

- [54] **HYDRAULIC GRINDING METHOD**
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- [51] Int. Cl. .... **B24b 1/00**
- [58] Field of Search ..... 51/281 P, 317, 318, 319,  
 51/321, 7, 26, DIG. 20

- [56] **References Cited**  
**UNITED STATES PATENTS**

587,892	8/1897	Walter .....	51/318
2,419,687	4/1947	Lucky .....	51/318
3,521,412	7/1970	McCarty .....	51/7
3,559,351	2/1971	Richter .....	51/321

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[57] **ABSTRACT**

Sharp edges and burrs formed at the open ends of machined holes or at their intersections can now be removed efficiently by the method of the invention, in which a grinding medium composed of viscous oil and abrasive grits such as of alumina is forced through the machined hole alternately in opposite directions. During the grinding process, most of abrasive grits are held in the lower portion of the whole mass of the grinding medium used due to the difference in specific gravity between the two medium components and the upper thinner portion of the mass is forced through the hole alternately ahead of and following the thicker mass portion. This serves to effectively lubricate the machined hole and thus enables efficient removal of sharp edges and appendant burrs while eliminating any danger of the abrasive grits or aggregates thereof clogging the hole or marring the wall surface thereof irrespective of the hole diameter.

**2 Claims, 3 Drawing Figures**

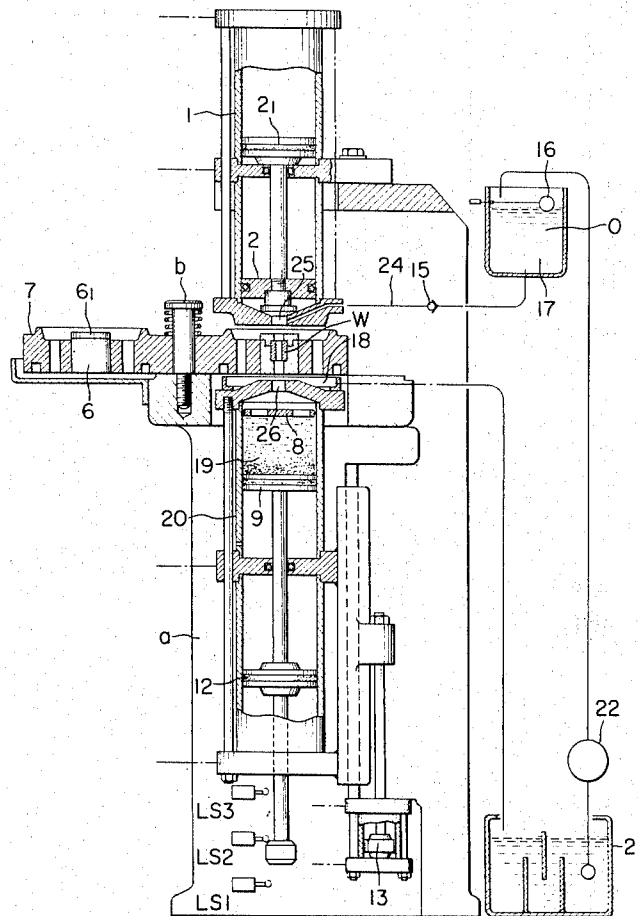


FIG. 1

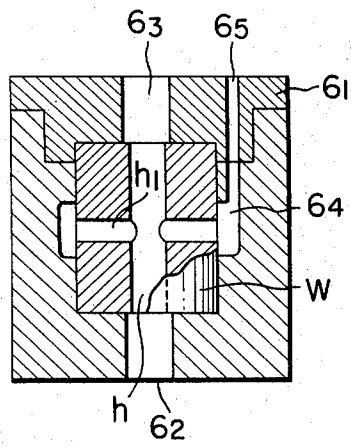


FIG. 3

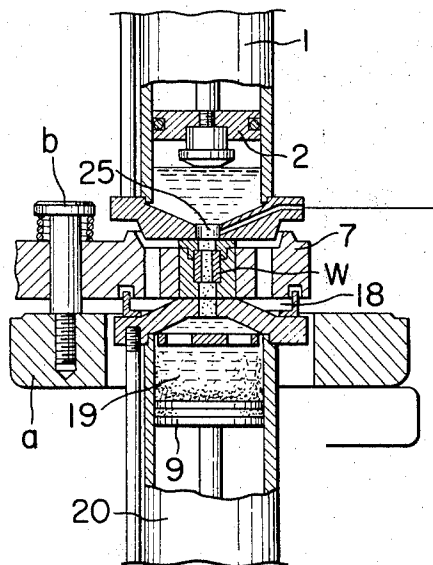
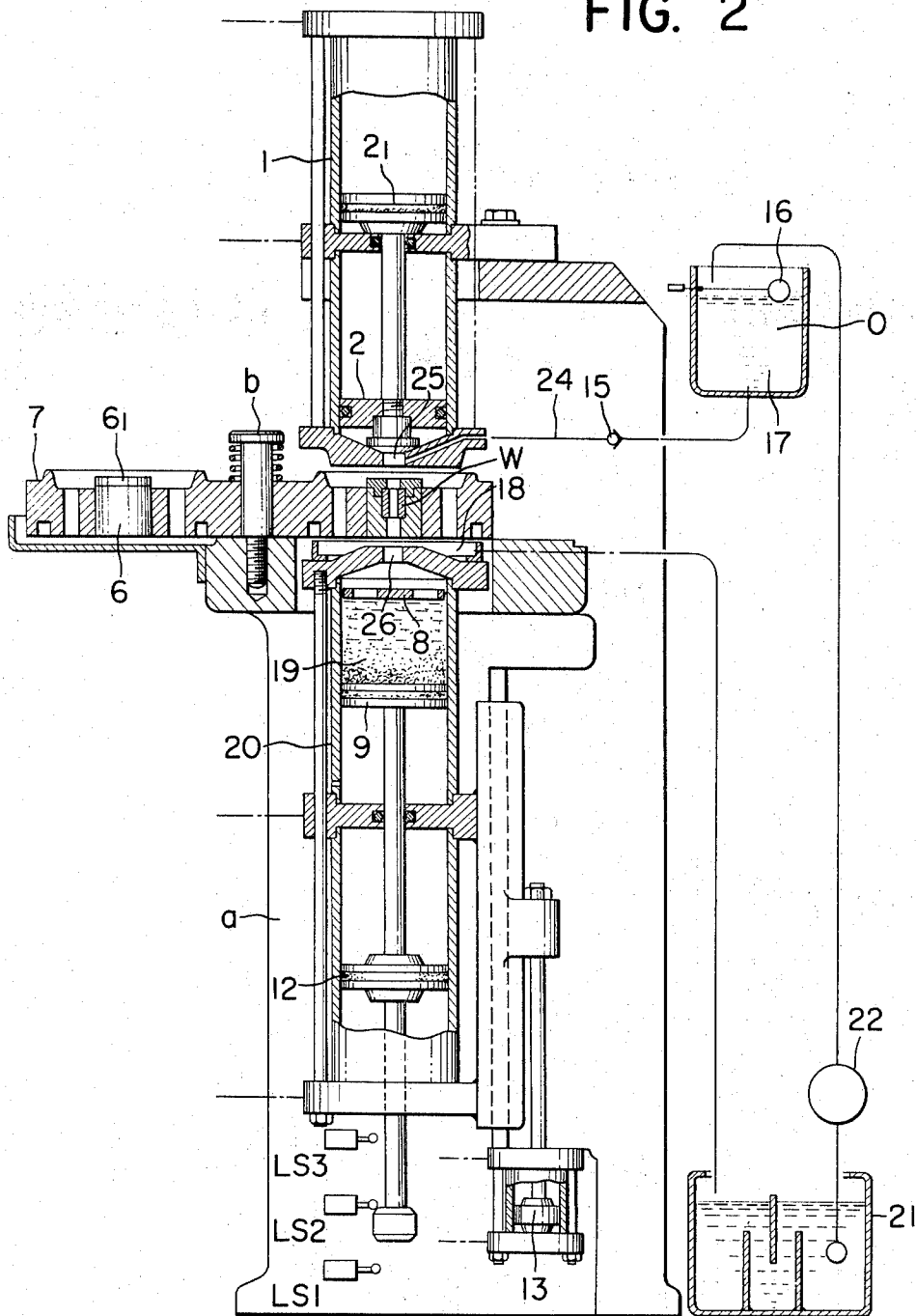


