July 10, 1962 F. W ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 1

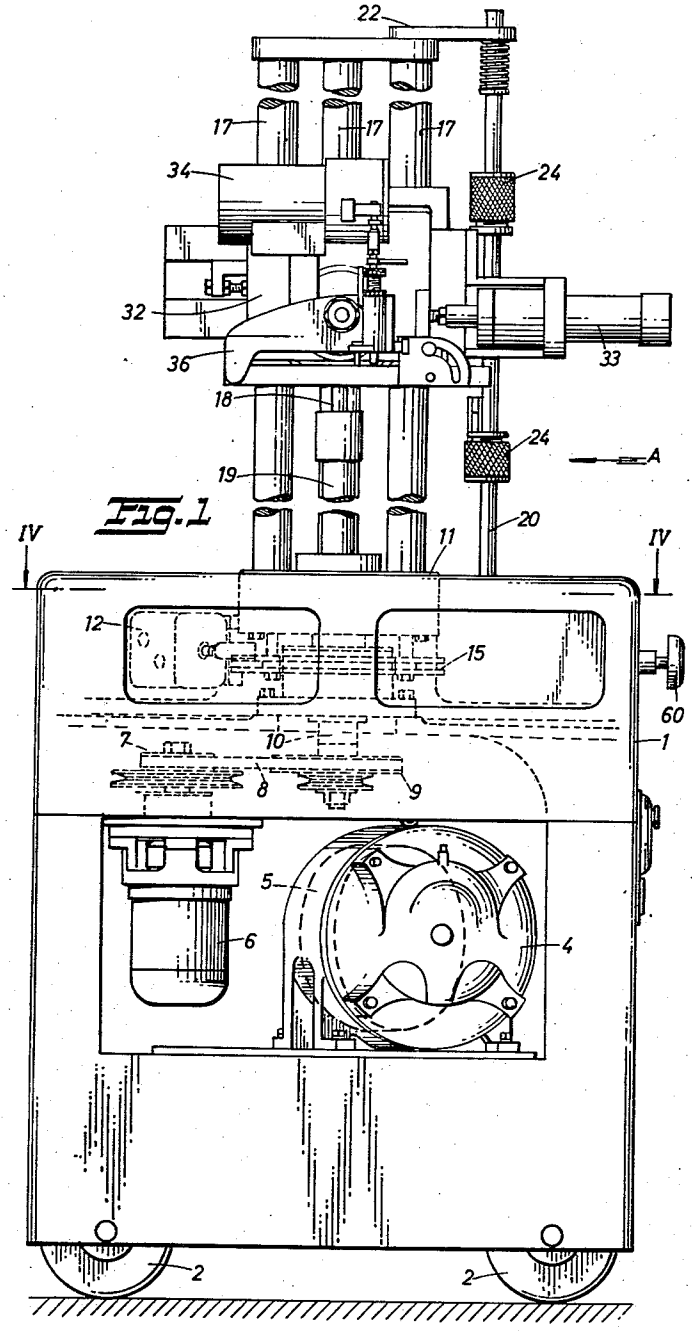


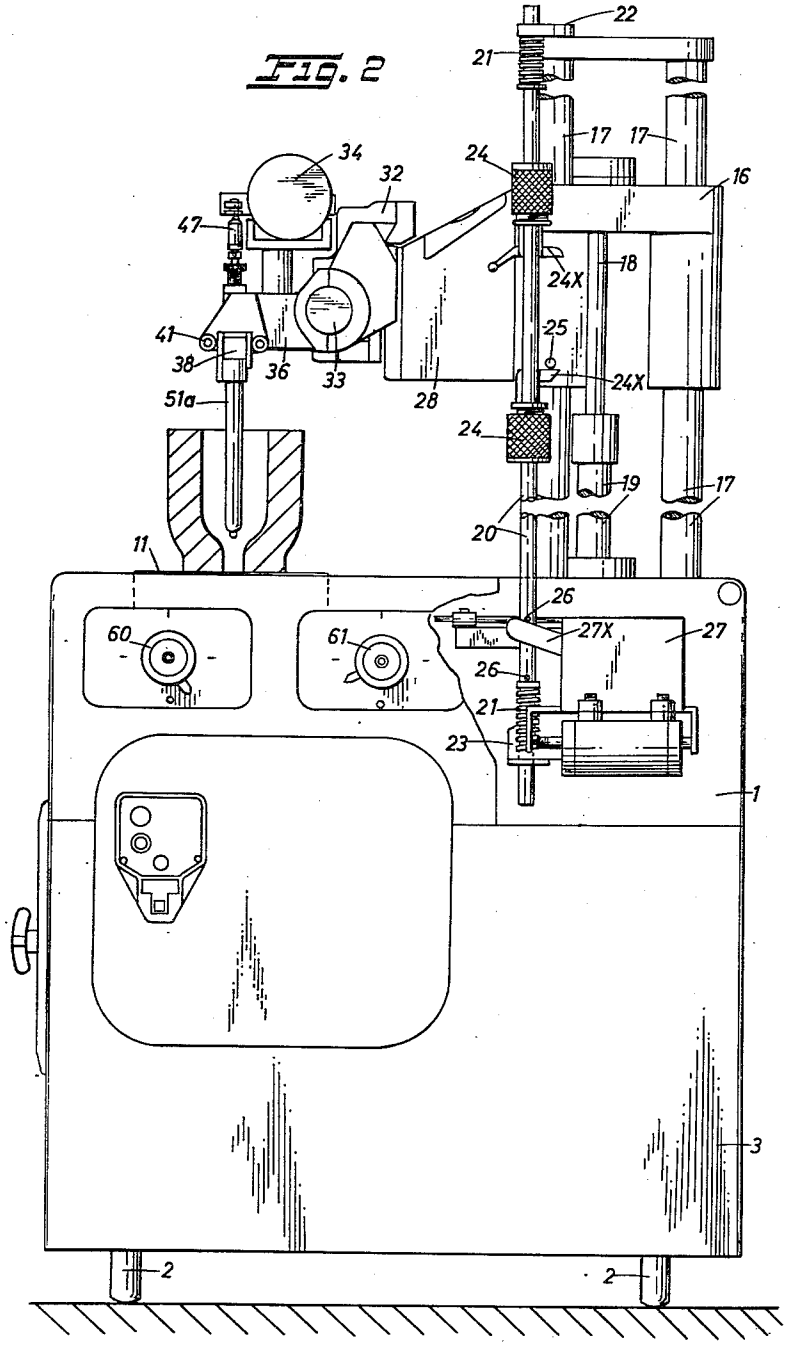
Fig. 1

July 10, 1962 F. W ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 2

Fig. 2



July 10, 1962 F. W. ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 3

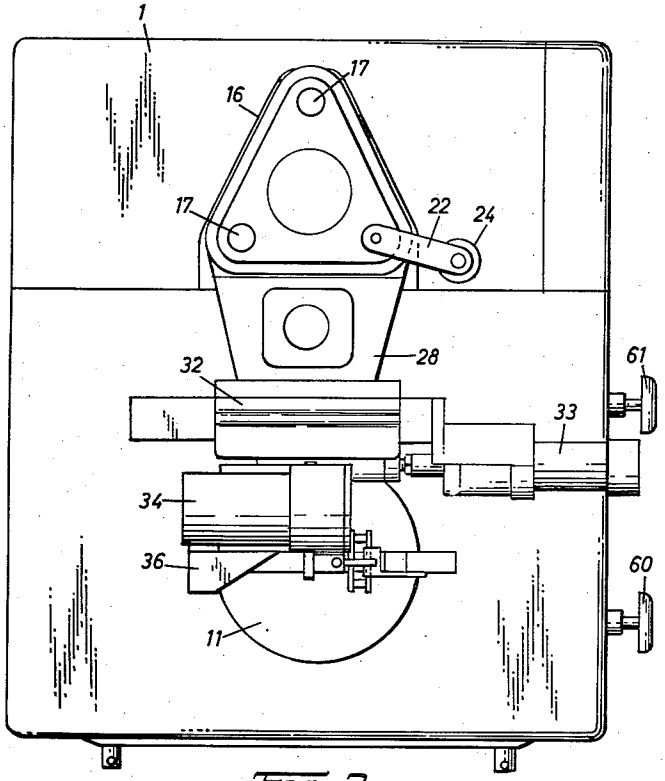
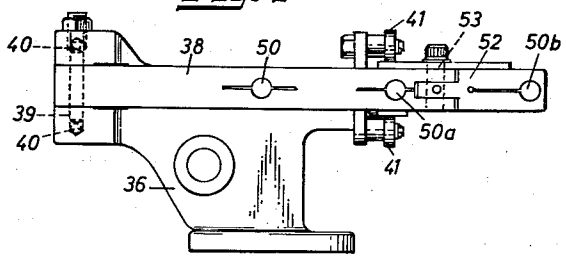


