

March 14, 1967

A. H. BANNER ETAL
PROFILE FORMING APPARATUS

3,308,720

Filed Sept. 27, 1965

4 Sheets-Sheet 1

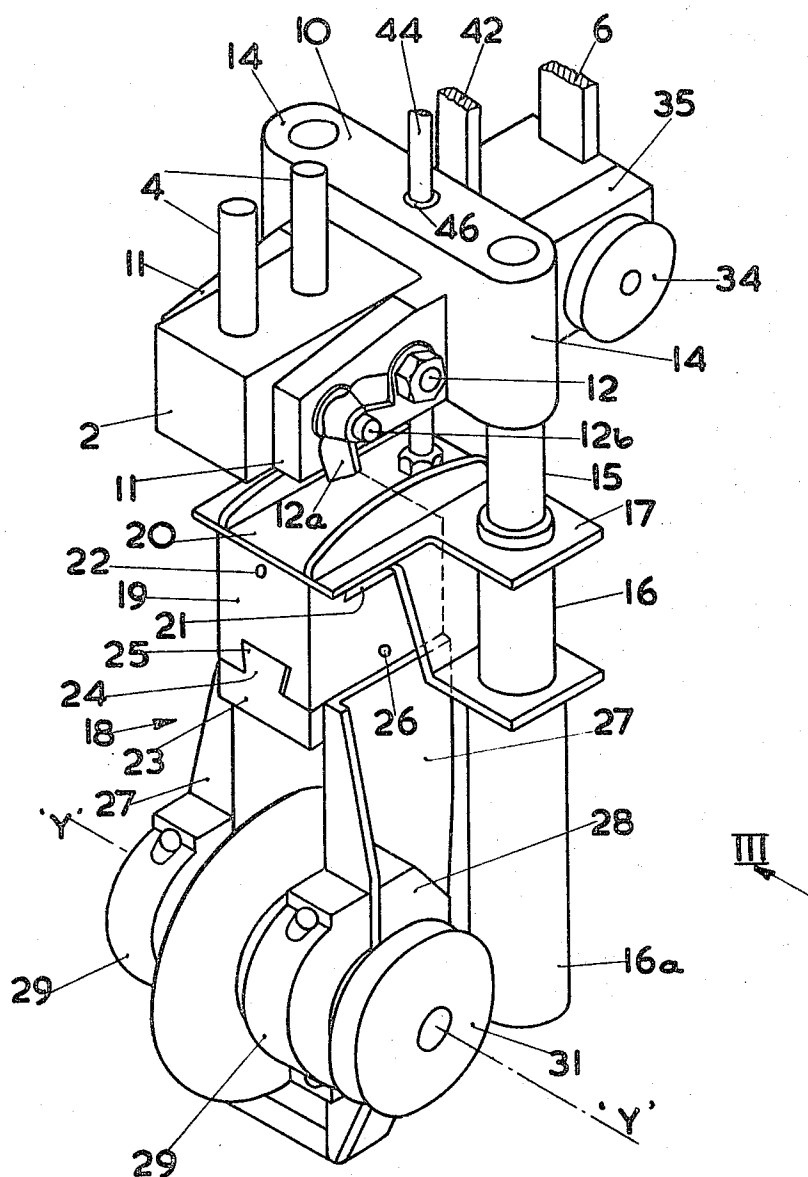


FIG. 1.