FIG. 2



## HYDRAULIC GRINDING METHOD

## BACKGROUND OF THE INVENTION

This invention relates to finishing or cleaning operations for parts having a machined hole or holes, for example, those of the automotive fuel system having a fluid-conducting hole or holes. In general, machined holes have sharp edges at their open ends or at their intersection with another hole or holes usually with burrs formed appendant to such edges either inside or outside of the machined hole. Burrs formed on any fluid conducting part must be removed completely before the part is assembled into the fluid system since otherwise they would impede proper functioning of the system by themselves falling off therein.

Accordingly, it has been usual to remove such burrs in advance by shot peening or fluid honing. Such conventional cleaning techniques, however, have involved a disadvantage that the part being cleaned is inevitably subjected to the grinding or cleaning effect over an area larger than required as the blast or jet formed cannot be localized as desired. Also, use of the ejecting nozzle is considerably limited as it cannot be fitted into such small holes as fluid passage bores of 3-mm. or less diameter. Thus, in the past, burrs on holes of such limited diameter and particularly those formed at their intersection have necessitated for their removal manual labor employing an appropriate needle-like tool. Obviously, with such manual operation any complete cleaning cannot be expected and only limited productivity has been obtainable.

## SUMMARY OF THE INVENTION

The present invention is intended to overcome such difficulties encountered in previous cleaning techniques and has for its primary object to provide a novel grinding method which makes it possible to remove any sharp edges and burrs formed around machined fluid passages including those formed at locations precluding application of any previous grinding or cleaning technique.

Another object of the present invention is to provide a grinding method of the character described in which not only sharp edges and burrs can be efficiently removed from machined fluid-conducting holes but also such holes can be effectively cleared of any slags or small fragments of stock material.

According to the present invention, there is provided a hydraulic grinding method particularly adapted for removal of sharp edges and burrs formed around machined holes at their open ends or at their intersection and in which method a grinding medium composed of a fluid of considerable viscosity and abrasive grits, such as fine particles of alumina, admixed to the fluid is forced to pass up and down through the machined hole by appropriate means, for example, including an upper and a lower hydraulic piston-cylinder assembly.

As will readily be noted, in the mass of such grinding medium the fluid and abrasive components tend at all times to separate from each other due to the difference in specific gravity between the two components. In other words, when a mass of such medium is left to stand in a vessel for any period of time the upper portion of the mass becomes scarce of abrasive grits compared with its lower portion, in which an increasing amount of grit deposit is obtained.

It is to be noted that such tendency of the medium components to separate under gravitation is fully utilized in the hydraulic grinding method of the invention. Namely, in the first stage of operation in which the grinding medium is forced up through the machined hole, the initial portion of the medium flowing through the latter is substantially formed of the viscous fluid and serves effectively to lubricate the machined hole to enable the following medium portion containing an increasing proportion of abrasive grits to flow through the hole efficiently under pressure and, subsequently, when the mass of grinding medium previously stored above the work is forced down therethrough, the downward flow of medium, containing a decreasing proportion of abrasive grits, initially works most intensively and finally acts to clean the hole while lubricating the latter in an efficient manner.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings, which illustrate one form of apparatus designed to carry out the grinding method of the invention and in which:

FIG. 1 is a vertical cross section of an example of work, showing it on an enlarged scale and in a position fixed in a set of jigs;

FIG. 2 is a partly schematic vertical cross-sectional view of the apparatus designed to perform the grinding method of the invention; and

FIG. 3 is a fragmentary vertical cross-sectional view of the apparatus showing the relative position of parts in a stage of operation.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and first to FIG. 1, there is shown a work W having intersecting fluid passage holes  $h$  and  $h_1$ , as a typical example of part having a machined hole or holes and to which the grinding method of the present invention is applicable to advantage. As shown, the work W has sharp edges at the opposite open ends of each of machined holes  $h$  and  $h_1$  and also interiorly at the intersection thereof. As is well known, burrs are formed along such edges and, if the machined part is assembled with such burrs left to remain thereon, they will fall off sooner or later to enter the fluid system to impede its proper functioning, as pointed out hereinbefore.