Fig. 3

Fig. 7



July 10, 1962 F. W ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 4

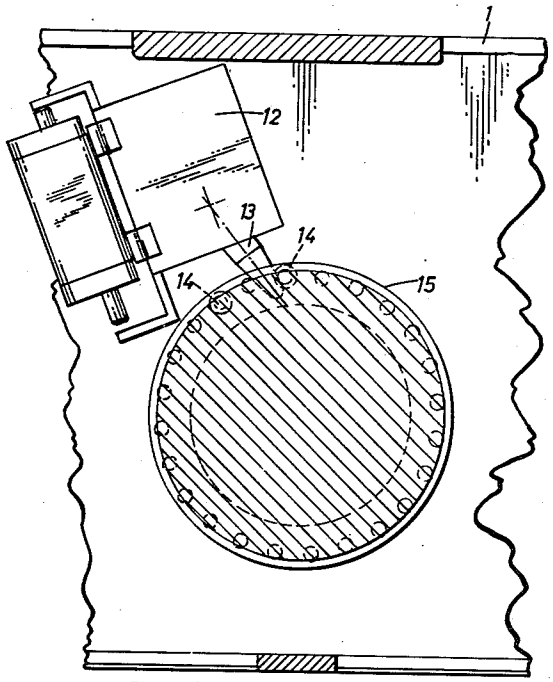
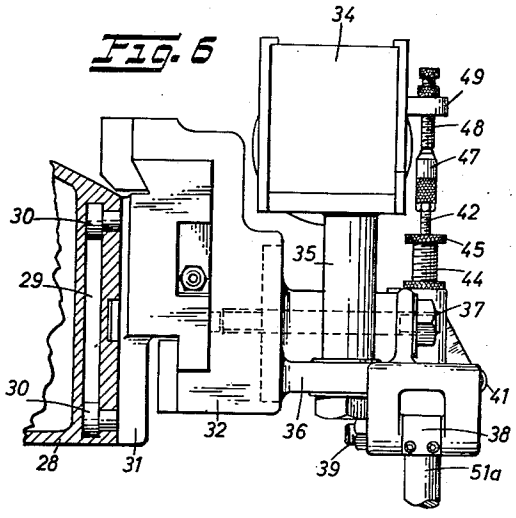


