United States Patent

Lerner

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[54] **SHADOW MASK HAVING DOUBLE-SIZED APERTURES**

[72] Inventor: **Martin L. Lerner**, River Forest, Ill.

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

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[52] **U.S. Cl.**.....**313/85 S**, 313/349

[51] **Int. Cl.**.....**H01j 29/06**, H01j 29/08, H01j 31/20

[58] **Field of Search**.....313/92 B, 85 S

[56] **References Cited**

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Primary Examiner—Robert Segal

Attorney—Francis W. Crotty

[57] **ABSTRACT**

The shadow mask of a color picture tube has a field of apertures each of which includes a small-diameter portion surrounded by a web usually having a thickness less than half the thickness of the sheet from which the mask is formed. The web thickness, instead of being uniform over the aperture field, decreases with radial distance from the center of the field.

3 Claims, 5 Drawing Figures

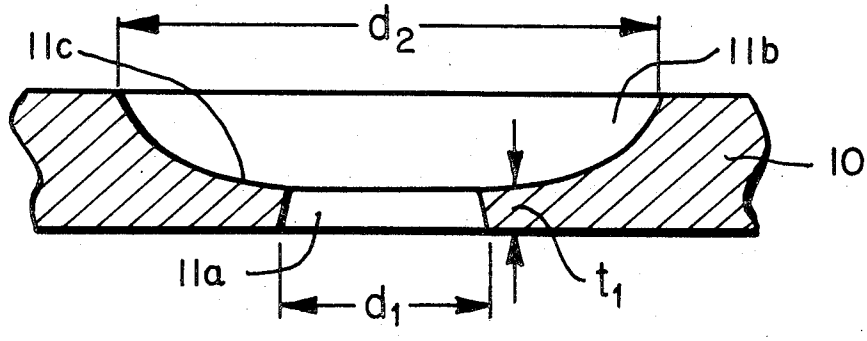


FIG. 1

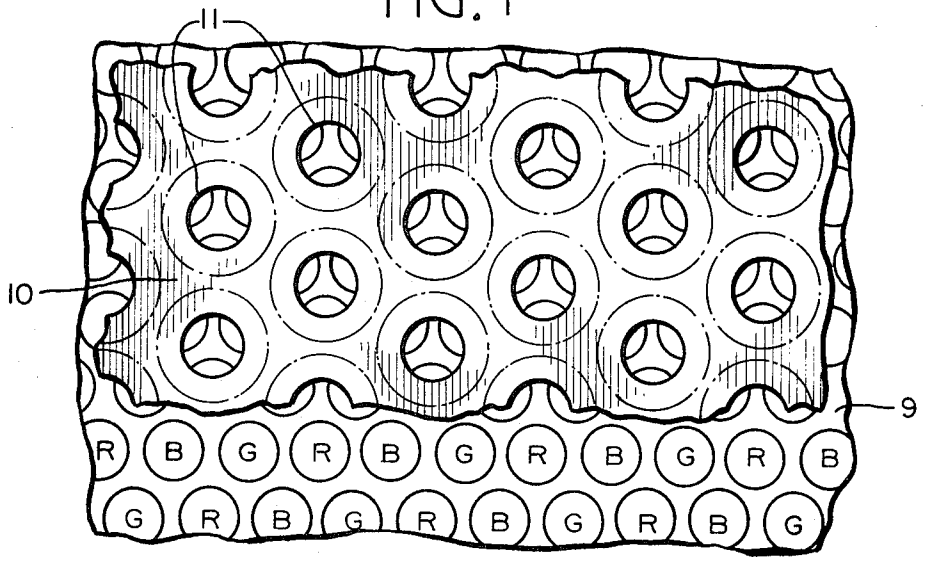


FIG. 2

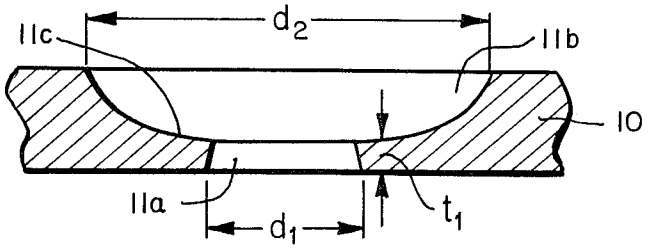


FIG. 2a

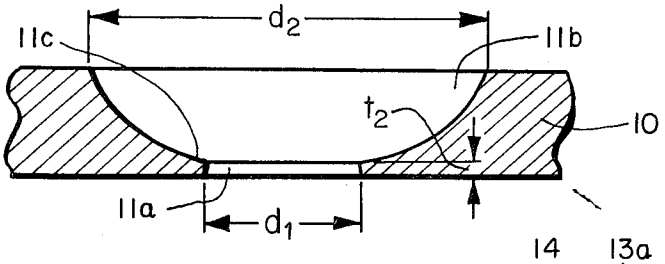
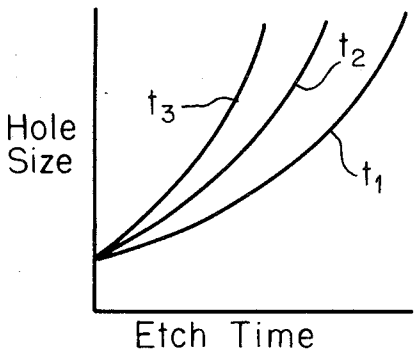


FIG. 3



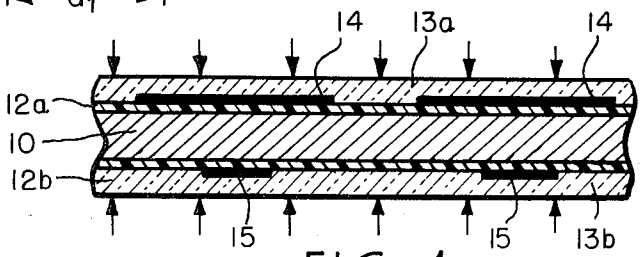


FIG. 4

Inventor
Martin L. Lerner
By Francis W. Crotty
Attorney

SHADOW MASK HAVING DOUBLE-SIZED APERTURES

CROSS REFERENCE TO RELATED APPLICATION

This application is related to and is a further development of the shadow mask structure described and claimed in application Ser. No. 811,318, filed Mar. 28, 1969, now U.S. Pat. No. 3,666,462 in the name of Sam H. Kaplan and assigned to the assignee of the present invention.

BACKGROUND OF THE INVENTION

As discussed in the Kaplan application, there are certain tube types of the shadow mask variety for which it is highly desirable that the apertures of the mask be larger in diameter than the phosphor dots which constitute the image screen. The most familiar examples of such tubes are the black surround and the post-deflection-acceleration tubes.

