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Dietch

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[54] **INTERMEDIATE SUB-ASSEMBLY FOR USE IN MAKING COLOR PICTURE TUBES**

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Related U.S. Application Data

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[52] **U.S. Cl.** .....**95/1 R,** 313/85 R, 313/92 B

[51] **Int. Cl.** **G03**

[58] **Field of Search** .....95/1; 313/85, 92 B

[56] **References Cited**

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3,616,732 11/1971 Rucinski .....95/1 R

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[57] **ABSTRACT**

An intermediate sub-assembly for manufacturing a color cathode-ray tube of the shadow mask type which comprises a shadow mask of opaque material provided with a plurality of apertures in a predetermined array and a corresponding plurality of optical lens elements directly supported by the shadow mask and individually in registration with a respective one of the apertures to provide for optical exposure through the shadow mask of image screen areas smaller than the apertures.

1 Claim, 6 Drawing Figures

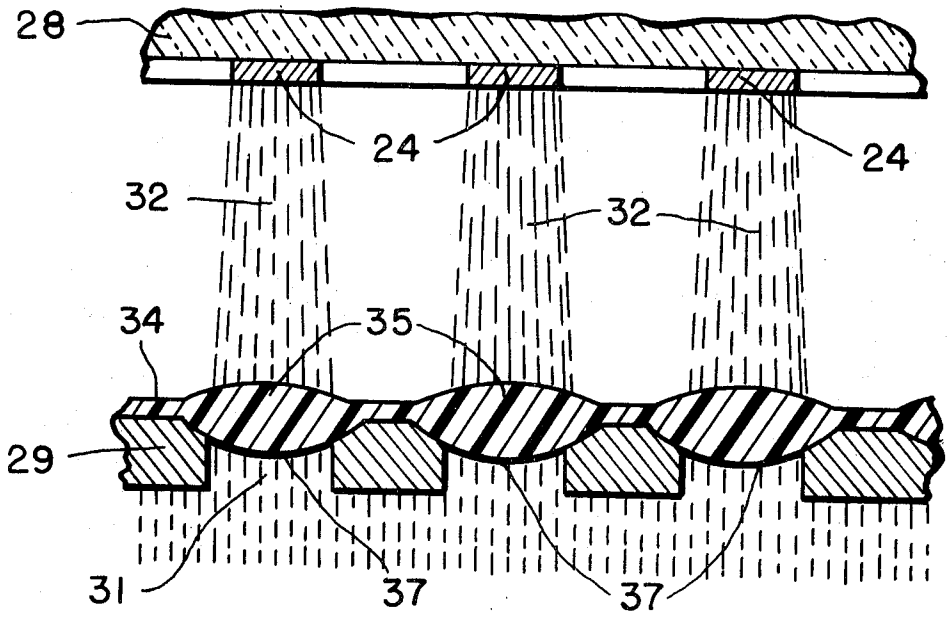


FIG. 1

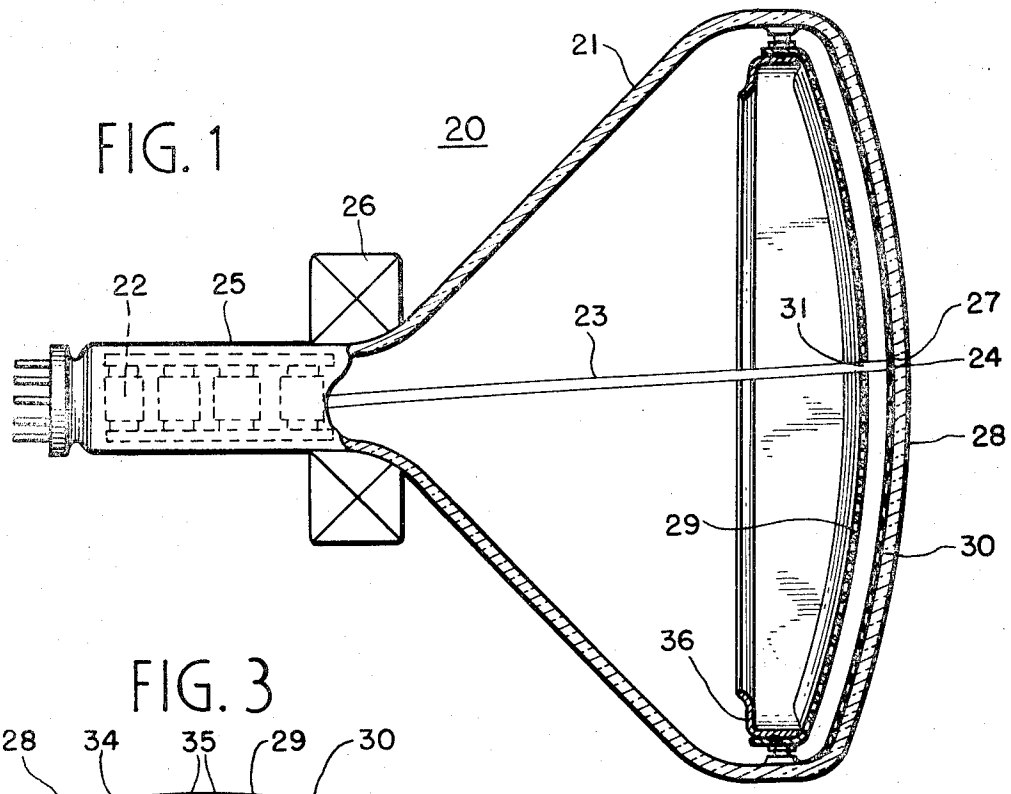


FIG. 3

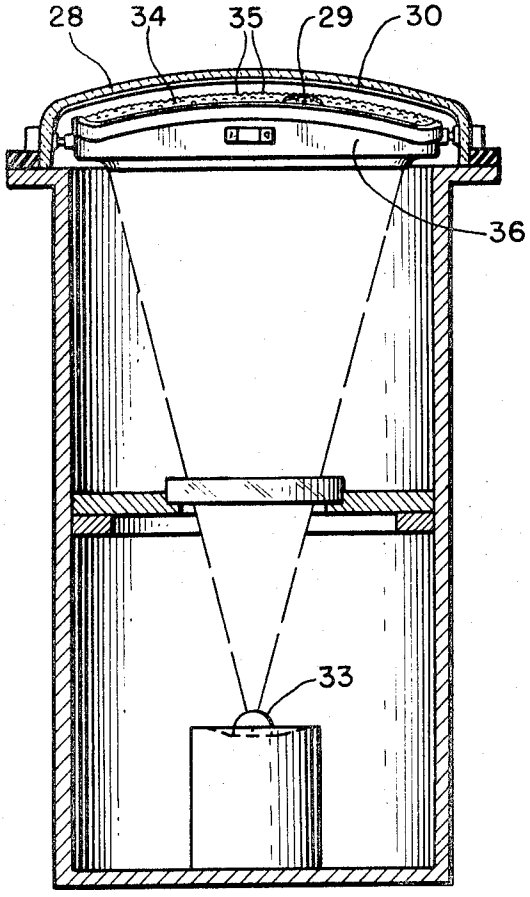


FIG. 2

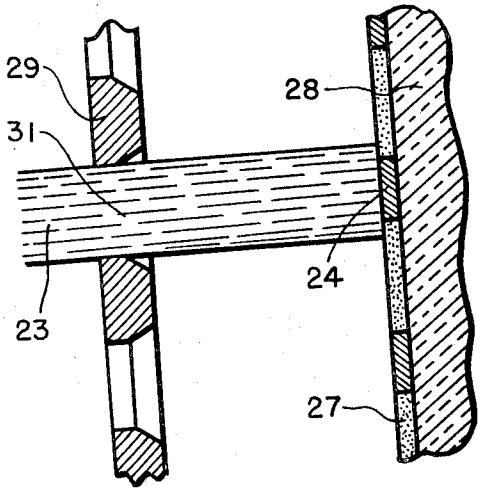
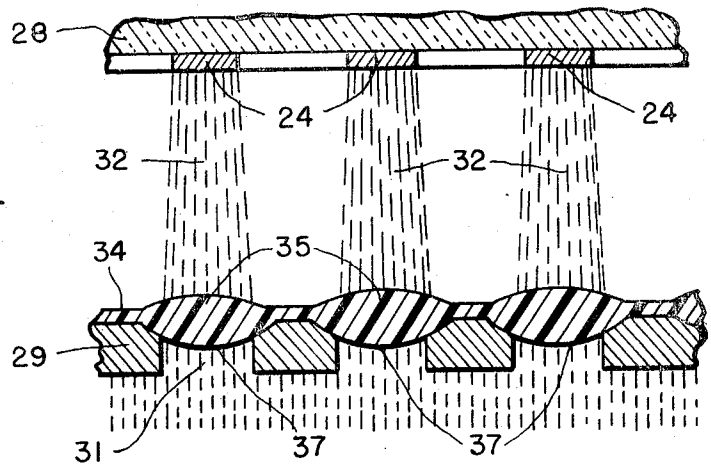