Again referring to FIG. 1, the work W is snugly fitted in a set of jigs 6 and 6<sub>1</sub> formed with respective vertical holes 6<sub>2</sub> and 6<sub>3</sub>, which are in alignment, in this case, with the machined hole  $h$  in the work W. Another hole 6<sub>4</sub> formed in the lower jig 6 is in communication with horizontal hole  $h_1$  in work W and with a vertical hole 6<sub>5</sub> formed in the upper jig 6<sub>1</sub>. As shown, holes 6<sub>2</sub>, 6<sub>3</sub> and 6<sub>4</sub> have each a diameter slightly larger than that of the respective adjoining machined hole  $h$  or  $h_1$  in the work W so that the end edges of the machined holes  $h$  and  $h_1$  are wholly exposed to the jig holes.

Description will next be made of the construction and operation of the grinding apparatus shown in FIGS. 2 and 3.

The apparatus includes a machine frame  $a$  and a turn table 7 rotatably mounted on a shaft  $b$  fixed to the upper portion of frame  $a$ . On the table 7 are mounted

a number of works *W* at equal circumferential distances through the intermediary of respective sets of jigs 6 - 6<sub>1</sub>, the table being rotatable to set the works *W* successively in working position aligned with the axes of an upper and a lower piston-cylinder assembly which in turn are aligned with each other. The works *W* mounted on the table have each its vertical hole *h* in communication with the top and bottom sides of the table 7 through the intermediary of respective vertical holes formed in the jigs 6 and 6<sub>1</sub>.

The upper piston-cylinder assembly includes a hydraulic cylinder structure 1 secured to the top of machine frame *a* and defining an upper and a lower chamber accommodating respective pistons 2<sub>1</sub> and 2, which are connected with a piston rod slidably extending through the partition wall between the two chambers. The bottom wall of the cylinder structure 1, defining the bottom of the lower cylinder chamber, is formed with an axial hole 25.

The lower piston-cylinder assembly includes a hydraulic cylinder structure 20 having an upper and a lower chamber defined therein to accommodate respective pistons 9 and 12, which are connected with each other by means of a piston rod slidably extending through the partition wall between the two chambers. As shown, the piston rod extends downwardly through the bottom of the lower cylinder structure 20 to serve the purpose described hereinafter. In the embodiment shown, the lower piston-cylinder assembly is supported by a hydraulic actuator 13 through the intermediary of its plunger for vertical movement. The cylinder structure 20 has a top wall formed with an axial hole 26 in aligned opposite relation with the hole 25 formed in the bottom of the upper cylinder structure 1.

Reference characters LS1, LS2 and LS3 designate respective limit switches operable by the enlarged bottom end of the piston rod of the lower piston-cylinder assembly to produce electrical control signals and serve to control the hydraulic operation of the apparatus, as described hereinafter in detail.

Another feature of the apparatus includes a washing system which comprises a tank 17 for holding a supply of washing oil 0 and an oil reservoir 21.

Reference numeral 24 designates an oil conduit connecting the tank 17 with the bottom of the upper cylinder structure 1 and opening at the lower end into the hole 25. Reference numeral 15 designates a non-return valve arranged in the conduit 24; 16 designates a float switch arranged to maintain a predetermined level in the oil tank 17; and 18 designates an oil pan arranged on top of the lower cylinder structure 20 to receive washing oil 0 returning to the oil reservoir 21. Reference numeral 22 indicates an oil pump operable to replenish the oil tank 17 with oil from the reservoir 21 under the control of float switch 16.

Referring again to FIG. 2, reference numeral 19 designates a mass of grinding medium composed of a viscous oil and abrasive grits admixed thereto and shown stored in the upper chamber of the lower cylinder structure 20 in a position supported by upper piston 9 therein. As shown, the abrasive grits are substantially deposited on the piston 9 and the top portion of the stored mass of medium is practically formed of viscous oil alone. It will readily be seen that the vertical position of piston 9 at this time is determined by limit switch LS2.

