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GRINDING OR HONING DEVICE

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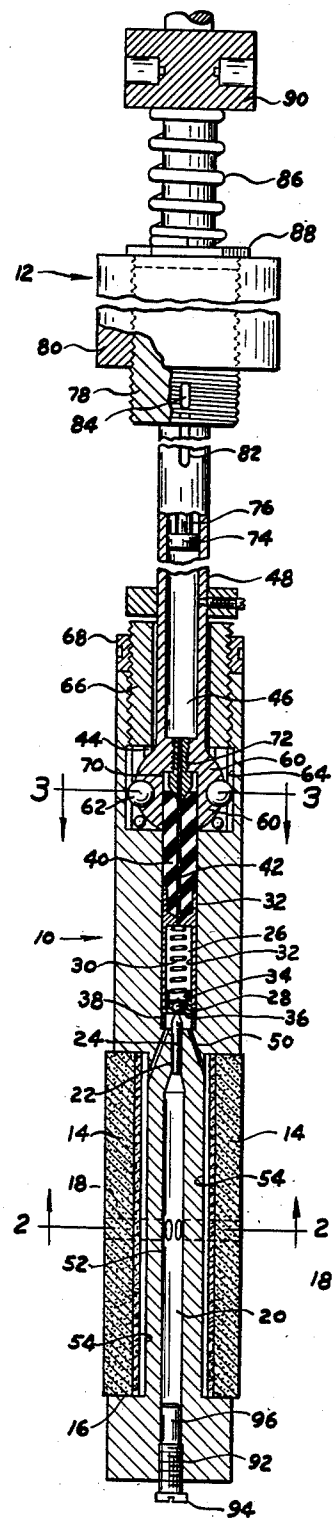


Fig. 1

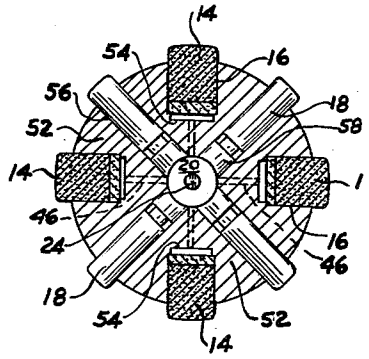


Fig. 2

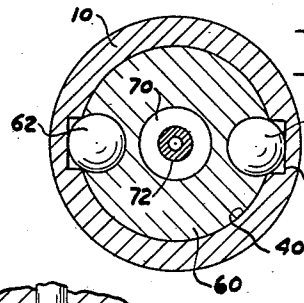


Fig. 3

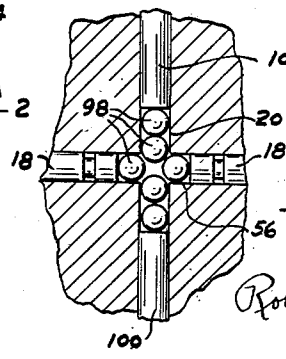


Fig. 4

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GRINDING OR HONING DEVICE

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13 Claims. (Cl. 51—184.1)

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This invention relates to abrading or honing tools and more particularly to improvements in the adjustment of the honing elements and in the method of effecting such adjustments.

It has been the common practice heretofore to provide a circularly spaced set of abrading elements on a rotating and axially movable head for finish grinding bores and to provide hydraulic pressure for effecting radial expansion of the honing elements into engagement with the bore. Considerable difficulty has been encountered in controlling the exent of radial movement of the honing elements to stop their grinding operation at the desired diameter of the bore. Some attempts have been made to provide automatic means for controlling the movement of the honing elements. For such purpose a controlling fluid supplied under constant pressure has been suggested which vented or discharged onto the wall of the bore and utilized the drop in pressure resulting as the bore enlarged to control the extent of radial movement of the honing elements. Such control mechanism required a large and complicated number of parts including electrical circuits and switches and was not satisfactorily accurate under all conditions.

