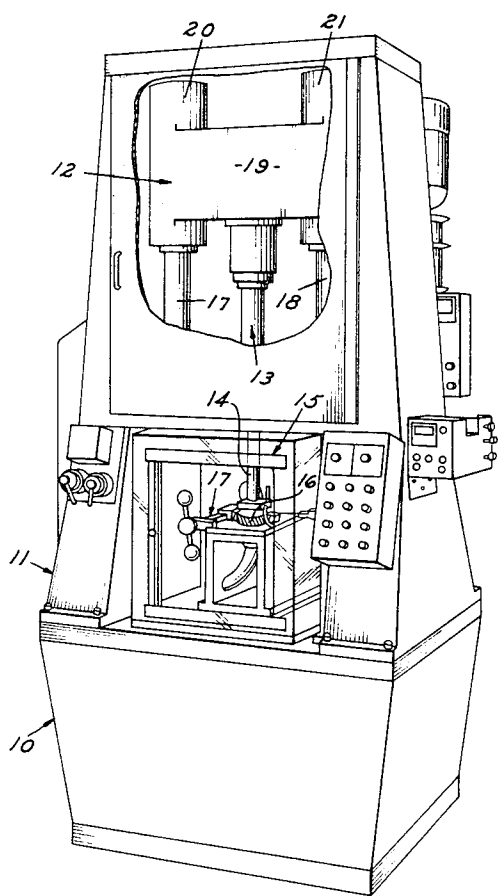


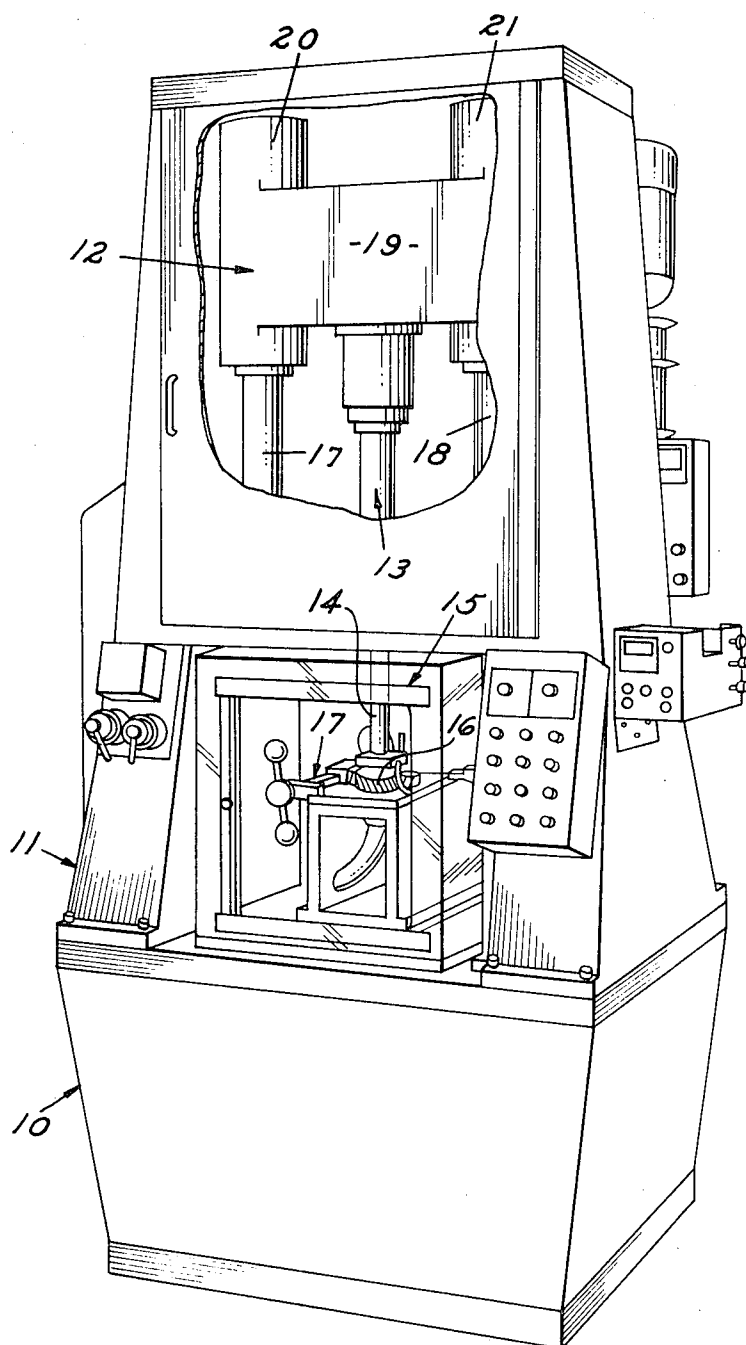
[72] Inventors **Myron P. Ellis**
Royal Oak;
Richard J. Gavasso, Detroit, both of Mich.
[21] Appl. No. **838,113**
[22] Filed **July 1, 1969**
[45] Patented **Oct. 26, 1971**
[73] Assignee **Micromatic Hone Corporation**
Detroit, Mich.

