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G. STARK ET AL

3,489,671

DEVICE FOR ELECTROCHEMICAL FORMING OF RECESSES, PROJECTIONS
OR THE LIKE CONTOURS ON WORKPIECES

Filed Oct. 2, 1967

3 Sheets-Sheet 1

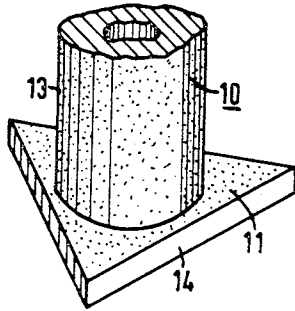


Fig. 1a

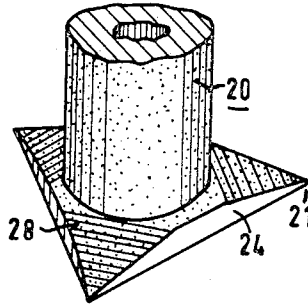


Fig. 2a

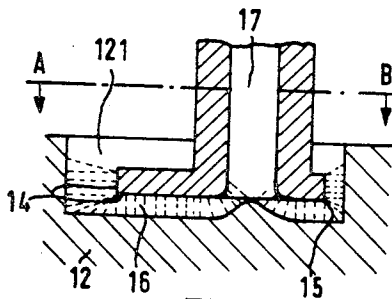


Fig. 1b

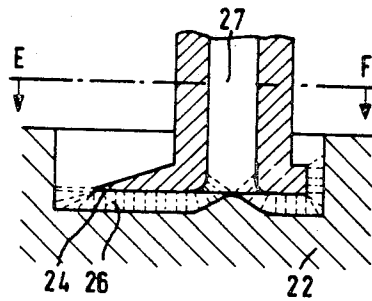


Fig. 2b

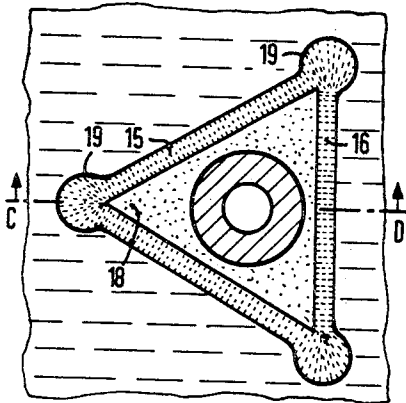


Fig. 1c

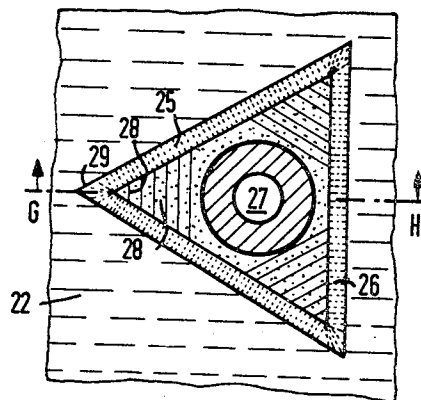


Fig. 2c

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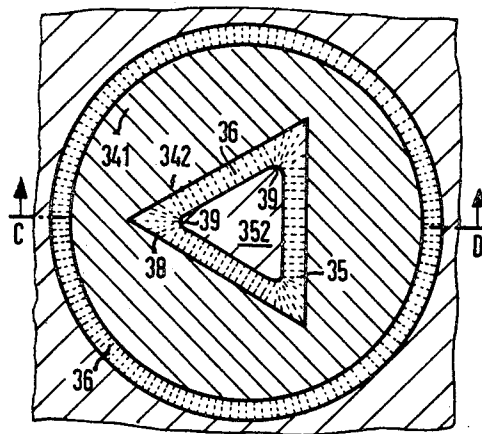
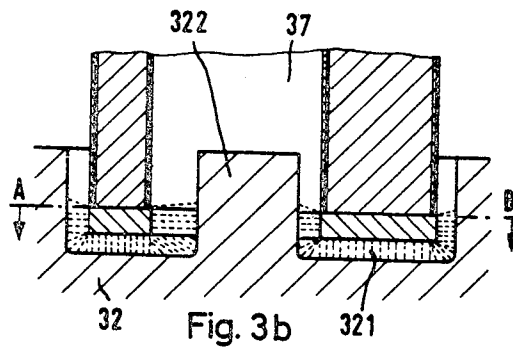
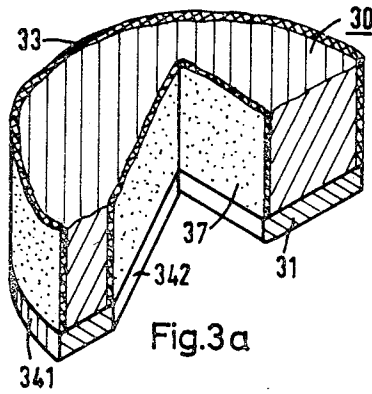
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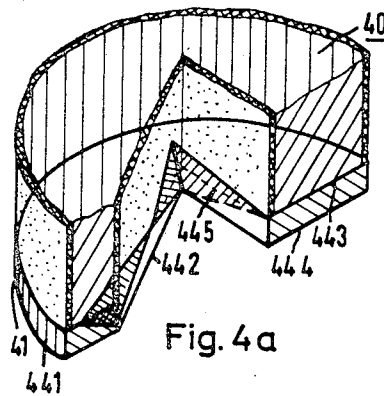


Fig. 4a

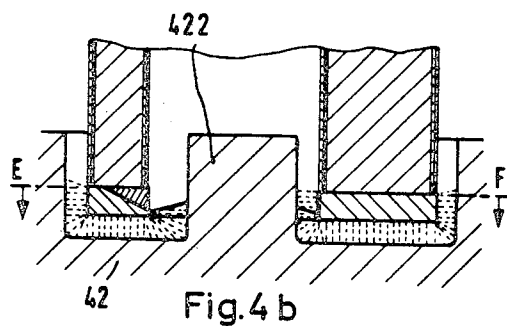


Fig. 4b

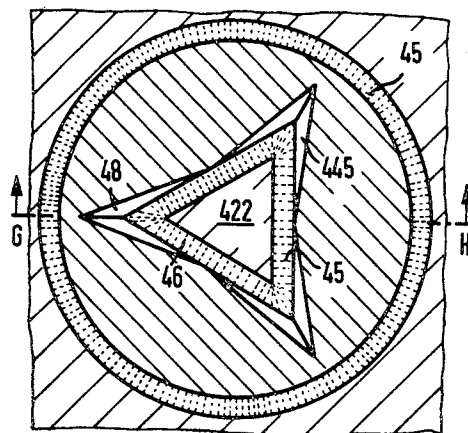


Fig. 4c

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DEVICE FOR ELECTROCHEMICAL FORMING OF RECESSES, PROJECTIONS OR THE LIKE CONTOURS ON WORKPIECES

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6 Claims

ABSTRACT OF THE DISCLOSURE

The cathodic tool electrode used for electrolytically producing recesses, projections or other contours on anodically connected workpieces has a foot whose base contour determines the desired profile of the workpiece. The electrode foot, during use of the device, forms with the workpiece a perimetric gap which is traversed by a flow of electrolyte for removing material from the workpiece, thus converting its contour to an image of the electrode-foot contour. To secure a sharp image at the corners or edges of the contour, the effective current-outflow areas of the electrode foot are reduced at the corner localities as compared with the outflow areas elsewhere along the foot perimetric contour. This is done, without interrupting or otherwise affecting the accurate contour shape of the foot base, by tapering the height of the foot structure toward the corner localities or by covering the lateral areas close to the corner localities with insulating varnish or a metallic deposition that polarizes cathodically more strongly than the bulk of the foot material.

Our invention relates to the production of contours or profiles on workpieces by electrolysis with the aid of a cathodic template or die electrode which is shaped in accordance with the desired contour and which is moved relative to the workpiece to be shaped. During forming operation the cathodic tool electrode forms a perimetric gap with the anodically connected workpiece, and a flow of electrolyte is continuously passed through the gap.

