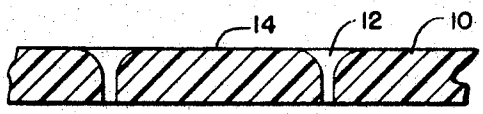
Aug. 12, 1969 K. W. FRANKS 3,461,045

METHOD OF PLATING THROUGH HOLES

Filed Oct. 21, 1965

FIG. 1



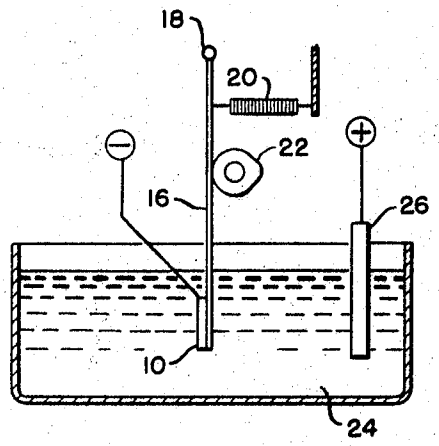


FIG. 2

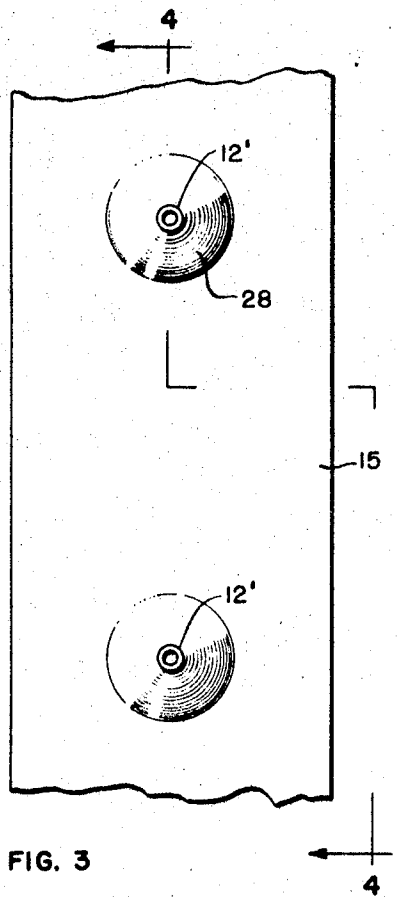


FIG. 3

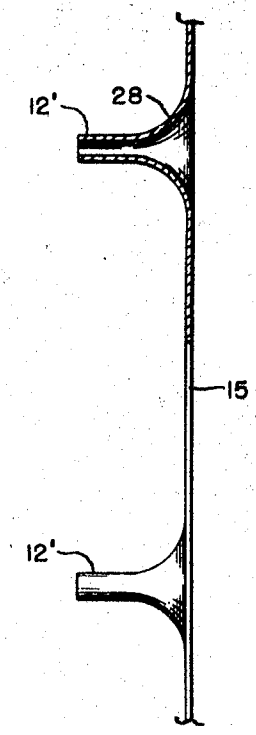


FIG. 4

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METHOD OF PLATING THROUGH HOLES

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ABSTRACT OF THE DISCLOSURE

In electroforming a nozzle terminating in a thin-walled tube of greater length than its diameter, a hole conformed to the outside contour of the nozzle is formed through a body of wax. A thin coating of silver then is deposited on the surface of the wax and on the inside surface of the hole. The coated mold form then is immersed in an electrolyte as a cathode, and nickle is electrodeposited onto the silver coating. The cathode mold form periodically is moved through the electrolyte in order to force fresh electrolyte into the restricted area of the tube to replace the electrolyte which has been spent by deposition onto the walls of the tube.

This invention relates to electrodeposition of metal and more particularly to methods of electroplating in areas where the free and uniform flow of ions and the electrolyte is restricted.

The art of "electroforming" involves depositing metal by electroplating onto a suitable cathode form as more fully described in Patent No. 1,445,792, granted to William H. Cole on Mar. 20, 1923. In the use of this method, difficulties arise when the shape of the part to be formed becomes so intricate that the free flow of electrolyte is impaired by the closeness of adjacent surfaces, resulting in unacceptable variations in the thickness of the deposit.