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Primary Examiner—John H. Mack
Assistant Examiner—T. Tufariello
Attorney—James H. Bower

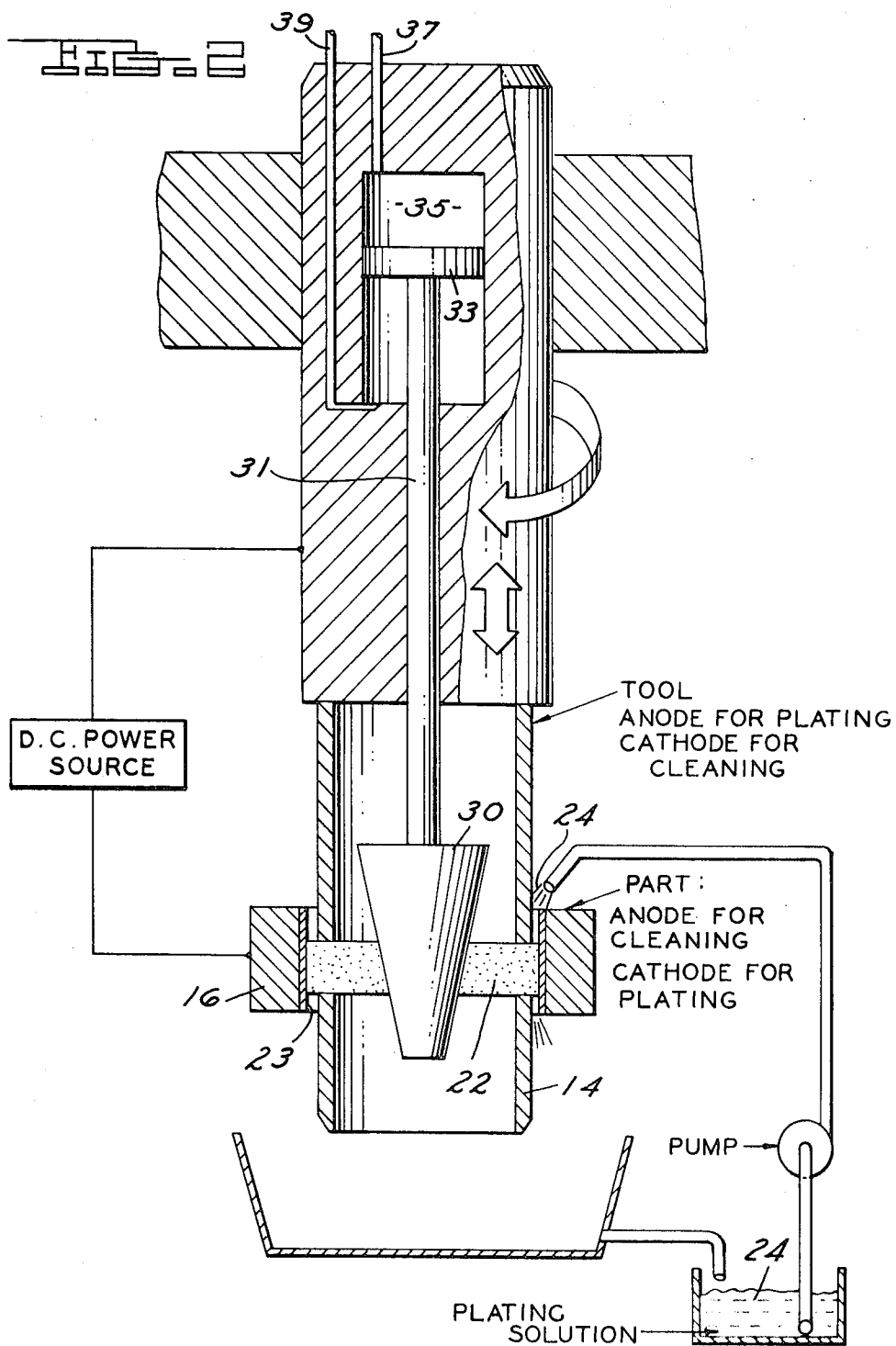
[54] **ELECTROPLATE HONING METHOD**
3 Claims, 5 Drawing Figs.
[52] U.S. Cl..... **204/26,**
204/143 G, 204/217, 204/224
[51] Int. Cl..... **C23b 5/56,**
B23p 1/00, B23p 1/02
[50] Field of Search..... **204/26,**
217, 224, 143 M, 143 G