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4 Sheets-Sheet 2

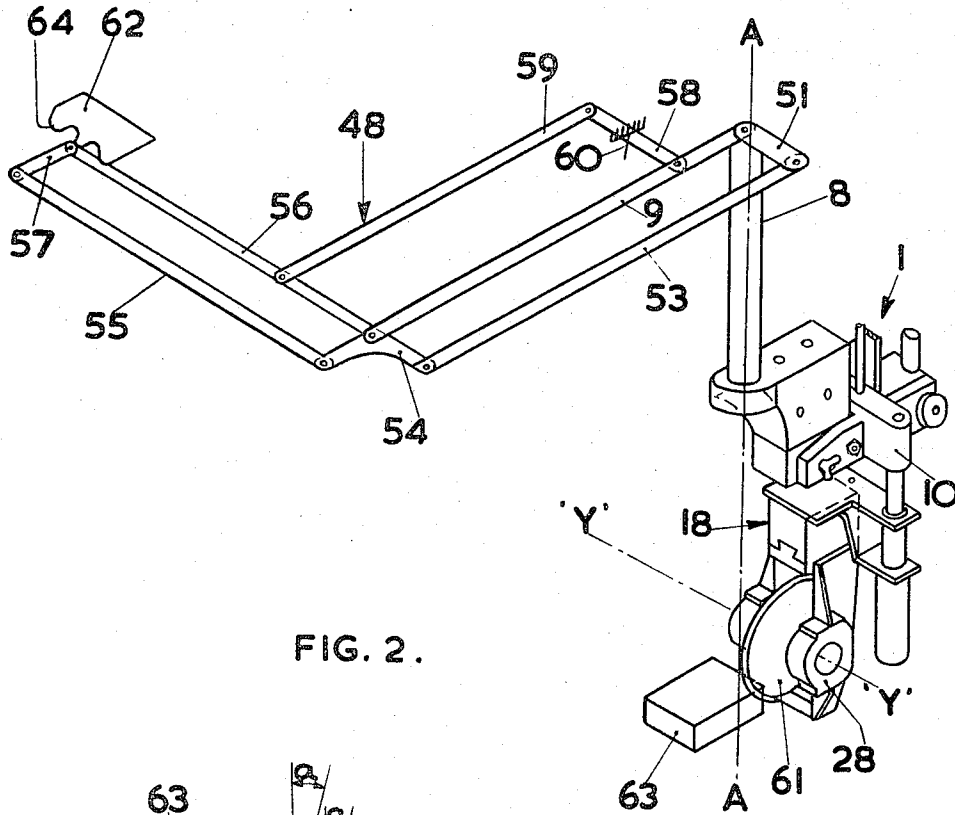


FIG. 2.

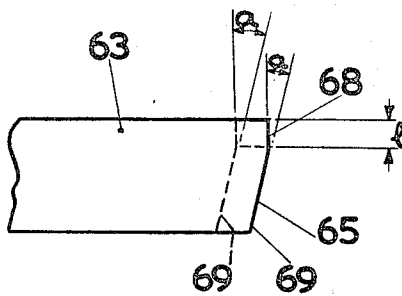


FIG. 5.

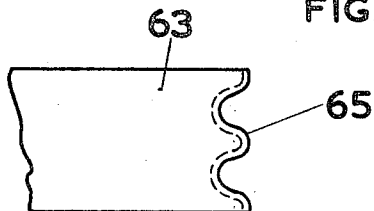


FIG. 6.

