

**July 31, 1973**

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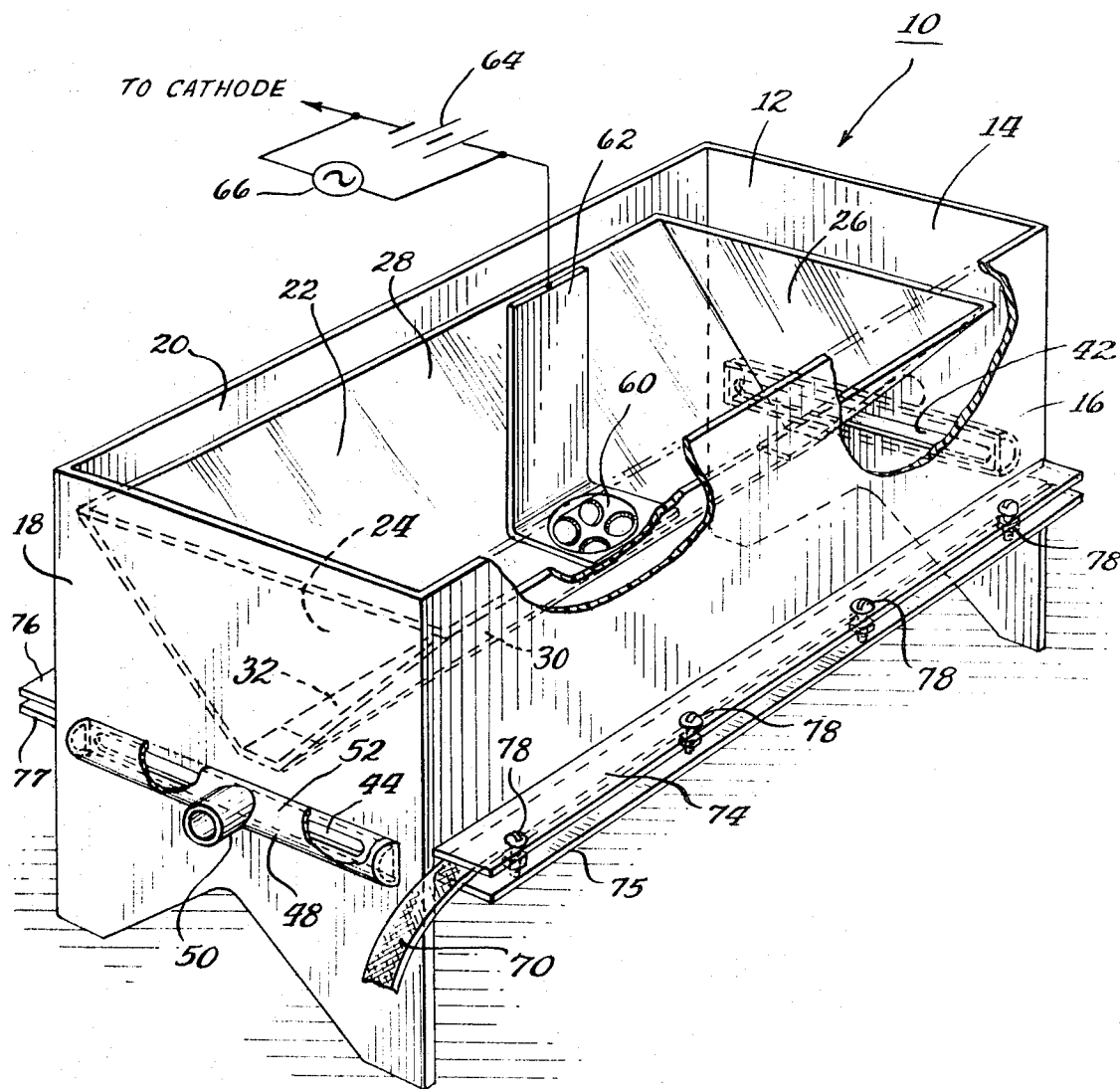
**3,749,653**

## PROCESS OF ELECTROLYTIC ETCHING

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3 Sheets-Sheet 1

Fig. 1.



