An electrolytic machining cathode electrode for producing a small diameter cavity in a metallic anode workpiece. The electrode has an elongated hollow metallic stem with a circular transverse cross section. The electrode is formed with an uninsulated working tip at one end and a hollow rear portion at the other end of larger outer diameter than the forward portion of the electrode for providing strength thereto. The outer surface of the electrode is coated with an electrical insulating material.

5 Claims, 3 Drawing Figures
ELECTROLYTIC HOLE FORMING CATHODE ELECTRODE

BACKGROUND OF THE INVENTION

I. Field of the Invention

This invention relates to electrolytic machining, and more particularly to an improved cathode electrode of increased strength for use in electrolytic drilling of small diameter holes.

II. Description of the Prior Art

Paralleling the development of new and difficult to machine high temperature materials has been the development of the removal of the material by electrolytic processes. During the operation of an electrolytic material removal process, a cathodic tool approaches an anodic workpiece, while an electrolyte is passed between the tool and the workpiece. When the tool and the workpiece are sufficiently close to one another, a "deplating" type of action occurs at the anode.

In the generation of cavities, by the above process, having a relatively small diameter compared with their length it is generally necessary to apply to the outer portion of the cathodic tool a coating of dielectric material which will prevent the electrolytic action from taking place between the sides of the cathodic tool and the penetrated portion of the workpiece. Such cathodic tools or electrodes are usually tubular in form, allowing the electrolyte to be supplied through a central passage formed through the electrode. The electrolyte escapes through a gap maintained between the forward uninsulated working tip of the electrode and the internal surface of the aperture being formed.

One such electrode of the general type described is disclosed in U.S. Pat. No. 3,336,213, issued Aug. 15, 1967, and comprises a cylindrical stem having an uninsulated working tip and an outer coating of non-conductive material extending rearward from its working tip. When such electrodes are used in forming apertures having a relatively small diameter as compared with their length, the electrodes have a tendency to vibrate and even to bend and otherwise distort due to the forces exerted thereon by the flowing electrolyte, which flows through the center of the electrode and around its working tip to exit between the outer surface of the electrode and the inner surface of the aperture. The bending and other distortions of the electrode result in the formation of non-linear and otherwise imperfect small diameter relatively deep cavities.

SUMMARY OF THE INVENTION

The present invention overcomes this difficulty of the prior art by providing an electrode of increased strength for forming apertures which have a small diameter in comparison to their length. As in the prior art, this electrode is tubular in form with an outer coating of dielectric material.

The electrode of the present invention comprises a hollow tubular metallic stem and a dielectric material coated on the outer surface of the stem. The metallic stem is preferably cylindrically shaped with an uninsulated working tip formed at one end from the circular cross section of the cylindrical stem. A cylindrical support of larger outer diameter and thicker wall is secured to the rear portion of the stem, providing the necessary strength to the electrode for forming long, small diameter passages in a workpiece. In a second embodiment, the larger diameter support member is integral with the metallic stem.

DESCRIPTION OF THE DRAWINGS

The description refers to the accompanying drawings wherein like reference characters refer to like parts throughout the several views, and in which:

FIG. 1 is a longitudinal view in section of a hollow tubular electrode of the present invention prior to the start of processing a workpiece.

FIG. 2 is a longitudinal view in section of the electrode of FIG. 1 penetrating the workpiece; and

FIG. 3 is a longitudinal view in section of a second embodiment of the electrode of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the electrode of the present invention, generally indicated at 10, has a circular transverse cross section and comprises an electrical conducting hollow tube 12. The tube 12 has a forward tip 14 formed from the circular cross section of the tube 12. An electrical insulating material 16, preferably an acrylic plastic, is coated over the outer surface of the tube 12 and extends rearward from the working tip 14.

The tube 12 is hollow to accommodate the flow of electrolyte through the tube toward the workpiece 18, as shown by arrows 20 in FIGS. 1 and 2. The material of the tube 12 may be any electrical conducting material, but preferably is a metal or metal alloy which does not react with the electrolyte to be passed through the tube. The electrolyte may be a 2-10% aqueous solution of hydrochloric acid or sulfuric acid, but preferably has an acid concentration within the range of 2-3%.

A support member 22, preferably cylindrically shaped and having a larger outer diameter and thicker walls than the tube 12, is formed with a longitudinally extending cylindrical passage 24 through which the electrolyte may flow. The rear end of the tube 12, preferably with outwardly turned flange 25, is secured to the forward end of the support member 22 as by welding or soldering as indicated at 26.

Referring to FIGS. 1 and 2, the coated tube 12 is first located opposite the surface 28 to be processed and in alignment with the initial desired direction of stock removal, as shown by line 30 in FIG. 1. The workpiece 18 carries a positive direct current charge, while support member 22 and the tube 12 carry a negative direct current charge, for example as from the terminals of a direct current power generator (not shown). As the electrolyte flows in a direction as indicated by the arrows 20, through passage 24 and internal passage 32 formed in the tube 12, it carries a negative electrical charge or ion towards the positive workpiece 18. Upon exiting from the end 34 of the tube 12 and contacting the positive charged surface 28 of the workpiece, the negative ion is neutralized and a minute portion of the material of the workpiece thus is removed.

