

[54] **METHOD FOR ETCHING APERTURED WORK PIECE**

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[52] **U.S. Cl.** **156/11; 156/18; 96/36.1**

[51] **Int. Cl.²** **B29C 17/08**

[58] **Field of Search** **156/3, 8, 11, 13, 18; 96/36.1, 36, 38.3**

[56] **References Cited**

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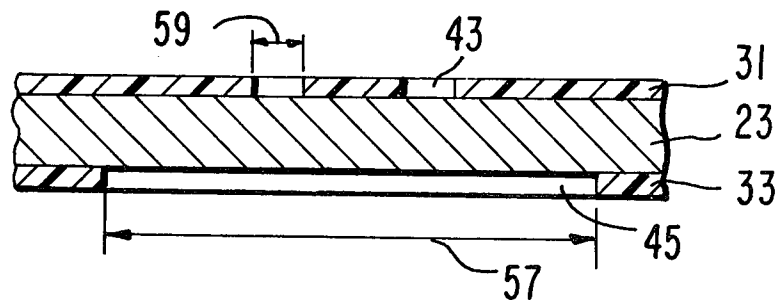
2,437,228	3/1948	Mears et al.	96/38.3
2,750,524	6/1956	Braham.....	96/36.1
3,329,541	7/1967	Mears	156/11
3,609,033	9/1971	Frantzen.....	96/36.1
3,679,500	7/1972	Kubo et al.	156/17

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Assistant Examiner—Jerome W. Massie
Attorney, Agent, or Firm—G. H. Bruestle; L. Greenspan

[57] **ABSTRACT**

Method for etching an apertured work piece, such as a shadow mask for a color television picture tube, comprises coating opposite major surfaces of a thin metal sheet with etch-resistant patterns. The pattern on one major surface comprises an array of larger open areas surrounded by etch-resistant material, and the pattern on the opposite major surface comprises smaller open areas of similar shape and registered with the larger open areas on the one major surface. Each of the smaller open areas has therein a still-smaller solid area of etch-resistant material. The coated sheet is then etched from both sides to produce the desired apertures, and then the coatings are removed from the sheet.

9 Claims, 9 Drawing Figures



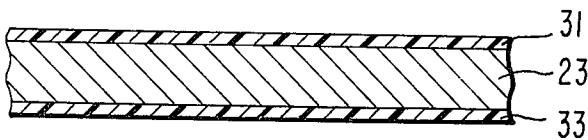
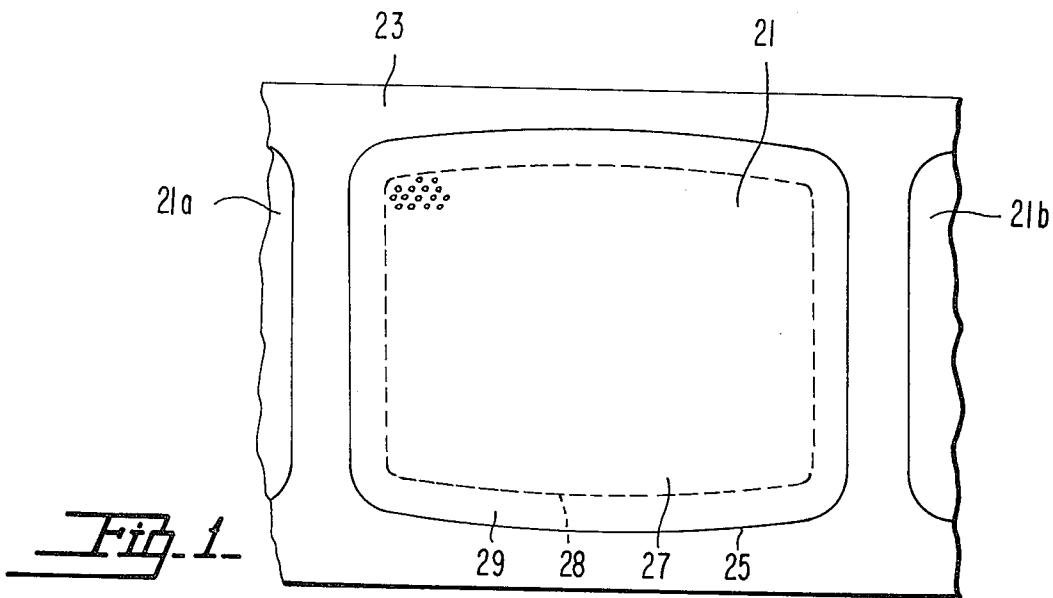