An important object of the present invention is to provide an improved method of and means for controlling the extent of radial movement of the abrading or honing elements and to accomplish this operation in an accurate and automatic manner with a minimum number of parts. Another important object of the invention is to provide an improved tool for honing and grinding but also adaptable for reaming and the like which is a self-contained hydraulically operated unit attachable to and detachable from a machine and is self-operable to determine the limits of the grinding or cutting operation for which it is designed. A further important object of the invention is to provide an improved honing tool and the like which is constructed in a novel manner to contain a body of fluid for radially moving the abrading or cutting elements and a second body of fluid for controlling the operation of the first fluid body, the second body of fluid being sealed in a novel manner in the operating head of the tool and being provided with novel means for varying its controlling action on the first fluid.

The invention is herein illustrated as applied to grinding or honing tools but it is to be understood that the operating and controlling features of the invention are applicable to other types of tools such as cutting and reaming devices. In one illustrated embodiment of the invention a

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fluid under pressure is utilized to advance the abrading elements into engagement with the wall of a bore in a workpiece. Although such operating fluid may be supplied from an outside source associated with the machine to which the tool is attached, it is preferred that the fluid be confined within a relatively sealed chamber incorporated in the tool and that the tool be provided with variable means for building up the pressure of the fluid to the desired amount for actuating the abrading elements. Also incorporated in the head of the tool are novel sizing elements which are radially movable with the abrading elements to maintain continuous contact with the surface being ground. Associated with these sizing elements and responsive to the positions assumed thereby is a novel control means for governing the action of the fluid acting on the honing or abrading elements. Preferably this control means is a second body of fluid sealed under regulatable pressure within the tool. This second body of fluid serves to couple the sizing elements with valve means controlling the action of the first fluid body on the abrading elements. Preferably the two fluids are liquids, such as thin oil, and arranged to oppose one another in their action on the valve means.

In another illustrated embodiment of the invention solid matter in the form of small spheres are used in the same manner as the fluids previously mentioned for controlling the action of the abrading elements.

Various other objects, advantages and meritorious features of the invention will become more fully apparent from the following specification, appended claims and accompanying drawings wherein:

Fig. 1 is a view, partly in longitudinal section and partly in elevation, of a honing tool embodying features of the invention,

Fig. 2 is a cross sectional view through the tool of Fig. 1 taken along line 2—2 thereof,

Fig. 3 is a cross sectional view taken along line 3—3 of Fig. 1, and

Fig. 4 is an enlarged fragmentary sectional view taken through the head portion of a honing tool illustrating a modification of the invention.

Referring particularly to the drawing, the honing tool illustrated therein is adapted to be attached to a part in the machine which is rotatable and axially movable while rotated. While so rotated, the abrading elements of the tool will grind the wall of a bore of a workpiece into which the tool extends. The tool, in general, comprises a lower working head 10 which enters the bore

and an upper end section 12 which is attached to the machine part.

The working head carries one or more honing sticks or stones 14, there being four shown in the illustrated embodiment of the invention, which are equally circularly spaced apart around the axis of the head as is evident in Fig. 2. The body portion of the head is preferably exteriorly cylindrically shaped and of a diameter slightly less than that of the bore size for which it is intended in order to freely enter the bore. Cut or otherwise formed in the exterior surface of the head 10 are a plurality of longitudinally extending grooves 16 corresponding in number to the number of honing stones employed and shaped to receive the honing stones. Four such grooves are shown in the present embodiment of the invention, one for each honing stone. Each honing stone 14 is capable of radial movement in its respective groove as will be explained more fully hereinafter.

Also carried by the head 10 of the tool are one or more sizing elements or pins 18 which are operable to engage the wall of the bore and control the functioning of the tool. Four such sizing pins are shown in the illustrated embodiment of the invention and they are equally circularly spaced apart from one another and angularly offset to the grooves 16 so as to be disposed therebetween. The pins 18 may be cylindrical in formation as shown and disposed on a transverse plane preferably intermediate the opposite ends of the honing sticks 14 on the section line 2—2 of Fig. 1. The outer ends of the pins may have carboloy or diamond inserts for contact with the wall of the bore being ground.