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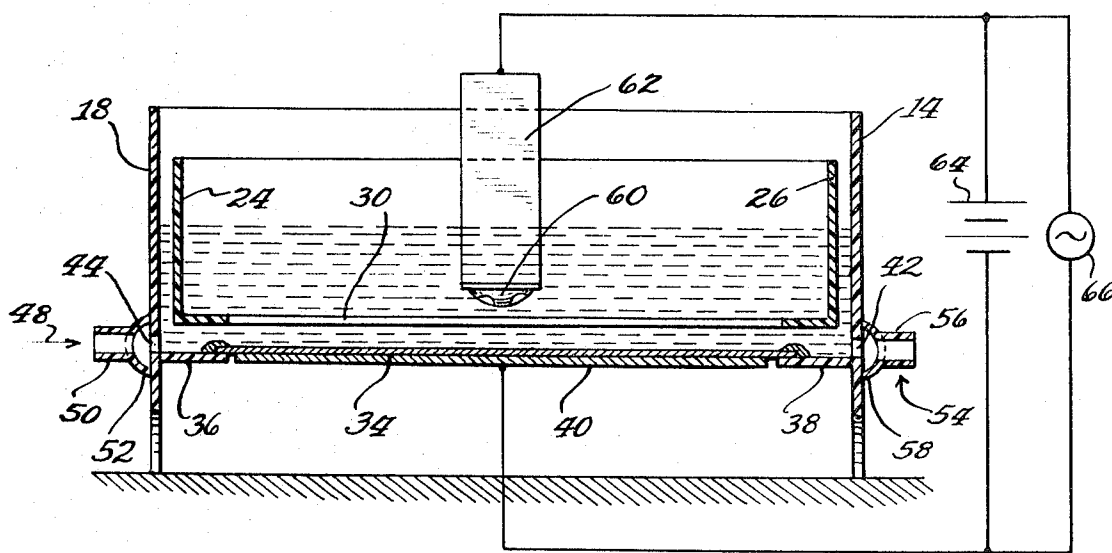
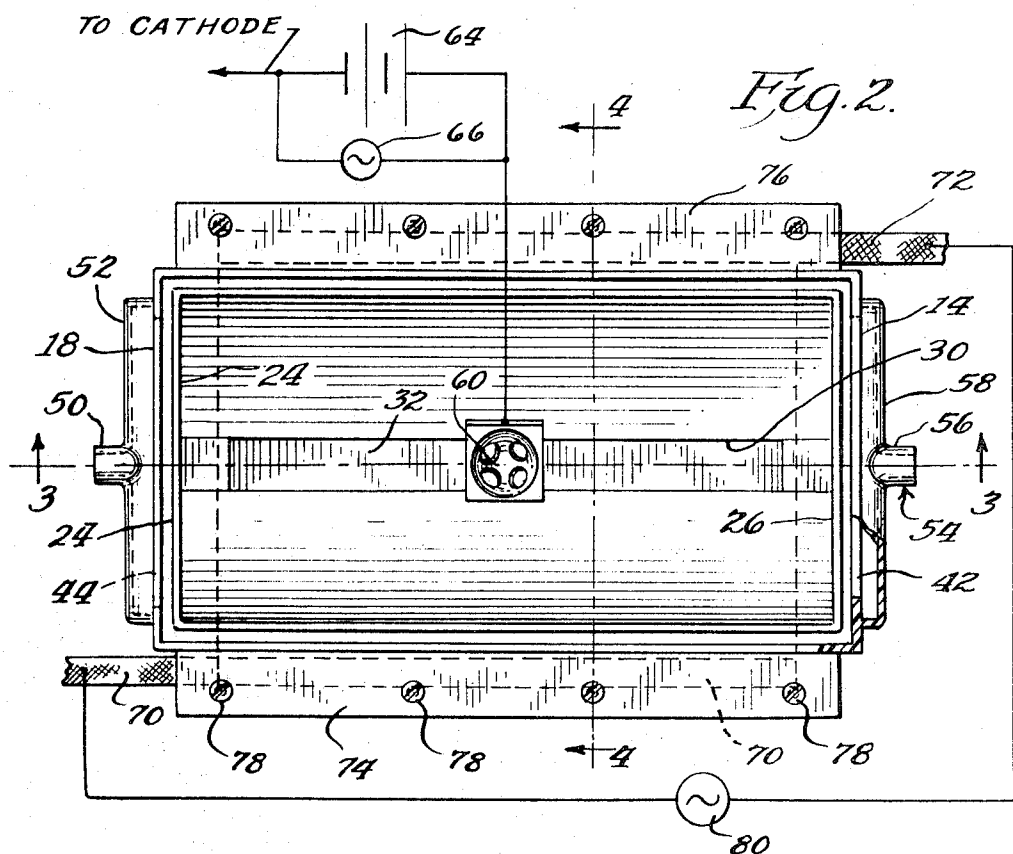


