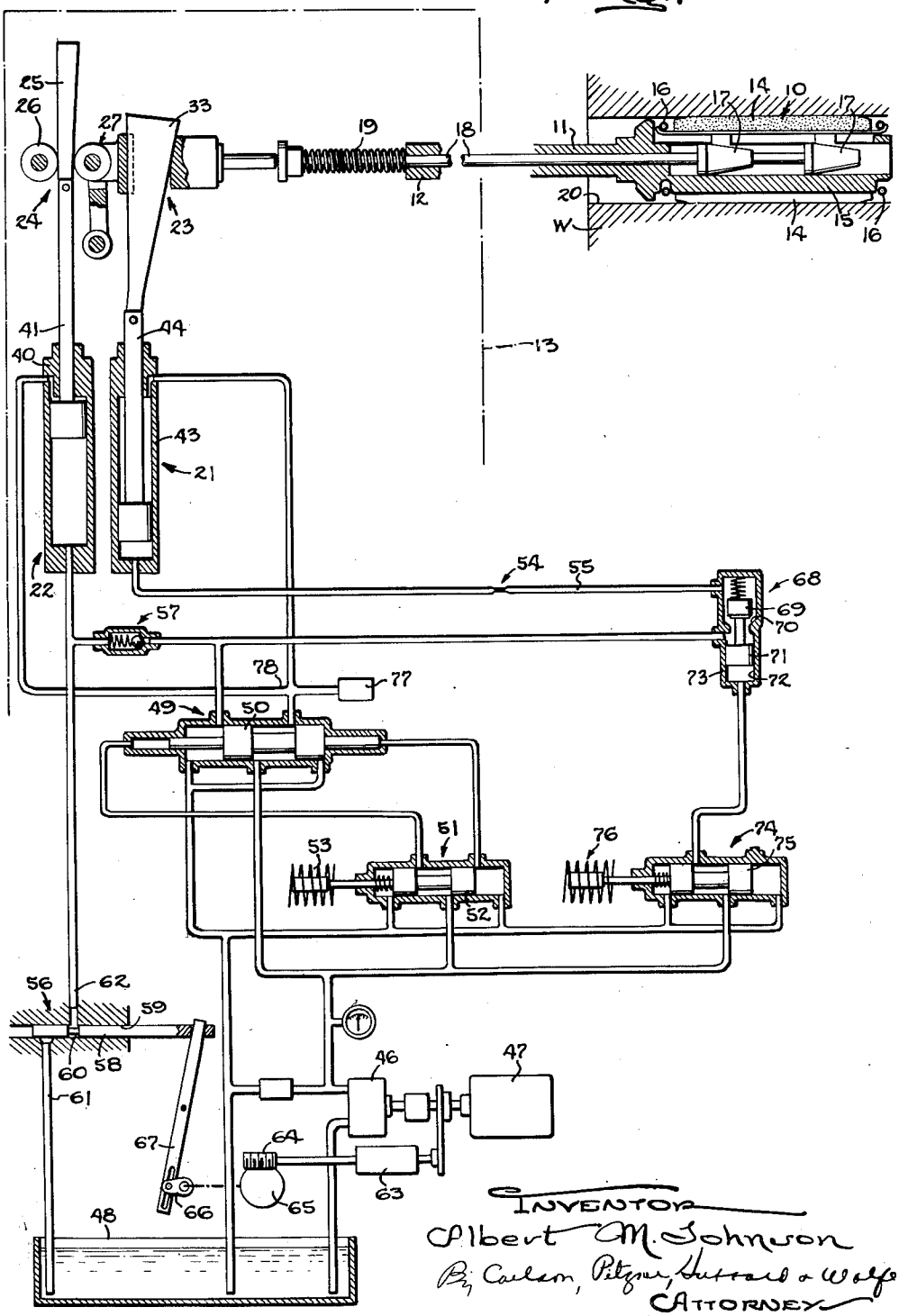
May 14, 1957 A. M. JOHNSON 2,791,871

HONING MACHINE

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