Fig. 4

Fig. 6



July 10, 1962 F. W. ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 5

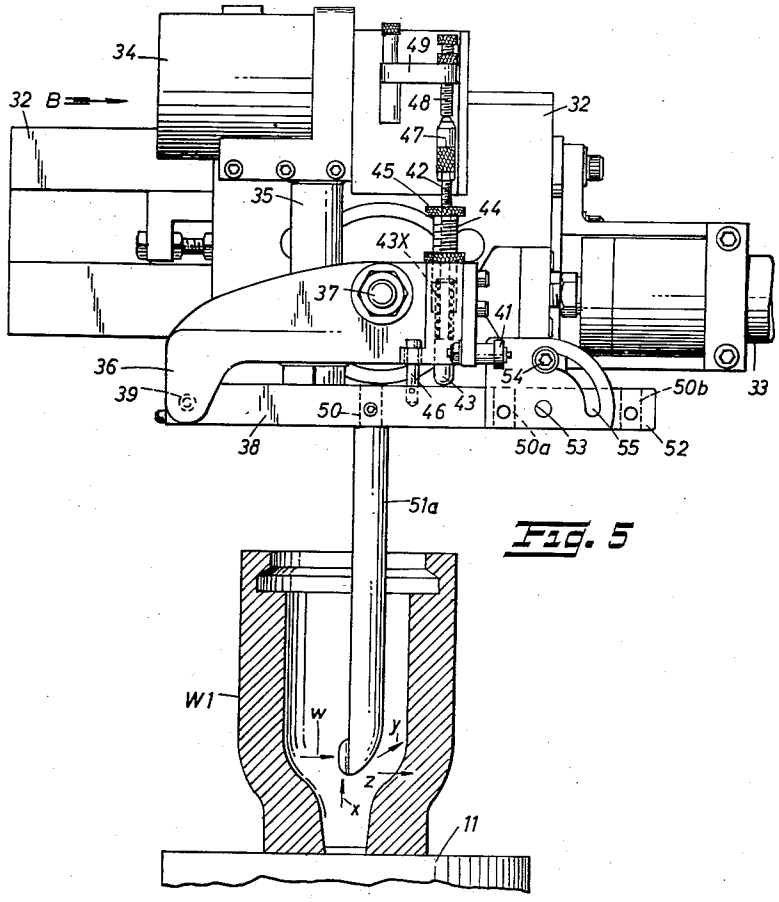


Fig. 5

July 10, 1962 F. W. ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 6

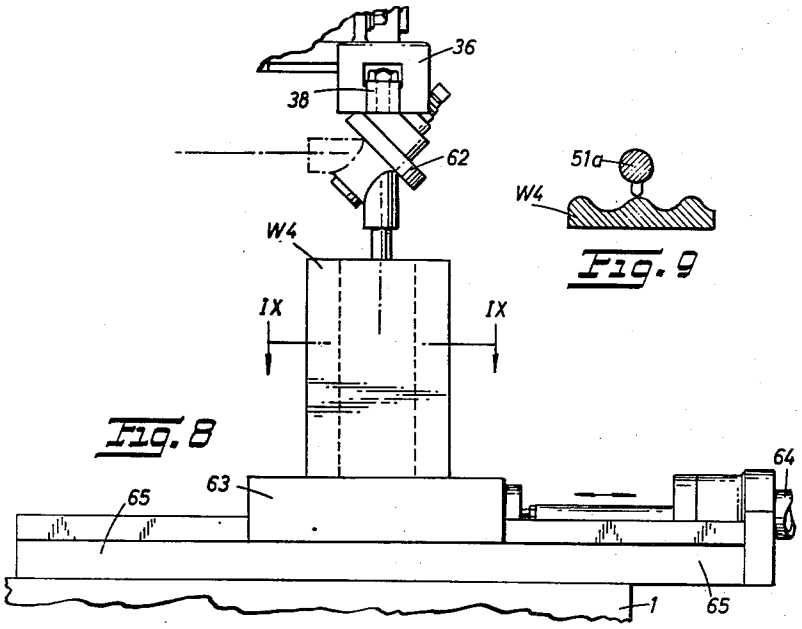


Fig. 8

Fig. 9

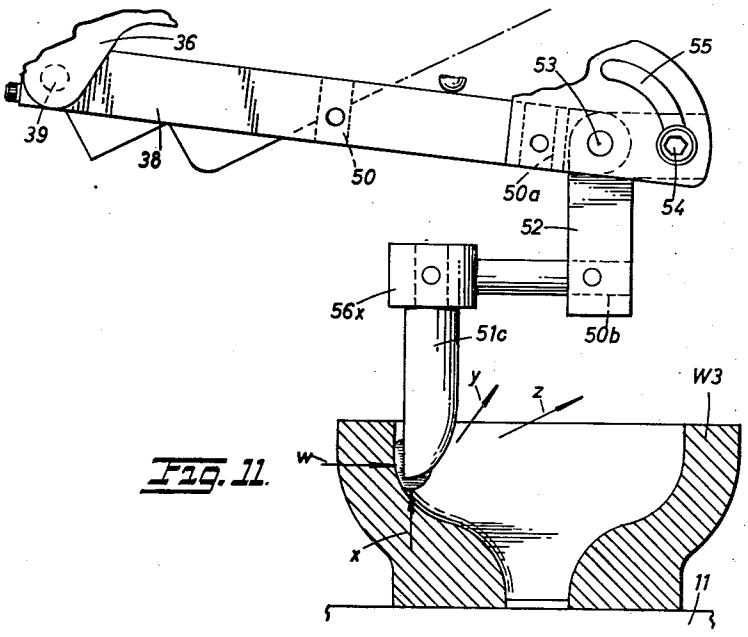


Fig. 11

July 10, 1962 F. W ARMYTAGE 3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Filed June 20, 1960 7 Sheets-Sheet 7