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4 Sheets-Sheet 3

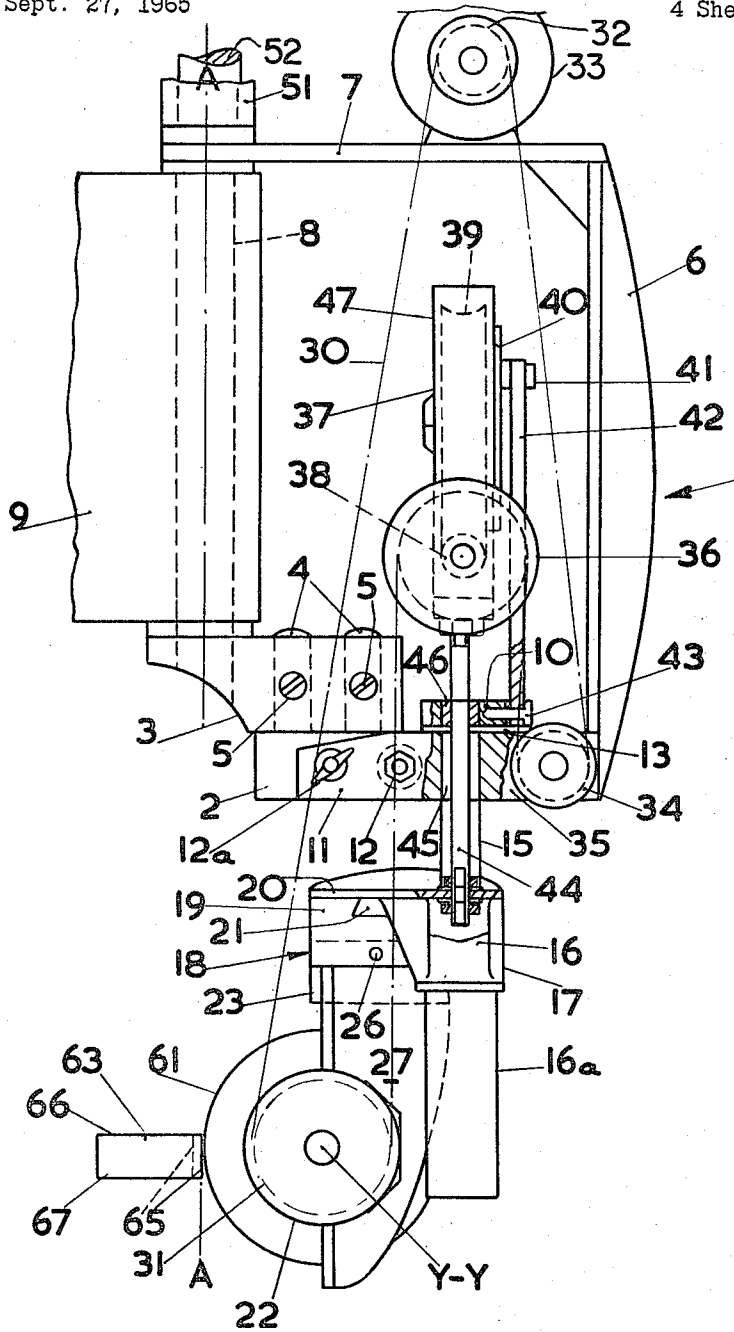


FIG. 3.

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4 Sheets-Sheet 4

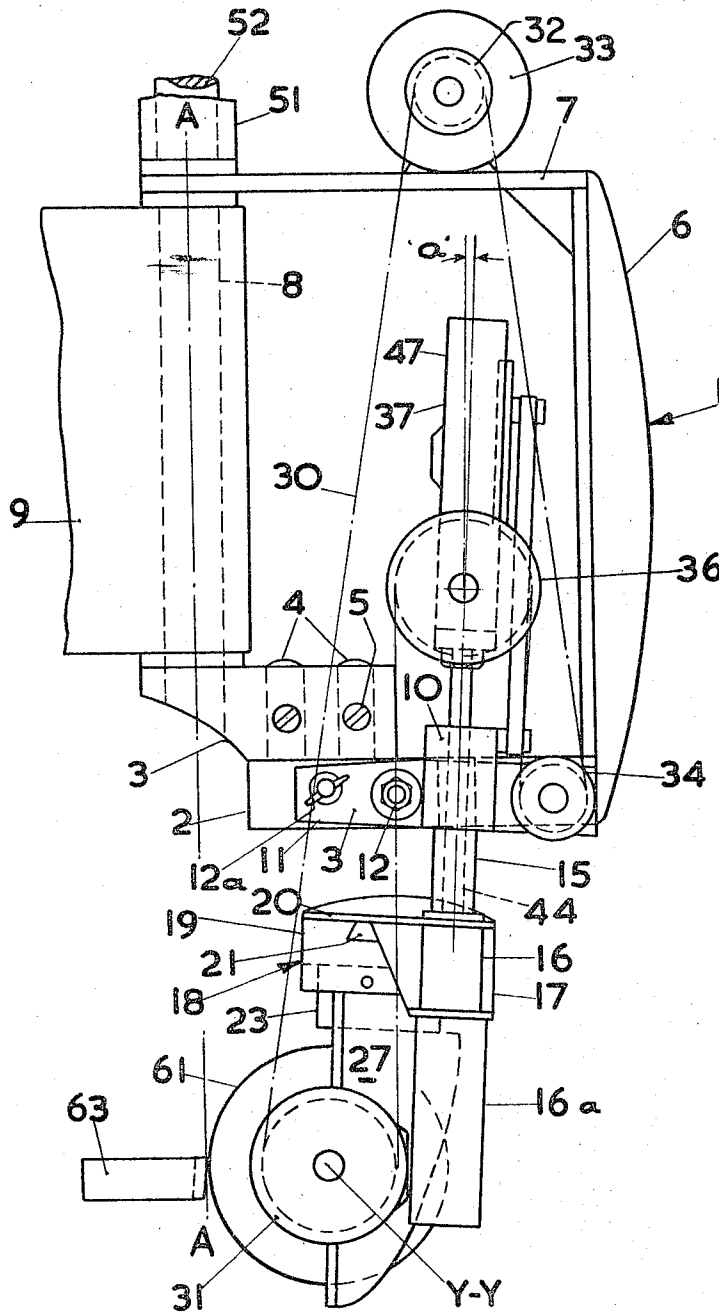


FIG. 4.

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1

3,308,720

PROFILE FORMING APPARATUS

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Claims priority, application Great Britain, Nov. 20, 1964, 47,368/64

8 Claims. (Cl. 90—13.1)

This invention relates to profile forming apparatus for forming profiles on workpieces and more particularly, but not exclusively, it relates to profile forming apparatus for the form grinding of profiles having clearance angles upon workpieces such as, for example, metal blanking dies.