Fig. 1



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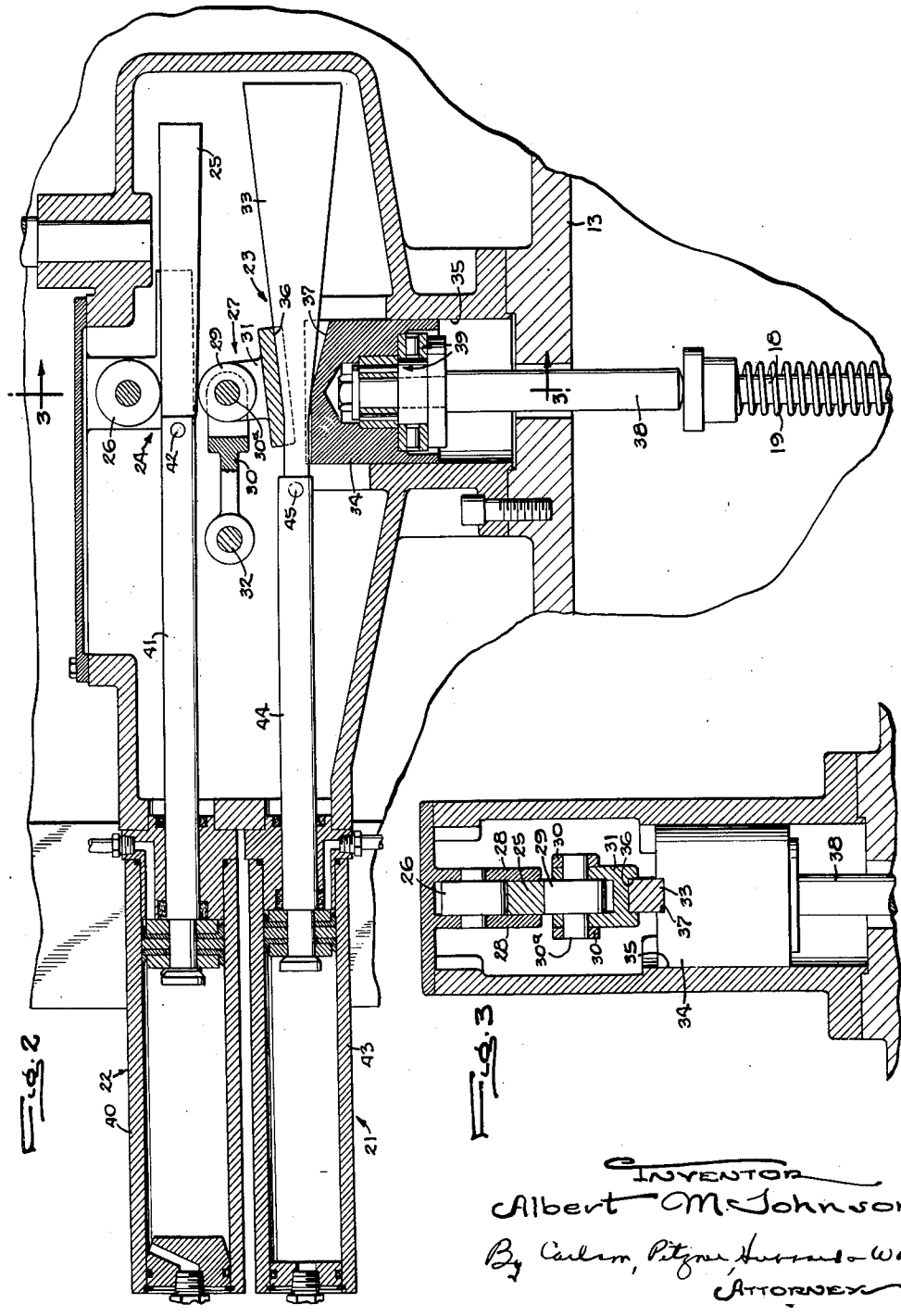