Fig. 2

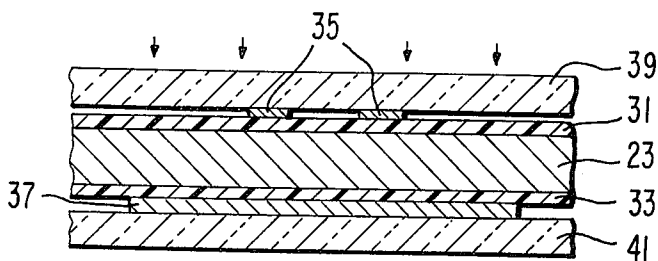


Fig. 3

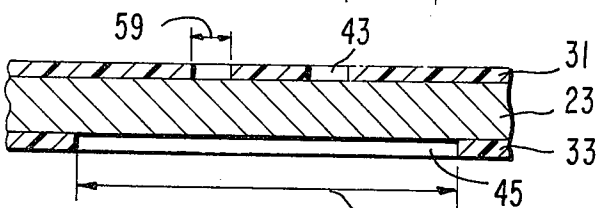


Fig. 4

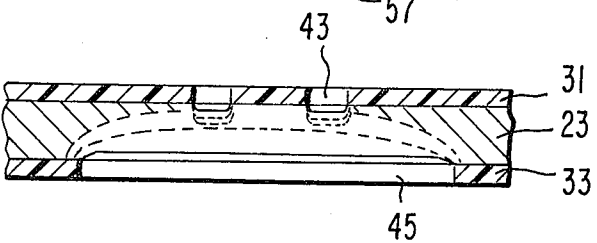


Fig. 5

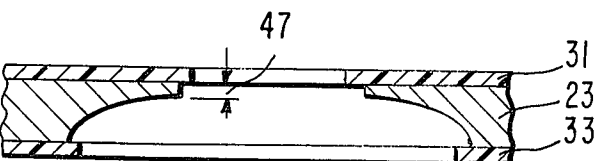


Fig. 6

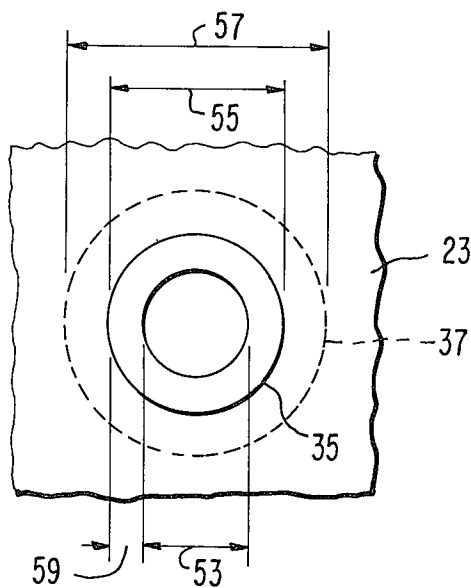


Fig. 7.

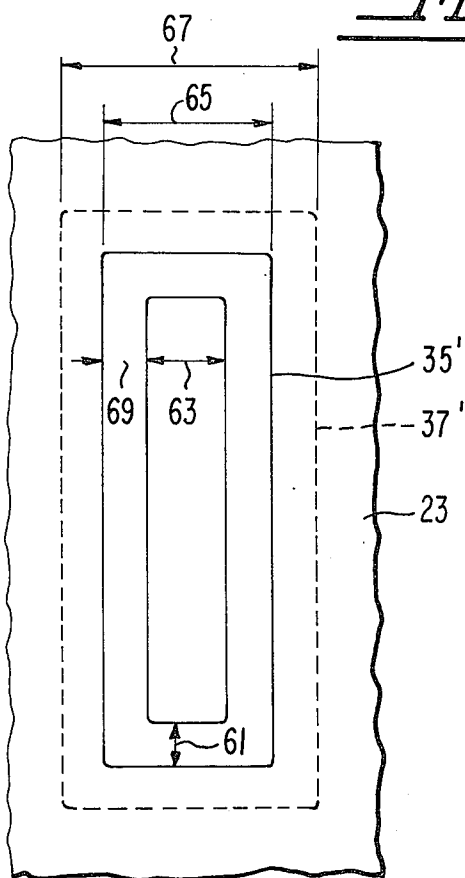


Fig. 8.