Known for such electrochemical forming purposes are tool electrodes of various cross-sectional shapes, for example triangular, rectangular or round shape. Generally an aqueous electrolyte solution is supplied through the hollow workpiece into the active gap, and the current densities are maintained 2 to 3 orders of magnitude higher than in conventional galvano-techniques such as electroplating processes. Due to carrier-exchange phenomena, the electrochemical action of the electrolyte dissolves the material in accordance with the feed travel workpiece of the tool. It has been found, however, that when using tool electrodes with corner or edge profiles, an increased removal of material will occur at the corresponding corners and edges of the workpiece, due to the increase in current density at the points and edges formed by the tool contour.

It is an object of our invention to provide a device for the electrochemical forming of recesses, projections or the like contours on metallic workpieces that obviates the just mentioned difficulties and secures a more accurate shaping of the workpiece at corners or recesses without unduly reducing the useful life of the equipment.

A device according to the invention for the electrochemical forming of metallic workpieces is equipped with a cathodic tool electrode designed either as a positive die (full cross section) or as a negative die (hollow cross section) and composed of an electrode shank and an electrode foot joined with the shank; and the electrode

foot has a profile-determining base surface whose perimetric contour corresponds to that to be produced on the workpiece and has corners or points protruding outwardly or tapering inwardly at an acute angle. It is an essential requirement of the invention that at such corner localities the electrode foot is given a reduced effective current-outflow area as compared with corresponding areas elsewhere along the perimeter, and that the reduction in effective outflow area leaves the profile-determining base contour of the electrode foot completely undisturbed. In other words, the reduction in effective current-outflow area at the corner points of the electrode foot is not brought about by cutting any recesses into the contour or changing in any other way the shape of this contour at the base surface of the electrode foot.

With reference to an electrode foot which moves as a plunger in a direction perpendicular to the workpiece top surface and into a hollow of the workpiece or around the workpiece, it is particularly advantageous to provide for the above-mentioned reduction in effective current-outflow area at the corner points, by giving the thickness (axial height) of the electrode foot a shape tapering toward the corner points. That is, in such a device the electrode foot has a larger thickness at the straight or smoothly round contour portions than at the corners or points where the foot is bevelled toward the corner points.

Another way of reducing the effective area of the current outflow at the electrode foot is to cover the foot near the corner localities with insulating material preferably insulating varnish such as epoxide resin. Another way of reducing the effective outflow area is to deposit upon the electrode foot a conducting layer of metal that polarizes cathodically more strongly than the cathode material proper. For example, a coating of lead may be galvanically deposited upon the corner regions of the electrode foot.

The invention will be further described with reference to embodiments illustrated by way of example on the accompanying drawings in which:

FIG. 1a shows perspective a tool electrode having an electrode foot of uniform thickness; FIG. 1b is a vertical section through the same electrode, showing it during its use, the section being along the line C-D in FIG. 1c; and FIG. 1c is a horizontal section along the line A-B in FIG. 1b.

FIGS. 2a, 2b and 2c illustrate by respective representations corresponding to those of FIGS. 1a, 1b and 1c, a forming tool whose electrode foot also has a triangular base shape but whose corners are tapered in accordance with the present invention. The section shown in FIG. 2c is along the line E-F in FIG. 2b, and the section shown in FIG. 2b is along the line G-H in FIG. 2c.

FIG. 3a is a perspective and sectional view of another tool electrode, only the electrode foot being shown; FIG. 3b is a vertical section of the same electrode foot during operation, the section being along the line C-D in FIG. 3c; and FIG. 3c is a horizontal section of the same tool along the line A-B in FIG. 3b.

FIG. 4a is a perspective and sectional view of a tool electrode similar to that of FIG. 3a but embodying the present invention for securing sharp corners at the workpiece; FIG. 4b is a vertical section through the same tool, the section being along the line G-H in FIG. 4c; and FIG. 4c is a horizontal section along the line E-F in FIG. 4b.

The tool electrode 10 shown in FIGS. 1a, 1b and 1c is provided with a prismatic foot 11 having a triangular base surface. The foot is coaxially mounted on a tubular shank. The surface areas of the electrode remote from the workpiece or facing away therefrom are coated with an insulating jacket 13 so that the electric current passes

only through the exposed current-outflow areas 14 from the cathodic electrode to the workpiece 12, this being indicated by current flow lines 15. The resulting electrolysis causes material to be dissolved and removed from the workpiece 12 so that a recess 121 is produced therein. During operation, the aqueous electrolyte is supplied through the central duct 17 in the shank of the electrode 10 and passes at high speed through the machining gap 16 between the electrode 10 and the workpiece 12, thus also providing for the required cooling and the replenishing of electric charge carriers. At the corner regions 18 of the current-outflow areas 14 there occurs a locally limited increase in current density, this being particularly apparent from FIG. 1c. The increased density increases the removal of material and thus causes an unsharp imaging at 19 manifested by widening of corners and rounding of edges in the workpiece.