Fig. 2

Fig. 3

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HONING MACHINE

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Fig. 4

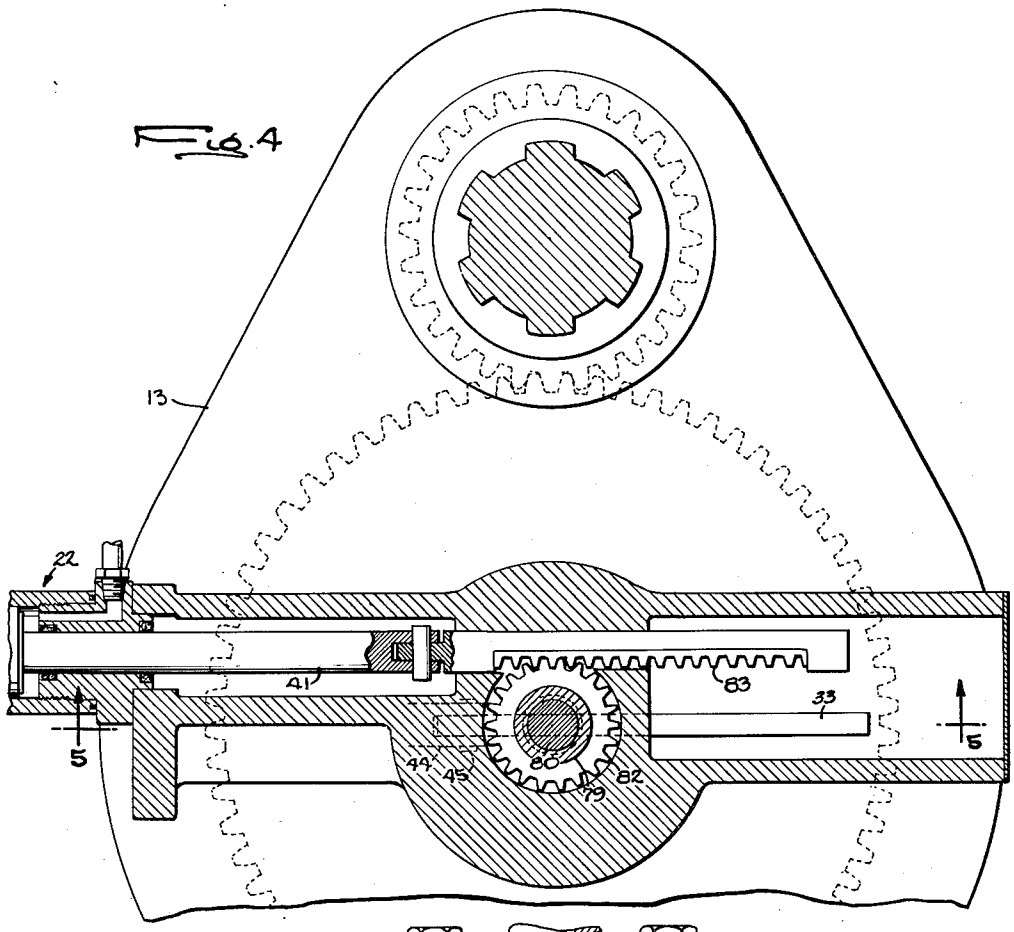
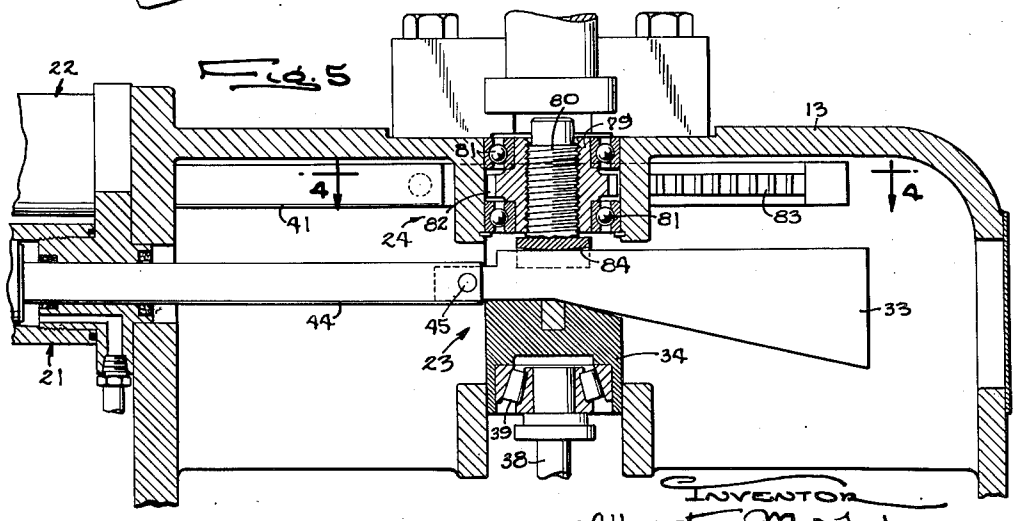


Fig. 5



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2,791,871

HONING MACHINE

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Application May 3, 1954, Serial No. 427,239

9 Claims. (Cl. 51—184.3)

This invention relates generally to honing machines and, more particularly, to a hone expanding mechanism of the type shown in U. S. Letters Patent to Johnson 2,294,184 in which a rod is shifted relative to the hone body by a power actuator first to expand the honing stones rapidly against the wall of a bore of a workpiece and then to continue the expansion to feed the stones at a slow rate.

The primary object of the invention is to improve the hone expanding mechanism to the Johnson patent and provide more precise control of the feeding movement of the honing stones while still enabling the stones to be expanded rapidly against the bore wall without damage to the stones.

Another object is to provide a novel mechanism by which the motions of two power actuators are transmitted to the shiftable rod to expand the stones against a bore wall at different rates and under different pressures when the respective actuators are energized.

A more detailed object is to transmit the motions of the power actuators to the rod through two novel connections which are extensible in the direction of rod movement and one of which is shiftable bodily in such direction to avoid interference with operation of the other connection.

The invention also resides in the novel manner of locking the driven element of the rapid expansion actuator in its advanced position after the honing stones engage the bore wall.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a schematic view and hydraulic circuit diagram of a hone expanding mechanism embodying the novel features of the present invention.

Fig. 2 is a fragmentary sectional view showing the expanding mechanism and the head supporting this mechanism and the hone.