The head 10 of the tool is axially bored out to provide a series of communicating passages and chambers of various dimensions. In the area of the honing sticks 14 the head 10 is provided with an elongated chamber 20 adapted to contain a controlling medium such as a body of fluid. The lower end of the chamber 16 opens out through the forward end of the head and is closed by means of an adjustable cap as will be more fully explained hereinafter. The opposite or upper end of the chamber 20 is reduced in size to form a short section 22. Located in this short passage section is a pin 24 preferably tapered at its upper end which sealingly fits within the passage but is capable of axial travel therein. The short passage 22 opens into a wider chamber 26 wherein a valve means in the form of a ball check valve 28 is disposed. A coiled spring 30 also in the chamber 26 urges the ball valve to a seating position.

In the illustrated embodiment of the invention, the ball valve 28 and its spring 30 are supported in an assembly of elements in the chamber 26 including a relatively long sleeve 32 fitting the chamber and occupying the major portion of the lower half thereof. Telescopingly received within the lower end of the tube is a retainer 34 for the ball valve including a transverse wall 36 having a central chamfered aperture therethrough for seating the ball valve. The transverse wall extends beyond the part of the retainer entering the sleeve 32 to form a peripheral shoulder upon which the lower end of the sleeve rests. The transverse wall 36 may be spaced from the lower end of the chamber 26 by a ring-shaped member 38 as shown in Fig. 1. The relationship of the parts in the lower portion of the chamber 26 is such that the tapered end of the pin 24 is disposed closely adjacent to the ball valve and is capable of unseating the same and opening the aperture through the transverse wall 36 in a manner hereinafter described.

Located in the upper half portion of the chamber 26 is a member 40 of resilient material having a narrow axial duct 42 therethrough opening out through the opposite ends thereof. The upper end of the sleeve 32 may be shaped with a cup-shaped recess to receive and support the lower end of the member 40 in the manner shown in Fig. 1. The axial duct in the member 40 communicates through a narrow passage in the upper end of the sleeve 32 with the interior thereof. The upper end of the resilient member 40 projects beyond the upper end of the chamber 26 and enters a relatively large cavity 44 in the upper end of the head 10. As hereinafter described the upper projecting end of the resilient member 40 cooperates with a universal joint coupling the head to the upper section 12 of the tool.

The axial duct 42 of the resilient member 40 communicates at its upper end with the bore 46 of a hollow shaft 48 constituting a part of the upper section 12 of the tool. In the embodiment of the invention illustrated herein the bore 46 of the shaft serves as a chamber for containing the major portion of a second body of fluid which as hereinafter described communicates with the bases of the grooves 16 in which the honing sticks 14 are received to force the latter radially outward from the head.

The bottom portions of the grooves 16 in which the honing sticks are mounted communicate with the lower end of chamber 26 to receive fluid under pressure. This is accomplished as shown in the illustrated embodiment of the invention by means of small inclined ducts or passages 50, one for each groove, which converge toward one another and open through the lower end wall of the chamber 26. The passages 50 diverge away from one another as they lead to their respective grooves and open into the latter under the honing stick 14 received therein. Each honing stick is supported on a sealing member 52 which extends across the bottom of the honing stick as shown in Fig. 2. Each groove is provided with a shallow channel 54 in the base thereof extending longitudinally the full length of the groove and having a width slightly less than that of the groove as shown in Fig. 2. The shallow channel of each groove provides a clearance between the bottom face of the sealing member and the bottom of the channel into which the fluid under pressure from chamber 26 is delivered.

As previously mentioned, the elongated chamber 20 in the lower end section of the head 10 contains a medium such as a body of fluid which when the tool is in operation is under pressure. This fluid acts on the inner ends of the sizing elements or pins 18 and urges the same radially outwardly of the head 10. Each sizing pin is slidably fitted into a radial bore 56 of the head and the outer end section of the pin normally projects beyond the peripheral surface of the head 10 as shown in Fig. 2. Each pin 18 is connected by a reduced neck portion to a plunger 58 which works in the inner end of its bore 56 in which the pin is received. Suitable sealing means may be provided around the neck portion of each pin to prevent leakage of fluid. The inner end of each plunger may be arcuately shaped to conform to the curvature of the wall of the chamber 20, as shown in Fig. 2. The inner curved ends of the plungers are exposed to the

body of fluid contained within the chamber 20 and it is evident that when pressure is built up in the fluid body that it will cause the plungers and the sizing pins connected thereto to move outwardly radially in their respective bores.