The form grinding of workpieces is now well established. In one method of form grinding, a workpiece is mounted upon apparatus with a surface which is to be provided with a desired ground profile, in engagement with the periphery of a grinding wheel which has been dressed to an acute angle. The grinding wheel is mounted within a wheel housing which is connected by a pantograph device with a stylus so that movement of the grinding wheel is controlled by movement of the stylus. By moving the stylus around the profile of a template form, the grinding wheel is caused to reproduce a similar, but smaller, profile upon the surface of the workpiece, in accordance with the mechanical advantage of the pantograph device. The stylus is pivotal about its point of contact with the template and the grinding wheel is pivotal about a pivotal axis which lies tangential to the periphery of the wheel at its point of contact with the workpiece. A parallelogram linkage connects the stylus with the grinding wheel housing so that pivotal movement of the stylus about its point of contact produces a corresponding pivotal movement of the grinding wheel about its pivotal axis to assist the wheel in following the desired ground profile. In cases where it is desired that a ground profile is required having a clearance angle, the workpiece is set in the apparatus at that angle with respect to the pivotal axis of the grinding wheel. However, although this apparatus produces a clearance angle, it cannot produce a constant clearance angle around a complicated profile.

Furthermore, a land of constant width cannot be obtained around the profile unless the workpiece is set up in different positions during grinding and separate grinding operations are carried out at different parts of the workpiece after each set up of the workpiece. This method of grinding is, therefore, very time consuming.

In an alternative known method of form grinding, the template and workpiece are reciprocated vertically in unison, the stylus and grinding wheel being connected together by a pantograph device and parallelogram linkage as described above and also being operably connected to reciprocate together in horizontal planes. The end of the stylus provided for engagement with the profile of the template is formed at an acute angle to the horizontal plane whereby vertical reciprocatory movement of the template effects reciprocatory horizontal movement of the stylus. This horizontal movement is imparted to the grinding wheel during vertical reciprocation of the workpiece so that a constant clearance angle equal to the acute angle of the stylus end is provided around the ground profile of the workpiece. The performance of this method is, however, only possible upon high cost specialised machines.

According to the present invention, profile forming apparatus comprises a tool holder, a tool holder support and guide means to allow for reciprocal movement of the tool holder relative to the support, and in which the tool

2

holder has holding means for rotatably holding a rotary cutting tool with its rotational axis located in a predetermined fixed location and extending in a predetermined direction relative to the holder, the tool holder is pivotal about an axis which extends in a direction normal to said predetermined direction, and the guide means, in any desired pivotal position of the tool holder, permits reciprocal movement of the holder, relative to its pivotal axis, along a path which lies in a plane containing the pivotal axis and which extends in a direction at an angle to the direction of the pivotal axis so that reciprocation of the tool holder along said path effects movement of the predetermined fixed location of the axis of a cutting tool towards and away from said pivotal axis.

A rotary cutting tool for use in apparatus as defined in the last preceding paragraph is preferably a grinding wheel but may alternatively be a milling cutter.

Preferably, the guide means is adjustable relative to the support to alter the angle between the direction of the path of reciprocation of the tool holder and the direction of the pivotal axis. Preferably also, the guide means is adjustable relative to the support to adjust the path of reciprocation of the tool holder between its position in which it extends in a direction at an angle to the direction of the pivotal axis and another position, in which it extends in a direction parallel to the direction of the pivotal axis with the predetermined fixed location of the rotational axis of the tool disposed a constant distance from the pivotal axis of the tool holder, and during part at least of the reciprocal movement of the tool holder when the path of reciprocation extends in the direction at an angle to the direction of the pivotal axis, the distance measured between the pivotal axis and the predetermined fixed location varies between a measurement substantially equal to, and a measurement less than, said constant distance.

In addition, in a preferred construction, a pantograph and parallelogram-linkage device, operable by a stylus, is provided to control movement together of the tool holder and its pivotal axis relative to the stylus and pivotal movement of the tool holder around its pivotal axis so that when a rotary cutting tool is provided in the tool holder, a predetermined profile may be formed on a workpiece held in engagement with the peripheral surface of the tool by movement of the stylus around a template with a part of the stylus in engagement with the template.

The invention also includes a workpiece provided with a profile by the use of apparatus according to any of the preceding claims.

One embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a perspective view of part of a profile forming apparatus;

FIGURE 2 is a perspective view of the part of the apparatus of FIGURE 1, but on a smaller scale than in FIGURE 1, showing the apparatus provided with a pantograph and parallelogram-linkage device which is shown diagrammatically;

FIGURE 3 is a side elevational view, partly in cross-section, of the apparatus, in the direction of arrow III in FIGURE 1, showing a drive means for the apparatus, and illustrating the apparatus set-up for grinding a desired profile on a workpiece with zero clearance angle;

FIGURE 4 is a side elevational view of the apparatus showing the apparatus setup for grinding the workpiece to provide the profile with a clearance angle;

FIGURE 5 is a side elevational view of the finished workpiece showing the final profile having a land and clearance angle;

FIGURE 6 is a plan view of the finished workpiece shown in FIGURE 5.

3

Referring to FIGURES 3 and 4 of the drawings, a profile forming apparatus incorporates a rigid tool holder support 1 comprising a block 2 located in a desired position against a block holder 3 of the support by dowel pins 4, secured adjacent to one end of the block, screws 5 securing the block and block holder together. The support also comprises a vertical brace 6, which is secured at its lower end to the end of block 2 remote from dowel pins 4 and carries, at its upper end, one end of a horizontal platform 7 of the support. A vertical shaft 8 extends between and is secured within the block holder and within the other end of platform 7. Between its ends, the shaft 8 is pivotal within one end of a link 9 of a pantograph and parallelogram-linkage device (to be described) so that the whole of the tool holder support and the parts of the apparatus which it carries (now to be described) is pivotal about the axis A—A of the shaft.

As shown in FIGURES 2, 3 and 4, but more particularly in FIGURE 1, a bridge member 10 of inverted U-shape, straddles the upper surface of the block substantially midway between the ends of the block. Integral side arms 11 of the bridge member extend along the sides of the block 2 towards one end thereof, and the bridge member is pivotally mounted upon a horizontal spindle 12 projecting from the sides of the block and through the side arms, so that the bridge member is pivotal about the spindle in a plane containing the pivotal axis A—A. A gap 13 (FIGURE 3) is provided between the bridge member and the upper surface of the block to allow for pivotal movement of the bridge member. The bridge member may be locked in any desired angular position by wing nuts 12a on studs 12b which extend through arcuate slots (not shown) in arms 11 and into the block 2.

As is particularly shown in FIGURE 1, at each side of the block 2, the bridge member 10 is provided with a lug 14. A tool holder guide means is provided comprising two parallel cylindrical guide bars 15, each bar having an upper end secured within a lug 14 and depending from the lug. As is shown by a comparison between FIGURES 3 and 4, the bridge member is adjustable from a position (FIGURE 3) in which the bars 15 lie parallel to the pivotal axis A—A, into any desired position (limited by the amount of gap 13) in which the bars 15 extend at an angle to the pivotal axis (FIGURE 4). The tool holder guide means also comprises two sleeves 16 slidably mounted one upon each bar 15, and a prefabricated plate structure 17 which bridges the gap between the two sleeves 16 and is welded to each sleeve. Dust caps 16a, forming a coaxial extension of sleeves 16, shroud the lower parts of the bars 15.

A tool holder 18 (FIGURES 1, 3 and 4) comprises a first carriage 19 which is horizontally slidably carried beneath a flat bridge portion 20 of the structure 17 by a dovetail guide rail 21 secured to the bridge portion. The tool holder is, therefore, slidably movable alternatively away from one sleeve 16 and towards the other sleeve to adjust its position as will be described. A fixing screw (not shown) is received in screw-threaded engagement with a bore 22 (FIGURE 1) in the carriage 19 for operation to engage the rail 21 to releasably secure the carriage in position upon the rail.

A second carriage 23 of the tool holder is horizontally slidably mounted beneath the carriage 19 by means of a dovetail guide rail 24, formed integrally with the carriage 23 and received within a complementary shaped groove 25 in the carriage 19. The carriage 23 is slidable relative to carriage 19 in a direction normal to that in which the carriage 19 is movable relative to the plate structure 17. A fixing screw (not shown), received in screw-threaded engagement with bore 26 of carriage 19, is provided to releasably secure carriage 23 upon carriage 19.

