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Lerner

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[54] **APPARATUS FOR RE-ETCHING A COLOR CATHODE RAY TUBE SHADOW MASK**

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[73] Assignee: **Zenith Radio Corporation,** Chicago, Ill.

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[21] Appl. No.: **436,243**

Related U.S. Application Data

[62] Division of Ser. No. 243,945, April 14, 1972, Pat. No. 3,808,071.

[52] **U.S. Cl.** **156/345;** 156/16

[51] **Int. Cl.** **C23f 1/02**

[58] **Field of Search** 156/7, 16, 18, 345, 8; 96/36.1

[56] **References Cited**

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Primary Examiner—William A. Powell

Assistant Examiner—Brian J. Leitten

[57] **ABSTRACT**

An apparatus is depicted for re-etching the apertures of a color cathode-ray tube shadow mask of the type which comprises a multiplicity of apertures arranged in a predetermined pattern and having an initial predetermined size relationship from aperture to aperture. The shadow mask has a predetermined first set of apertures which are susceptible of enlargement at a faster rate than a predetermined second set of apertures upon exposure to an etchant capable of attacking the shadow mask. The apparatus comprises means for supporting the shadow mask and spray means for applying more of the etchant to the second set of apertures than to the first set of apertures such as to at least partially compensate for the greater susceptibility to enlargement by etching of the first set of apertures than the second set of apertures and promoting equalization of enlargement of both sets of apertures. The spray means is depicted as including a plurality of spray nozzles and a shield for at least partially shielding the shadow mask from the spray nozzles such that a greater amount of etchant is applied to the second set of apertures than to the first set of apertures.