A distinctly preferred form of black surround tube is described and claimed in U.S. Letters Pat. No. 3,146,368, issued on Aug. 25, 1964 and likewise assigned to the assignee of this invention. It differs from conventional shadow mask color tubes in that a dark or light-absorbing material, such as graphite, is deposited on the faceplate in circumscribing relation to each of the multiplicity of dots of different phosphors deposited on the faceplate. Additionally, the phosphor dots are smaller than in the conventional shadow mask tube and the apertures of the shadow mask exceed the phosphor dots in dimension to preserve the tolerance or guard band which, in the conventional tube, is afforded by constraining the beam diameter to a size which is less than the phosphor dots. The dimensional change of the black surround tube, with dots smaller in size than the electron beams, permits full utilization of the phosphor deposits and also makes possible, at least in the central portion of the screen, the application of light-absorbing material to approximately half of the screen area. As described in the above-identified patent, this leads to desirable increases in both contrast and brightness.

A similar dimensional relation of phosphor dot to shadow-mask aperture is required in post-deflection-acceleration tubes because of the focusing effect on the electron beams relied on to direct a larger percentage of electrons through the apertures of the mask than is the case of the conventional shadow mask tube not having post-deflection-acceleration or focusing.

While a variety of proposals have been made heretofore concerning the mask structure to be utilized in tubes of the type under consideration, the structure of the Kaplan application has found greatest acceptance in the mass production of black-surround shadow mask tubes. The advantage of the Kaplan structure is of particular value in what has become known as the re-etch process of producing color tubes. In that process the shadow mask is initially formed with apertures of accurately controlled dimension as required for using the mask in photoprinting the phosphor screen. After screening has been accomplished, the mask is subjected to another etching process or is said to be "re-etched." The re-etching enlarges the holes to a final desired size in which the hole dimension exceeds the dot diameter in the amount required for the guard band alluded to above.