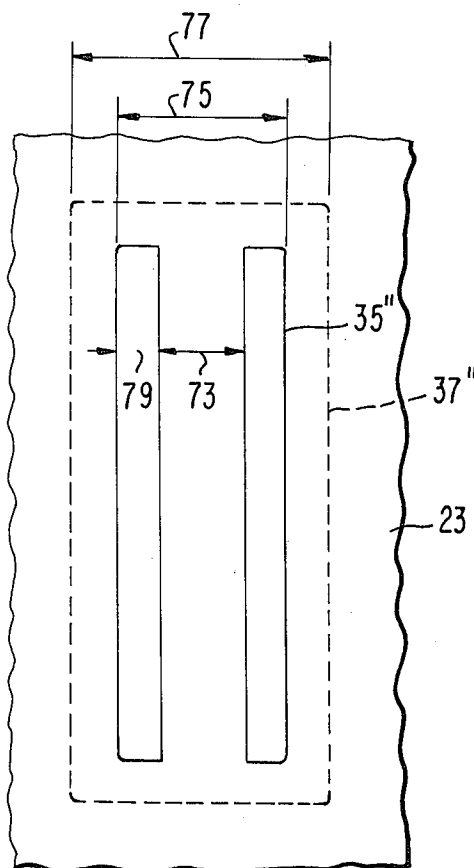


Fig. 9.

METHOD FOR ETCHING APERTURED WORK PIECE

BACKGROUND OF THE INVENTION

This invention relates to a novel method for etching an apertured work piece and particularly for etching the apertures in a shadow mask for a color television picture tube.

A shadow-mask-type color television picture tube includes a color-selection electrode closely spaced within the tube from a viewing-screen structure. The electrode is in the form of a perforate or apertured mask which shadows portions of the viewing screen from the electron beams during the operation of the tube. In order to reduce scattering of beam electrons off the sides of the apertures, during electron-beam scanning, it is the practice to taper the apertures, with the smaller-sized part of the taper towards the electron-beam source and the larger-sized part of the taper towards the screen structure. For practical reasons in the fabrication process, the narrowest part of each aperture is a "knife edge" which is located a short distance in from the mask surface. The short distance is referred to as the "step height" of the knife edge.

In U.S. Pat. Nos. 2,750,524 to F. G. Braham and 3,679,500 to N. Kubo et al., there are described methods for etching the mask apertures for a color-selection electrode in a manner which results in a small step height. Both methods involve two separate etching steps and two separate resistcoating steps.

SUMMARY OF THE INVENTION

The novel method for producing an array of tapered apertures in a metal sheet comprises coating opposite major surfaces of the sheet with etch-resistant patterns, the one pattern on the one major surface comprising larger open areas surrounded by etch-resistant material, and the other pattern on the opposite major surface of the sheet comprising similarly-shaped, but smaller, open areas registered with the larger areas on the one side. Each of the smaller open areas has therein a still-smaller solid area of etch-resistant material. Preferably, the still-smaller solid area is in at least one dimension thereof, at least 1.0 mil wide and at least 2.0 mils smaller than the smaller open area. The both sides of the coated sheet are etched simultaneously until the desired tapered apertures are produced in the sheet. Then, the etching is stopped, and the etch-resistant patterns are removed from both major surfaces.

By employing the still-smaller solid areas of etch-resistant material within the smaller open areas as described above, the step height can be reduced and the uniformity of the knife edge can be improved over prior processes. The use of the openings produced by this combination of etch-resistant patterns permits etching to occur from both surfaces of the sheet but controllably limits the etching from the surface carrying the pattern with the smaller open areas. The novel method requires only a single coating step and a single etching step to achieve what is achieved in two steps with the above-cited prior-art methods.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a metal sheet after etching according to the novel method.

FIGS. 2 through 6 are sectional views through one aperture of a metal sheet illustrating the steps of one embodiment of the novel method.

FIG. 7 is superimposed plan views of the etch-resistant patterns for one element of a master plate for producing circular apertures according to one embodiment of the invention.

FIG. 8 is superimposed plan views of the etch-resistant patterns for one element of a master plate for producing slit apertures according to another embodiment of the invention.

FIG. 9 is superimposed plan views of the etch-resistant patterns for one element of a master plate for producing slit apertures according to still another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a plan view of an etched apertured mask blank 21 as it emerges from the etching machine. The mask blank 21 (which is to be used in a color television picture tube) is in a metal sheet 23 comprising a succession of such mask blanks 21a, 21, and 21b which are etched through at the margins 25 thereof except at convenient points (not indicated) sufficient to hold the mask blank 21 in place in the sheet 23. The mask blank 21 is comprised of an apertured central portion 27 defined by the broken line 28; and a skirt or peripheral portion 29 which is not apertured, although in some embodiments it may be etched partly through. This application is particularly concerned with etching the apertures in the apertured central portion 27. The apertures may be round and arranged in a hexagonal, diamond-shaped or other array. Or, the apertures may be rectangular slits arranged in vertical rows; for example, 6-mil by 30-mil slits on 30-mil centers. The apertures may be of other shapes and arrangements. In any of the embodiments, the width may be uniform or may be graded in width or diameter from the center to the edge of the array as is known in the art.