This invention had its inception in the development of a method of manufacturing such devices as the nozzle of an ink transferring device, particularly of the type disclosed in Patent No. 3,060,429, granted Oct. 23, 1962, to C. R. Winston. In the device disclosed in that patent to Winston, ink is supplied at substantially atmospheric pressure to a nozzle. An electrical potential is impressed upon the ink through a metallic electrode, to cause the ink to become charged. A different and variable potential is impressed upon a valving electrode; and when a sufficient potential difference exists between the ink and the valving electrode, a convex meniscus of ink forms at the orifice of the nozzle. When the potential difference is increased, a fine stream of ink droplets will be drawn from the nozzle. It is further disclosed in the patent that by means of two pairs of deflecting electrodes—one pair providing for vertical deflection and the other pair providing for horizontal deflection—the ink may be caused to impinge on a record medium and trace alphanumeric or any other desired characters.

In experimentation with an ink transferring device of the type disclosed in the patent to Winston, it was found that the geometry of the nozzle had a considerable effect upon the results obtained, particularly the clarity of characters. The ink used is a dielectric and does not readily accept a uniform density of charge when moving at high speeds. It was found that by supplying the ink through a relatively long and very small-diameter, nozzle-like tube before permitting the ink to issue in droplets from the end of the nozzle, the flowing of the ink along the internal surface of the nozzle causes a transfer to the ink of the desired uniformity of bulk electrical charge that is needed to cause the ink to travel from the tip of the nozzle to the desired location on the paper.

The manufacture of such a nozzle having a long, gradually sloping tube of the proper configuration and inside diameter was found to involve substantial problems. It developed that in order for the ink flow from the nozzle to be capable of being turned on and off under the control of the valving electrode, the wall thickness of the nozzle tube should be a minimum. With the nozzle turned off but maintaining a sufficient potential to produce a meniscus, the diameter of the meniscus is substantially equal to the outside diameter of the nozzle tube. When ink flow is again initiated at the nozzle, the first droplet has a diameter approximately equal to the outside diameter of the tube; and succeeding droplets have a diameter approximately equal to the inside diameter of the tube, since they are drawn from the nozzle without having opportunity to spread over the end of the wall of the nozzle. In order to minimize the excess diameter of the first droplet, a wall thickness of the nozzle tube of only a few thousandths of an inch is desirable; but this dimension is approximately of the same order of magnitude as the inside diameter of the tube. Experimentation led to the conclusion that the method known as "electroforming" could possibly yield the proper shape and size of the nozzle but there did not appear to be known in the art a method of electroforming through long, small-diameter holes.

Therefore, it is an object of the present invention to improve electrodeposition of metal in restricted areas.

Another object of the present invention is to electroform small objects of intricate shape.

In accordance with the preferred embodiment of the present invention, as applied to the electroforming of a nozzle terminating in a thin-walled tube of greater length than diameter, a hole conformed to the outside contour of the nozzle is formed through a body of wax. A very thin coating of silver is then deposited on the surface of the wax as well as on the inside surface of the hole. The coated mold form is then immersed in an electrolyte as the cathode, and nickel is electrodeposited onto the silver coating. From time to time, the wax cathode mold form is drawn rapidly through the electrolyte in order to force fresh electrolyte into the restricted area of the tube to replace that electrolyte which has been spent by deposition onto the walls of the tube.

A more complete understanding may be had by reference to the following detailed description when considered in conjunction with the attached drawing wherein:

FIG. 1 is a cross-section of the wax mold in which the hole has been formed;

FIG. 2 shows a device for periodically passing the cathode mold form through the electrolyte in order to renew the electrolyte in the confined area of the cathode;

FIG. 3 is an end view of the completed, thin-walled nozzle after the wax cathode mold form has been melted away; and

FIG. 4 is a cross-section of the nozzle taken along line 4—4 of FIG. 3.

Referring now to the drawing there is shown, in cross-section, in FIG. 1, a flat piece of plastically-deformable wax **10** approximately .046" thick in which a hole **12** has been formed by a mandrel in the exact contour of the outside of the nozzle to be manufactured. The top surface **14** of the wax **10** and the inside of the hole **12** are coated with a very thin layer of silver, according to methods well known in the prior art. This silver is then used as a cathode onto which a coating of nickel is electroplated.