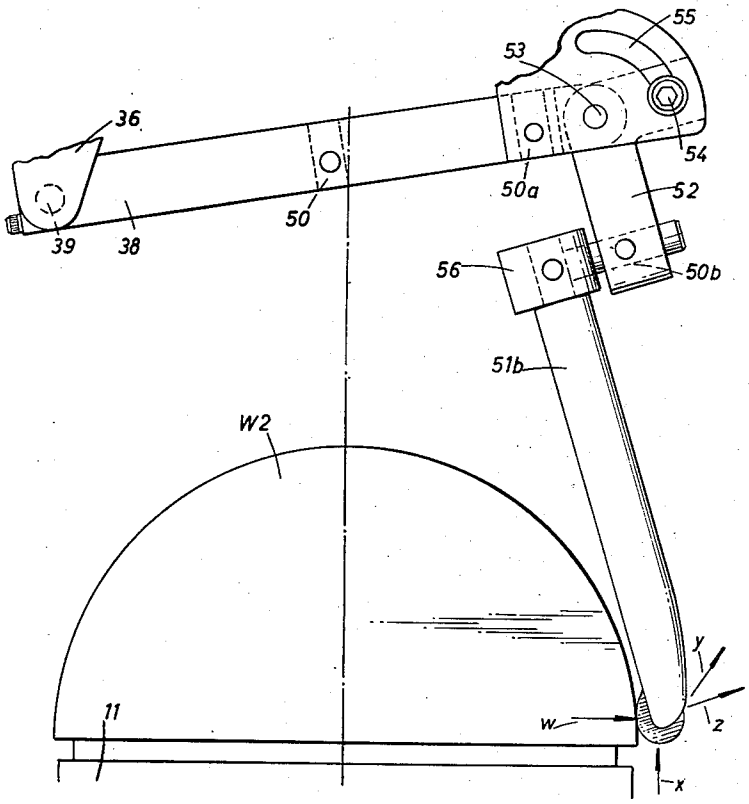


Fig. 10

United States Patent Office

3,043,057

Patented July 10, 1962

3,043,057

MACHINE FOR ABRASIVE FINISHING OF CONTOURED OR PROFILED SURFACES

Frederick W. Armytage, Foundry Lane, Knottingley, England

Filed June 20, 1960, Ser. No. 37,520
Claims priority, application Great Britain June 20, 1959
8 Claims. (Cl. 51—67)

This invention relates to the honing, lapping, polishing or similar abrasive treatment of contoured or profiled surfaces. Heretofore this treatment has been manually controlled so far as the guiding of the abrasive tool or medium and its pressure against the surface and its speed of travel thereover was concerned, and consequently the amount of material removed from the workpiece and the uniformity and quality of the surface finish depended largely upon the skill of the operator.

The object of the present invention is to provide a machine capable of abrasively treating contoured or profiled surfaces without human guidance once it has been set in operation and capable of producing rapidly and accurately a surface finish having a high degree of uniformity.

To this end a machine according to the invention includes means for moving the contoured or profiled surface of the workpiece relative to the abrasive tool or medium, means for traversing said tool or medium over and in contact with said surface so as to treat the whole of the desired area thereof, and hydraulic tracer valve mechanism arranged to be actuated by movement of said tool or medium and thereby to maintain the latter in contact with said surface with a substantially constant predetermined pressure. By these means the abrasive tool or medium itself acts as a stylus or tracer foot and through the tracer valve operates automatically to follow the contour or profile of the surface with a constant pressure.

In order to enable the machine to produce the desired high quality finish on workpieces of widely differing shapes, sizes and surface contours, means are provided for varying independently the speed at which the workpiece is moved and the speed at which the abrasive tool or medium is traversed, whereby the relative movement between the tool and the workpiece can be caused to take place at a speed which ensures the necessary high quality surface finish.

The form of movement given to the workpiece and to the tool may vary according to the type of work which the machine is required to do. One or both movements might be reciprocatory or rotary, and preferably the combination of movements is arranged to cause the tool to cover the contoured or profiled surface in a non-repeating pattern.

In treating workpieces on which the surface extends through 360° or substantially so it is found convenient to rotate the workpiece and to reciprocate the tool across its surface transversely to the path in which the latter rotates.

Provision may also be made for oscillating the workpiece through any suitable included angle up to 360° in order to provide the surface honing to a contour which it is more convenient to deal with in sections, as for instance in a glass container mould which is in two or more parts.

It has been found advantageous to oscillate the hone across the two mating parts separately.

The tool and tracer valve are mounted on a carrier which is slidable in a reciprocatory head under control from the tool actuated valve, and this carrier or the tool itself or both independently is or are adjustable angularly to enable the tool to approach the workpiece surface at the most advantageous angle.