Fig. 3.

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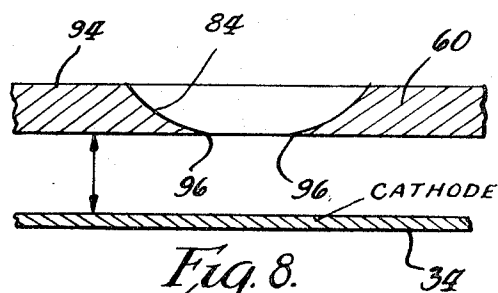
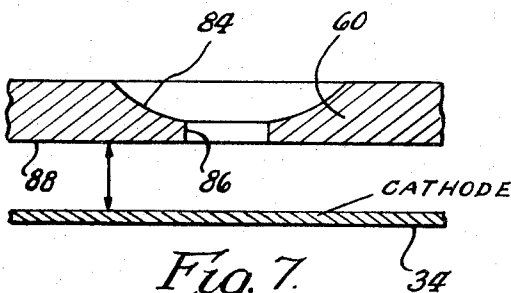
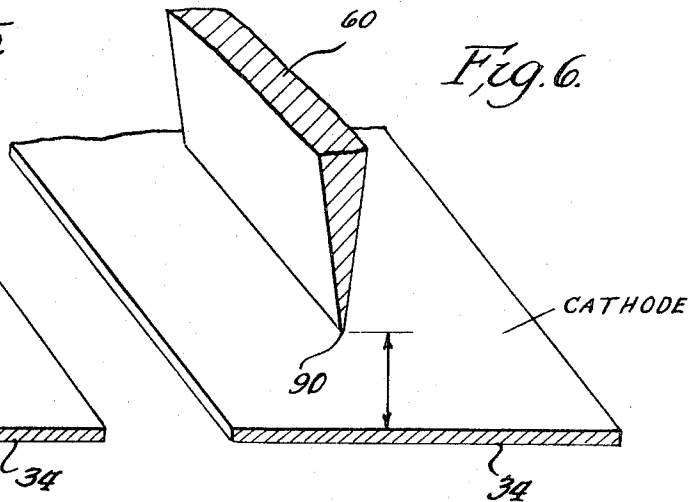
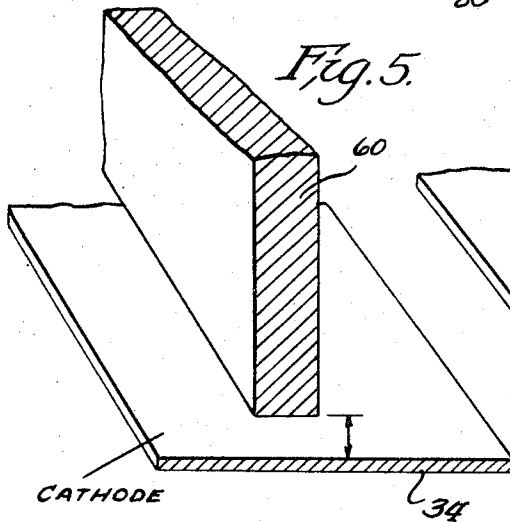
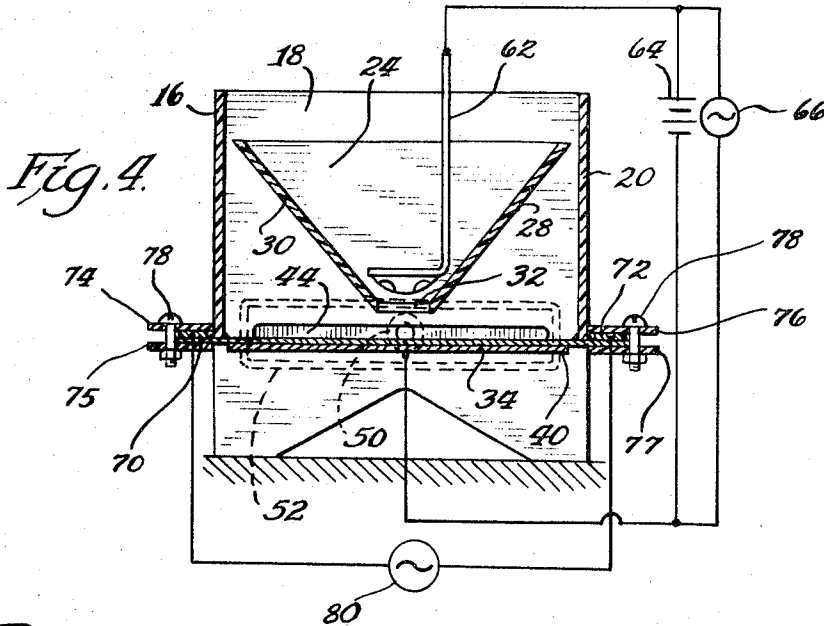
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PROCESS OF ELECTROLYTIC ETCHING