FIG. 4



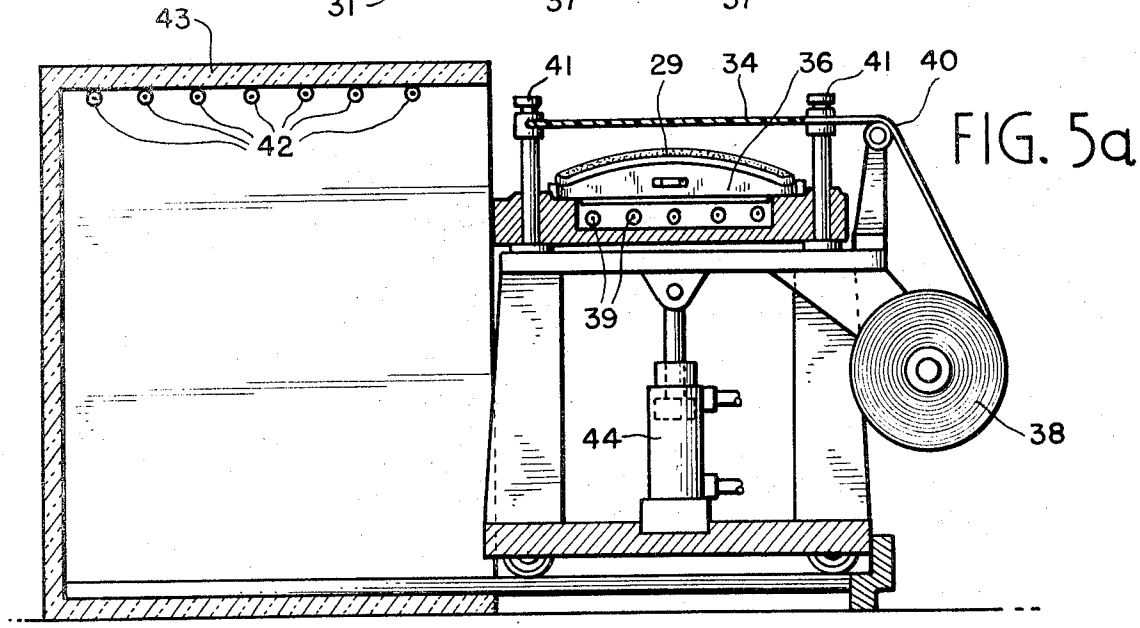
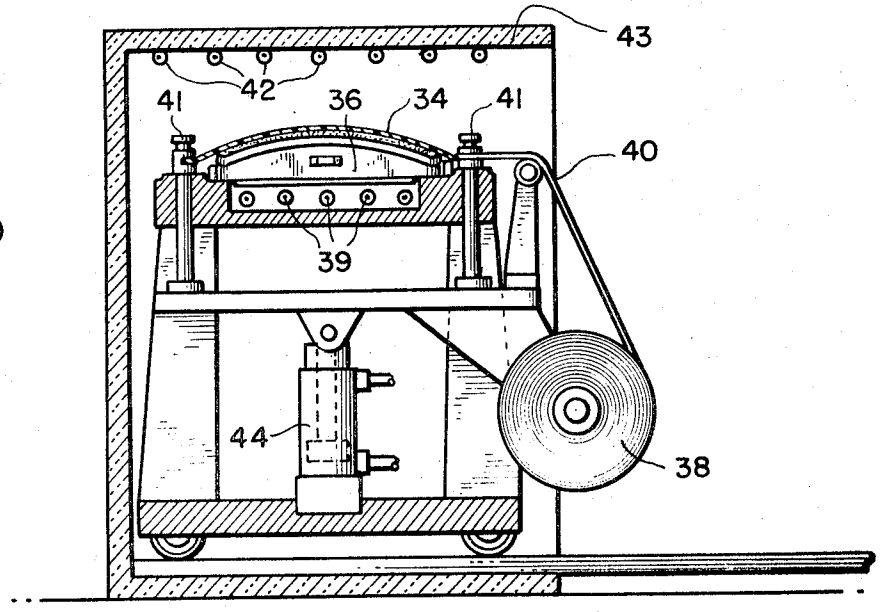


FIG. 5a

FIG. 5b



INTERMEDIATE SUB-ASSEMBLY FOR USE IN MAKING COLOR PICTURE TUBES

RELATED APPLICATION

This application is a division of application Ser. No. 22,963 filed Mar. 26, 1970 and assigned to the assignee of this invention.

BACKGROUND OF THE INVENTION

The present invention relates generally to cathode-ray tubes used in color reproduction and more particularly to color reproducing cathode-ray tubes affording improve brightness and contrast.