Fig. 3 is a fragmentary sectional view taken along the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary sectional view of the head and a modified form of expanding mechanism taken along the line 4—4 of Fig. 5.

Fig. 5 is a fragmentary sectional view taken along the line 5—5 of Fig. 4.

The hone expanding mechanism shown in the drawings to illustrate the present invention is especially adapted for use in a production type honing machine having a honing tool 10 which is carried on the end of a jointed shank 11 coupled to a spindle 12 journaled in a hollow head 13. The tool comprises a series of stones 14 angularly spaced around a body 15 and normally held by springs 16 against conical cams 17. The latter are fast on a rod 18 extending axially through and reciprocable in the tool shank and the spindle and yieldably urged in the hone contracting direction or to the left as viewed in Figs. 1 and 2 by a spring 19 acting between the

rod and the head. When the rod is moved axially relative to the head and the tool and toward the latter or to the right as viewed in Figs. 1 and 2, the stones 14 are expanded against the wall 20 of a bore of a workpiece W, the outward pressure on the stones being continued while the spindle is rotated relative to the head and reciprocated axially with the latter to enlarge the bore to the desired size. Rotation of the spindle 12 relative to the head, the mounting of the head for reciprocation, and reciprocation of the head to effect the honing operation may be effected in a suitable manner well known in the art, for example, as shown and described in detail in the Johnson patent referred to above.

The present invention contemplates a new and improved hone expanding mechanism which enables one power actuator 21 to be utilized to advance the rod 18 and expand the stones 14 into engagement with the bore wall 20 at a rapid rate and under a pressure insufficient to break the stones and a second power actuator 22 to continue the movement of the rod and feed the stones outwardly against the bore wall at a slow precisely controlled rate and under a higher pressure without being affected by the presence of the rapid expansion actuator. Generally, the mechanism comprises two connections 23 and 24 acting jointly between the head 13 and the rod 18 and individually extensible in the direction of rod movement, the driven members of the actuators being coupled to the respective connections for extension of each of the latter when its associated actuator is energized. One connection 23 acting between the rod and the other connection 24 is shiftable bodily in the direction of rod movement to avoid interference with the operation of the other connection when the latter is extended.

One of the connections 23 and 24, in this instance the slow expansion or feed connection 24, is a cam 25 in the form of a wedge extending and shiftable transversely of the direction of rod movement and acting on opposite sides against a fixed abutment 26 and one side of a movable abutment 27 on the head 13 to separate the abutments when the wedge is advanced or shifted downwardly as viewed in Fig. 1. Herein, the fixed abutment 26 is a roller disposed between and rotatably mounted on two plates 28 (Fig. 3) projecting from the head and straddling the wedge to guide the latter in its reciprocating movement. The movable abutment 27 which constitutes the driven element of the slow connection, comprises a roller 29 and a U-shaped member 31 mounted on the forked outer end of an arm 30 which is swingable about a fixed pivot 32 on the head 13 for bodily shifting of the abutment toward and away from the fixed abutment in the direction of rod movement. The roller 29 which engages the wedge 25 is disposed within the forked end of the arm and is journaled on a pin 30^a extending through and beyond the latter to provide pivotal supports for the straddling legs of the U-shaped member 31.

A similar wedge-shaped cam 33 is utilized in the rapid expansion connection 23 and acts on one side against the U-shaped member 31 of the movable abutment 27 and on the other side against the expanding rod 18 through the medium of a cup-shaped member 34 slidable longitudinally of the rod in a bore 35 in the head 13. The wedge is guided for movement transversely of the direction of rod movement by the walls of a slot 36 formed in the movable abutment member 31 and another slot 37 in the opposed end of the cup 34, the latter thus being held against rotation in the bore 35. A rod 38 journaled in bearings 39 carried by the cup 34 projects axially therefrom and into abutment with the expanding rod 18 and, together with the cup, constitutes the driven member of the rapid expansion connection 23. The bearings 39 reduce friction between the cup 34 which is non-rotatable and the rod 38 which, along with the expanding rod 18,

tends to rotate with the spindle 12. The spring 19, acting against the expanding rod 18 to shift the same toward the fixed abutment 26, holds the parts of the two extensible connections in abutting relation.

The power actuators 21 and 22 in this instance are of the hydraulic type, the slow actuator 22 comprising a cylinder 40 secured to the head 13 and having a piston whose rod 41 extends normal to the direction of movement of the expanding rod 18 and is connected by a pivot 42 to the small end of the slow wedge 25. The rapid expansion actuator 21 comprises a similar cylinder 43 secured to the head and having a piston whose rod 44 extends parallel to the rod of the slow actuator and is coupled to the rapid expansion wedge 33. To permit bodily shifting of the latter away from the fixed abutment 26 and relative to the piston rod 44 while maintaining the coupling between the two, this coupling comprises a swivel joint 45 in the form of a pin pivotally connecting the piston rod and the adjacent small end of the wedge. Pressure fluid is supplied to the actuators in this instance from a common source 46 comprising a pump which is driven by an electric motor 47 and whose inlet communicates with a sump 48.

