, which is set to open at a pressure lower than the setting of the relief valves 23 and 21, will open and the pressure in the line 18 will be that required to operate the relief valve 27.

By adjusting the set screw 31 of the relief valves, as illustrated in Fig. 2, the tension on a spring 32 is adjusted to regulate the pressure on the valve 33. Regulation is thereby provided to the fluid delivered to the chamber 34 where the pressure will build up sufficiently to open the valve 33 to by-pass fluid to the conduit 35 into the reservoir 16. By selecting the proper position of the valves 26 and 29, any of the relief valves 21, 23 and 27 may be made effective relative to the supply line 18 to thereby regulate the pressure of the fluid delivered through the line to the valve 14.

The flexible conductors 13 are connected to the conductors 36 and 37 which are joined by the couplings 38 and 39 respectively, to the upper and lower ends of the cylinders 41 of the honing tools 11. A piston 42 is mounted in the cylinder 41 and is actuated in reciprocation by the fluid introduced in the cylinder on one or the other side of the piston. The piston 42 has an extension 43 thereon in engagement with a plunger 44 which has, on the end thereof, conical shaped camming surfaces 45 which engage the projections on the abrading shoes 46 and which, when moved axially of the tool, control the radial position of the abrading elements 47. The plunger 44 carries a pin 48 which extends through slots 49 in the wall of the tool. The ends of the pin 48 project into a collar 51 which is slidable in a threaded sleeve 52 limited by a projecting flange 53 to thereby control the degree of expansion permissible to the abrading stones 47. By adjusting the sleeve 52 the degree of radial movement of the abrading stones 47 is thereby regulated.

The valve 14, as illustrated in Figs. 4 and 5, embodies a housing 55 having an axially disposed opening 56 therein in which a plunger 57 is shiftable. Piston heads 58 and 59 carried by the plunger have a close fit with the walls of the opening 56 and control the passage of fluid from the delivery line 18 through the opening 61 and from either opening 62 and 63 to the flexible conductors 13 to the honing tool. When the fluid is passing through one of the openings 62 or 63 fluid is returned from the honing tool through the other opening and conducted to the reservoir from the opening 64 through the conductor 19.

Various means may be employed for operating the solenoid actuated valves 14, 25, and 29, such as counters, timing switches and the like, and for the purpose of illustration, we have shown time switches 66, 67, and 68. The time switch 66 is set to shift and retain the valve 14 in a position to expand the abrading head of the tool and retain it expanded through the entire cycle of operation. The time control switch 67 is set to function after the switch 68 has energized the valve 26 to have the pressure in the delivery line 18 controlled by the pressure control valve 27. The time switch 68 controls the valve 26 to have the pressure control valve 23 effective when the valve 29 is closed.

When honing a cylinder for example, the honing tool is introduced thereto and the time switches 66 and 68 are closed, the former of

which shifts the plunger 57 on the valve 14 to introduce fluid through the conductors 37 into the top of the cylinder 41 to urge the plunger 43 downwardly. Since the time switch 68 was closed at the same time the valve 26 opens and the pressure in the line 18 is relieved by the pressure relief valve 23. In this manner, an initial low pressure is provided for expanding the abrading elements 47 into contact with the cylindrical surface of the work piece. In view of the rough walls within the cylinder, light pressure is desired during the initial machining phase of the honing cycle.

After a predetermined time of operation regulated by the time switch 68, the electric circuit to the solenoid of the valve 26 is opened, the valve 26 thereby becomes closed, rendering the relief valve 21 effective to control the pressure in the delivery line 18. Higher pressure is thereby delivered to the piston 42 of the honing tool and a material increase in pressure obtains between the surface of the abrading stones 47 and the wall of the cylinders.

After a predetermined time, regulated by the setting of the time switches 67 and 68, both of the valves 26 and 29 are open to thereby have the pressure in the supply line 18 controlled by the pressure relief valve 27. The pressure required to operate this valve may be materially less than that to operate the valve 23 so that the pressure employed for the finishing operation is thereby materially reduced.

In cases where the initial starting pressure and the finishing pressures are substantially the same, the pressure relief valve 23 may be employed for controlling both pressures and in such instance the valve 29 and pressure relief valve 27 are omitted. After the finishing operation, all of the switches 66, 67, and 68 are open, the valves 26 and 29 are closed and the plunger 57 of the valve 14 is reversed to have the pressure in the delivery line 18 introduced through the conduit 36 into the lower part of the cylinder 41 to move the piston 47 upwardly to thereby permit the abrading stones 47 to move radially inwardly under the bias of garter springs 69.

Referring to Figures 6, 7, and 8, we have illustrated a further method of controlling the pressure on the abrading stones during the honing operation. In this construction, a reservoir 71 containing a fluid, such as oil, is connected with a pump 72 to deliver said fluid under pressure to a regulating valve 73 from which fluid passes from the conduit 74 to the valve 14. A valve 75, similar to valve 14, is connected to a solenoid operated regulating valve 73 by a conduit 76. The solenoid of the valve 75 is controlled by a time switch 77 in a similar manner to that of the valve 14 by the time switch 66. The regulating valve 73 is similar to the pressure relief valve 21 of Fig. 2 with the exception that pressure from the chamber 34 is conducted through an orifice 78 beneath the piston head 79 forming part of the valve 33. The piston head 79 has an orifice 81 therethrough which is materially less in cross-sectional area than the orifice 78 connecting the chamber 34 to the under side of the piston 79. The area above the piston is connected through a passageway 82 to the conductor 76 communicating the valve 75.