The mask blank 21 is etched into a regular-carbon or low-carbon cold-rolled-steel sheet about 4 to 10 mils in thickness. The etching may also be conducted in sheets of other materials, such as invar alloy, or a copper-nickel alloy. The sheet 23 is unwound from a first roll thereof, passed through the various operations including cleaning, coating, drying, exposing, developing, etching, washing and drying (as will be described below), then rewound on a second roll. Subsequently, the second roll is unwound and the mask blanks 21 are stripped or torn from the sheet 23. The mask blanks 21 are then heat treated (annealed), roller leveled, formed on a press, and then blackened as is known in the art, to produce masks suitable for assembly into a picture tube.

FIGS. 2 through 6 show a sequence of steps that may be used in making a round aperture in the central portion 27 of a hexagonal array of apertures in a 6-mil-thick strip of cold-rolled steel, as shown in FIG. 1. The sheet 23 is coated on both major surfaces with suitable light-sensitive coatings 31 and 33 of etch-resistant materials, such as dichromate-sensitized fish glue, as shown in FIG. 2. After the coatings have dried, the coated strip is positioned in a chase, such as is shown in U.S. Pat. No. 3,751,250 to J. J. Moscony et al., between two light-opaque master patterns; one master pattern 35 for the coating 31 on the one major surface of the sheet 23; and the other master pattern 37 for the

other coating 23 on the other major surface of the sheet 23, as shown in FIG. 3. The light-opaque patterns may be of chromium or nickel metal coated on the inner surfaces of glass plates 39 and 41 respectively so that the patterns are physically against the coatings 31 and 33. The one master pattern is annular or ring shaped about 5-mils outside diameter and 3-mils inside diameter. The other master pattern 37 is disc or solid circular shaped about 16 mils in diameter. Center lines of the one and the other master patterns are coincident, but may be offset from one another if desired.

As shown in FIG. 3, the coatings 31 and 33 on the one and the other surfaces of the sheet 23 are now exposed to hardening radiation (shown by the arrows above and below the glass plates 39 and 41), as from a carbon-arc source, which radiation passes through the glass plates 39 and 41 incident on the coatings 31 and 33. The radiation insolubilizes the coatings 31 and 33 except where the one and the other master patterns 35 and 37 shadow the coatings. When the coatings are suitably exposed, the exposure is stopped, and the master patterns removed.

The coatings are now developed as by flushing with water or other aqueous solvent to remove the unexposed, shadowed portions of the coatings 31 and 33. As shown in FIG. 4, after development, the sheet 23 carries on its one surface an etch-resistant coating having an annular opening 43 therein and, on its other major surface, an etch-resistant coating 33 having a circular or disc-shaped opening 45 therein.

The sheet 23 with the etch-resistant coatings thereon is now etched in a single step to produce the desired tapered aperture. FIGS. 5 and 6 show the coated sheet 23 at an early stage (FIG. 5) and then at the end of etching (FIG. 6). The etching is conducted in the usual manner employing a ferric chloride-hydrochloric acid liquid etchant. At the initial stage shown in FIG. 5, the etchant has dissolved a small amount of the surfaces of the sheet 23 in the uncoated areas thereof. FIG. 5 also shows, by dotted lines, various subsequent etching surfaces that the etchant is believed to advance to.

The use of an annular opening 43 instead of a disc-shaped opening on the one major surface severely restricts the effective etching from that surface to defining the aperture shape, thereby imparting only a small step height 47, as shown in FIG. 6. If the annular opening 43 were replaced with a disc-shaped opening, the step height would be substantially greater. The coatings 31 and 33 on the one and the other surfaces of the sheet 23 are removed from the strip after the etching has been completed, and the work piece is ready for further processing.