Such an unsharp forming is avoided by virtue of an electrode according to the invention as shown in FIGS. 2a, 2b and 2c. The individual items in these illustrations, are denoted by reference numerals whose last digit is identical with the last digit of the numeral applied to the functionally corresponding item in FIGS. 1a to 1c. The corner region 28 of the electrode foot 21 tapers toward the corner point, thus reducing the current outflow areas 24 at these points. In this manner a substantially uniform distribution of the current flow lines in the machining gap 26 between the workpiece 32 and the electrode foot 24 can be obtained, so that the corner and edge region 29 obtains the desired sharp contour shape according to FIG. 2c.

The electrode foot 31 of the electrode 30 shown in FIGS. 3a, 3b, 3c has outer circular current-outflow areas 341 as well as inwardly directed current-outflow areas 342 which form a triangular hollow. When the electrode 30 is moved toward and into the workpiece 32, it electrolytically produces corresponding recesses 321 and a triangular column 322. The shaped surface of the tool is coated at 33 with insulating material. The electrolyte is supplied through the central hollow 37. As will be seen from the flow lines 35 indicated in the machining gap 36 between electrode 30 and workpiece 32, there occurs a considerable crowding of the flow lines in the corner region 38 within the gap 36 so that an increased removal of material takes place at the edges 39 of the triangular column 322 whereby the edges of this column become undesirably rounded.

Such an unsharp imaging is avoided by the tool electrode according to the invention shown in FIGS. 4a to 4c. The current-outflow areas 442 of the electrode foot 41 are so shaped that the upper plane 443 of the electrode foot 41 is widened in the corner region 48, this being best apparent from FIG. 4c. The lower plane 444 of the electrode foot 41, however, retains the original triangular shape of the base surface. The widened profile of the plane 443 is joined with the original triangular base plane 444 by sloping transition areas 445. This shape of the inner current outflow areas 442 secures a substantially uniform current density as indicated by flow

lines 45 in the internal machining gap 46, and thus secures sharp corners at the triangular column 422.

By virtue of the fact that the invention avoids any interruption of the electrode base configuration such as by slots or recesses, the useful lifetime of the tool is prolonged and trouble due to a clogging of such slots or recesses with conductive material is avoided.

To those skilled in the art it will be apparent from a study of this disclosure that our invention permits of various modifications with respect to design and sharp of the electrochemical tool electrodes and hence may be given embodiments other than particularly illustrated and described herein, without departing from the essential features of the invention and within the scope of the claims annexed hereto.

We claim:

1. Device for electrochemical forming of recesses, projections or the like contours on metallic workpieces, comprising a cathodic tool electrode having an electrode shank and an electrode foot joined with said shank, said electrode foot having a profile-determining base surface with a perimetric contour corresponding to that to be produced on the workpiece and being adapted to form with the workpiece a perimetric gap to be traversed by electrolyte for removing material from the workpiece and converting it to an anodic image of said electrode contour, said perimetric contour of said electrode-foot base having corner localities, and said foot retaining said base-surface contour at said corner localities but having at said corner localities a reduced effective current outflow area as compared with said areas elsewhere along said contour.

2. In a device according to claim 1, said electrode foot having an axial height tapering toward said corner localities to provide for said locally reduced effective current outflow areas.

3. In a device according to claim 1, said electrode foot having an insulating coating for providing said locally reduced effective current outflow areas.

4. In a device according to claim 1, said electrode foot having at said areas of reduced effective current outflow a surface layer cathodically more strongly polarizable than the foot material proper.

5. In a device according to claim 1, said electrode foot protruding radially from said shank and having an outer perimeter of locally pointed shape.

6. In a device according to claim 1, said electrode foot having a cavity with an inner perimeter of locally pointed shape.

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