In the Kaplan mask structure the apertures of the mask are essentially the same throughout the entire field of apertures. Each such aperture has a small-diameter portion as well as a large-diameter portion. These two portions are in communication with one another and are in coaxial alignment and they, in effect, cause the small-diameter aperture portion to be surrounded by a web which usually is considerably less in thickness than half the thickness dimension of the sheet from which the mask is constructed. A particular benefit of this arrangement is that the re-etch is accomplished quickly by primarily attacking the web elements in enlarging the apertures of the mask. Obviously, this is most desirable because it tends to minimize the effect of the etchant on the planar surfaces of the mask and tends, therefore, to retain its mechanical strength. While Kaplan's structure has been and is successfully used in the mass production of the black-surround type of shadow mask tubes, an undesirable grading of apertures in the re-etch step has been experienced which may be avoided by utilizing the improvement of the present invention.

Accordingly, it is an object of the invention to provide a novel and improved shadow mask for a color picture tube.

It is a specific object of the invention to improve the structure of a shadow mask for a color picture tube fabricated in accordance with the principles of re-etch.

Finally, it is another specific object of the invention to improve the shadow mask component of a color picture tube featuring black-surround or post-deflection acceleration.

SUMMARY OF THE INVENTION

A shadow mask structure for a color picture tube embodying the invention comprises a sheet of material that may be chemically milled, as by etching. The sheet has a multiplicity of generally similar apertures disposed throughout a field of a particular configuration. Each of the apertures has a small-diameter portion of a maximum depth not exceeding half the thickness of the sheet and each aperture further has a large-diameter portion in communication and in coaxial alignment with its small-diameter portion to define therewith a web which surrounds the small-diameter portion. The thickness of that web varies with the radial distance of its associated aperture from the center of the aperture field.

BRIEF DESCRIPTION OF THE DRAWING

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 connection with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a fragmentary view of the screen section and associated shadow mask of a shadow mask type of color tube;

FIGS. 2 and 2*a* are enlarged detailed views of individual apertures included in the aperture field of the shadow mask of FIG. 1;

FIG. 3 includes a series of curves representing the effect of etching on hole size with varying thicknesses of the mask immediately adjacent the hole being enlarged; and

FIG. 4 is another fragmentary view illustrating a process step in the initial fabrication of the mask structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Color tubes of the type under consideration may have circular or rectangular envelope configurations at the faceplate or screen section which includes the image area. In this area, there is a repeating sequence of phosphor deposits representing the three primary colors because commercial television is currently practiced as an additive type of system. The phosphor deposits may take any of a variety of forms such as stripes, hexagon, circular dots or the like. The specific configuration of the envelope or of the elemental phosphor deposits is of no particular moment but, for convenience, it will be assumed that the tube under consideration is rectangular and has a mosaic screen defined by a multiplicity of dot triads each of which constitutes a dot of green phosphor, a dot of blue and a dot of red phosphor.

In FIG. 1, the screen 9 has phosphor deposits represented by circles and the legends G, B and R symbolically designate those of the deposits which are formed of green, blue and red phosphors respectively. It will be observed that the phosphor dots, instead of being in tangential contact, are separated from one another and this results from the fact that they are smaller than usual, that is to say, smaller than generally employed in the shadow mask type of color tube. Where the tube having the screen structure of FIG. 1 is of the black-surround variety, a light-absorbing material or pigment covers all elemental areas of the screen that are exposed between the phosphor dots. For convenience of illustration, however, the light-absorbing or surround material has not been represented in the drawing nor would that material necessarily be present for a post-deflection-acceleration tube.

Superposed over and in close spaced relation to the screen or image area of the tube is a shadow mask 10. It is a sheet of material that may be chemically milled as, for example, being treated with an etchant. A number of materials are suitable but most generally a copper alloy or cold rolled steel is employed. The sheet is relatively thin and, in commercial practice, is usually cold rolled steel having a thickness of 6 to 7 mils. The sheet has a multiplicity of apertures 11 disposed throughout a field of particular configuration chosen to match the configuration of the screen or image area of the tube. For the case under discussion, the apertures are arranged in a rectangular field of essentially the same dimensions as the field of phosphor deposits applied to the faceplate. While details of the apertures will be considered more particularly hereafter, it is sufficient to point out at this juncture that the holes or apertures of the mask should correspond in configuration to that of the phosphor deposits. Accordingly, since it has been assumed that the image area features phosphor dot triads, the mask apertures 11 are circular as illustrated. The mask 10 has a configuration essentially the same as that of the faceplate of the tube and both approximate a spherical section. When the mask is installed within the tube, each of its apertures 11 is aligned with an assigned dot triad so that three beams issuing from the usual gun cluster (not shown) reach the screen by passing through a hole of the mask at such an angular relation that each beam is able to impinge only upon the color phosphor deposit to which it has been assigned. In these respects, the mask-screen structure is entirely conventional.

