March 14, 1972 W. ERICKSON, JR 3,649,394

3-DIMENSIONAL CONE ANTENNA METHOD

Filed April 3, 1969 3 Sheets-Sheet 1

Fig. 1.

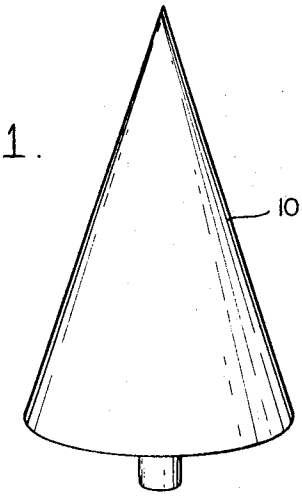
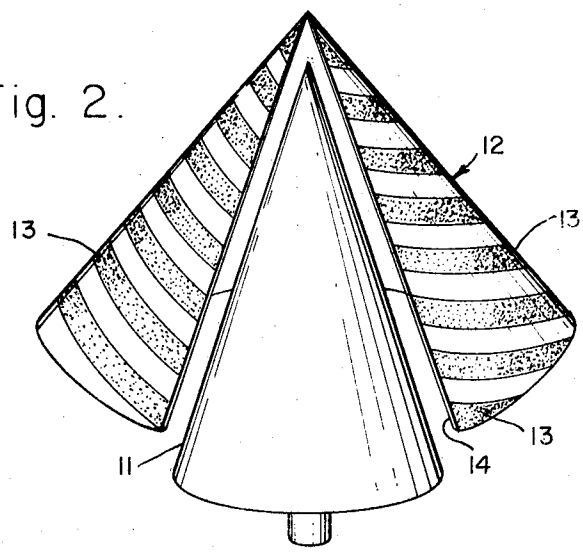


Fig. 2.

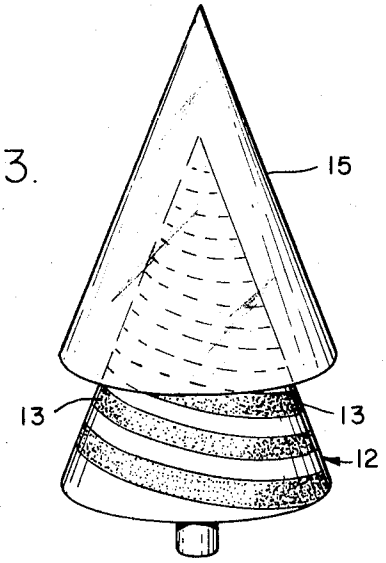


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3-DIMENSIONAL CONE ANTENNA METHOD

Filed April 3, 1969 3 Sheets-Sheet 2

Fig. 3.