The cyclic operation of the apparatus described above is as follows.

At the start of operation, the turn table 7 is turned to place one of the works *W* mounted thereon in the working position aligned with the axes of the upper and lower piston-cylinder assemblies and the whole of the lower piston cylinder assembly is raised under the action of hydraulic actuator 13 until the turn table 7 is pressed against the bottom of the upper cylinder structure 1, when the work *W* is clamped between the upper and lower cylinder structures 1 and 20 in a fluid tight manner through the jigs 6 - 6<sub>1</sub>, as shown in FIG. 3. Completion of such clamping action is detected from the rising movement of the lower cylinder structure 20 and, under the detecting signal, the pistons 9, 12 in the lower cylinder 20 and those 2, 2<sub>1</sub> in the upper cylinder 1 start to rise in unison. Consequently, the grinding medium 19 held in the lower cylinder 20 is forced into the upper cylinder 1 and more particularly into the lower chamber thereof through hole 26 in the top wall of the lower cylinder 20, hole 6<sub>2</sub> (FIG. 3) in lower jig 6, hole *h* in work *W*, hole 6<sub>3</sub> in upper jig 6<sub>1</sub> and through hole 25 in the bottom of upper cylinder 1. On this occasion, initially the upper layer of grinding medium substantially formed of viscous oil is forced up into the upper cylinder, effectively lubricating the whole passageway including holes 26, 6<sub>2</sub>, *h*, 6<sub>3</sub> and 25 in advance of the following medium flow containing a successively increasing proportion of abrasive grits. Owing to this, any danger that the working area including machined hole *h* be clogged with abrasive grits is effectively prevented despite of the throttling effect of the work hole *h*.

Completion of the rising movement of the pistons 9, 12 in the lower cylinder structure and those 2, 2<sub>1</sub> in the upper cylinder structure is detected by the top limit switch LS3 and all of these pistons start to descend under the control of the signal from limit switch LS3 and, as a consequence, the mass of grinding medium previously forced into the upper cylinder 1 is forced back into the lower cylinder 20. On this downward working stroke, it will be readily noted that initially the bottom portion of the whole mass of grinding medium, containing the highest proportion of abrasive grits, is forced down through the working area and the top layer substantially formed of viscous oil is forced down into the lower chamber last of all or just before the limit switch LS2 is actuated to produce a signal of completion of the grinding stroke and accordingly the pistons 2 and 2<sub>1</sub> are brought to a stop in abutting engagement with the bottom of the respective cylinder chambers. Incidentally, the amount of movement of the pistons up to this time in either direction can be properly selected according to the amount of grinding required.

After the stoppage of the pistons 2 and 2<sub>1</sub> in the upper cylinder 1, pistons 9 and 12 in the lower cylinder 20 continue to descend until the lowermost limit switch LS1 is actuated to produce a stop signal. This additional descent of pistons 9 and 12 covering the distance between limit switches LS2 and LS1 makes the pressure in the space above the mass of grinding medium in the lower cylinder subatmospheric so that the non-return valve 15 is opened to allow washing oil 0 to flow down through the conduit 24, hole 25 in the bottom of the upper cylinder 1 and through the vertical hole *h* in work *W* into the lower cylinder. Reference numeral 8 in FIG. 2 designates a slotted float plate arranged in the lower cylinder 20 to cover the surface of the mass of

grinding medium 19 when it is stored therein and intended to prevent the stored mass of grinding medium 19 from being disturbed by the down flow of washing oil 0 into the lower cylinder while allowing the oil to be stored on the mass of grinding medium 19.