The pressure delivered to the chamber 34 initially raises the valve 33 against the tension of the spring 32 which thereby controls the pressure initially employed for expanding the

abrading element. Fluid flows through the passage 78 to the underside of the piston head 79, and due to the fluid present on the opposite side of the piston a substantially balanced condition results. When the flow of fluid from the conduit 76 is less than that through the orifice 81 pressure will build up on the top side of the piston head 79 to thereby assist the spring 32 in endeavoring to hold the valve 33 closed. The increased pressure built up in the chamber 34 necessary to raise the valve 33 will be present in the delivery conduit 74. As the unit pressure in the chamber above piston head 79 increases, in the manner above described, the pressure in chamber 34 also increases by virtue of the bias of spring 32 reacting against a gradually balanced pressure area. Should, however, the unit pressure in the chamber above piston head 79 become exactly equal to the unit pressure in the chambers beneath piston head 79 and 34, the spring 32 would, in effect, be biased against an infinite pressure on a theoretically zero area causing the pressure of the fluid in conduit 74 to build up to the limit of pressure suppliable by the pump 72. To guard against such a circumstance, we have provided a by-pass or relief valve 89 which is shown in detail construction in Figure 2. The spring of this valve is adjusted to the maximum unit pressure desired during the honing operation. When the flow of fluid from the conduit 76 is greater than the flow of fluid through the passageway 81, the pressure is gradually relieved on the top side of the valve 79 and the pressure to operate the valve 33 likewise reduces, which gradually reduces the pressure in the delivery conduit 74 until the unit pressure operating upon the combined cross-sectional areas of plunger 33 and the lower side of piston head 79 offsets the pre-set bias of the adjustable spring 32 in valve 73. The setting of this last mentioned spring determines the minimum pressure obtainable during the honing operation. With this arrangement the pressure on the piston 42 of the honing tool 11 is initially loaded with a predetermined low pressure which slowly increases during a predetermined time cycle of operation controlled by the time switch 77 and thereafter the pressure slowly reduces through the finishing operation.

This control of the pressure is regulated by the valve 75 which, as illustrated in Fig. 6, is provided with needle control valves 84 and 85. The stems 86 of the valves are adjustable so that a very fine bleeding of the liquid through the valves results. The valves are connected by conductors 87 to a line 88 which returns the fluid to the reservoir 71. When a plunger 59 of the valve 75 is shifted to one position, such as that illustrated, fluid from the conduit 76 passes through the needle valve 85, the rate of flow of fluid therethrough is less than that through the orifice 81 and pressure will build up on the top of the valve 79 and in the delivery conduit 74. The pressure will continue to build up until the pressure reaches that for which the spring in valve 89 is adjusted. Thereafter, the time switch 77 opens and de-energizes the solenoid of the valve 75 which permits the plunger 59 to shift to its opposite position. The fluid above the piston 79 will be conducted through the needle valve 84, the flow through which occurs at a greater rate than through the orifice 81 which thereby gradually reduces the pressure in the delivery conduit 74. This reduction of pressure will continue until the spring 32 in valve 73,

alone functions, or until the end of the cycle of operation when the timing switch 66 opens and operates the valve 14. The valve 14 reverses the flow of fluid relative to the piston 42 and the plungers 44 are moved upwardly to permit the abrading elements of the honing tool to be moved radially inwardly toward the axis of the tool. Low pressure will be present in the conduit 74 due to the fact that the needle valve 84 relieves the pressure on the top of the piston 79.

To start the cycle of honing operation, the time switches 66 and 67 are energized to close the circuit to the solenoid of the valves 14 and 75. The plunger 67 is moved to a position to supply fluid above the piston 42. The time switch 77 upon becoming energized moves the plunger 89 to the position illustrated in Fig. 6 to have the flow of fluid from above the piston 79 occur through the needle valve 85. The valve 85 bleeds fluid therethrough at a rate less than that which passes through the orifice 81. The initial low pressure will urge the abrading elements against the wall to be machined during the beginning of the abrading operation. The pressure will automatically and gradually increase as the area of contact becomes greater between the gradually smoothing surface of the wall and the abrading elements. The maximum pressure is reached during the roughing operation, which pressure slowly decreases so that by the end of the roughing operation a pressure will be present satisfactorily low to produce the finishing operation. This cycle of reducing pressure occurs after the time switch 77 is de-energized to connect the valve 84 to the conduit 76. After the finishing cycle has been completed, the time switch 66 opens the electric circuit to the solenoid of the valve 14 which is shifted to produce the retraction of the abrading elements.