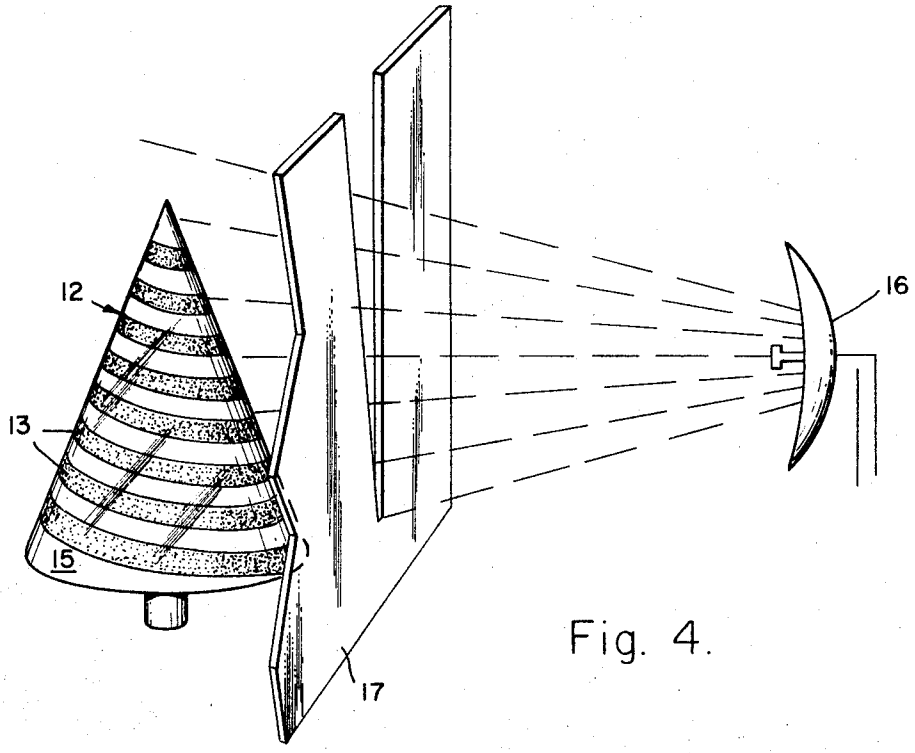


Fig. 4.

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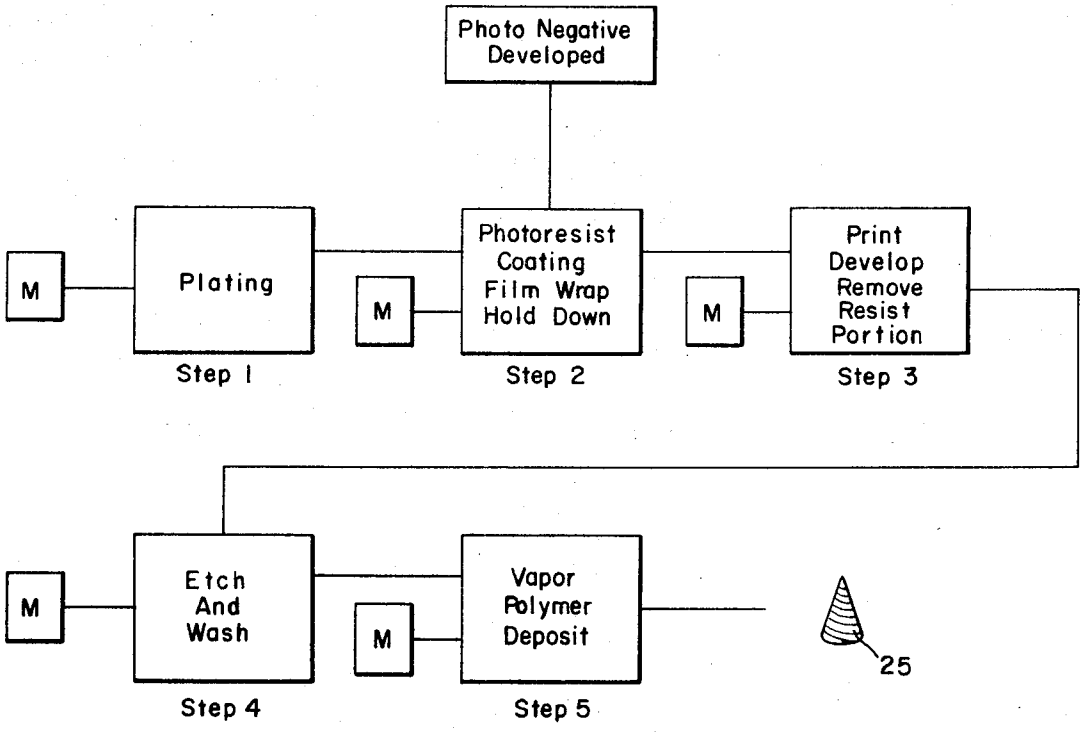


Fig. 5.