The tool holder also comprises holding means for a rotary cutting tool. This holding means includes two parallel spaced-apart brackets 27, welded to the carriage

4

23. Each bracket 27 comprises a diametrically-split bearing housing 28, of which a detachable bearing cap 29 is detachably held in position, in known manner, by bolts (not shown) to releasably hold a bearing for the rotary cutting tool. The two housings 28 of the brackets are disposed so that they will rotatably carry a rotary cutting tool with its rotational axis Y—Y in a predetermined fixed location and extending in a predetermined direction relative to the holder as shown in FIGURE 1. As may be seen from FIGURES 3 and 4, in which the axis Y—Y lies normal to the plane of the drawing, the pivotal axis A—A extends in a direction normal to the predetermined direction of axis Y—Y.

The apparatus is also provided with an endless drive means for rotating a cutting tool. As shown in FIGURES 3 and 4, this drive comprises an endless drive belt 30 which extends around a pulley wheel 31, rotatably mounted within one of the bearings held by a housing 28 with its rotational axis coincident with the predetermined fixed position of axis Y—Y. The belt also extends around a pulley wheel 32 which is driven by an electric drive motor 33, carried by the platform 7, around pulley wheel 34 which is rotatably mounted upon an extension 35 of the bridge member 10, and around another pulley wheel 36.

Means are provided for reciprocating the tool holder relative to the support by sliding movement of the sleeves 16 along bars 15. This reciprocating means comprises a gear mechanism which consists of a worm and worm-wheel speed reduction unit 37 having a worm 38 and wormwheel 39. A circular disc 40 secured coaxially to the wormwheel shaft carries, at an eccentric position, a shouldered pin 41 to which is pivotally mounted one end of a connecting rod 42, the other end of which is pivotally mounted upon the bridge member 10 by means of pin 43. The pulley wheel 36 is secured, coaxially with respect to the worm 38, to an extension of the worm to drivably connect the endless drive means to the reciprocating means. Rotation of the pulley wheel 36 by the endless belt causes the reduction unit to reciprocate in a direction parallel to the bars 15 by virtue of the coupling of the unit to the rod 42, and also by virtue of which, reciprocation is effected with simple harmonic motion. The reciprocation is imparted to the tool holder by means of a rigid connection bar 44 which passes through a clearance hole 45 (FIGURE 3) in the block 2 and is slidable within a bush 46 of the bridge member 10, the ends of the connection bar being secured, one to the casing 47 of the reduction unit 37 and the other to the flat bridge portion 20 of the plate structure 17. The clearance hole 45 is sufficiently large to allow for pivoting of the bridge member, and thus the connection bar, upon the block 2 to provide the maximum angle which may be required between the bars 15 and the pivotal axis A—A.

The pantograph and parallelogram-linkage device 48, of which link 9 forms a part, is shown in FIGURE 2. The device 48 is shown diagrammatically only, for purposes of clarity, whereas, in practice, the links of the device would have a substantial depth to provide rigidity as is illustrated for link 9 in FIGURES 3 and 4. In these figures, the link 9 extends for substantially the whole of the distance between the platform 7 and block holder 3.

As shown in FIGURE 2, the device 48 comprises a link 51 one end of which is secured to an extension 52 of the shaft 8 (FIGURES 3 and 4). The other end of link 51 is pivoted to one end of a link 53 which lies parallel to link 9, the other end of link 53 being pivoted to one arm of a bell crank lever 54 which is also pivoted to the link 9. Parallel links 55 and 56 are pivoted each by one end, respectively, to the other arm of the bell crank lever and to the pivotal connection of the link 9 with the bell crank lever. The other ends of the links 55 and 56 are pivoted to a stylus arm 57 carrying a stylus (not shown), an end of which is provided for engagement with the profile of a template in known manner, this end of the stylus lying

on the axis of the pivotal connection between the arm 57 and link 56.

The remainder of the device 48 comprises a link 58 and link 59 which are pivoted to one another and also, respectively, to the links 9 and 56 so that the link 58 lies parallel to link 56 and link 59 lies parallel to link 9. Means, such as a pin or screw-threaded means (not shown), is provided at point 60 on link 58 to provide a fixed pivot point for the device 48 when mounted upon a machine.

Angular movement of the stylus about the pivotal connection of links 56 and 57, is faithfully reproduced in the shaft 8 about pivotal axis A—A through the links 51, 53 and 55 and lever 54, while the links 9 and 56 remain stationary, so that all of these parts of the device constitute a parallelogram-linkage. Movement of the stylus about pivot point 60 is transmitted by movement of the links 56, 59, 58 and 9 to move the shaft 8 and the tool holder in a controlled manner also relative to point 60, the amount of movement of the shaft 8 being dependent upon the mechanical advantage of the device 48. The links 56, 59, 58 and 9, therefore, constitute a pantograph-linkage of the device, the links 9 and 56 being common to both linkages.