As previously mentioned, the lower end of the upper part 12 of the tool is received in the cavity 44. The hollow shaft 48 is provided on its lower extremity with a spherical ball-shaped end section 60 which constitutes a part of a universal joint. Carried by the spherical end section are one or more locking balls 62 which drivingly couple the shaft to the head 10 of the tool. For this purpose the inner wall of the cavity 44 is provided with grooves 64 in which the balls 62 are partly received, as illustrated in Fig. 3. In this manner the shaft 48 is drivingly coupled to the head 10 for joint rotation, yet permitting the head 10 to have limited universal movement relative to the shaft to accommodate itself to any misalignment of the tool in the bore to be ground. The upper end of the cavity 44 is closed by an externally threaded sleeve 66 which is threaded in the upper section of the cavity. As shown, the sleeve 66 has an internal diameter slightly greater than the external diameter of the shaft 48 to provide a clearance therebetween for permitting a limited angular movement of the latter. The sleeve 66 is locked in place by a ring 68 threaded thereto and abutting the upper end of the part 10.

To provide communcation between the chamber 46 and the axial duct 42 of the resilient member 40 as well as to receive the upper end of the latter, the spherical part 60 of the universal joint is provided with an axial passage 70 therethrough. This passage is wider at its lower end and receives the upper end of the resilient member 40. In the upper narrower portion of the passage there is threadedly received a nipple 72. The nipple extends downwardly into the wider portion of the passage 70 and is provided with a conical shaped head which seats on the upper end of the resilient member 40 in the manner shown in Fig. 1. The passage through the nipple provides communication between the chamber 46 and the axial duct of the resilient member 40. The flexible character of the resilient member enables it to follow any angular displacement of the upper and lower sections of the tool while maintaining fluid tight communication between the chambers 26 and 46.

Although the chamber 46 formed by the hollow interior of the shaft 48 may communicate with an outside source of fluid under pressure, it is preferred to confine the fluid body wholly in the tool and provide means incorporated in the tool for building up pressure on the fluid body. For this purpose a plunger 74 is reciprocatingly disposed in the hollow interior of the shaft and cooperates with the wall thereof to close the chamber 46 at its upper end. The plunger is joined to a rod 76 of reduced dimension which extends upwardly and is connected to mechanism for shifting the plunger axially in the hollow shaft.

It is preferred to use incompressible fluids for either one or both of the fluids contained in the chamber 20 and in the chamber 46 and the passages leading therefrom. Suitable fluids for this purpose are either light or heavy oils for lubricating or hydraulic uses. It is thus understood that in one desirable operating arrangement the chamber 20 contains a body of oil or like liquid and the chamber 46 and its connecting passages contains a second body of oil or like liquid. The two liquid bodies are kept separate from one another and one controls the action of the other, as hereinafter described.

The mechanism for moving the plunger 74 in the hollow shaft may be of any suitable means, but is herein shown as comprising an externally threaded sleeve 78 to which is threadedly connected a surrounding collar 80. The hollow shaft 48 is provided above the plunger with diametrically opposed longitudinal slots, one of which is shown at 82 through which a cross pin 84 extends. The cross pin 84 is free to move up and down the slots and its intermediate portion is fixed to the plunger rod 76 and its opposite ends are received in and secured in the sleeve 78 for joint travel therewith along the shaft.