Expansion of the honing stones 14 at different rates and under different pressures when the respective actuators 21 and 22 are energized is achieved by the making of the wedges 25 and 33 of different shapes and by the application of forces of different magnitudes to the wedges for advancing the latter. Where, as in the present instance, both cylinders are supplied pressure fluid from a common source 46, such force differential is obtained by making of the slow cylinder 40 larger in diameter than the rapid expansion cylinder 43. Although both wedges are of generally V-shape, the acute included angle between the active sides of the rapid expansion wedge 33 is substantially larger than that of the slow wedge 25 and, herein, is approximately 18 degrees as compared to 2 degrees for the slow wedge. Thus, shifting of the rapid expansion wedge a given distance transversely of the direction of rod movement results in extension of the shiftable connection 23 a greater amount to expand the honing stones than the slow connection 24 is extended by shifting of the slow wedge 25 the same distance. Since the range of extension of the slow connection 24 is considerably less than that of the rapid expansion connection 23, it is preferred to make the latter the bodily shiftable connection as described above, thereby reducing the distance through which this connection is moved.

The admission of pressure fluid to opposite ends of the two cylinders 40 and 43 from the source 46 is controlled by a main valve 49 whose movable element 50 is shifted back and forth by pressure fluid under the control of a pilot valve 51. The latter is a four-way valve whose movable element 52 is spring urged into one position for shifting the movable element of the main valve to connect the head ends of the cylinders to the source and the rod ends thereof to the sump 48 to retract the wedges 25 and 33. When a solenoid 53 is energized, the movable element of the pilot valve is shifted to its other position (Fig. 1) for shifting the main valve element 50 to admit pressure fluid to the rod ends of the cylinders and advance the wedges. The rate of advance of the rapid wedge 33 is determined by a restriction 54 in a line 55 connecting the head end of the rapid cylinder 43 to the sump 48 through the main valve 49. Advance of the slow wedge 25 is effected at a slow, precisely controlled rate by metering of the escape of fluid from the head end of the slow cylinder 40 through the medium of a pump 56. A check valve 57 in a line between the main valve 49 and the head end of the slow cylinder permits the flow of pressure fluid to the cylinder end along this line but blocks the escape of fluid in the opposite direction.

In the present instance, the metering pump 56 comprises a piston 58 slidable back and forth in a bore 59 in the head 13 between one position in which an annular metering groove 60 on the piston communicates with a line 61 connecting the bore to the sump 48 and another position in which the groove communicates as shown in Fig. 1 with a line 62 connecting the bore and the head end of the slow cylinder 40. The piston 58 is reciprocated at a constant rate by the motor 47 which is connected through variable speed gearing 63, a worm 64 and worm wheel 65, and a crank 66 to one end of a lever 67 fulcrumed on the head and pivotally and slidably connected at its other end to the piston. The frequency of reciprocation of the piston and thereby the rate of intermittent advance of the slow wedge 40 may be changed by adjustment of the variable speed gearing to vary the angular speed of the worm 64 and the crank 66.

To insure that the slow expansion movement of the honing stones 14 is under the exclusive control of the slow power actuator 40, novel means is provided to lock the rapid expansion wedge 33 in its advanced position at the completion of the rapid expansion movement of the stones 14 and throughout the slow expansion movement. This means comprises a valve 68 adapted when closed to block the escape of fluid from the head end of the rapid cylinder 43 and means for closing this valve in response to a pressure build-up in the rapid cylinder after the stones engage the bore wall 20. The valve 68 is located in the line 55 between the main valve 49 and the head end of the cylinder and includes a member 69 spring urged toward a closed position against a seat 70 but movable away from the latter against the spring action when the line 55 is connected to the source 46.

To maintain the blocking valve 68 open during the rapid expansion movement, the valve member 69 is carried by the rod of a piston 71 slidable in a bore 72 in the valve body 73 and shiftable to a valve-open position when pressure fluid is admitted to the bore. Such admission of fluid is controlled by a two-way valve 74 whose movable element 75 is spring urged toward a position in which the blocking valve bore is connected to the sump 48 to relieve the pressure on the piston 71 and permit the blocking valve to close. When a solenoid 76 is actuated upon energization of the winding thereof, the valve element 75 is shifted to connect the bore to the source 46 (Fig. 1).