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3 Sheets-Sheet 3



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## PROCESS OF ELECTROLYTIC ETCHING

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8 Claims

### ABSTRACT OF THE DISCLOSURE

An electrolytic etching system of the type in which an anode-workpiece and a cathode are located in an electrolytic solution. The undesirable insulative coating which is generally provided on the cathode during etching is alleviated by applying an alternating electric potential across the workpiece-facing surface of the cathode while a voltage is simultaneously applied across the anode and cathode.

### BACKGROUND OF THE INVENTION

The process of electrolytic etching is well-known for removing material from metal to form printing surfaces and for many other purposes. Generally the workpiece to be etched forms the anode which is placed in an electrolytic solution with a cathode, and when a voltage source is placed across the anode and cathode, the passage of current through the electrolyte removes metal from the anode-workpiece and liberates it at the cathode. Various types of electrolytic etching procedures are described, for example, in (1) the United States patent to Brislee et al., No. 2,172,158, (2) an article by Samuel Wein entitled "Electrolytic Etching" in the October 1941 issue of Metal Finishing, pp. 546-548, (3) the United States patent to Frantzen, No. 3,325,384, and (4) the United States patent to Trzyna et al., No. 3,578,574.

In order for production of electrolytically etched materials to be efficient, it is important that the etching take place rapidly, that the electrolytic solution remain useful for a long period of time, and that the system be relatively maintenance-free. However, prior art electrolytic etching systems have been relatively slow, have required that the electrolytic solution be changed often and be checked constantly and that the cathode be scraped clean very frequently. Typically during electrolytic etching using prior art techniques, the cathode obtains a hard insulating coating which is difficult to remove, but must be constantly removed in order to provide efficient etching. As the coating develops during the etching process, the rate of etching diminishes and after substantial buildup the etching rate may become negligible. Further, if the insulative coating is not carefully and totally removed, the resulting etched product may not be uniformly etched.