Yieldingly urging the collar 80 and the sleeve 78 downwardly is a coiled spring 86 encircling the upper end of the shaft 48. The lower end of the coiled spring 86 seats on an annularly shaped member or washer 88 and the opposite end thereof seats on a member 90 shaped in any suitable manner for driving connection to the machine upon which the tool is mounted. The washer 88 has a circular dimension such that it bears upon the upper end of the collar 80, as shown in Fig. 1, and by virtue of the tension of the spring 86 it exerts a yielding force tending to drive the collar 80 downwardly on the shaft 48. Since the collar is coupled to the sleeve 78 and the latter is connected to the plunger rod 76 by means of the cross pin 84, the force exerted by the spring 86 is conveyed to the plunger 74 causing the latter to exert pressure on the confined fluid in the chamber 46. The pressure exerted by the plunger 74 is capable of adjustment by threadedly rotating the collar 80 relative to the sleeve 78. The engaging threads of these two members will shift the plunger 74 either downwardly or upwardly depending on the direction of the relative rotation of the collar. Thus, the pressure exerted by the plunger 74 on the confined fluid in the chamber 46 may be conveniently adjusted by rotation of the collar 80 relative to the sleeve 78.

The ball valve 28 in its closed position, as shown in Fig. 1, functions to cut off delivery of the fluid for moving the honing sticks 14 radially outwardly. The aperture in the transverse wall 38 upon which the ball seats is complementary to the curvature of the ball so that in the fully seated position of the ball it completely cuts off the flow of fluid from the chamber 26 to the ducts 50. The pointed end of the pin 24 in the short narrow passage section 22 normally bears against the ball valve 28 in its closed position, as shown in Fig. 1. Upon upward movement of the pin 24 from the position shown in Fig. 1, it will lift the ball valve 28 and unseat it. This will open the aperture in the transverse wall 38 and permit fluid in the chamber 26 to flow therefrom through the ducts 50 to the bases of the grooves 16. It is thus apparent that when the ball valve is unseated and pressure is built up in the fluid in the chamber 46, such as exerted by the plunger 74, it will force the fluid through the duct 42 of the flexible member 40 and thence by chamber 26 and the ducts 50 to the bases of the grooves where the pressure will force the honing sticks 14 outwardly relative to the head 10.

The delivery of pressure to the honing sticks will only occur when the ball valve 28 is unseated by the pin 24. The movement of the latter is governed by the pressure of the controlling me-

dium or fluid in the chamber 20. If the pressure in the chamber 20 is sufficient to overcome that of the fluid in the chamber 46 and the valve spring 30 it will move the pin 24 upwardly and unseat the ball valve, thereby allowing fluid to flow through the ducts 50 to the honing sticks. The two fluid bodies are kept separate from one another by the pin 24, the latter being incapable of traveling sufficiently to permit the fluid confined in the chamber 20 from entering the chamber 26. When the pressure of the fluid in the chamber 46 is greater than the pressure of the fluid in the chamber 20 it will force the ball valve downwardly and cause it to fully seat thereby cutting off the delivery of fluid to the bases of the grooves in which the honing sticks 14 are located.

The pressure of the fluid in the chamber 20 is controlled by means of an adjustable cap located in the lower or forward end of the part 10 of the tool. As shown in Fig. 1, the adjustable cap comprises an externally threaded member 92 having a slightly enlarged head 94 at its base or outer end and a plunger 96 projecting from its opposite or upper end. The enlarged head 94 is provided with a slot or any other suitable means to which a tool may be applied for rotating the member 92 to vary the extent the plunger 96 projects into the chamber 20. In one direction of its rotation, the member 92 will move the plunger 96 upwardly in the chamber 20 increasing the pressure of the fluid contained therewithin and causing the pin 24 to move upwardly and unseat the ball valve 28. It is obvious that rotation of the member 96 in the opposite direction will retract the plunger 96 and reduce the pressure of the fluid confined within the chamber 20.