ABSTRACT: An electroplate honing technique that utilizes electrochemical honing to clean the metallic surface of a workpiece with current flow in one direction, then with the current flow reversed, utilizes an electroplate honing cycle to plate or deposit metal on the surface of the workpiece, then finally terminating the flow of current and utilizing a honing cycle to generate the surface finish desired by mechanical abrasion.



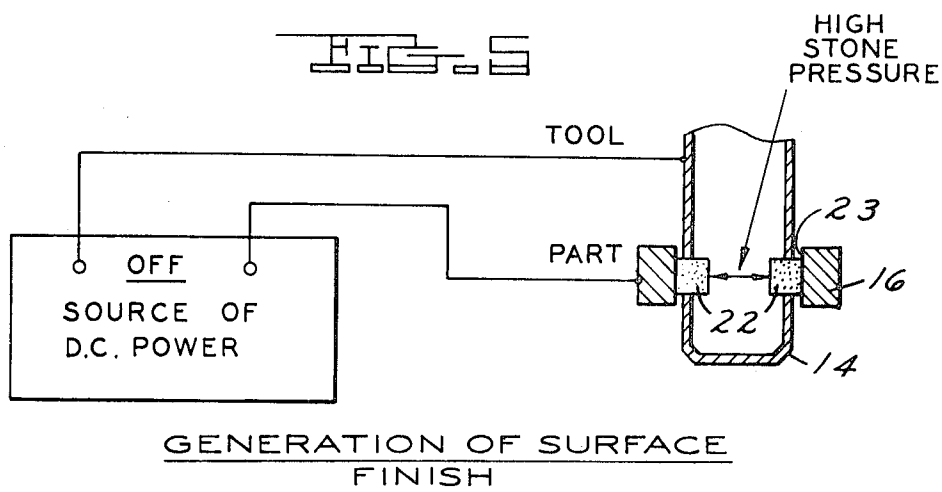
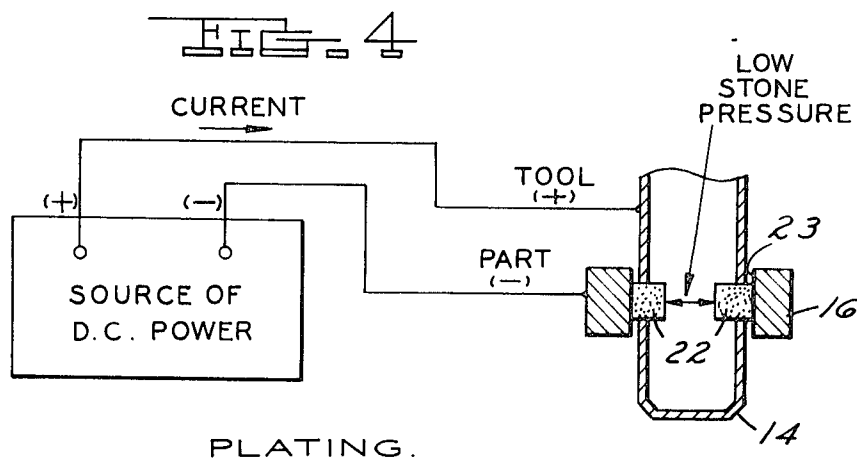
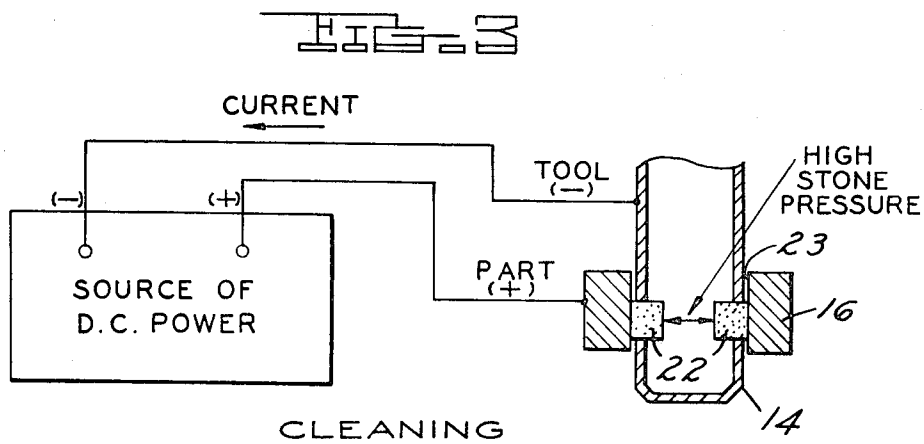


INVENTORS
MYRON P. ELLIS
RICHARD J. GAVASSO



INVENTORS
MYRON P. ELLIS
RICHARD J. GAVASSO
BY

James H. Bower
ATTORNEY



INVENTORS
MYRON P. ELLIS
RICHARD J. GAVASSO
BY

James H. Bower

ATTORNEY

ELECTROPLATE HONING METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the honing art and more particularly to an electroplate honing method whereby the surface of the metal is first cleaned by a combined electrochemical machining and honing process, then plated so that the plated surface is mechanically honed or cut to the desired surface characteristics.

2. Description of the Prior Art

It is known and recognized to utilize plating and burnishing or polishing at the same time. That is, the surface of the material is polished or burnished at the same time that the plating solution is pumped into the environmental area. Other processes involve a simultaneous burnishing and plating operation while the workpiece is immersed in a plating solution.

SUMMARY OF THE INVENTION

According to the present invention, the electroplate honing method combines the surface cleaning characteristics of electrochemical honing, the high metal deposition rate of high current density electroplating and the accurate abrading of honing. It eliminates the need for acid etching of the surface to be plated and/or the masking of adjacent surfaces. The metal is deposited only on surfaces in close proximity to the electrode. The electrode in this instance is also the honing tool.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of an electroplate honing apparatus made in accordance with the principles of the present invention;

FIG. 2 is a fragmentary perspective view of a workpiece being operated by the electroplate honing tool to illustrate the principles of the present invention;

FIG. 3 is a schematic representation of the typical plating cycle in which the surface of the workpiece is being cleaned;

FIG. 4 is a schematic representation in which the surface of the workpiece is being plated;

FIG. 5 is a schematic representation showing the surface of the workpiece being abraded without the benefit of any electroplating or electrochemical means.