The build-up of pressure in the rod end of the rapid cylinder 43 is sensed by a pressure responsive switch 77 connected to the lines 78 between the main valve 49 and the rod ends of the two cylinders. This switch controls the solenoid 76 for the two-way valve 74 and is operable to deenergize the solenoid winding for connection of the blocking valve bore 72 to the sump 48 when the switch is actuated by a pressure build-up resulting from engagement of the stones 14 with the bore wall 20.

The cam of either of the extensible connections 23 and 24 also may take the form of a screw or rotary wedge. Such a construction is shown in Figs. 4 and 5 in which the slow or feed connection 24 comprises a nut 79 corresponding to the slow wedge 25 of the preferred form of the invention of Figs. 1 to 3 and threadably receiving a screw 80 corresponding to the movable abutment 27. The nut is journaled in fixed bearings 81 which correspond to the fixed abutment 26 on the head 13 and is formed on its exterior with gear teeth 82 which mesh with a rack bar 83 guided for reciprocation on the head and pivotally connected to the piston rod 41 of the slow actuator 22. The purpose of this connection is to avoid binding of the rack bar 83 on the head due to inaccuracies in the mounting of the actuator 22. A slot 84 in one end of the abutment screw 80 receives the rapid expansion wedge 33 which is connected by the swivel joint 45 to the piston rod 44 of the rapid actuator as described above and acts between the screw and the cup 34, the walls of the slot 84 engaging the sides of the rapid wedge to prevent rotation of the screw with the nut.

As the piston rod 41 of the slow actuator 22 and the rack bar 83 thereon advance, the nut 79 is rotated in a counterclockwise direction as viewed in Fig. 4 to extend

the slow connection 24 by shifting the screw 80 away from the fixed abutment bearings 81. Rotation of the nut in the opposite direction retracts the screw. The pitch of the threads of the screw and nut is selected in accordance with the controlled rate of advance of the rack bar 83 to provide the desired slow rate of expansion of the stones 14.

In the operation of the improved hone expanding mechanism shown in Figs. 1, 2, and 3, let it be assumed that the motor 47 is energized to provide pressure fluid at the source 45 and reciprocate the piston 58 of the metering pump and that the solenoids 53 and 76 are deenergized with the wedges 25 and 33 in their retracted positions as shown in Fig. 2. The energizing circuits for the solenoids 53 and 76 are completed in a manner well known in the art in response to entry of the honing tool 10 into a work bore 20 as a part of the cycle of the machine of which the expanding mechanism is a part.

As soon as the two solenoids 53 and 76 are energized, pressure fluid is admitted through the two-way valve 74 to the bore of the blocking valve 68 to open the latter and through the main valve 49 to the rod ends of the cylinders 40 and 43 to advance the wedges 25 and 33. The feed wedge 25 moves intermittently at the slow rate determined by the fluid flow through the metering pump 56 and the rapid wedge 33 advances at the faster rate determined by the restriction 54.

Such advance of the rapid wedge extends the shiftable connection 23 by moving the cup 34 away from the movable abutment 27 and thereby advances the expanding rod 18 to expand the honing stones. The slopes of the wedges and the rates of advance of the pistons in the respective cylinders are such that, when both actuators are acting on the rod, the diameter of the bore will increase at a fairly rapid rate. On the other hand, when the slow actuator 22 is acting alone, the bore diameter increases at a much slower rate. This slow rate of expansion is selected to correspond approximately to the rate of wearing off of one type of hone stone and the work material on which the hone is to operate and may be varied by adjustment of the variable speed gearing 63 to suit given operating conditions.

Advance of the rapid wedge 33 and the rapid expansion of the stones 14 continues until the latter actually contact the bore wall 20. At this time, the pressure builds up in the rod end of the rapid cylinder 43 and the switch 77 is actuated thereby to deenergize the solenoid 76 for the two-way valve 74 and connect the bore 72 of the blocking valve 68 to the sump 48. As a result, the blocking valve closes to prevent the escape of fluid from the head end of the rapid cylinder, so that, with pressure fluid still in the rod end of the latter, the piston thereof and therefore the rapid wedge 33 are locked effectually in advanced position. The pressure applied to the stones 14 by the rapid actuator acting through the rapid wedge is insufficient to damage the stones upon engagement with the bore wall 20. The extent of shifting of the rapid wedge 33 is determined by the amount of wear on the stones 14, the wedge automatically compensating for wear on the stones. Thus, when the latter are new, the wedge advances only a short distance beyond its retracted position shown in Fig. 2 and, as the stones wear, this distance increases until the wedge is near the end of its range as shown in Fig. 1.