In order that the invention may be clearly understood

and readily carried into effect the same will now be more fully described with reference to and by the aid of the accompanying drawings, which illustrate by way of example one construction of machine (and some modifications thereof) embodying the invention and suited mainly for treating the interior or exterior of workpieces on which the surface to be treated extends substantially around 360°.

In these drawings:

FIGURE 1 is an elevation of the machine from which the tool and workpiece are omitted.

FIGURE 2 is an end elevation seen in the direction of arrow A in FIGURE 1 but showing a tool and workpiece in position;

FIGURE 3 is a plan of FIGURE 1;

FIGURE 4 is a partial horizontal section on the line IV—IV of FIGURE 1;

FIGURE 5 is a view similar to that in FIGURE 1 of the tool holding and tracer deflecting mechanism mounted with the tracer valve upon a tracer-controlled tool slide;

FIGURE 6 is an end elevation seen in the direction of arrow B in FIGURE 5, parts being shown in section;

FIGURE 7 is an underneath plan of the tool holding and tracer deflecting mechanism shown disconnected from the tool slide;

FIGURE 8 is a partial view of modifications showing a reciprocatable work slide for use in place of the rotatable work table and showing a three-station turret which can be used to hold three tools;

FIGURE 9 is a horizontal section on the line IX—IX of FIGURE 8 showing how the tool could operate on a "flat" workpiece in that instance;

FIGURES 10 and 11 are detail views of adjustable extensions for the tool holder.

Referring first to FIGURES 1 to 4, the machine has a frame **1** supported on wheels **2** and carrying in its lower part **3** an oil reservoir. An electric motor **4** drives an oil pump **5** which draws oil from the reservoir and pumps it to an oil motor **6** through pipe connections (not shown). The oil motor **6** drives through a V belt **8** and pulleys **7**, **9** the shaft **10** of a circular rotatable magnetic worktable **11** whose speed can be maintained substantially constant during the honing operation.

The worktable can be rotated in either direction continuously. Alternatively, if desired to suit the workpiece to be treated, the work table can be oscillated under preset control of an oil hydraulic reversing mechanism **12** (see FIGURE 4) whose actuator arm **13** is alternately operated by two dogs **14** inserted in a reversing disc **15** secured on the work table shaft **10**.

Above the worktable is a reciprocatory head **16** vertically slidable upon three pillars **17** by the ram rod **18** of and oil hydraulic ram working in a cylinder **19** mounted with the pillars on the machine frame **1**. The ram can be set to reciprocate the head **16** over a predetermined length of stroke at a predetermined substantially constant speed during the honing operation, the oil being supplied to the cylinder **19** by the pump **5**. A reversing rod **20** supported by centralising springs **21** in brackets **22**, **23** secured respectively to the top of the pillars **17** and to the frame **1** carries two stops **24** having projections **24X** engageable by a dog **25** on the head **16**. The stops can be roughly adjusted along the rod quickly by a sliding movement or slowly to give accurate adjustment by a micrometer screw. The rod **20** has two pins **26** arranged to operate alternately the actuator bar **27X** of an oil hydraulic reversing mechanism **27** mounted in the frame **1**. This mechanism **27** and the reversing mechanism **12** can be of any suitable construction, but are preferably constructed and arranged as described and shown in my pending British patent application No. 30,457/58.

Referring more particularly to FIGURES 5 to 7, the head **16** carries a saddle **28** having an annular T-sectioned slot **29** in which engage the heads **30** of studs secured in a tracer-controlled tool slide **31**. By this means the tool slide **31** can be adjusted angularly relative to the head in a vertical plane through 360°, although a swivelling movement of about 180° would be sufficient to meet most variations in the shape of the contoured surfaces to be treated.

The saddle **32** of the tool slide **31** is reciprocated by a ram working in an oil hydraulic cylinder **33** in known fashion under control from a tracer valve **34** of a suitable construction similar to those used for automatic hydraulic copying tracers of machine tools, and preferably a valve embodying the constructional features disclosed in my British Patent No. 692,642. The tracer valve is coupled by pipe connections (not shown) to the cylinder **33** and to a source of oil under pressure (independent of the oil pump **5**) as will be understood by those skilled in the art.

The tracer valve is secured by its stem **35** in a bracket **36** which is secured to the saddle **32** by a stud **37** whose axis is parallel to the swivelling axis of the saddle itself. On slackening this stud the bracket can be adjusted angularly relative to the saddle in a vertical plane through 360°.