The mask while in planar sheet form is provided with the field of apertures 11 dimensioned as required to use the mask in screening through photoprinting techniques. It is not necessary to recite the screening process because, of itself, it constitutes no part of the present invention and is now thoroughly understood in the art. Suffice it to say that the mask, stamped or otherwise configured to have the proper shape in relation to the faceplate and bearing holes 11 dimensioned for screening, is used in three photoprinting steps in each of which one of the green, blue and red phosphors is deposited in proper location on the screen to define dot triads. After that has been accomplished, the mask is etched again to open or enlarge its apertures 11 to the end that they have a desired relation and exceed the phosphor dots in dimension by a predetermined amount. The present invention is addressed most specifically to the mask structure and the details of its apertures to the end that the final structure eventuating from the re-etch process is distinctly improved over that obtained by practices of the prior art.

More particular attention is now directed to FIG. 2 which depicts the details of mask apertures 11 at the center of the field of apertures. Each such aperture has a small-diameter portion 11*a* which usually has a maximum depth t_1 not exceeding half the thickness of the sheet from which mask 10 is constructed. The aperture further has a large-diameter portion 11*b* in communication and in coaxial alignment with small-diameter portion 11*a* and collectively they define a web 11*c* which surrounds small-diameter portion 11*a*. At the center of the mask the web has its maximum thickness t_1.

FIG. 2*a* represents the details of apertures at or close to the edge of the aperture field. It is generally the same as that described in connection with FIG. 2, differing principally in that the web 11*c* has a reduced thickness t_2. Its small-diameter portion 11*a* may have the same dimension d_1 and its large-diameter portion 11*b* may have the same diameter d_2 as the corresponding portions of the centrally located apertures, such as that illustrated in FIG. 2. In other words, the apertures at the center have a web of maximum thickness t_1 while those at the edge of the field have a minimum thickness t_2 and the mask is constructed so that the thickness of the web 11*c* varies with radial distance from the center of the aperture field. Specifically, the thickness decreases with increasing radial displacement from the center of the field. This is in distinction to the prior screen structure wherein the web thickness t_1 is substantially uniform over the entire field.

The advantage derived from the described mask structure is most clearly explained by considering the response of the previous structure to the re-etch step. In the prior practice where the web dimension t_1 is the

same over the entire field, when the mask has finished its role in screening and is introduced into an etching apparatus, it is found that an undesired grading pattern results. That is to say, the small-diameter portion **11***a* of each aperture is enlarged in the re-etch process but the enlargement is greatest in the center of the aperture field and is substantially less at the edges. Assume for purposes of illustration that the initial diameter d_1 of the small-diameter portion is 9 mils which is appropriate for screening. During the re-etch process in accordance with present commercial practices, the small-diameter portion at the center of the aperture field enlarges to about 14.9 mils whereas the enlargement of apertures at the edge of the field is only about 11.9 mils. This comes about for at least two reasons. In the first place, the spray in the re-etch chamber is more easily directed at a proper angle to the apertures in the center of the mask than at the edges because of the domed shape of the mask. Consequently, the etchant strikes the apertures at the edge of the field at an acute angle and therefore is not as effective in re-etching as at the center where the angle of attack is more nearly 90°. Additionally, since the etchant tends to run along the surface of the mask there frequently is less etchant effective in re-etching at the edge than at the center of the structure. In any event, a hole grading of 14.9 mils at the center to 11.9 mils at the edge is frequently obtained and is generally undesired. It is preferred that the apertures have the same diameter throughout the field or, if they be graded, the grading should be much less and, illustratively, should be approximately 14.9 mils at the center and 13.7 at the edge. Neither condition is fulfilled with prior mask structures and this deficiency is overcome by the mask described and illustrated fragmentarily in FIGS. **2** and **2***a*.

The characteristic curves of FIG. **3** show the response of the mask material to an etchant such as ferric chloride. It will be observed that for a given duration of the re-etch process, the hole size increases as the web dimension t is reduced. Accordingly, the mask of the present invention has holes which initially have the same dimension d_1 of the small-diameter portion **11***a* but the web **11***c* is graded from a maximum value t_1 at the center to a minimum value t_2 at the edge of the field of apertures. By control of this grading, it is entirely feasible to achieve a final dimension of the small-diameter portions **11***a* at the center of the mask of 14.9 mils or some other desired value and a dimension of 13.7 or other desired grading at the edge of the aperture field.