It will thus be seen that we have employed the fluid delivered directly by a pump and have controlled the delivered pressure thereof by employing suitable relief valves. Through the operation of the valves, the pressure on the honing tools is maintained at various stages through different phases of the machining cycle. The pressure may be a predetermined amount or may gradually be built up and reduced during the honing operation and in repetitive phases if desired. The initial pressure may be such as to permit the grinding away of sharp machine marks left in the wall to be honed without materially damaging the surface of the abrading element. When area contact occurs between the surface and the stones, a materially increased pressure is employed for effecting the desired stock removal from the workpiece. Thereafter, a reduced pressure is utilized to produce the finish desired on the surface.

While we have described and illustrated several embodiments of our 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 our invention, as set forth in the accompanying claims.

What we claim is:

1. The method of abrading which includes the steps of, initially abrading with a light pressure, thereafter abrading with a greater pressure, and finishing with said initial pressure.

2. The method of abrading in three stages which includes, initially abrading at low pressure to base metal, abrading at high pressure to remove base metal, and abrading at reduced

pressure to finish the surface of the base metal which has been machined to size.

3. The method of abrading which includes the steps of, moving the abrading elements into contact with the surface to be machined, progressively increasing the pressure therebetween during the roughing operation, and near the end of the operation decreasing said pressure through the finishing phase of the honing cycle.

4. The method of abrading which includes the steps of, initially machining at a low pressure, thereafter increasing said pressure during the preliminary phase of the honing cycle, and decreasing said pressure for the operation during the finishing phase of said cycle.

5. In an abrading device, an abrading element, means for advancing said element into contact with a surface to be machined, means for initially applying a low pressure between said element and surface, means for thereafter applying higher pressure between said element and surface, means for applying a reduced pressure near the end of the honing operation, and means for controlling the duration of application of various pressures during the initial, roughing and finishing phases of the honing cycle.

6. In an abrading device, an abrading element, means for advancing said element into contact with a surface to be machined, fluid means for applying pressure to said abrading element, a first pressure control valve, a second pressure control valve for producing a higher pressure between said element and said surface and a valve for rendering said first control valve effective.

7. In an abrading device, an abrading element, means for advancing said element into contact with a surface to be machined, fluid means for applying pressure to said abrading element, a first pressure control valve, a second pressure control valve for producing a higher pressure between said element and said surface, a valve for rendering said first control valve effective, a third pressure control valve for providing a still different pressure to said abrading element, and a second valve for rendering such third pressure control valve effective.

8. In an abrading device, an abrading element, means for advancing said element into contact with a surface to be machined, fluid means for applying a pressure to said abrading element, a first pressure control valve, a second pressure control valve for providing a higher pressure between said element and said surface, a valve for rendering said first control valve effective, a third pressure control valve for providing a still different pressure to said element, a second valve for rendering such third pressure control valve effective, and means for controlling the application of said pressures during the various phases of operation during the honing cycle.

9. In an abrading device, an abrading element, means for advancing said element into engagement with a surface to be abraded, fluid means for applying a low initial unit pressure between said element and said surface and increasing said pressure to a predetermined maximum and thereafter decreasing said pressure to a predetermined minimum; and means for controlling the rates of increase and/or decrease of said pressures to maintain or retard, respectively, the abrading action of said elements.

10. The method of abrading which includes the steps of moving the abrading element into engagement and upon a surface to be machined, moving said element relatively to said surface

to effect an abrading action and subjecting said element to varying degrees of pressure, commensurate with the changing character of said surface, during the operation thereon, to maintain an effectual penetration of the abrading particles of said element into said surface; and thereafter decreasing the applied pressure to reduce the pressure between said element and said surface to diminish the amount of said penetration to promote dulling of the abrasive particles and refinement of finish on said surface.

11. The method of abrading which includes the steps of moving the abrading element into contact and upon a surface to be machined, maintaining pressures between said element and said surface proportionate to their area of contact as the character of said surface changes, and subsequently reducing said pressures to dull the abrasive particles in said element and thereby further increase the said area of contact during the final stage of operation.

12. In a hydraulic power transmission for operating a honing machine the combination with a translatable head and an expansible hone carried thereby, of a fluid motor for effecting expansion and contraction of the hone, a pump for supplying pressure fluid to operate the motor, and means for regulating the fluid pressure effective on said motor to thereby control the ex-

pansive force exerted by the hone, said means including a valve for by-passing a portion of the fluid delivered by the pump, a piston for operating the valve and having one side freely communicating with the delivery side of the pump and its other side in restricted communication therewith, and a pilot relief valve for controlling the exhaust of fluid from said other side of the piston.

13. In a hydraulic power transmission for operating a honing machine the combination with a translatable head and an expansible hone carried thereby, of a fluid motor for effecting expansion and contraction of the hone, a pump for supplying pressure fluid to operate the motor, and means for regulating the fluid pressure effective on said motor to thereby control the expansive force exerted by the hone, said means including a member shiftable to control the quantity of fluid delivered to the motor, a piston for operating said member and having one side freely communicating with the delivery side of the pump and its other side in restricted communication therewith, and a pilot relief valve for controlling the exhaust of fluid from said other side of the piston.

KIRKE W. CONNOR.
JOHN E. KLINE.