As soon as the blocking valve 68 closes, the rapid wedge 33 is locked in its advanced position by pressure fluid introduced into the rod end of the cylinder 43 and expansion of the stones 14 continues at the feed rate under the exclusive control of the slow wedge 25 and without interference from the rapid wedge 33. By virtue of the swivel connection 45 between the rapid wedge and its actuating piston rod 44, this wedge may shift away from the fixed abutment 26 and relative to its piston rod without disturbing its setting determined by the blocking valve. The pressure applied to the stones by the slow actuator 22 acting through the slow wedge is considerably higher than that of the rapid actuator 21, being on the order of 50 pounds per square inch of stone area in this instance. By the maintenance of pressure fluid in the rod end of the slow cylinder 40 during metering of the escape fluid from the head end, the advance of the slow wedge 25 may be precisely and accurately controlled.

During the slow expansion of the hone 10 at the preselected rate, the hone is reciprocated back and forth in the work bore as described above. Such reciprocation and slow expansion of the hone continues until a signal is given to indicate the termination of the honing cycle as by a suitable gaging device for measuring the size of the workpiece bore or after a predetermined number of reciprocations of the hone in a manner well known in the art. In response to such a signal, the pilot valve solenoid 53 is deenergized and the main valve 49 is reversed to admit pressure fluid to the head ends of the cylinders through the check valve 57 and the blocking valve 68 and thereby retract both wedges 25 and 33 rapidly. The expanding rod 18 then retracts under the action of its spring 19 and the stones contract out of engagement with the bore wall 20 under the action of the springs 16 so that the hone 10 is ready to be withdrawn from the workpiece W.

The operation of the modified expanding mechanism of Figs. 4 and 5 is similar to the preferred form described above, the slow actuator 22 rotating the nut 79 in a counterclockwise direction as viewed in Fig. 4 to advance the screw 80 and the stones 14 at the slow feed rate after the wedge 33 is locked in its advanced position following rapid expansion of the stones. During such advance of the screw, the wedge shifts bodily relative to its actuating piston rod 44 as permitted by the swivel connection 45.

I claim as my invention:

1. In a honing machine, the combination of, a head, a fixed abutment on said head, a hone carried by said head and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod movable relative to the hone body and away from and toward said abutment to expand and contract the honing stones and yieldably urged in the hone contracting direction, a movable abutment disposed between and spaced from said fixed abutment and said rod and shiftable bodily in the direction of rod movement, a wedge acting on opposite sides against said abutments and shiftable transversely of said direction to separate the abutments, a second wedge acting between said movable abutment and said rod and shiftable transversely of said direction to separate the rod and movable abutment and bodily in the direction of rod movement to permit separation of the abutments, and two power actuators having driven elements connected to the respective wedges and movable to shift the latter individually to advance said rod and expand said stones at a rapid rate into engagement with the wall of a work bore and then at a slow rate.

2. In combination with a head and a hone mounted thereon and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable forth and back relative to the hone body and the head to expand and contract the honing stones and yieldably urged in the hone contracting direction, an expanding mechanism comprising two cennections acting jointly between said head and said rod and individually extensible in the direction of forward movement of the rod, a first one of said connections including a wedge acting between the driven member of the other connection and said rod and mounted on said head to shift bodily in the direction of rod movement to permit extension of said other connection and transversely of such direction to extend said first connection,

a power actuator including a driven element connected to said wedge to shift the same in said transverse direction to extend said first connection and expand said stones at a rapid rate when the actuator is energized while permitting bodily shifting of the wedge relative to the actuator, and a second power actuator having a driven element coupled to said other connection and movable to extend the latter and shift said wedge bodily to advance said rod and expand said stones at a slow rate when the second actuator is energized.

3. In combination with a head and a hone mounted thereon and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable forth and back relative to the hone body and the head to expand and contract the honing stones and yieldably urged in the hone contracting direction, an expanding mechanism comprising two connections acting jointly between said head and said rod and individually extensible in the direction of forward movement of the rod, a first one of said connections including a wedge acting between the driven member of the other connection and said rod and mounted on said head to shift bodily in the direction of rod movement to permit extension of said other connection and transversely of such direction to extend said first connection, a power actuator including a driven element connected to said wedge to shift the same in said transverse direction to extend said first connection and advance said rod to expand said stones at one rate when the actuator is energized while permitting bodily shifting of the wedge relative to the actuator, and a second power actuator having a driven element coupled to said other connection and movable to extend the latter and shift said wedge bodily and advance said rod to expand said stones at a differenet rate when the second actuator is energized.

4. In combination with a head and a hone mounted thereon and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable forth and back relative to the head and the hone body to expand and contract the honing stones and yieldably urged in the hone contracting direction, an expanding mechanism comprising two connections acting jointly between said head and said rod and individually extensible to advance the rod in the hone expanding direction, one of said connections acting between said rod and the other connection and including a wedge movable trasversely of the direction of rod movement to extend the connection and longitudinally of such direction to permit extension of the other connection, a first power actuator having a coupling with said wedge and operable when energized to advance the wedge transversely to extend the connection and advance the rod to expand said stones, said coupling permitting bodily shifting of the wedge longitudinally of said rod movement and relative to said first actuator and said head, and a second power actuator having a driven element coupled to the other connection and operable to extend the latter when the actuator is energized.