We have discovered a novel electrolytic etching system which provides a relatively rapid etch, permits long use of maintenance-free electrolytic solution and prevents any substantial buildup of the undesirable insulative coating on the cathode which has been described above.

Further, we have found that our novel etching system permits the electrolytic solution to remain at a relatively low temperature during the etching process. This enables areas of the workpiece which are not to be etched to have a light etch-resistant covering as compared to the etch-resistant covering required in prior art electrolytic etching systems in which the electrolyte is heated to a much higher temperature. For example, in some prior art systems the portion of the workpiece not to be etched must have expensive and complex photoresist materials very strongly attached to said portion. In contrast, our invention permits portions of the workpiece not to be etched to be coated with simple materials, such as hydrocarbons known

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as waxes having a low melting point, or paraffin waxes, or plastic tape and the like. All of these materials can withstand the relatively low temperatures of the electrolyte used in our etching system, while the higher temperatures used in prior art etching systems would cause removal of the materials from the metallic surface being etched.

Additionally, we have found that our electrolytic etching system is of significant use in the polishing arts because our system has a tendency to remove the surface flaws such as burrs from material, and a workpiece surface that is placed substantially parallel to the surface of the cathode will tend to become planar even though said workpiece surface was originally somewhat non-planar. In other words, using our system the workpiece surface is electrolytically planed and honed because of the tendency of our system to remove the peaks of surface deformities.

### BRIEF DESCRIPTION OF THE INVENTION

In the illustrative embodiment of the invention, electrolytic etching apparatus is provided wherein a metal anode-workpiece and a cathode are positioned in a tank containing an electrolytic solution. A voltage source is connected across the anode and cathode to etch uncovered portions of the workpiece. The improvement comprises one surface of the cathode facing the anode, with said anode-facing surface of the cathode having connected thereto a pair of spaced electrically conductive leads. Means are provided for applying an alternating electric potential across the leads while the voltage from said voltage source is simultaneously applied across the anode and cathode.

In the illustrative embodiment, the cathode forms one portion of the tank whereby only the anode-facing surface of the cathode communicates with the electrolytic solution. Further, the leads are connected only to the anode-facing surface. It has been found that this construction alleviates the undesirable insulative coating that is typically formed on the cathode in prior art electrolytic etching systems.

In the illustrative embodiment, the voltage source which is connected across the anode and cathode comprises a D.C. source having a significant A.C. component. The current parameters in the etching system are such that the electrolytic solution is maintained at a temperature below 130° F. during etching, preferably approximately 115° F.

A more detailed explanation of the invention is provided in the following description and claims, and is illustrated in the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an electrolytic etching tank constructed in accordance with the principles of the present invention, with portions of the tank broken away for clarity;

FIG. 2 is a top view thereof;

FIG. 3 is a sectional elevation thereof, taken along the line 3—3 of FIG. 2;

FIG. 4 is a sectional elevation thereof, taken along the line 4—4 of FIG. 2;

FIG. 5 is a greatly enlarged perspective view of a workpiece and cathode arrangement prior to etching;

FIG. 6 is a greatly enlarged perspective view of the workpiece and cathode arrangement of FIG. 5, subsequent to etching;

FIG. 7 is a greatly enlarged elevational view of a workpiece and cathode arrangement prior to etching; and

FIG. 8 is a greatly enlarged elevational view of the workpiece and cathode of FIG. 7, subsequent to etching.

## DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

Referring to FIGS. 1-4, there is shown therein a tank 10 having an open top 12 and four sides 14, 16, 18 and 20, which sides are formed of an electrically insulative material such as polyvinylpropylene (PVP) or another plastic. Located within the tank is a trough 22 also formed of electrically insulative material and having opposite parallel ends 24, 26 which are connected by sides 28, 30 which angle outwardly toward the open top of tank 10, as can be seen most readily in FIGS. 1 and 4. The bottom of trough 20 defines an elongated opening 32 which extends substantially the length of tank 10.