GENERAL DESCRIPTION

FIG. 1 shows a perspective view of an illustrative embodiment which comprises a hollow base generally indicated by the numeral 10 on which is mounted a column generally indicated by the numeral 11. As shown, the numeral 12 generally indicates a spindle and/or ram assembly on which is operatively mounted a tool spindle generally indicated by the numeral 13. A tool member generally indicated by the numeral 14 is connected to the spindle 13. The tool member 14 extends downwardly into operative engagement with the workpiece 16 held in a workpiece fixture 17 that is disposed in a transparent fixture enclosure 15. The workpiece 16 is illustrated as comprising a gear. The honing apparatus includes means for reciprocating and rotating the tool member 14 relative to the workpiece 16 as described in detail hereinafter. The tool member 14 carried means for maintaining it in a spaced-apart position relative to the surface of the workpiece 16 which is being machined in a manner described in U.S. Pat. No. 3,390,068, issued to M. P. Ellis et al. on June 25, 1968, and assigned to the present assignee of the application. As described hereinafter, the plating solution is supplied to the gap or space between the tool 14 and the workpiece surface during the machining operation and direct current is simultaneously passed between the workpiece 16 and the tool member 14 as described hereinafter.

As shown in FIG. 1, the spindle head assembly 12 is slidably mounted for vertical reciprocating movement on a pair of vertical, spaced apart guide members 17 and 18. The spindle

head assembly 12 includes the central housing 19 on each side of which is integrally formed the vertically disposed guide sleeves 20 and 21.

The spindle head assembly 12 is adapted to be reciprocated upwardly and downwardly by a pair of hydraulic cylinders not shown but described in the hereinabove mentioned U.S. Pat. to Ellis et al., No. 3,390,068. It will be understood that the hydraulic cylinders may be operated and controlled by any suitable hydraulic controlled circuit means. An illustrative control circuit which may be employed to operate the hydraulic cylinders is shown in FIG. 51 of the hereinabove mentioned patent to Ellis et al.

The machine used is basically a honing machine such as described in the above mentioned patent. A rectifier supplies the direct current to the operation. During plating the honing tool acts as the anode, having a positive potential, and the workpiece is the cathode. The plating solution is pumped into the gap between the tool and the surface being plated.

A typical plating cycle is as follows:

1. A short deplating period, approximately 10 seconds, is used to clean the surface by an electrochemical honing process such as described in the above-mentioned patent to Ellis et al. The honing tool at this time is negative and the workpiece is positive as shown in FIG. 3. The tool is expanded so that the stones 22 are abrading the surface 23 of the workpiece 16. The plating solution is flooding the tool and the workpiece at the gap between the surface 23 of the workpiece and the tool 14.

2. At the end of this time period the direction of current flow is now reversed so that the workpiece has a negative potential as shown in FIG. 4. The pressure of the honing stones 22 is reduced. Consequently, metal is plated onto the surface uniformly at a rate depending on the solution being used, the current density, and in some cases the temperature of the solution. The stones are in a low stone pressure state thereby abrading the surface throughout the plating cycle to eliminate "treeing," refine the grain structure of the plated metal and generate accurate geometry.

3. When the bore is plated to the desired size, the flow of current is terminated and the pressure on the stones 22 is increased, as shown in FIG. 5, to generate the surface finish desired. That is, in the last stages there is no current flow between the tool and the workpiece, consequently, the only generation of surface finish is done by mechanical abrading.