4 Claims, 6 Drawing Figures

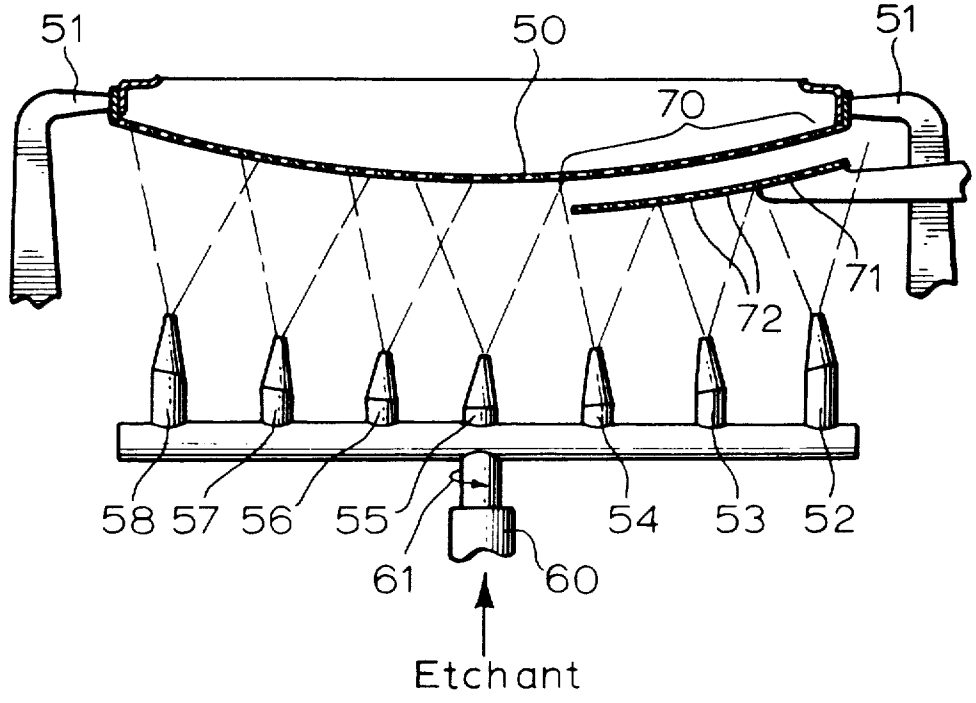


FIG. 1

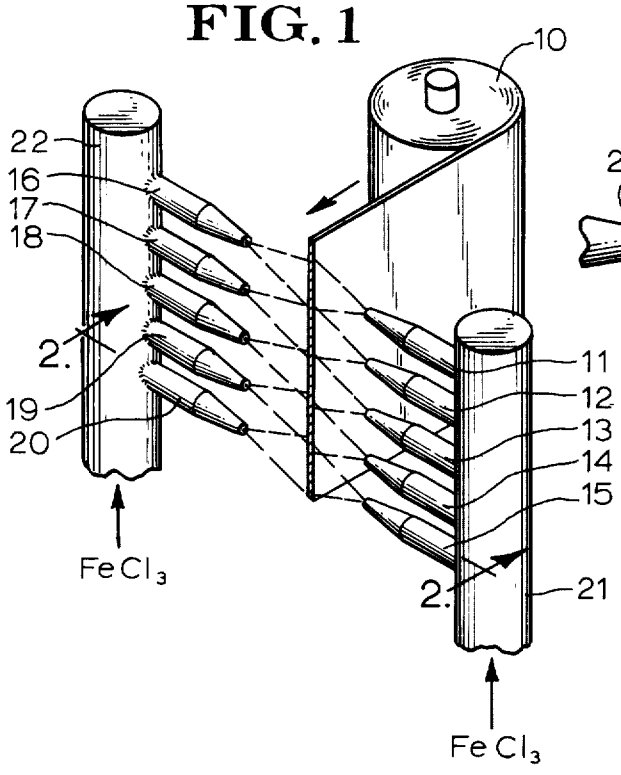


FIG. 2

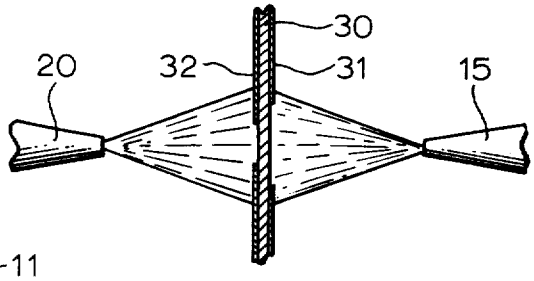


FIG. 3A

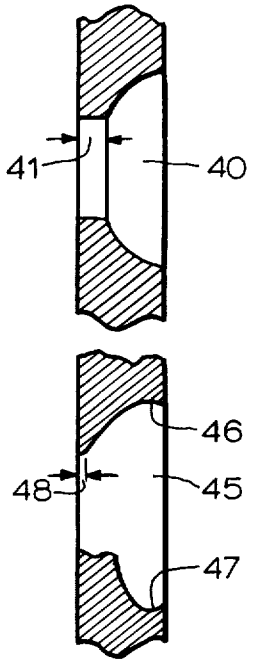
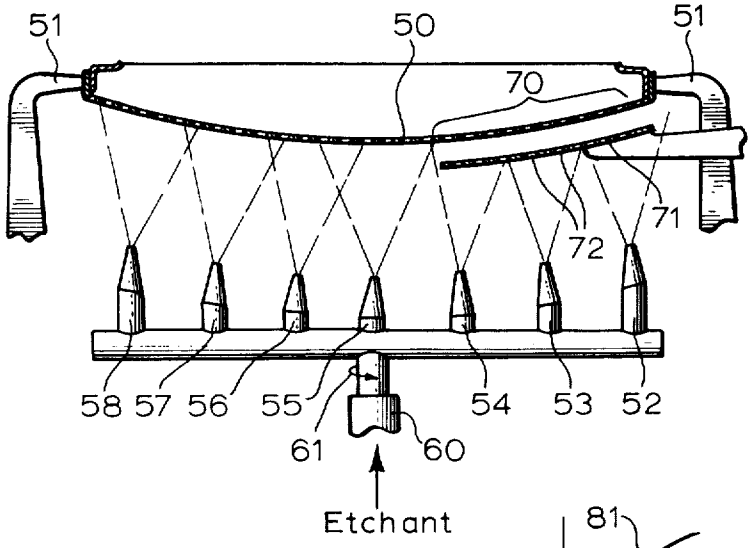