In the operation of the device, the fluid in the chamber 20 which acts on the plungers 58 of the sizing pins 18 is initially adjusted to the desired amount to shift the plungers to the desired diameter of the bore to be ground. This may be accomplished, for example, by inserting the head 10 of the tool into a bore of a gauge having the precise diameter to which it is desired to grind the bore of a workpiece. While in the gauge the cap 92 is adjusted to build up pressure on the confined fluid in the chamber 20 sufficient to project the sizing pins outwardly into engagement with the wall of the gauge bore without, at the same time, unseating the ball valve 28 and allowing the second fluid body to radially expand the honing sticks. Thereafter, the head 10 of the tool is inserted into the bore of a workpiece to be ground. Since this bore is of less diameter than that for which the sizing pins have been set, the latter will be compressed or forced radially inwardly by engagement with the bore. Since the confined liquid in the chamber 20 is incompressible, the only element which is movable to allow the sizing pins to collapse is the pin 24. This will move upwardly and unseat the valve and expose the entrance ends of the ducts 50 to the fluid confined in the chambers 26 and 46.

After the tool is inserted into the bore to be ground, the collar 80 is threadedly adjusted to cause the plunger 74 to exert pressure on the fluid confined in the chamber 46. Since the valve 28 is unseated, the fluid confined in the chamber 46 is permitted to move downwardly through the passages leading to the bases of the honing sticks and will force the honing sticks radially outwardly and into engagement with the bore to be ground.

As the bore of the workpiece is ground, the pressure of the fluid in the chamber 20 causes the sizing pins 18 to move outwardly with the honing sticks and maintain continuous contact with the wall of the bore. As the sizing pins move outwardly in their respective passages during the grinding or honing operation, they permit the fluid confined in the chamber to follow their movement, thereby reducing the pressure acting on the pin 24. When the sizing pins reach the diameter for which they were initially set, the pin 24 will have traveled downwardly sufficiently to bring the ball valve 28 into seated position where it will cut off further delivery of fluid through the ducts 50 to the bases of the honing sticks 14. This will automatically prevent further outward radial movement of the honing sticks and stop their grinding operation even though the tool continues to rotate. If the bore to be ground is deep and the tool is axially moved into an unground section, the sizing pins will be slightly collapsed causing the valve to unseat and the operation of grinding the bore may be continued without the necessity of any adjustment of the tool.

A modification of the invention is shown in Fig. 4 wherein, in lieu of a fluid medium in the chamber 20 for controlling the movement of the sizing pins 18, there are provided a plurality of solid elements in the form of spherical members or balls 98. These balls are compactly arranged in the chamber 20 and such that at least one ball is positioned in each sizing pin bore 56 and acts on the inner end of the sizing pin. In the center of the chamber 20 opposite the entrances to the sizing pin bores a clearance is provided between the balls as is evident in Fig. 4. As the series of balls in the chamber 20 are compressed by forces acting on either or both ends thereof this clearance is reduced and the balls in the sizing pin bores are forced radially outwardly and project their respective sizing pins beyond the external diameter of the head 10. Adjustment means similar to that described in connection with Fig. 1 may be employed to exert a compressive force on the balls from the lower end of the head 10. This adjustable feature includes a plunger 100 corresponding to plunger 96 previously described but may be longer than the latter to project further into the chamber 20. At the opposite end of the series of balls in the chamber 20 and bearing thereagainst is the base end of a pin 102 corresponding to the valve unseating pin 22 previously described. The action and operation of the balls 98 is similar to that of the fluid body for which they are substituted and radially shift the sizing pins 18 outwardly or inwardly depending upon the compressive forces acting on the balls.

What I claim is:

1. In a device for honing out bores, a rotatable body, a plurality of radially movable honing stones carried by the body in circularly spaced relation therearound and movable into engagement with the bore to be ground, a plurality of radially movable sizing elements carried by the body in circularly spaced relation therearound and movable into engagement with the bore to be ground, separate fluid pressure means for moving said honing stones and said sizing elements into engagement with the bore to be ground, and means responsive to the pressure of the fluid means for moving the sizing elements and operable to limit the action of the fluid pressure means for moving the honing stones.

2. In a grinding or honing device, a rotatable body, a plurality of abrading members carried

by the body in circularly spaced relation around the axis of rotation thereof and capable of being moved radially outwardly of the body for engagement with the wall of a bore in which the body is inserted, force exerting means for acting on said abrading members to shift the same outwardly into engagement with the wall of a bore in which the body is inserted, a measuring element carried by the body and capable of being moved outwardly from the body for engagement with the wall of a bore in which the body is inserted, force exerting means for acting on the element to shift the same outwardly of the body to maintain continuous contact with the wall of the bore as it is being ground, means for regulating the extent of the outward movement of said element and for limiting its outward movement to a desired position, and means responsive when said element reaches said limiting position for discontinuing the application of the force exerting means acting on the abrading members.