Experience with various mask structures supports the conclusion that the described mask with graded web sections **11***c* greatly facilitates attaining uniform limiting apertures **11***a* across the aperture field in the re-etch process or apertures that are graded as desired with radial distance from the center of the field. Efforts to achieve that result with the prior mask structure having web elements **11***c* of essentially the same thickness throughout the field are so cumbersome as to be difficult to practice on a commercial basis. What is required is adjustment of the angular direction of the etchant as it is sprayed on the mask throughout the field and also grading of its concentration or rate of flow to achieve the desired aperture pattern in the re-etch step. As stated above, the same result is more readily attained without having to grade the spray if instead one grades the web elements **11***c* in the manner described.

In constructing a shadow mask for a 25-inch shadow mask tube embodying the present invention, the following representative dimensions have been used successfully:

initial diameter d_1 of aperture portions **11***a*	9 mils
diameter d_2 of aperture portions **11***b*	22 mils
thickness of web portions **11***c*	2 mils at the center of the field. 1 mil at the edge of the field.
enlarged diameter of aperture portions **11***a*	14.9 mils at the center. 13.7 mils at the edge of the aperture field.

A mask structure having graded web elements **11***c* may be prepared through processes known in the art. As indicated in FIG. **4** a sheet **10** of cold rolled steel from which the mask is to be constructed has both faces provided with a coating **12***a* and **12***b* of a light-sensitive material having the property that its solubility in a solvent changes upon exposure to actinic energy. Preferably, the coating **12***a*, **12***b* is formed of a negative resist which is characterized by the fact that its solubility is essentially destroyed upon exposure. It is of course preferable to use a resist that is soluble in water and suitable materials are polyvinyl alcohol or fish glue sensitized with ammonium dichromate. After the blank **10** has been coated with such a resist, an image of the desired aperture pattern is established thereon by contact printing. For example, a glass plate **13***a* is applied over one surface of the mask and a similar plate **13***b* is applied to the opposite surface of the mask. Plate **13***a* has opaque sections **14** which correspond in configuration and dimension to the large-diameter portions **11***b* desired for the apertures of the mask. Similarly, plate **13***b* has opaque portions **15** which correspond to the small-diameter portions **11***a* desired of each aperture of the mask. The plates are, of course, arranged so that the opaque portions **14** and **15** are in coaxial alignment and an exposure is then made by directing ultraviolet light onto the assembly as indicated by the arrows. This creates latent images of the large-diameter and small-diameter portions of each aperture to be formed in the mask and those images are developed by removing plates **13***a*, **13***b* and washing sheet **10** in water. Those portions of the resist coating **12***a*, **12***b* that have been protected against exposure by opaque portions **14**, **15** of the plates wash off and expose elemental areas of sheet **10** that are to be attacked by the etchant. The sheet is then subjected to an etching apparatus where the small-diameter portions **11***a* and large-diameter portions **11***b* are formed by etching. Since the sheet **10** is, at this juncture, in planar form, precise control of the etching may be attained throughout the aperture field and the etching is graded so that an over-etch condition takes place at the edges of the aperture field. This results in the minimum web thickness t_2. Of course, another and convenient method of grading the web elements **11***c* is to grade the images so that the diameter d_2 of the large-diameter portions **11***b* of the apertures increase with radial distance from the center

of the field. By increasing the dimension with radial distance one may attain the desired grading of the web 11*c*.

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. A shadow mask structure for a color picture tube comprising:

a sheet of material that may be chemically milled having a multiplicity of similar apertures disposed throughout a field of a particular configuration;

each of said apertures having a small-diameter portion and further having a large-diameter portion in communication and in coaxial alignment with said small-diameter portion and defining therewith a web which surrounds the small-diameter portion of such aperture, each such web having a discrete thickness at its boundary with the small-diameter portion of its associated aperture,

and the thickness of each web being inversely proportional to its radial distance from the center of said field.

2. A shadow mask structure in accordance with claim 1 in which the small-diameter portions of all of said apertures have approximately the same diameter.

3. A shadow mask structure in accordance with claim 1 in which the diameter of said large-diameter portion of said apertures increases with the radial distance of any such aperture from the center of said field.

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