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3-DIMENSIONAL CONE ANTENNA METHOD

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U.S. Cl. 156—16 5 Claims

ABSTRACT OF THE DISCLOSURE

The method of consistently prefabricating 3-dimensional circuitry and particularly improved nose cone 3-dimensional antennas meeting the requirements of element tolerance control by providing a rotating conductor cone, as a basic configuration, coating the conductor surface with a photoresist, applying a photoprinting film of the required configuration, bonding the film to the photoresist, exposing the film to a light source while rotating the film coating surface, rotatably etching the printed pattern, cleaning the etched pattern, and depositing a continuous insulating film of poly-p-xylylene polymer overlying and supporting the etched circuitry configuration, and product.

BACKGROUND OF THE INVENTION

Nose cones are presently prefabricated mechanically with 6 spiral arms cut from sheet copper and cemented to a plastic cone using a spiral tracer lathe following a master model. Otherwise, the cones are prepared in sections and cemented to a base. Consequently, at the present time, 2-dimensional antenna configurations having narrow band characteristics are used. Various attempts to meet the requirements for a broad band capability have been attempted. Such structures, as provided and the methods therefor do not provide economical, lightweight, replaceable and reproducible single surface-of-revolution, as 3-dimensional cone shapes, incorporating various patterns of any complexity, or afford means for combining very thin electrically conductive and insulating materials of 3-dimensional configuration having specific reproducible properties suitable for economically replaceable airborne antennas, aerodynamically flush on aircraft or lightweight, collapsible types for spacecraft, or missile antennas, as are needed for operation over broad band frequencies.

For example, copper coated polyphenylene oxide can be made into cones and suitable patterns provided. However, stresses in the conductor coating sheet, plus stress during fabrication of the cone result in dimensional changes which are unacceptable electrically. Likewise, filler degrades required dielectric properties and plastics, such as "Mylar" and "Teflon" do not have acceptable electrical properties.

Consequently, the nose cone art has been without efficient 3-dimensional cones, or circuitry, and without an economical process for effecting production quantities of repreducible antennas of specific properties suitable for operating over a large band of frequencies, as present methods do not provide the required dimensional tolerances on materials having the proper dielectric properties.

PRESENT INVENTION

The invention or improvement herein relates to the method of economically effecting the production of reproducible thin 3-dimensional circuitry systems having a complexity of geometric conductor design, or pattern, of prefabricated shape with operating reliability, and products produced thereby.

More particularly, the invention or improvement resides in a method for economically providing for the mass production of single surface-of-revolution, replaceable,

lightweight, 3-dimensional airborne cone antennas of high resolution exposure, the prefabricated cone having specific properties suitable for broad band capability meeting the requirements of element tolerance control (±.0005" on all critical areas), element adhesion and stable reproducible dielectric properties, and the product produced thereby.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a conductor cone in partial prefabrication.

FIG. 2 shows a film wrap in partial placement.

FIG. 3 shows a cone film hold down in exploded form.

FIG. 4 illustrates a method of photographically exposing the coated film.

FIG. 5 shows a schematic of the steps of the method herein provided.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In step 1 of the process, referring to FIG. 1, with reference to FIG. 5, there is first provided a rotatable mandrel plated with a thin copper covering shell. The copper shell **10** is formed in a conventional copper plating bath utilizing a conventional pump and filter system with rotating cathode holder and suitable controls (not shown) to provide a fine grained copper shell overlying a stainless steel, or aluminum, mandrel. The mandrel is first coated with indium (partially shown) which serves as an etch resistant conductor surfacing during copper plating and also acts as a parting agent to release the finished part from the mandrel. The indium is preferably applied by brush plating or dip (melting point 313° F.). However, a plating bath and its attendant accessories may be used, at greater cost in fabrication. If the mandrel is aluminum, it is prepared by zincating and treatment in an acid bath prior to the application of the indium coating.