Positioned directly under opening 32 and forming the bottom wall of the tank 10 is a stainless steel plate 34 which is sealed to flanges 36 and 38, which flanges extend from sides 14 and 18 of the tank. Plate 34 is rectangular in outline, is substantially planar, and in the illustrative embodiment is  $\frac{1}{16}$  inch in thickness. Fastened to the undersurface of plate 34 is a substantially planar copper plate 40 which, in the illustrative embodiment, is  $\frac{1}{4}$  inch in thickness. The top surface of copper plate 40 and the undersurface of steel plate 34 are in intimate contact with each other.

Although no limitation is intended, in the illustrative embodiment, sides 16 and 20 are 20½ inches long, sides 14 and 18 are 9½ inches long and the tank is 6 inches deep. Slot 30 and focusing member 22 are 1½ inches in width and 12 inches in length, steel plate 34 is 12 inches in width, 16 inches in length and  $\frac{1}{16}$  inch thick while copper plate 40 is 6 inches in width, 15½ inches in length and  $\frac{1}{4}$  inch thick.

Side 14 of tank 10 defines a slot 42 communicating with the inside of the tank, while side 18 of the tank defines an oppositely positioned slot 44. Inlet conduit 48 comprising inlet pipe 50 and extending portions 52 is connected to side 18 about slot 44 and likewise, outlet conduit 54 comprising pipe 56 and extending portions 58 is connected to side 14 about slot 42. The electrolyte, which in the illustrative embodiment of the invention preferably comprises three parts phosphoric acid to one part water, is pumped into conduit 48 and exits via conduit 54, with continuous flow being utilized during the etching process.

The anode-workpiece 60 is carried by a suitable holder 62 with the workpiece 60 being formed of stainless steel, such as type 302 stainless, and the holder 62 being electrically conductive wherein a source of direct current 64 is connected from holder 62 (positive terminal of D.C. source) to copper plate 40 (negative terminal of D.C. source). Also connected across the anode-workpiece (60, 62) and the cathode (34, 40) is a supply of alternating current 66 which together with D.C. source 64 effectively produces across the anode-workpiece and cathode an A.C. modulated direct current. It is to be understood that the A.C. need not be sinusoidal but may take other forms instead.

Referring to FIGS. 3 and 4 in particular, it can be seen that the top surface of steel plate 34 serves as the bottom surface of the tank 10. We have found that by allowing the electrolyte to communicate only with the top surface of the cathode and by applying an alternating potential across said cathode, an important effect, which we designate the *Trzyna effect*, occurs. The "alternating potential" is defined herein as any non-constant potential having a definable (although possibly variable) frequency. Although a sinusoidal wave form is acceptable, as are many other wave forms, a square wave is preferred.

Prior art electrolytic etching techniques have been plagued by an insulative coating which forms on the cathode during etching and which must be scraped off in order to achieve effective etching. The *Trzyna effect* is the substantial non-presence of such a coating when the top surface of the cathode only is in communication with the

electrolyte and when an alternating potential is applied across only the top surface of the cathode during etching. Under certain circumstances, a small amount of coating may result, but this coating generally does not adhere to the cathode surface.

In order for the *Trzyna effect* to occur, in the illustrative embodiment, as discussed above, the top surface of the cathode (which cathode comprises steel plate 34 and copper plate 40) forms the bottom of the tank 10 containing the electrolyte. An electrically conductive braid 70 is placed on the top surface of steel plate 34 along one longitudinal edge thereof outside of the tank, and a second electrically conductive braid 72 is positioned on the top surface of plate 34 along the opposite longitudinal edge thereof outside of the tank. Braids 70 and 72 are clamped tightly against the top surface of steel plate 34 by means of plastic strips 74, 75 (for braid 70) and plastic strips 76, 77 (for braid 72), as shown most clearly in FIGS. 1 and 4. The clamping force is effected by suitable fasteners 78.