3. In a grinding or honing tool, a rotatable body, a plurality of abrading members carried by the body in circularly spaced relation around the axis of rotation thereof and capable of being moved radially outwardly of the body for engagement with the wall of a bore in which the body is inserted, means for delivering fluid under pressure to the abrading members to shift the same outwardly into engagement with the wall of a bore in which the body is inserted, a plurality of sizing elements carried by the body in circularly spaced relation around the axis of rotation thereof and capable of being moved substantially radially outwardly of the body for engagement with the wall of a bore in which the body is inserted, means for exerting pressure on the sizing elements to shift the same outwardly of the body to maintain continuous contact with the wall of a bore being ground by the abrading members, control means for limiting the extent of the outward movement of the sizing pins, and valving means for controlling the operation of said fluid pressure delivery means and operatively connected to the sizing elements so as to substantially cut off the fluid pressure delivery means when the sizing elements reach the controlled extent of their outward movement.

4. In a grinding or honing tool, a rotatable body, a plurality of abrading members carried by the body in circularly spaced relation around the axis of rotation thereof and capable of being moved radially outwardly of the body for engagement with the wall of a bore in which the body is inserted, means for delivering fluid under pressure to the abrading members to shift the same outwardly into engagement with the wall of a bore in which the body is inserted, a plurality of sizing elements carried by the body in circularly spaced relation around the axis of rotation thereof and capable of being moved substantially radially outwardly of the body for engagement with the wall of a bore in which the body is inserted, means for exerting pressure on the sizing elements to shift the same outwardly of the body to maintain continuous contact with the wall of the bore being ground by the abrading members, said pressure exerting means progressively decreasing in pressure as the sizing elements move outwardly, and control means for cutting off the flow of fluid in said fluid pressure delivery means and responsive to said pressure exerting means, said control means being operable to cut off the flow of fluid in said fluid pressure delivery means when the pressure of said pressure exerting means falls below a certain level.

5. In a grinding device, a rotatable body adapted to carry an expandible and contractible abrading member, fluid pressure responsive means for expanding the abrading member, a source of pressure fluid communicating with said fluid pressure responsive means, valve means movable to open or close the communication between said source and said fluid pressure responsive means, an outwardly movable measuring element carried by the body for contacting the surface engaged by the abrading member, means for maintaining said element in continuous contact with the surface engaged by the abrading member, means rendering the valve means responsive to the movement of the measuring element and causing the valve means to move to closed position when the measuring element has moved a certain extent of its outward movement, and means for modifying said last means to regulate the extent of outward movement of the measuring element before the valve means moves to closed position.

6. In a grinding tool having a body and an abrading member mounted therein for movement outwardly relative to the body, means responsive to fluid pressure for moving the abrading member outwardly from the body and into engagement with a surface to be ground, means for delivering fluid under pressure to said fluid pressure responsive means for moving the abrading member outwardly relative to the body, a valve for controlling the flow of fluid through said fluid delivery means, a measuring element mounted in the body and projecting outwardly therefrom for contact with the same surface engaged by the abrading member and operable to measure changes in the level of the surface engaged by the abrading member, and means operatively connecting the measuring element with the valve and effective to vary the flow of fluid through said fluid delivering means in response to changes in the level of the surface engaged by the abrading member.

7. In a metal working device, a tool for doing work upon a work piece, fluid pressure means for urging the tool toward and into engagement with a work piece and including a fluid pressure delivery conduit and a valve in the conduit, a measuring instrument for controlling the operation of the tool, means for continuously urging the measuring instrument into contact with the surface of the work piece engaged by the tool, said means including a pressure chamber the pressure of which varies in accordance with changes made in the surface of the work piece engaged by the tool, and means responsive to such variations in pressure and operatively connected to said valve to control the valve and thereby vary the fluid pressure delivered by said conduit for urging the tool into engagement with the work piece.