The forming mandrel may serve for completing fabrication of the cone. As an alternative, the copper cone **10** may be removed from the plating mandrel by heating in an oven about 350°–360° F. to soften the indium and using air to blow the copper cone off the forming mandrel. Thereafter, the copper cone can be placed on a treating mandrel for fabrication of the cone, by the following steps.

The copper coated mandrel is washed clean of the plating solution and as exemplified in FIG. 2 is next coated with a suitable conventional photoresist **11** used in photoresist methods. For example, although other commercially available photoresists or known compositions thereof may be used, if desired, asuitable conventional photoresist composition is the currently known "Kodak III" preferably thinned to 7.5 to 8 centipoises viscosity. The resist composition and its viscosity are optional dependent upon the operator's desire for best results. Several photoresists are on the market, and selection and use thereof optional to practitioner of the method herein. This photoresist is then heat treated or baked at a conventional setting temperature in this case of about 120° F. and a predeveloped negative photoprinting film **12** of the desired circuitry pattern is wrapped around the resist coated cone. For example, as the 8 arm antenna design **13**.

Such photoprinting negatives are preferably prepared by direct contact printing from a suitable master, in a computer process, with a light beam (not shown), eliminating camera errors and costly photoreduction steps. The negative film is cut and modeled, as along line **14**, to permit wrapping it about the resist coated copper cone. The negative design is prepared for cutting and wrapping about the mandrel with the edges of the circuitry in meeting or edge overlap relationship. Alternatively, the edges can meet in a

spiral shape chosen so that the lap occurs in that area of metal to be subsequently etched away, reducing the precision required for alignment of the film.

Over the film warp is next placed a hold down transparent plastic cone **15** of polymerized plastic, as poly (ethyleneglycolteraphthalate) to make the negative film **12** conform intimately to the photoresist.

When the cone is thus prepared, it is, in the next step, exposed to a suitable light source, as arc lamp **16**, through shield **17**, while slowly rotating the mandrel, as by motor M, (diagrammatically illustrated in FIG. 4). After exposure, the polymerized hold down film and negative are removed and the photoresist circuitry pattern developed by conventional processing. After development, the undesired or non-patterned photoresist portion is removed in a conventional manner, leaving the developed or hardened pattern as an etching resist. Before or after removal of the undesired film, the pattern may be dyed and "touched up" for etching.

In the next step of the process, the patterned copper cone is transferred to a washing and etching spray chamber wherein the mandrel is slowly rotated and places the cone pattern under the force of a ring of at least 3 sprays directing a conventional ferric chloride or sulfuric-chromic etchant onto the design pattern. When the design pattern is all that remains, or etching is completed, the design and the mandrel are cleaned and washed clear of the etchant and remaining photoresist.

In step 5, the mandrel with its cleaned design pattern is rotated in a suitable vacuum chamber and an insulating film of a thickness up to 5 mils or more poly-p-xylylene is deposited over the etched circuitry network and the bare areas forming a firm support web for the conductors. The poly-p-xylylene film is provided by vapor phase polymerization of para-xylylene, halogenated-p-xylylene alkyl or aryl or substituted para-xylylene, or mixtures thereof. The para-xylylene or substituted para-xylylene is provided by sublimation and the vapor pyrolyzed at about 950° C. in the presence of steam. Otherwise, the preparation of the coating of polymerized p-xylylene can be effected by vaporization under (about .1 torr) vacuum at melting temperatures of about 200° C. to 280° C. The vapor is passed to a pyrolysis or cleavage zone maintained at 500–600° C. and into the cooler deposition zone, at room temperature or lower, with suitable vacuum pump and protective traps (not shown). Cooling of the vapor to a temperature below about 50° C. effects a continuous film deposit of at least about .005" poly-p-xylylene over the circuitry and bare mandrel areas to form a continuous substituted plastic cone of polymerized monomers or polymers bonding and covering the electrical conductors in insulated and supported, spaced relationship. Repeating the steps of polymerization deposit provide a film thickness on the order of .015". When the cone is formed on the original mandrel, separation of the conductors, as the antenna elements, may be effected by trimming the base free of polymers and heating the mandrel to 350° to 360° F. to softening the idium coating and lifting the cone from the mandrel. Otherwise, when the copper cone, formed of about 2 mil thickness, is transferred to a treating mandrel, the polymers are trimmed from the base and the prefabricated cone is removed. The cone rotation is effected by motors M, at about 10 r.p.m.'s, as diagrammatically illustrated.