FIG. 7 shows, superimposed upon one another, the one and the other master patterns in the working plates in plan view. The significant dimensions of the annular openings of the one master pattern are the inside diameter 53, the outside diameter 55, and the width 59 of the annular opening, which is one half the difference between the inside diameter and the outside diameter. In practical embodiments, the inside diameter 53 of the annular area should be about 1.0 to 8.0 mils, and the outside diameter 55 should be about 3 to 10 mils. Preferably, the difference between the inside and outside diameter is at least 2.0 mils so that the width 59 of the annulus is at least 1.0 mil. The significant dimension for the circular opening of the other master pattern is the diameter 57, which may be, in practical embodiments, about 12 to 20 mils. Where the apertures are graded in

size from the center to the edge of the apertured portion 27, the diameters of the annular openings are graded. In a typical case, the outside diameter of the annular opening 35 may grade from about 9.5 mils at the center of the mask to about 7.5 mils at the edge of the apertured portion 27 of the mask. The inner diameter of the annular opening 53 may also be graded, but the width 59 is preferably at least 1.0 mil using present state-of-the-art etch-resistant patterns. As the width 59 decreases, the step height decreases to a minimum of about 1.0 mil and then increases. In this embodiment, the diameter 57 of the circular area on the reverse side is about 16 mils but is not critical and may be between 12 and 24 mils. Where the apertures are graded in size, the larger circular areas may or may not be graded in size. A typical center-to-center aperture spacing is about 25 mils.

The invention may be applied to producing rectangular slit apertures, as shown for the superimposed master patterns shown in FIG. 8. The one master pattern 35' (solid lines) and the other master pattern 37' (dotted line) are shown in the shape of rectangles with rounded corners. For the one master pattern 35', the outside width 65 is about 5 mils and the outside length is about 30 mils in one embodiment. The inside width 63 is about 2 mils and the inside length is about 27 mils. In other embodiments of the one master pattern, the inside width 65 may vary from 1 to 10 mils and the outside width may vary from 3 to 20 mils. However, the difference between the inside width and the outside width is preferably at least 2 mils so the width of the annular spacing 69 and 61 is at least 1 mil. The other master pattern 37' may vary between 12 and 24 mils in width and between 20 and 50 mils in length. However, each of the length and width dimensions of the other master patterns should be larger than the corresponding dimension of the one master pattern.

FIG. 9 shows still another embodiment of the invention as an array of rectangular slits. The slit aperture master pattern shown in FIG. 9 differs from that of FIG. 8 in that, in the one master pattern 35'', the length of the still-smaller solid area is equal to the length of the smaller open area. For practical reasons, it has been found that annular spacing 61 of the one master pattern of FIG. 8 may be omitted and substantially equivalent results may be obtained to those obtained with the master patterns shown in FIG. 8. Thus, in the slit aperture embodiment shown by the master patterns in FIG. 9, it is necessary in only one dimension of the one master pattern that the still-smaller solid area is at least 2.0 mils smaller than the smaller open area. This requirement is satisfied by the horizontal pattern and dimensions shown in FIG. 9.

I claim:

1. A method for producing an array of tapered apertures in a thin metal sheet comprising

- coating opposite major surfaces of said sheet with etch-resistant patterns, the pattern on one major surface comprising an array of open areas surrounded by etch-resistant material, and the pattern on the opposite major surface comprising open areas of smaller shape but smaller than the open areas on said one major surface and registered with said larger open areas, each of said smaller open areas having therein a solid area of etch-resistant material that is still smaller than said smaller open area, each still-smaller solid area being continuous and unbroken by open areas,

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b. simultaneously etching both sides of said coated sheet until said tapered apertures are produced in said sheet,

c. and then removing said etch-resistant patterns from both major surfaces of said sheet.

2. The method defined in claim 1 wherein said still-smaller solid area is, in at least one dimension thereof, at least 1.0-mil wide and at least 2.0 mils smaller than said smaller open area.

3. The method defined in claim 2 wherein, in said one dimension, said smaller open areas are about 6 to 10 mils wide and said still-smaller solid area is about 2 to 3 mils wide.

4. The method defined in claim 1 wherein said larger open areas are substantially circular areas about 12 to 20 mils in diameter, and said smaller open areas are substantially circular areas about 6 to 10 mils in diameter.

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5. The method defined in claim 4 wherein said still-smaller solid areas are circular and concentrically placed within said smaller open circular areas, said smaller open areas being about 2 mils in diameter larger than said still-smaller solid areas.

6. The method defined in claim 1 wherein said larger open areas are substantially rectangular areas about 12 to 20 mils wide and said smaller open areas are substantially rectangular areas about 4 to 10 mils wide in the same dimension as said larger rectangular areas.

7. The method defined in claim 6 wherein said smaller open areas are about 2 mils wider than said still-smaller solid areas.

8. The method defined in claim 6 wherein the lengths of said still-smaller solid areas are equal to the lengths of said smaller open areas.

9. The method defined in claim 6 wherein the lengths of said still-smaller solid areas are at least 2 mils shorter than the lengths of said smaller open areas.

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