The hole **12** in the wax **10** has a diameter, at the thinnest point, of only .005 to .010 inch, and accordingly electroplating by simple immersion of the cathode form in an electrolyte yields unsatisfactory results. As soon as the electrolyte in the confined area of the hole deposits

its nickel ions in the form of metallic nickel on the walls of the hole, the ion concentration of the electrolyte in this confined area becomes so low that further electroplating in this area will be impractical. In order to elimiate this condition, the wax mold **10** is mounted as shown in FIG. 2, on support **16**, which is suspended on a pivot **18** and biased by a spring **20** to rotate in the counterclockwise direction against the surface of a cam **22**. The cam **22** is continuously driven at approximately four revolutions per minute, and as it rotates, it periodically drives the cathode support **16** in the clockwise direction about pivot **18** and then permits cathode support **16** to fall back to its original position under the urging of its spring **20**. Every time that the cathode support **16** is driven clockwise about pivot **18**, the silver-coated wax mold **10** is driven to the left through the tank of electrolyte **24** at .4 inch-per-second or more, forcefully driving electrolyte through the hole **12** in the wax mold **10**, renewing the spent electrolyte in the confined area of the hole. An anode **26** is provided to maintain ion concentration in the tank of electrolyte **24**.

After sufficient nickel has been electrodeposited, the wax is melted away from the deposited nickel leaving the nozzle as shown in FIGS. 3 and 4 with the top plate **15** shown as constituting a flat mounting plate with the metal that has been depositeed in the hole **12** now comprising the nozzle. The nozzle **12** is flared into the planar plate **15** by a smooth, arcuate curve **28** to facilitate the even flow of ink.

It has been found that in the operation of the ink transfer device disclosed in the above-mentioned patent to Winston a satisfactory nozzle will result if the inside diameter of the nozzle is between .003 and .008 inch, but with pressure produced by a slight head of liquid ink, the inside diameter of the tube must be less than .015 inch to prevent free flow of ink from the nozzle. In order that the first drop from the nozzle not be of excessive size so as to cause a blot of ink on the paper, the outside of the nozzle should be maintained at less than .020 inch diameter at the nozzle tip. Ideally, the outside diameter of the nozzle should be no more than .001 or .002 inch greater than the inside diameter of the nozzle. These dimensions for the inside and outside diameter of a nozzle which is to be turned on and off result in an optimum of between .0005 and .002 inch wall thickness and as the wall thickness increases up to, perhaps .005 inch, the first droplet following turn-off becomes increasingly large relative to the subsequent droplets, to the detriment of printing quality.

In view of the small diameter and wall thickness of the nozzle, electroforming appears to be the most practical if not the only method of making this article.

Although only one embodiment of the invention is shown in the drawing and described in the foregoing specification, it will be understood that invention is not limited to the specific embodiment described, but is capable of modification and rearrangement and substitution of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. A method of electroforming a tubular article having a length greater than a maximum outside diameter of 0.010 inch and a wall thickness not exceeding 0.002 inch, using a wax preform having a hole formed therethrough conforming in shape to the outer peripheral dimension of the tubular article, and said wax preform having a coating of a first metal susceptable of having a second metal electrolytically deposited thereon, which consists:

immersing said first metal coated preform in an electrolyte solution having suspended therein a bar of said second metal;

periodically oscillating the preform to and fro within said solution to pass the plating solution through said opening, while,

applying electrical energy to render cathodic said first metal coated preform and to render anodic said second metal;

removing the preform from the electrolyte upon electroplating a layer on said preform of said second metal of a thickness not exceeding 0.002 inch, said thickness being at least thick enough to form a structurally stable tubular article when the preform is removed from the tube; and

removing the wax preform leaving the metallic tubular article intact.

2. A method of electroforming a curved, tapered nozzle of a predetermined metal, having a length greater than a maximum outside diameter of 0.020 inch, a minimum outside diameter not exceeding 0.010 inch, and a wall thickness not exceeding 0.002 inch, which comprises:

forming a sheet of wax into a preform having an opening extended therethrough conforming to the outer configuration of the nozzle;

depositing a metal coating on the top surface and the opening of said preform, which coating is characterized in the ability of having said predetermined metal electrodeposited thereon;

immersing said metal coated preform in an electrolyte solution having suspended therein a bar of said predetermined metal;

periodically oscillating the preform to and fro within said solution to pass the plating solution through said opening, while,

applying electrical energy to render cathodic said metal coating and render anodic said predetermined metal;

removing the preform from the electrolyte upon electroplating on said preform and within said opening a layer of said predetermined metal which is less than 0.002 inch thick; and

removing the wax preform leaving the structurally stable, metal nozzle.

References Cited

UNITED STATES PATENTS

1,188,228	6/1916	Woodward	204—9
2,260,893	10/1941	Ewing	204—9
3,345,741	10/1967	Reimann	204—15

FOREIGN PATENTS

153,231	10/1920	Great Britain.
598,722	5/1960	Canada.

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U.S. Cl. X.R.

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