In use of the apparatus, it is mounted at its pivot point 60 on the head of a surface grinding machine (not shown). A resinoid bonded diamond rotary grinding wheel 61, having its periphery preformed with a nose to an inclusive angle of 30° and a nose radius of .005 inch, is rotatably mounted within the bearings and located between the housings 28 so that the pivotal axis Y—Y is in the predetermined fixed position as described above, the wheel 61 being drivably connected to pulley wheel 31. With the guide bars 15 located parallel to pivotal axis A—A as shown in FIGURE 3, the carriages 19 and 23 of the tool holder are then adjusted in position upon the guide rails 21 and 24 until the pivotal axis A—A lies at a tangent to the grinding wheel at the part of the wheel periphery for engagement with a workpiece (see FIGURE 3), this position being checked by a dial indicator in known manner. The vertical positioning of the guide bars to make them parallel to axis A—A may also be checked by a dial indicator instrument. As shown in FIGURE 2, a template 62 is set-up in the machine for co-operation with the stylus, and a workpiece 63 is located and held in a desired position upon a magnetic chuck (not shown) of the machine for a first profile grinding operation.

The electric motor 33 is then energized to drive the endless belt 30 so as simultaneously to rotate the grinding wheel and reciprocate the tool holder in the manner described above. The stylus is then moved along and in engagement with the profile 64 of the template. During this movement, whilst moving over any curved portion of the profile, the stylus is held in a position substantially normal to a tangent at its point of engagement with the curve by pivoting the stylus arm 57 about the pivotal axis of its connection to link 56. Also, if the stylus moves along a rectilinear part of the profile of the template, it is pivoted to orientate it into a position in which it lies normal to that part of the profile.

The movement of the stylus around the template is transmitted by the device 48 to the tool holder support 1, to move the grinding wheel 61 relative to the workpiece and perform a cutting operation to produce the desired ground profile 65 on the workpiece (FIGURE 5). During grinding, the tool holder and its support are caused to pivot about the pivotal axis A—A by pivoting of stylus arm 57 so that the grinding wheel always lies in a position substantially normal to a rectilinear part, or substantially normal to a tangent of any curved part of the desired profile which is being ground at any instant. Also during grinding, the grinding wheel is reciprocated vertically in a plane containing the pivotal axis A—A, with the point of its surface in engagement with the workpiece lying so that the pivotal axis A—A is at a tangent to the

surface at this point, the rotational axis Y—Y of the wheel, therefore, being disposed a constant distance from axis A—A. At the end of this first grinding operation, the ground profile 65 extends normal to both upper and lower surfaces 66 and 67 of the workpiece (FIGURE 3).

It is now required, on a second grinding operation, to provide the profile with a clearance angle α (FIGURE 5) which is constant at any section of the workpiece taken normal to the point of the profile through which the section extends. After de-energisation of motor 33, the wing-nuts 12a are loosened to allow for pivotal movement of the bridge member 10 upon the block 2. The bridge member is then pivoted until in side elevation, as shown in FIGURE 4, the guide bars 15 extend in a direction at the required angle α to the direction of the pivotal axis. The bridge member is then re-locked in position. Because the bars 15 now extend at angle α to the pivotal axis A—A, during reciprocation of the tool holder the grinding wheel will be moving in a direction at angle α to the pivotal axis so that the pivotal axis will only form a tangent to the surface of the grinding wheel at one position of its reciprocation. During the forming of the clearance angle on the profile, it is also necessary to ensure that a land 68 (FIGURE 5) of the profile is provided at a predetermined depth l . To ensure this, it is necessary to adjust the position of carriage 23 until the pivotal axis A—A forms a tangent to the grinding wheel at such a vertical position of the wheel relative to the workpiece that the land 68 is provided with its predetermined depth. This adjustment is easily effected by persons skilled in the art.

After re-energisation of the motor, the second grinding operation then takes place in a manner similar to that described for the first operation, except that, during grinding and for any pivotal position of the tool holder relative to the pivotal axis A—A, the tool holder and the grinding wheel move along a path lying in a plane containing the pivotal axis A—A and extending in a direction at an angle α to the pivotal axis.

During the second grinding operation, grinding of an inclined portion 69 of the profile (FIGURE 5) takes place during reciprocatory movement of the grinding wheel between positions in which the axis Y—Y lies at a distance from the pivotal axis which is substantially equal to and a distance less than the constant distance mentioned for the first grinding operation.