As the work continues, the electrode 10 gradually penetrates the workpiece 18, as is indicated in FIG. 2. In this condition, the electrolyte flows through the passage 32 of the tube 12 and out the end 34 between the working tip 14 and the bottom of the aperture being formed. The electrolyte continues to flow upward as shown in the drawing and around between the outer surface of the electrode 10 and the inner cylindrical surface of the aperture being formed to carry away the
material removed from the workpiece which enters in solution in the electrolyte.

The electrode of the present invention is primarily for use in forming deep, very narrow passages in a workpiece. As the cathodic tool penetrates farther and farther into the workpiece, the electrical insulation prevents side electrolytic action which would otherwise occur through the electrolyte between the outer lateral surface of the tube 12 and the aperture formed in the workpiece 18. Therefore, the outer dielectric coating is very important to the proper operation of the electrode. The coating as shown in the drawings preferably extends rearward from the working tip 14 and covers the outer surface of both the tube 12 and the member 22.

A further problem in producing accurate small diameter apertures or cavities using tubular electrodes through which the electrolyte is passed is the avoidance of electrode deflection as a result of excessive electrolyte pressure and velocity, which produces bending forces on the electrode. Therefore, in order to form accurate apertures, it is desirable to provide some support for the electrode. In the present electrode, this support is provided by the support member 22, which provides the support necessary to resist the twisting and bending effects of the flow of the electrolyte.

In order to prevent plating of the tip of the electrode, the current supply may be periodically reversed, as is well known in the art. Alternately, plating may be prevented by flowing fresh electrolyte only once through the gap.

Referring to FIG. 3, a second and preferred embodiment of the electrode used to form long, small diameter passages in a workpiece is illustrated as having an elongated thin walled tubular stem 36. The stem 36 which is preferably formed from nickel, includes a small diameter forward portion 38 terminating in a working end 40, which is the cross section of the forward portion 38. The rear portion of the stem 36 tapers outwardly to form a larger diameter rear section 42 of increased wall thickness, which supplies the necessary support to the smaller diameter forward portion 38. The outer surface of the stem 36 is coated with an electrical insulating material 44, preferably an acrylic plastic, and the stem 36 is formed with a central passage 46 for the passage of electrolyte therethrough in the direction as indicated by arrow 48. In addition to increasing the overall rigidity and sturdiness of the electrode the larger diameter rear portion thereof provides a wider electrolyte passageway resulting in a better flow of electrolyte than is obtained with a small diameter substantially long passageway.

A preferred method for forming the electrode shown in FIG. 3 is as follows: An elongated glass mandrel having a small and a large diameter portion corresponding to the sections 38 and 42 of the electrode is first coated with silver nitrate. A coating of nickel is then deposited over the silver nitrate, preferably by conventional electrolysis plating processes. The forward portion 38 and the working end 40 of the stem 36 are preferably thin walled and within the range of 0.001 to 0.005 inch in wall thickness. The enlarged diametrical portion 42 is preferably formed with a somewhat thicker wall up to 0.01 of an inch thick. After the formation of the thin walled nickel coating, the glass mandrel is removed and the bottom portion of the outside surface of the nickel coating is coated with an acrylic plastic, preferably of a thickness of approximately 0.0005 inch. The forward portion 38 and the working tip 40 are preferably cylindrically shaped with an outer diameter between 0.007 of an inch and 0.03 of an inch for the formation of small diameter holes to a depth of 1 inch.

An alternate to the above method is to chemically reduce a "flash" coating, such as of silver from a silver nitrate solution, onto the surface of the glass mandrel. Then standard electrodeposition processes can be used to coat the initial "flash" coat of silver with other stronger, tougher metals, such as nickel.

The electrodes of the present invention are preferably used in electrolytic machining processes operating at from 4 to 10 volts with a low electrolyte pressure, preferably less than 35 p.s.i.

Having thus described the invention by way of two examples given for illustrative purposes, what is sought to be protected by U.S. Letters Patent is as follows:

1. An electrode for use as a cathode electrode in an apparatus for forming relatively deep small diameter holes electrolytically in a metallic anode workpiece, said electrode comprising a hollow elongated metallic member having a forward portion provided with an uninsulated working tip, said forward portion being relatively thin-walled and having a relatively small external transverse dimension and extending rearward from said working tip, a relatively thick-walled rear portion having a larger external transverse dimension than said working tip and said forward portion, an intermediate portion of a wall thickness and an external transverse dimension progressively increasing from said forward portion to said rear portion, and a coating of electrical insulating material encasing the outer surface of said metallic member and extending rearward from said working tip over said forward and intermediate portions and at least part of said rear portion, wherein said hollow elongated metallic member has an internal transverse cross area at said rear portion larger than the internal transverse cross area of said forward portion.

2. An electrode as defined in claim 1, wherein said forward portion comprises a cylindrical member extending forward from said rear portion.

3. An electrode as defined in claim 2, wherein said working tip comprises the circular cross-sectional end of said cylindrical member.

4. An electrode as defined in claim 1, wherein the rear portion of said hollow elongated metallic member is integral with said forward portion thereof.

5. The electrode of claim 4 wherein the working tip and the forward portion of said elongated metallic member has an outer diameter in the range of 0.007 inch to 0.03 inch, said intermediate portion has a wall thickness in the range of 0.001 to 0.005 inch and the rear portion of said hollow elongated member has a wall thickness substantially more than that of said intermediate portion up to a maximum of 0.01 inch.

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