The bracket **36** carries a tool-holding and tracer-deflecting mechanism. This consists of a deflector arm **38** pivoted at one end in the bracket by a pivot pin **39** with ball bearings **40** to give maximum freedom from friction. The arm near its other end works between two freely rotatable guide rollers **41** which are mounted on the bracket **36** to guide the arm in its vertical movement with the minimum of friction and yet to resist sideways pressure on the arm. Mounted in the bracket **36** is a deflector spindle **42** whose foot **43** is urged into contact with the arm **38** by a coil spring **43X** surrounding the spindle within a sleeve **44** which is screwed into the bracket by a knurled head **45** to compress the spring. By this means a pre-determined constant pressure can be exerted upon the deflector arm **38**, the downward movement being limited by a stop pin **46**. The spindle **42** carries a nose piece **47** which makes point contact with a stud **48** secured in an arm **49** which is arranged to actuate the spool or equivalent movable member of the tracer valve **34**.

The deflector arm **38** has well spaced from its pivot point alternative sockets **50**, **50***a*, **50***b*, to receive the shank of a honing or like tool **51***a* in the form of a spindle which extends in the opposite direction to the deflector spindle and which has applied to or secured on its foot, on the side facing towards the deflector arm pivot and/or on its end, a stone or other suitable form of abrasive element. The socket **50***b* is provided in an L-shaped arm **52** pivoted at **53** on the arm **38** and adjustable through 90° by a clamping stud **54** working in a segmental slot **55**.

As indicated in FIGURE 5, the socket **50** may be used for internal honing of workpieces such as the bottle mould W1 shown and the socket **50***a* for external honing of suitable workpieces. Alternatively, as shown in FIGURES 10 and 11 by securing the tool in an adaptor **56** or **56X** which in turn is secured in the socket **50***b*, the tool **51***b* or **51***c* can be made to approach the work at the most suitable angle, that shown in FIGURE 10 being suitable for treating a hemispherical workpiece W2 whilst that shown in FIGURE 11 is suitable for treating the inside of a cup-shaped workpiece W3. In both these figures the bracket **36** has been angularly adjusted, either by itself or by the angular adjustment of the tracer-controlled tool slide or by the combined angular adjustment of both these members. The combination of these two swivelling movements enables the tool foot to be brought to bear on the contoured surface from the most advantageous angle in each particular case.

The operation of the machine is as follows. With the

workpiece held on the worktable **11**, the tool foot set conveniently to the contour face to be honed and the stroke of the head **16** set by the rod **20** to suit the height of such face, the oil pump **5** is started, the speeds of the rotary worktable and of the reciprocatory head are adjusted by the control knobs **60** and **61** which are capable of giving an infinite speed variation over a predetermined range, and honing commences. The tool foot is held against the workpiece surface with a constant pressure which can be predetermined by the setting of the spring **43X**, and any increase in this pressure applied by the contour to the tool foot at any point between *w* and *x* (see FIGURES 5, 10 and 11) will move the foot away in the direction of arrow *y* and operate, through the tracing valve, the tool saddle **32** which will move away in the direction of arrow *z*. Similarly any decrease in the pressure of the foot on the surface causes corresponding opposite movements. Thus in effect the tool itself is a sensing head which is traversed over the surface of the workpiece by (in the above example) a combination of rotary and reciprocatory movements at a predetermined speed, whereby the rate of metal removal can be smaller and slower than with other honing or polishing machines, thereby producing a better surface finish with the minimum amount of material removed in the process.

In order to make more certain the movement of the tool over the contoured surface in a non-repeating pattern, control means may be incorporated in the hydraulic circuit to the head-reciprocating ram to give this ram different speeds on its upward and downward strokes.

By using a single oil pump to supply oil to both the oil motor operating the table and the ram operating the head, the total volume of oil supplied is divided between these two in the correct proportion to ensure the maximum "footage" (i.e. area of contoured surface treated per unit time).

The tool on the deflector arm can swing freely about the arm pivot to follow the contour on the workpiece but is guided so as to resist the torque exerted on it by the rotating workpiece. By mounting the tool spindle at a point offset from the arm pivot the spindle can yield to lengthwise pressure as well as sideways pressure to operate the deflector arm regardless of the direction of movement of the reciprocating head at that moment.