Also during the second grinding operation, so long as the grinding wheel is always controlled to lie in a position either substantially normal to a rectilinear part or substantially normal to a tangent of any curved part of the desired profile which is being ground at any instant, then the inclined portion 69 of the profile will be formed at the constant clearance angle α and the land 68 with its constant depth l .

In a modification of the above described apparatus, the grinding wheel is rotated by an independent drive and reciprocation of the wheel is effected by hydraulic or pneumatic means.

In the event that a grinding wheel or other rotary cutting tool is required of different diameter from that of wheel 61, the carriage 23 may be adjusted upon carriage 19 to adjust the constant distance between the predetermined fixed location of the axis Y—Y and pivotal axis A—A.

The apparatus in the embodiment described above is cheaper than the previously known highly specialised machines which also provide a constant clearance angle on a profile of a workpiece. Moreover, the apparatus described above is, in effect, an attachment which may be fitted to a conventional workshop surface grinding machine to provide constant clearance angles upon workpieces, whereas in the normal use of such a machine, the provision of a constant clearance angle is impossible.

We claim:

1. Profile forming apparatus comprising a tool holder,

a tool holder support, guide means carrying the tool holder and by means of which the tool holder is movable in a reciprocable manner upon the tool holder support, and reciprocating means operably connected to the tool holder for reciprocating it relative to the support, and in which the tool holder has rotary cutting tool holding means for rotatably holding a rotary cutting tool with its rotational axis located in a predetermined fixed location and extending in a predetermined direction relative to the tool holder, at least the tool holder and guide means have a pivotal axis about which they are pivotable and which extends in a direction normal to said predetermined direction of the cutting tool axis, and, in any desired pivotal position and during pivotal movement of the tool holder and guide means relative to the pivotal axis, the tool holder is reciprocably movable by the reciprocating means, upon the guide means and relative to the tool holder support, along a path which lies in a plane containing the pivotal axis and which extends in a direction at an angle to the direction of the pivotal axis and also at an angle to a plane lying normal to the direction of the pivotal axis.

2. Apparatus according to claim 1 wherein the guide means is adjustable in position upon the tool holder support to alter the angle between the direction of the path of reciprocation of the tool holder and the direction of the pivotal axis, and locking means are provided for releasably holding the guide means in any desired position of adjustment upon the tool holder support.

3. Apparatus according to claim 1 wherein the guide means is adjustably mounted upon the tool holder support to adjust the path of reciprocation of the tool holder between its position, in which it extends in a direction at an angle to the direction of the pivotal axis, and another position, in which it extends in a direction parallel to the direction of the pivotal axis with the predetermined fixed location of the rotational axis of the tool disposed a constant distance from the pivotal axis of the tool holder, and during part at least of the reciprocal movement of the tool holder when the path of reciprocation extends in the direction at an angle to the direction of the pivotal axis, the distance measured between the pivotal axis and the predetermined fixed location varies between a measurement substantially equal to and a measurement

less than, said constant distance, and locking means are provided for releasably holding the guide means in any desired position of adjustment upon the tool holder support.

4. Apparatus according to claim 3 wherein adjusting means are associated with the holding means by which the holding means is adjustable in position upon the tool holder and relative to the pivotal axis to adjust the position of the predetermined fixed location of the rotational axis of a tool relative to the pivotal axis and alter said constant distance.

5. Apparatus according to claim 1 wherein a gear mechanism reciprocating means is operably connected to the tool holder for reciprocating the tool holder relative to the tool holder support.

6. Apparatus according to claim 5 in which the tool holder is provided with an endless drive means having connecting means for drivably connecting the drive means with a rotary cutting tool, when the tool is carried in the holding means, for rotating the tool.

7. Apparatus according to claim 6 wherein the endless drive means is also drivably connected to the reciprocating means for the tool holder.

8. Apparatus according to claim 1 and including a pantograph and parallelogram linkage device operably connected to the tool holder for moving the tool holder about its pivotal axis in response to movements of a stylus carried by said device, said device being operable upon movement of the stylus to move and control movement of the tool holder and its pivotal axis relative to the stylus and to pivotally move the tool holder around its pivotal axis by an amount determined by the amount of movement of the stylus.

References Cited by the Examiner

UNITED STATES PATENTS

2,074,844	3/1937	Hill	90—15
2,498,012	2/1950	Sjostrand	51—100 X
2,708,815	5/1955	Studer	51—100

FOREIGN PATENTS

907,027	3/1954	Germany.
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