8. In a surface grinding device, an abrading member for grinding a surface, fluid pressure means operable to urge the member toward and into engagement with the surface to be ground and including a fluid pressure delivery conduit and a valve in the conduit, a measuring instrument for controlling the operation of the abrading member, means for continuously urging the measuring instrument into contact with the surface being ground, said means including a con-

fined substantially incompressible mobile medium, and means operatively associated with said valve and with said incompressible mobile medium and responsive to the movement of the latter resulting from the movement of the measuring instrument for moving the valve and thereby varying the amount of fluid pressure acting on the abrading member.

9. In a surface grinding device, a body, at least one abrading member carried by the body and movable outwardly therefrom for engaging and grinding an adjacent surface, fluid pressure responsive means in the body for moving the abrading members outwardly of the body, means for delivering fluid under pressure to the body and into communication with said fluid pressure responsive means, valve means in said delivery means and controlling the amount of fluid under pressure delivered thereby, said body having at least one outwardly opening recess, a sizing element in each recess and movable outwardly of the recess for engagement with the surface being ground, said body having a chamber communicating with the base of each recess, a substantially incompressible mobile medium in said chamber and entering each of said recesses for contacting the sizing elements and for following the sizing elements as they move outwardly in response to changing levels of the surface being ground, and means operatively connected to said valve and to the incompressible mobile medium and responsive to the movement of the latter resulting from the movement of the sizing elements for moving the valve and thereby varying the amount of fluid pressure acting on the abrading members.

10. In a surface grinding device, an abrading member for grinding a surface, fluid pressure means operable to urge the member toward and into engagement with the surface to be ground and including a fluid pressure delivery conduit and a valve in the conduit, a measuring instrument for controlling the operation of the abrading member, means for continuously urging the measuring instrument into contact with the surface being ground, said means including a confined substantially incompressible liquid medium, and means operatively associated with said valve and with said liquid medium and responsive to the flow of the latter resulting from the movement of the measuring instrument for moving the valve and thereby varying the amount of fluid pressure acting on the abrading member.

11. In a surface grinding device, an abrading member for grinding a surface, fluid pressure means operable to urge the member toward and into engagement with the surface to be ground and including a fluid pressure delivery conduit and a valve in the conduit, a measuring instrument for controlling the operation of the abrading member, means for continuously urging the measuring instrument into contact with the surface being ground, said means including a confined plurality of spherical elements contactually engageable with one another to serve as a force transmitting medium, and means operatively associated with said valve and with said force transmitting medium and responsive to the movement of the latter resulting from the movement of the measuring instrument for moving the valve and thereby varying the amount of fluid pressure acting on the abrading member.

12. In a surface grinding device, an abrading member for grinding a surface, fluid pressure means operable to urge the member toward and into engagement with the surface to be ground and including a fluid pressure line and a valve in said line, means for controlling the valve and thereby the operation of the abrading member, said means including a measuring instrument contactually engageable with the surface being ground and movable to follow the changes in the level of such surface as it is being ground, and a confined substantially incompressible mobile medium forming an operative connection between the measuring instrument and the valve and rendering the valve responsive to the movement of the medium resulting from the movement of the measuring instrument.

13. In a surface grinding device, means for urging an abrading member toward and into engagement with the surface to be ground including a conduit for delivering fluid under pressure for effecting such movement of the abrading member, a valve seat in the conduit past which the fluid under pressure is delivered, a valve member engageable with the valve seat to cut off fluid flow in the conduit and movable away from the seat to permit fluid flow thereby, a sizing element arranged to contact the surface being ground and being movable to follow the changes in the level of the surface as it is being ground, an operative connection between the valve member and the sizing element and coupling the two together for joint movement such that when the sizing element moves to follow the changing level of the surface being ground the valve member moves toward the valve seat and finally into engagement therewith, and control means for modifying said operative connection to vary the extent of such movement of the sizing element before the valve member engages the seat.

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