If desired, instead of using the single tool as above described, a turret **62** (see FIGURE 8) may be secured in any one of the sockets **50**, **50***a*, **50***b* in the deflector arm **38** and adapted to hold (for example) three tools, say a roughing hone, a medium hone and a finishing hone, any one of which can be turned into working position at choice and locked there.

In a modified form of the construction above described (see FIGURES 8 and 9) suited for treating a "flat" workpiece W4 on which the contours extend across a substantially plane surface so that it is more convenient to reciprocate the workpiece relative to the tool instead of rotating it, a workholding saddle **63** reciprocated by the ram of a hydraulic cylinder **64** is slidable on a workslide **65** secured upon the machine frame **1** instead of the rotary worktable, the latter being immobilised if left in place in the machine. The saddle **63** is mounted so as to be reciprocated in a direction at right angles to that in which the tool slide **31** reciprocates or at any other angle best suited to the contour to be treated in each particular case, and the ram (fed with oil from the oil pump **5**) could have its length and speed of stroke varied as previously described with reference to the vertical ram to suit each job. Thus a vertical reciprocation of the tool **51***a* and a horizontal reciprocation of the workpiece could be arranged to cover any "flat" contoured area with a non-repetitive pattern, the contoured surface being mounted in a mainly vertical plane.

In a further modified arrangement (which will be readily understood without illustration), and with the contoured surface held face upwards on the rotatable

worktable, the tracer-controlled tool slide would be swung through approximately 90° compared with its previously described direction so that the variations in the depth or height of the contour would be taken care of by the deflection of the tracing valve through the tool-holding mechanism pressing the tool down onto the contoured surface. In this case an additional ram-operated slide (or the workslide already referred to) may be interposed between the swivelling tracer-controlled tool slide and the vertically reciprocatable head carrying it, whereby the tool can be given a constant horizontal reciprocatory movement suitable for treating (say) convexed or concaved contours on a workpiece mounted flat on the rotatable worktable.

I claim:

1. In a machine for the abrasive finishing of contoured surfaces of workpieces, the combination of an abrading tool, means for holding a workpiece, means for moving said workpiece and holder for cutting movement relative to said abrading tool, means for holding said abrading tool and for traversing it over and in contact with the contoured surface of said workpiece to thereby treat the whole of the desired area thereof, a hydraulic tracer valve mechanism mounted to be traversible with said tool, and to cause said tool to follow said contoured surface, a tool-holding and tracer-deflecting mechanism for transmitting deflections of said tool produced by its contact with said contoured surface to said tracer valve and means maintaining said tool in contact with said surface with a substantially constant predetermined pressure.

2. A machine according to claim 1 including means for varying independently the speed at which the workpiece is moved and means for controlling the speed at which the abrading tool is traversed, whereby the relative movement between the tool and the workpiece takes place at a sufficient speed to ensure a high surface finish.

3. A machine according to claim 2, wherein said means for varying the speed of said workpiece and the means for controlling the speed of the tool are each operatively connected to driving means and a hydraulic transmission therefor operated by oil hydraulic pressure supplied from a single source, in which the total volume of oil supplied to said source is divided between each of said two driving means in predetermined proportion.

4. A machine according to claim 3 wherein said tool holding and tracer deflecting mechanism is actuated by upward and sideways movement of said abrading tool, and in which said abrading tool projects down from said mechanism.

5. A machine according to claim 4, wherein said tool holder of said tracer deflecting mechanism pivoted for vertical movement and includes means for securing a tool therein to one side of said pivotal point, including means for guiding said holder for free vertical movement to resist movement of said holder in the other direction by the action of the moving workpiece on said tool.

6. A machine according to claim 5 wherein said means for exerting a predetermined pressure of said tool against the workpiece is adjustable within limits which avoid restricting the accuracy of the reaction of the tracer valve.

7. A machine according to claim 6 wherein said tool holding and tracer deflecting mechanism is mounted on a head for vertical reciprocation relative to said substantially horizontally movable workpiece and is provided with means for angular adjustment relative to said head in a substantially vertical plane to enable the tool to be presented to the workpiece surface at a predetermined angle.

8. A machine according to claim 7 wherein said tool holding and tracer deflecting mechanism is mounted on a tracer controlled tool slide which is in turn mounted on said reciprocatory head, and both said mechanism and said slide are angularly adjustable relative to the mounting member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,354,347	Peets	July 25, 1944
2,391,983	Kutzler	Jan. 1, 1946
2,887,827	Conte et al.	May 26, 1959