In this system, the electrical configurations are maintained and retained in stable relationship, as in the 8 arm cone apex illustrated, meeting the requirements of element tolerance control (±.0005" on all critical areas), element adhesion and stable reproducible properties, providing superior strength, heat resistance, electric and dielectric properties. In addition, the system provides economic variation, at a minimum of tooling costs, of a large variety of less regular configurations that are required for cone-antenna and other 3-dimensional circuitry systems. In either case, the prefabricated circuitry (cone antenna) is prepared for application and mounting for use in radar and/or communication circuitry (now shown).

Having described the present embodiments of my discovery in accordance with the patent statutes, it will now be apparent that some modifications and variations may be made without departing from the spirit and scope thereof. The specific embodiments described are provided by way of illustration and are illustrative of my discovery, invention or improvements which are to be limited only by the terms of the appended claims.

What is claimed is:

1. The method of providing a thin three-dimensional conductor pattern in fabricated cone form comprising the steps:

(1) coating a cone-shaped rotatable mandrel with a continuous film of separable conductor;

(2) coating the continuous film of conductor with a photoresist;

(3) placing about said photoresist a photo-negative film of circuitry design:

(4) encasing said photo-negative in a transparent polymer plastic to conform said negative intimately against said photoresist;

(5) exposing said encased film to a light source while slowly rotating said encased photo-negative;

(6) removing said plastic encasement and negative film, and developing the circuit pattern design in the photo-resist coating;

(7) removing the resist coating portion about said developed pattern design;

(8) etching said conductor coating film and removing the exposed portion of said conductor from about said developed pattern design;

(9) removing said developed resist coating pattern design and washing said design and mandrel free of contaminants;

(10) depositing an insulating and continuous supporting polymerized film over said design and said mandrel, and

(11) removing said polymer film and circuitry design cone from said mandrel and

(12) obtaining a three-dimensional fabricated cone patterned conductor supported by said polymerized film.

2. The process of claim **1** wherein the mandrel is first provided with an indium coating and the conductor coating is copper.

3. The process of claim **1** wherein the said transparent polymer plastic is a prefabricated polymerized film of poly (ethyleneglycolteraphthalate).

4. The process of claim **1** wherein the supporting insulating film is poly-p-xylylene.

5. The process of preparing a cone antenna with supported electric circuitry therein of an antenna pattern within ±.0005" tolerance comprising the steps:

(1) prepare a copper cone by:

(a) coating the surface of a rotatable cone mandrel with indium metal, and

(b) depositing a copper coating over the indium surface;

(2) coating the copper coating with a photoresist and bake;

(3) wrap a photo printing film of the required electrical configuration around the copper coated mandrel and enclose the film tightly against the photoresist coating with a transparent plastic;

(4) rotate mandrel, expose the photo printing film to a light source and develop the copy of the electrical configuration produced in the photoresist;

(5) remove the excess photoresist from the copper surface leaving the developed circuitry pattern thereon;

(6) rotate the mandrel and etch the uncovered copper from the mandrel surface, remove the remaining

photoresist and clean the exposed circuitry and mandrel of contaminants;

(7) rotate the mandrel and deposit a coating of poly-p-xylylene polymers over the electrical design configuration and bare mandrel areas,

whereby is obtained a 3-dimensional cone configuration separable from said mandrel and of insulated and supported electric circuitry.

References Cited

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U.S. Cl. X.R.

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