FIG. 3B

FIG. 4



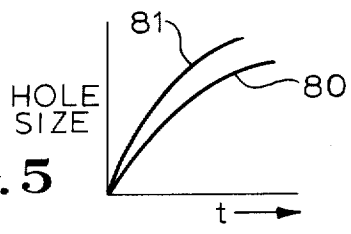


FIG. 5

APPARATUS FOR RE-ETCHING A COLOR CATHODE RAY TUBE SHADOW MASK

RELATED APPLICATION

This application is a division of application Ser. No. 243,945, filed Apr. 14, 1972, now U.S. Pat. No. 3,808,071, and assigned to the assignee of this application.

BACKGROUND OF THE INVENTION

The invention is particularly concerned with screening of a color picture tube characterized by the fact that the viewable phosphor elements are smaller than the apertures of the color-selection electrode. Typical of this kind of tube is that which is known as a black-surround picture tube. The tube may come in different sizes and configurations, being either rectangular or round. The phosphor pattern usually consists of interleaved deposits of various phosphor materials arranged in the form of dot triads. The present invention however is not particularly affected by the choice of a particular dot triad structure, but for convenience, it will be assumed that the tube in process is rectangular and has dots or red, green and blue phosphor materials arranged to define a multiplicity of dot triads disposed throughout a rectangularly shaped image field.

The tube of the type under consideration differs from the more conventional shadow mask tubes, for example, in that the viewable phosphor deposits are reduced in size. In the conventional tube the phosphor dots are in tangential contact with one another, whereas in the black-surround tube to which this invention is especially directed, the reduced phosphor dots are separated from one another. Their separation provides elemental portions of the screen surface to which a black pigment or other light-absorbing material may be applied, surrounding each phosphor with the light-absorbing material and giving rise to its name "black surround" tube. In its preferred form, the phosphor dots are smaller in diameter than the holes of the shadow mask in order that the cross-sectional area of the electron beams will be larger than the phosphor dots to provide a guard band or tolerance for color purity in the picture tube. A tube of this description is the subject of U.S. Pat. No. 3,146,368 issued Aug. 25, 1964 in the name of Fiore et al and assigned to the assignee of the present invention. It has vastly improved brightness and contrast properties.

In the manufacture of tubes of the type under consideration, difficulty has been experienced in obtaining the necessary dimensional relationship of phosphor dots to electron beam size or cross-sectional diameter. An effective solution to the problem which is successful in the commercial production of black-surround tubes has been the re-etch or etch-back process. In accordance with that process the mask has a field of apertures that are etched initially to a predetermined size and in a predetermined size relationship from aperture to aperture for use in photoresist printing of the screen. This is a well-known printing process which takes advantage of the property of a photosensitive resist which, upon exposure to actinic energy, changes its solubility in a particular solvent. The most attractive embodiment of the screening process uses a water-based system comprising an aqueous solution of sensitized polyvinyl alcohol which is rendered insoluble in water when exposed to ultraviolet light. After the three phosphor materials have been applied to the screen area in locations precisely determined by exposure through the shadow mask of the color picture tube, that mask is then subjected to a second etching process in order to enlarge the apertures to a size greater than that which is used for screening.

One difficulty experienced in the re-etch or etch-back process has been that, although the apertures of the mask-in-process during screening are of the proper size, certain ones of the mask apertures have cross-sections which render them susceptible to enlargement at a faster rate than others. Consequently, uniform processing of the shadow mask during re-etch renders such apertures larger than desired compared to those apertures which enlarge at a slower rate. Therefore, a shadow mask having apertures of proper size in a final desired size relationship from aperture to aperture is difficult if not impossible to obtain using conventional methods.