An A.C. supply is connected across braids 70 and 72 to effectively provide an alternating potential across the top surface of plate 34. Effective results can be achieved when the supply from source 80 has a frequency from as low as 20 Hz. all the way up to the megHz. range. It is preferred that the frequency is above 40 Hz. and most preferably, around the 20 kHz. range. In another embodiment, the frequency of the alternating potential is varied during etching from 40 Hz. to 100 megHz. and back to 40 Hz. to produce an effective result in alleviating the undesirable insulative coating.

Although no limitation is intended, in a specific example, a tank having the parameters stated above was used to etch type 302 stainless steel. In some of the experiments, the steel was merely coated with plastic pressure-sensitive tape while in other experiments the steel was positioned in the manner indicated in FIGS. 5 and 7, without any insulative coating. With respect to FIG. 5, it can be seen that workpiece 60 comprises type 302 stainless steel with its edge lying parallel to the top surface of plate 34. In the FIG. 7 embodiment, a sheet of type 302 stainless steel is coined to form an opening defined by an arcuate wall 84 and a perpendicular wall 86. Under-surface 88 of workpiece 60 is parallel to the top surface of plate 34 in the FIG. 7 embodiment.

Utilizing the above-described parameters, the electrolyte was formed of three parts phosphoric acid to one part water. The D.C. voltage applied from source 64 was 24 volts with an A.C. voltage from source 66 being 25 volts at 60 Hz. overriding the 24 volts D.C. Ammeter measurements showed a D.C. current in the line of 30 amperes and an A.C. current of 10 amperes. The voltage applied from the source 80 across the top surface of plate 24 was 2.8 volts having a frequency of 20 kHz., with the measured current in the line being 6 amperes.

Utilizing the afore-mentioned parameters, steel having a thickness of .0102 and a weight of 8 grams was etched for six minutes and the resulting etched portions had a thickness of .0082 inch and weighed 6 grams. The temperature of the electrolyte remained approximately 106° F.  $\pm 8^\circ$  F.

One of the unusual results of using our system with the anode-to-cathode current being D.C. with an A.C. override and with an A.C. signal applied across the top surface of the cathode, is that the anode-workpiece becomes etched in the manner indicated in FIGS. 6 and 8. For example, the FIG. 5 workpiece 60, which is of uniform thickness, becomes etched to a tapered edge as shown in FIG. 6 with the edge 90 most closely adjacent the top surface of plate 34 having the least thickness and tapering outwardly and upwardly. It has been found that our system provides excellent blade edges in the manner just described wherein edge 90 is etched to an extremely sharp razor edge without requiring the detrimental honing process.

Likewise, utilizing our invention, surface 88 of the FIG. 7 workpiece will be etched upwardly while top surface 94 of workpiece 60 will remain substantially the same as prior to etch. Because of the upward etch provided to the FIG. 7 workpiece, an extremely sharp edge 96 is provided at the bottom of arcuate wall 84, as indicated in FIG. 8.

There are many other configurations of electrodes and tanks which are possible utilizing the principles of the present invention. For example, it may be desirable to have a greater surface of the cathode adjacent the workpiece. To that end, the cathode may take various curvilinear shapes with the stainless steel portion facing the workpiece and the copper cathode sheet being fastened to the opposite surface of the stainless steel plate.

Additionally, the cathode could be located on one side of the tank instead of at its bottom, with focusing member 30 being positioned in a sideway manner with respect to the side-positioned cathode.

Further, the entire tank could be cylindrical in shape, with a copper tube forming the center of the cylinder and having a stainless steel tube concentrically positioned about the copper tube in intimate contact therewith, with the stainless steel tube and copper tube forming the cathode. A concentrically positioned anode is spaced from the top surface of the steel cathode, with electrolyte flowing between the top surface of the steel cathode tube and the inner surface of the steel anode-workpiece. Electrical connections are as shown in FIG. 2 and, in this manner, a tubular workpiece could be etched evenly over its entire inner surface simultaneously.