Any amount of metal may be plated onto the surface that is kept clean by the honing stones. Termination of the plating may be achieved by a predetermined timing cycle or an automatic in-process gaging.

Materials Plated	Plating Rate
	Time to Deposit 0.001" Thickness
Copper	1 Minute
Bronze	2 Minute
Cobalt	2½ Minute
Nickel	2 Minute
Tin	¼ Minute

As shown in FIG. 2, the pressure of the honing stones may be accomplished by movement of a cone means 30 connected to a rod 31 slidable in tool 14. The rod 31 is connected to a piston 33 slidable in chamber 35. Movement of piston 33 is upward or downward directions is caused by providing fluid pressure through lines 37 and 39, depending on the direction of movement. The tool 14 is itself totally reciprocated and rotated in a manner well known in the art and in the above mentioned patent to Ellis et al.

For purposes intended, the description and drawings hereinabove is related to finishing the interior bore surface of a workpiece, however, the method described herein can be

applied to other structures, such as exterior surfaces of a cylindrical or spherical object, and flat plain surfaces.

What is claimed is:

1. In a method for finishing the surface of a workpiece with a tool having an electrically conductive tool body portion and at least one abrasive member supported by and adjustable outwardly from said tool body portion comprising the steps of:

1. providing relative movement between the honing tool and the work surface;
2. maintaining said electrically conductive tool body portion in a spaced relationship to the work surface;
3. flowing a plating solution between the work surface and the electrically conductive tool body portion;
4. passing a direct electric current from the work surface to the electrically conductive tool body portion through said plating solution to remove metal electrochemically from the work surface; keeping the abrasive member abrading the work surface to clean said work surface;
5. reversing the current flow so that the workpiece is negative potential and the tool is positive potential so that metal is plated onto the surface of the workpiece, keeping the abrasive member abrading the work surface with an adjustment in pressure during plating to keep the surface clean, refine the grain structure of the plated material, and correct errors in geometric shape;
6. terminating the supply of direct current flow; and,
7. advancing the abrasive member with increasing pressure onto the work surface to remove the metal mechanically from said work surface and generate a controlled cut surface finish.

2. A method of plating and electrochemically honing a metallic work surface with a honing tool having an electrically conductive tool body portion and at least one abrasive member supported by and adjustable outwardly from said tool body portion, comprising the steps of:

1. providing relative movement between the honing tool and the work surface;
2. maintaining said electrically conductive tool body portion in a spaced relationship to the work surface;
3. advancing the abrasive member into abrasive engagement

ment with the work surface to remove metal mechanically from the work surface;

4. flowing a plating electrolyte between the work surface and the electrically conductive tool body portion;
5. passing a direct electric current from the work surface to the electrically conductive tool body portion through said plating electrolyte to remove metal from the work surface and clean said surface mechanically and electrochemically;
6. reversing the flow of said direct electric current from said work surface to said electrically conductive tool to plate said work surface;
7. applying low abrasive pressure against said work surface as said work surface is being plated;
8. terminating the supply of direct electric current;
9. applying a high abrasive pressure against said work surface; and
10. retracting the abrasive member after a predetermined time interval.

3. A method of honing a metallic work surface with a honing tool having an electrically conductive tool body portion and at least one abrasive member supported by and adjustable outwardly from said tool body portion, comprising the steps of:

1. rotating and reciprocating the honing tool over the work surface;
2. maintaining said electrically conductive tool body portion in a spaced relationship to the work surface;
3. advancing the abrasive member into honing engagement with the work surface to remove metal mechanically from the work surface;
4. flowing a plating solution between the work surface and the electrically conductive tool body portion;
5. passing a direct electric current from the work surface to the electrically conductive tool body portion through the plating solution to remove metal from the work surfaces;
6. reversing the supply of direct electric current;
7. terminating the supply of direct electric current when the diameter of the bore is at the desired size; and
8. retracting the abrasive member after a timed interval.

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