The present invention is an attractive improvement in that it assures that all of the apertures of the shadow mask are of the proper size in a desired final size relationship from aperture to aperture.

OBJECTS OF THE INVENTION

It is an object of this invention to provide improved apparatus for re-etching a color tube shadow mask of the character described so as to produce an end product mask having apertures in a proper final size relationship from aperture to aperture notwithstanding the diverse re-etch enlargement rates of different sets of apertures in the mask.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements and in which:

FIG. **1** is a perspective schematic representation illustrative of a manufacturing apparatus used for manufacturing a shadow mask;

FIG. **2** is a fragmentary cross-sectional view taken on lines **2—2** of FIG. **1**;

FIG. **3***a* is a fragmentary cross-sectional view to an enlarged scale illustrative of the cross section of one of the apertures produced by the shadow mask manufacturing process;

FIG. **3***b* is a fragmentary cross-sectional view to an enlarged scale illustrative of the cross section of another aperture produced by the shadow mask manufacturing process;

FIG. **4** is a schematic representation of a shadow mask in position in a re-etch work station embodying the present invention and of the type which may be used to practice the present invention; and

FIG. **5** is a graph which is used in explaining the effects of different aperture cross sections in the re-etch process.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A screen of the black-surround tube may be prepared in either of two ways, that is to say, the black-surround

pattern may first be developed on the image area followed by the application of interleaved patterns of three different phosphor materials or the phosphors may be applied first after which the areas intervening the phosphor deposits are covered with light-absorbing material. In either event, the shadow mask is used in forming black-surround holes or phosphor deposits that are smaller in diameter than the apertures of the mask as finally installed in the tube. The present invention may be completely understood apart from a discussion of the process for forming the black-surround and therefore, this aspect will not be described.

The technique of applying a multiplicity of phosphor dot triads throughout the image or screen area of a rectangularly shaped color tube is well known to the art and need not be recited in detail here. Briefly, the faceplate section of the envelope, while still physically separated from the conical envelope portion, is chemically cleaned and then coated with a photosensitive material such as a water-base slurry of polyvinyl alcohol sensitized by ammonium dichromate. It is also common practice to include one of the three color phosphors as an ingredient of the slurry. Assume that green phosphor is the first to be applied. The slurry-coated faceplate with shadow mask installed is secured in an exposure position in an exposure chamber or lighthouse. A source of ultraviolet light, positioned to simulate the electron gun of the tube in process that is assigned to excite green phosphor, is energized to direct actinic energy through the apertures of the shadow mask to the coated image area. The portions of the slurry layer which are exposed are rendered insoluble in water and constitute a latent image of the green phosphor deposit. That image is developed, after the shadow mask has been removed, by washing the screen with water. This leaves deposits of green phosphor in elemental areas distributed throughout the screen or image area. In like fashion, but with slurries that individually have red and blue phosphor ingredients, the red and blue phosphor dots are established. It is, of course, required that the light source, in the application of each of these two additional phosphors, simulate the electron beams of the tube assigned to excite the respective phosphors. This is a well-known photo mechanical printing process in wide commercial use in the production of three-color shadow mask picture tubes. In the printing process the shadow mask serves as a pattern to precisely locate and dimension the various phosphor deposits that constitute the desired phosphor triads. To serve in that capacity, the mask is prepared with a dome shape which approximates a spherical section having a rectangular field of apertures or holes, individually smaller than desired in the final form of the mask but accurately dimensioned for use in screening. To achieve the desired final aperture size, the mask is re-etched after the screening shall have been accomplished and the remainder of this description will confine itself to the re-etching steps.