Alternatively, in order to etch the outer surface of a tubular workpiece a concentric system as described above could be utilized with the parts reversed so that the workpiece is in the inside of the system and the cathode is concentrically located about the tubular workpiece. The cathode is spaced from the outer surface of the workpiece with electrolyte flowing therebetween.

A novel process has been disclosed for producing the *Trzyna effect*. We have found that if there is no alternating potential across the workpiece-facing surface of the cathode, and if a direct current (with no A.C. override) is applied between the anode and cathode, a very hard insulative coating will build up on the cathode and a good abrasive will be needed to remove the coating. If there is no alternating potential across the workpiece-facing surface of the cathode, and if a direct current with an A.C. override is applied between the anode and cathode, the insulative coating will not adhere to the cathode quite as strongly as in the above example, although the coating will still act as an insulator and be very deleterious to etching. On the other hand, if you apply an alternating potential across the workpiece-facing surface of the cathode, and if a direct current with an A.C. override is applied between the anode and cathode, there may be no coating or the coating will be only a very fine dust which does not adhere to the cathode surface and is not deleterious to etching. Improved results can be achieved by varying the frequency of the alternating potential across the workpiece-facing surface of the cathode during etching.

Although illustrative embodiments of the invention have been shown and described, it is to be understood that

various modifications and substitutions may be made by those skilled in the art without departing from the novel spirit and scope of the present invention.

What is claimed is:

1. In an electrolytic etching process, the improvement comprising the steps of positioning an anode-workpiece and a cathode in an electrolytic solution, applying a voltage across the anode and cathode, and simultaneously applying an alternating electric potential across the workpiece-facing surface of the cathode while said voltage is being applied across the anode and cathode.

2. In an electrolytic etching process as described in claim 1, wherein said alternating electric potential has a frequency that is greater than 20 Hz. and said voltage comprises D.C. having a significant A.C. component.

3. In an electrolytic etching process as described in claim 1, including the step of affixing a pair of spaced electrically conductive leads only to the workpiece-facing surface of said cathode and applying to said leads said alternating electric potential.

4. In an electrolytic etching process as described in claim 1, including the step of locating only the workpiece-facing surface of said cathode in contact with the electrolytic solution.

5. An electrolytic etching process for metals which comprises the steps of: positioning an anode-workpiece in an electrolytic solution, positioning in said electrolytic solution only the workpiece-facing surface of a cathode, affixing a pair of spaced electrically conductive leads only to said workpiece-facing surface, and applying to said leads a source of alternating electric potential while simultaneously applying a voltage across said anode-workpiece and cathode, whereby the workpiece will be etched without coating said workpiece-facing surface of said cathode with a substantial insulative substance.

6. An electrolytic etching process as described in claim 5, wherein said alternating electric potential has a frequency that is greater than 20 Hz. and said simultaneously-applied voltage comprises D.C. having a significant A.C. component.

7. In an electrolytic etching process as described in claim 1, including the step of maintaining said electrolytic solution at a temperature below 130° F. during etching.

8. An electrolytic etching process as described in claim 5, wherein said spaced leads are connected to said anode-facing surface at an area which is not in contact with said electrolyte.

#### References Cited

##### UNITED STATES PATENTS

|           |         |                    |           |
|-----------|---------|--------------------|-----------|
| 2,590,927 | 4/1952  | Brandt et al. .... | 204—143 R |
| 3,399,130 | 8/1968  | Lovekin .....      | 204—142   |
| 1,567,791 | 12/1925 | Duhme .....        | 204—228   |
| 1,970,804 | 8/1934  | Kerk .....         | 204—228   |
| 3,450,605 | 6/1969  | McGivern, Jr. .... | 204—14    |

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204—129.55, 228, Dig. 8