5. In combination with a hone having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable back and forth relative to the hone body to expand and contract the honing stones and normally urged in the hone contracting direction, an expanding mechanism comprising two power actuators having driven elements movable at slow and rapid rates, couplings joining said elements to said rod and operable to move the same at rapid and slow rates when the respective actuators are energized, the rapid actuator comprising a piston and cylinder, means for delivering fluid to said cylinder to shift said rod and expand said stones against the wall of a work bore under a pressure insufficient to break the stones, a valve adapted when closed to block the escape of fluid from said cylinder and thereby lock the driven element of the rapid actuator in advanced position, and a device for sensing pressure changes in said rapid actuator and operable in response to a pressure build up after said stones engage the bore wall to close said valve.

6. In a honing machine, the combination of, a head, a hone carried by said head and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod movable relative to the latter and the honing body to expand and contract the honing stones and yieldably urged in the hone contracting direction, two connections acting jointly between said head and said rod and individually extensible through ranges of different lengths to advance the rod in the hone expanding direction, a first power actuator having a driven element coupled to the one of said connections with the larger range of expansion and movable when the actuator is energized to extend the connection and advance said rod to expand said honing stones against the walls of a work bore at a relatively rapid rate and under a pressure insufficient to damage the stones, a second power actuator having a driven element coupled to the connection with the shorter range and movable to extend the connection and expand said stones at a slower rate when the actuator is energized, a device for sensing contact of said stones with a bore wall, and mechanism controlling energization of said first actuator in response to said device and operable as an incident to contact of said stones with a bore wall to terminate expansion of the stones at said rapid rate.

7. In a honing machine, the combination of, a head, a hone mounted on said head and having a body and honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable forth and back relative to the hone body and the head to expand and contract the honing stones and normally urged in the hone contracting direction, two connections acting jointly between said head and said rod and individually extensible in the direction of forward movement of the rod, one of said connections acting between the other connection and said rod and shiftable bodily in the direction of movement of the rod to permit extension of the other connection, a power actuator having a driven element coupled to one of said connections and movable to extend the latter and expand said stones at a rapid rate when the actuator is energized, a second power actuator coupled to the other of said connections and movable to extend the latter and expand said stones at a slow rate when the actuator is energized and means for energizing said actuators in timed relation to each other first to expand said stones into contact with the wall of a work bore at said rapid rate and then, as an incident to such contact, to interrupt such expansion at said rapid rate and continue the expansion at said slow rate.

8. In combination with a head and a hone mounted thereon and having a body with honing stones expansible and contractible radially relative to the body in response to shifting of a rod back and forth relative to the body and the head, an expanding mechanism comprising first and second connections individually extensible in the direction of forward movement of said rod with one connection acting between said head and the other connection and with the latter acting between the one connection and the rod and mounted for bodily movement longitudinally of the rod to permit extension of the one connection while transmitting to the rod the longitudinal motion resulting from such extension, said first connection including a wedge movable transversely of the direction of rod movement to extend the connection, a power actuator including a driven element coupled to said wedge to shift the same in said transverse direction and advance said rod to expand said stones at one rate when the actuator is energized, and a second power actuator having a driven element coupled to said second connection and movable to extend the latter to expand said stones at a different rate when the actuator is energized.

9. In combination with a hone having a body and

honing stones expansible and contractible radially relative to the body, said hone having a rod shiftable back and forth relative to the hone body to expand and contract the honing stones and normally urged in the hone contracting direction, an expanding mechanism including a fluid pressure actuator having a driven element coupled to said rod to move the same to expand said stones at a rapid rate when the actuator is energized by the admission of pressure fluid thereto, means for delivering fluid under pressure to said actuator to shift said rod and expand said stones against the wall of a work bore under a pressure insufficient to damage the stones, a fluid line connected to said actuator and providing a passage for the escape of fluid from the actuator, a valve controlling the flow of fluid in said line and operable when closed to

block such flow, and a device for sensing pressure changes in said actuator and operable to close said valve to terminate expansion of said stones at said rapid rate in response to a pressure build-up after said stones engage the bore wall.

References Cited in the file of this patent

UNITED STATES PATENTS

2,294,184	Johnson	Aug. 25, 1942
2,343,275	Caldwell	Mar. 7, 1944
2,345,581	Caldwell	Apr. 4, 1944
2,386,901	Kline	Oct. 16, 1945
2,518,600	Cox	Aug. 15, 1950
2,616,225	Smole	Nov. 5, 1952
2,688,211	Strnad	Sept. 7, 1954