The general principles of chemical milling by which, for example, a metallic workpiece which is etchable in a particular etchant is provided with an aperture pattern are well known. Such a chemical milling apparatus is schematically illustrated in FIG. **1.** The metallic workpiece which eventually becomes the shadow mask is in a rolled up configuration such as steel roll **10.** It is disposed in a vertical position to be unwound so that the metal sheet may be pulled through the etching apparatus. The apparatus is provided with a plurality of spray nozzles on both sides of the vertically disposed workpiece, spray nozzles **11-15** being on one side and spray nozzles **16—20** on the other. The spray nozzles are disposed horizontally so that the etchant solution, normally ferric chloride, supplied through supply pipes **21** and **22** may be sprayed onto the vertically disposed workpiece in a direction which is normal to the workpiece. Deposited onto both sides of the metal sheet is a coating of material which is resistive to the ferric chloride etchant solution. The resistive material has previously been subjected to an exposure process the result of which can be more clearly seen in FIG. **2.** Metal sheet **30** is covered with layers **31** and **32** of etchant resistive material with exposed areas defining the desired aperture dimensions. Spray nozzles **15** and **20** spray the etchant solution on both sides of the sheet. The exposed areas on the side of sheet **30** sprayed by nozzle **15** are substantially larger in diameter than the exposed areas of the sheet on the side being sprayed by spray nozzle **20.** This is done to obtain an aperture having a small diameter on one side of the sheet and a larger diameter on the other.

Cross-sectional representations of the apertures produced by this process are shown in FIGS. **3***a* and FIG. **3***b*. Aperture **40** is typical of those apertures formed at the top of the vertically disposed metal sheet and which are of the generally desired cross-sectional configuration. The cross section of the aperture is uniform throughout its circumference and more importantly lip portion **41** is of a constant width. Unfortunately, not all of the apertures produced by the chemical milling process are of this uniform cross-sectional configuration. For example as shown in FIG. **3***b*, aperture **45** has a non-uniform cross section. It has a pronounced undercutting in portions **46** and **47** and also lip portion **48** is not of a constant width, being thinner at the top of the aperture than at the bottom. Aperture **45** is illustrative of those produced at the bottom of the vertically disposed metal sheet. The differing cross sections of apertures **45** and **40** is believed to result from aperture **45** experiencing a greater degree of etchant run off than aperture **40.** Note that the apertures formed at the bottom of the worksheet receive all of the etchant run off from those spray nozzles located above it while apertures formed at the top of the sheet are not subjected to appreciable run off. The run off is believed to interfere with the spray pattern and cause the differential etching of apertures near the bottom as illustrated by aperture **45.** Why this actually occurs is unknown.

Even though these non-uniformities in cross-sectional area occur, the aperture areas are still of proper size and in the proper size relationship from aperture to aperture.

Unfortunately, aperture **45** will enlarge at a faster rate during re-etch than aperture **40.** This is because of the narrow upper lip portion **48** of aperture **45** which will etch away faster than either the lower or upper lip portions of aperture **40.** If all of the apertures of the shadow mask were re-etched under the same conditions, the apertures at the bottom of the mask, with the general cross-sectional configuration of aperture **45,** will be too large in area and thus not be of the proper size or in the proper size relationship from aperture to aperture. For convenience, the apertures, represented by aperture **45** which will enlarge at a faster rate upon re-etch will be defined as as apertures comprising a first

set and those apertures represented by aperture **40** will be defined as apertures comprising a second set.

The inventive method re-etches the shadow mask in such a way that all the apertures achieve a final proper size in a final predetermined size relationship from aperture to aperture.

An apparatus embodying the present invention and which may be used in practicing the inventive method is shown in FIG. **4.** The shadow mask **50** is supported by support means **51** in a substantially horizontal position with the convex side of the aperture mask facing downwardly. A plurality of spray nozzles **52–58** are arranged in an array and are located beneath shadow mask **50.** The spray nozzles project an etchant, suitable for attacking the material of shadow mask **50** vertically upward to apply the etchant to the shadow mask in a substantially normal direction to the mask. The etchant is supplied to the spray nozzles through supply pipe **60** which is connected to an etchant supply tank (not shown). The array of spray nozzles may be rotated by a rotating means (not shown) as represented by arrow **61** to compensate for any non-uniformity in the spray projected from the spray nozzles.

