

continuous film is formed. This is necessary because the conductive silver film will not tolerate high current density.

Time required to deposit the thickness of metal needed for a given application can be calculated. Deposition normally continues for this time without interruption. In some cases, however, two separate plating steps are necessary to produce more complicated shapes. If the electroform in this instance is nickel, a copper strike may be required to improve adhesion of the second-stage deposit.

No special activation is necessary in two-stage plating of copper electroforms. Reversing current during deposition activates the surface and provides a uniform deposit.

Removal of Electroform Shell

Methods of removing the electroform from the mandrel are important because damage and distortion

of the electroform can occur. Separation methods depend upon the materials used for the mandrel and the electroform itself. If there is a difference in thermal expansion between the two, removal may be accomplished by heating or cooling the mandrel and/or electroform. Aluminum and certain other metals used as matrices may be etched away, if a permanent mandrel is not necessary. Waxes and low-melting alloys are removed by melting. Plastic mandrels are usually heated above the heat-distortion temperature (approximately 300 deg. F.) and delaminated (distorted) while hot.

When electroformed shells need added strength, welding, brazing and metal spraying are common methods of stiffening. Reinforcement with epoxy resins and glass fabrics is also desirable in certain applications.

TABLE I

Composition and Operating Conditions for Acid Copper Plating Solution Used in Electroforming

Copper sulfate	28 oz./gal.
Sulfuric acid	9 oz./gal.
WesX 313*	0.02 oz./gal.
Hydrochloric acid	55 cc/1000 gal.
Current density	150 a.s.f.
Temperature	70-120 deg. F.

*Westinghouse Electric Corporation, East Pittsburgh, Pa.

TABLE II

Composition and Operating Conditions for Barrett Nickel Sulfamate Plating Solution* Used in Electroforming

Nickel sulfamate	60 oz./gal.
Boric acid	4 oz./gal.
Antipit agent (SNAP)	0.05 oz./gal.
Stress reducer (SNSR)	1 oz./gal.
Current density	75 a.s.f.
Temperature	135 deg. F.

*Barrett Chemical Products Co., Shelton, Conn.