The signal produced by limit switch LS1 upon completion of the down stroke of the pistons 9, 12 causes the hydraulic actuator 13 to operate to cause the lower cylinder 20 to slowly descend and at the same time causes the pistons 9, 12 therein to rise until limit switch LS2 is actuated when the lower piston-cylinder assembly is restored to its initial position shown in FIG. 2 and the cycle of operation of the grinding apparatus is completed. During this last stage of operation, washing oil 0 previously stored in the lower cylinder 20 is forced up through the hole 26 formed in the top wall of the cylinder and collected in the oil pan 18 to return into the oil reservoir 21. On this occasion, the washing oil is initially directed through the work W and the clearance previously formed between the bottom wall of the upper cylinder 1 and upper jig 6<sub>1</sub> and further through the table 7 into oil pan 18 but afterward is directed through the clearance now formed between the lower jig 6 and the top wall of the lower cylinder 20 directly into the oil pan 18. Washing oil 0 stored in reservoir 21 is fed up through an appropriate filter means into tank 17 by means of pump 22 under the control of float switch 16.

Grinding medium 19 may have any appropriate composition including viscous fluid and abrasive grits. For example, a colloidal grinding medium composed of a lubricating oil having a viscosity ranging between SUS 600 - 2,000 (100°F) and granulated alumina admixed thereto in a proportion of 30 to 50 percent by volume is recommendable.

During the grinding process of the present invention, abrasive grits such as of alumina in the grinding medium tend to aggregate and mostly held in the lower portion of the whole mass of grinding medium under gravitation and, as described hereinbefore, are forced to pass through the working area mostly in the later or initial part of piston stroke of the hydraulic assemblies without the danger of clogging the working area. It is to be noted that the abrasive grits or aggregates thereof, when entering the machine hole *h* in the work, are forced to collide against the exposed edges of the work at the inlet end of the hole *h* and at its intersection with another machined hole *h*<sub>1</sub> and, under the compound effect of such collision and repulsion accompanying breakdown of aggregates, any sharp edges and burrs appendant thereto are effectively removed from the machined hole *h*. It will be readily recognized that such grinding or abrading effect is obtained at either end of the hole *h* as well as at its intersection with the other hole *h*<sub>1</sub> as the direction of flow of the grinding medium through the work W is alternately changed during the grinding process.

It is to be noted that the float plate 8 arranged in the lower cylinder 20 also serves to collect most of fragments of removed stock including burrs and enables them to be efficiently discharged out of the lower cylinder

together with the washing oil 0 at the last stage of the working cycle. It will be readily noted that the wall surface of the machined hole *h* is kept free from abrasion throughout the process since the grinding medium is allowed to pass smoothly over such surface under the self-lubricating effect of the medium despite of the limited hole diameter.

In cases where the grinding apparatus according to the present invention is to be shut down for any lengthy time, for example, exceeding a whole day, it is desirable to extract the supply of grinding medium out of the apparatus.

It will be apparent that the provision of a washing system such as described and shown herein not only enables the worked part to be automatically washed clean but also enables removed burrs and fragments of the work material to be automatically discharged and filtered off.

As apparent from the foregoing description, the grinding method of the present invention is highly advantageous in that it makes it possible to remove sharp edges and burrs formed at the ends of any machined hole or at its intersection with another hole or holes in an efficient manner irrespective of the hole diameter or the complicity of the hole intersection.

I claim:

1. A hydraulic grinding method for removal of sharp edges and burrs in a machined hole of a workpiece formed at its intersections with other holes, or at openings of the hole without abrading the interior surface of the hole, comprising the steps of:

permitting a mass of grinding medium composed of viscous oil and abrasive grits having a larger specific gravity than that of said viscous oil to settle to a desired extent in a manner so that the proportion of said abrasive grits in said viscous oil gradually increases downwardly from the top portion to the bottom thereof; forcing the settled grinding medium through said hole of said workpiece in one direction so that the upper portion thereof containing a smaller proportion of said abrasive grits initially passes through said hole and applies lubricity to the interior surface of said hole, the lower portion thereof containing a larger proportion of said abrasive grits applying thereafter an abrasive action on said sharp edges and burrs while retaining said interior surface of said hole free from abrasion; forcing the grinding medium passed through said hole to pass again through said hole in the opposite direction; and

repeating the preceding steps to the extent required for removal of said sharp edges and burrs.

2. A hydraulic grinding method as claimed in claim 1, further comprising the steps of:

directing thereafter a supply of washing oil through said machined hole successively so as to be collected substantially over the mass of grinding medium; and

discharging the supply of washing oil under pressure in advance of the start of a subsequent work cycle.

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