As explained earlier, the apertures comprising the first set, namely those enlargeable at a faster rate than those of the second set and having the general cross-sectional configuration of aperture **45** of FIG. *3b*, are located generally at the bottom of the metal worksheet of FIG. **1.** These apertures are represented as being located in area **70** of shadow mask **50** of FIG. **4.** As explained earlier, the difference in the enlargement rate of the two sets of apertures is compensated for. This is achieved by applying more etchant to the apertures of the second set. This may be accomplished by providing shield **71** to inhibit the etchant from attacking those apertures comprising the first set. The linear array of spray nozzles is rotated and the etchant from these nozzles is applied to the mask for a sufficient amount of time to allow the second set of apertures to become larger in size than the apertures of the first set. Then the etchant from spray nozzles **52–58** is applied to all of the apertures by removing shield **71** with removing means (not shown), or by placing the shadow mask into another etchant apparatus not having a shield.

To avoid having to remove shield **71** or placing the shadow mask into another etchant apparatus, the amount of etchant applied to the first and second set of apertures may optionally be controlled by perforating shield **71.** Perforations **72** of shield **71** allow less etchant to reach the first set of apertures in region **70** than reaches the non-shielded portions of the shadow mask comprising the apertures of the second set. The dimension and size of the perforations may be adjusted so that the proper amount of etchant is applied to each set of apertures.

FIG. **5** shows a graph representing the typical difference in the rate of enlargement of the apertures as represented in FIGS. *3a* and *3b*. Plot **80** represents a typical aperture-size-etch time relationship for an aperture having the general configuration of an aperture such as aperture **40** of FIG. *3a*. Plot **81** is a typical aperture size-etch time relationship for an aperture such as aperture **45** of non-uniform cross section and can be seen to have an etching rate greater than that of the aperture **40** represented in FIG. *3a*. A graph such as the one represented in FIG. **5** can be arrived at by empirical analysis for deriving the particular time parameters to be used for the inventive process.

The present invention provides an apparatus and a method of producing a color selection electrode having a multiplicity of apertures of the proper size and the proper size relationship from aperture to aperture notwithstanding the differences in the cross-sectional configuration of the apertures after an initial chemical milling process.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. Apparatus for re-etching the apertures of a color cathode-ray tube shadow mask of the type which comprises a convex-concave configuration, a multiplicity of apertures arranged in a predetermined pattern and having an initial predetermined size relationship from aperture-to-aperture, a predetermined first set of said apertures being susceptible of enlargement at a faster rate than a predetermined second set of apertures upon exposure to an etchant capable of attacking said shadow mask, said apparatus comprising:

support means for supporting said shadow mask in air with the convex side down; and

spray means including a plurality of spray nozzles positioned beneath said mask for projecting vertically upward a varying quantity of said etchant to said second set of apertures relative to said first set of apertures such as to at least partially compensate for the greater susceptibility to enlargement by etching of said first set of apertures than said second set of apertures and promote equalization of enlargement of both sets of apertures.

2. Apparatus as defined by claim **1** wherein said support means supports said mask so that said convex surface is toward said spray means and said spray means includes shield means for shielding and limiting the quantity of said etchant being projected on said first set of apertures by said spray.

3. Apparatus as defined by claim **2** wherein said shield means comprises a fixed perforate shield interposed between said spray nozzles and that portion of said shadow mask comprising said second set of apertures, covering said second set of apertures to cause a lesser quantity of said etchant to be applied to said first set of apertures than to said second set of apertures.

4. Apparatus as defined by claim **2** wherein said shield means comprises an imperforate shield adapted to be moved into and out of a shielding relationship between said spray nozzles and said shadow mask effectuating a differentiating quantity of projecting etchant on said first set of apertures relative to said second set of apertures.

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