In color reproducing cathode-ray tubes of the type with which the present invention is concerned, it is common to provide an evacuated envelope made of glass, metal or any other suitable material having an enlarged end carrying a front plate and at its opposite end a neck portion with an electrode arrangement formed of one or more electron guns for projecting a beam or beams of electrons toward the front plate. The energy of the electrons is converted into light by a suitable phosphor layer provided on the inside surface of the front plate, or on a separate screen structure provided within the envelope just behind and visible through the front plate. The phosphor screen is differentiated from point to point in that adjacent areas of different phosphor material produce light of different colors. Each of the elemental phosphor areas are spaced from all adjacent such areas by intermediate light absorbing areas. A color selection electrode or shadow mask made of a very thin metal sheet, which is opaque to the passage of electrons, is disposed between the electron gun assembly and the phosphor screen and adjacent to the screen. The mask is provided with a plurality of closely spaced apertures each of which is larger than and geometrically related to the different phosphor areas on the screen in a predetermined manner. Such a screen is well-known in the art and is described in Fiore et al. U.S. Pat. No. 3,146,368 which is assigned to the present assignee. The relation of the apertures to the phosphor areas is such that, by controlling the direction of the electron beam, different phosphor areas, producing predetermined color emission, can be selectively energized to produce a visible picture corresponding to the original scene. Another type of color cathode-ray tube affording improved brightness, having elemental phosphor screen areas smaller than the respective shadow mask apertures, and to the manufacture of which the present invention is particularly applicable, is the post-deflection-focus cathode-ray tube, well-known in the art, of which an example is described in Kaplan U.S. Pat. No. 3,398,309 which is assigned to the present assignee.

The process by which the elemental phosphor areas are deposited on the screen is well-known in the art. The shadow mask is used to determine the position of the elemental phosphor areas by projecting continuous and uniform actinic illumination over the back side of the shadow mask producing elemental light areas on the adjacent screen. The position of the light source, on the side of the shadow mask opposite the screen, duplicates the position of the corresponding electron gun element which will excite the elemental phosphor areas located by the elemental areas of light produced on the screen by the light source.

Since the elemental phosphor elements are required to be smaller than the corresponding apertures, a means must be provided for the exposure of areas of smaller size than the shadow mask apertures on the screen. One method to achieve this end has been to carry out the light exposure process having the apertures of the shadow mask the same size as the elemental phosphor areas. After the exposing process is completed it is then necessary to place the shadow mask in a suitable etching solution so that the apertures of the shadow mask may be made large enough to admit electron beam components of larger cross-sectional areas than the individual elemental phosphor areas.

Another method by which the elemental phosphor areas have been produced over areas smaller than the aperture size has been to use a shadow mask with apertures of final size and partially filled in by electroplating methods prior to the screen optical exposure process. After the screen exposure process is completed and the elemental phosphor area pattern has been deposited on the screen, the material electroplated into the apertures of the shadow mask is then removed by etching techniques to make the apertures their original size.

These methods of manufacturing a color cathode-ray tube, whose screen is covered with elemental phosphor areas, each elemental phosphor area being smaller in size than the individual shadow mask apertures, have exhibited numerous difficulties. The necessary extra process steps involved are expensive and difficult to control. Damage to a shadow mask by over-etching the apertures may result. It is well-known that in the present state of the art, once the formation of a multi-component phosphor screen has been completed, the shadow mask used during the exposure process for that screen must always be used in conjunction with that screen. If the shadow mask should be damaged, then it is necessary to completely reprocess that screen with another shadow mask. Such an occurrence is naturally undesirable. Another difficulty experienced with the methods previously discussed is that etching the apertures larger often results in the apertures being of undesired shape.

Accordingly, it is an object of the invention to provide an intermediate sub-assembly for use in the process of forming a multi-component phosphor screen with little or no probability that its shadow mask will be damaged in the process.

A further object of the invention is to provide an intermediate sub-assembly for use in the formation of a multi-component phosphor screen the elemental phosphor areas being the desired shape.

SUMMARY OF THE INVENTION

The invention provides an intermediate sub-assembly for use in the optical exposure process for the formation of a multi-component phosphor screen. The intermediate sub-assembly comprises a shadow mask having a plurality of apertures disposed in a predetermined array, and a corresponding plurality of optical lens elements directly supported by the shadow mask and individually in registration with a respective one of the apertures.

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 be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a cross-sectional view, partly cut away and partly schematic, showing in general certain of the basic components of a color reproducing cathode-ray tube of a type relating to the invention;

FIG. 2 is a fragmentary cross-sectional view of the screen and the mask at an enlarged scale illustrating an electron beam passing through the mask aperture and impinging upon one of the elemental phosphor areas in the tube of FIG. 1;

FIG. 3 is a cross-sectional view of a typical lighthouse used in the optical exposing process for the formation of a multi-component phosphor screen for use in a color cathode-ray tube;

FIG. 4 is a fragmentary cross-sectional view at an enlarged scale showing the relative position of the shadow mask and lens sub-assembly of the present invention to the phosphor screen being processed in the lighthouse;

FIG. 5*a* is a side view, partly in cross-section, of illustrative apparatus used to bring the transparent plastic sheet into contact with the shadow mask face for the formation of the individual lenses; and

FIG. 5*b* is a side view, partly in cross-section, of the apparatus of FIG. 5*a* in the position to form the individual lenses in the shadow mask.

A color cathode-ray tube **20** having a glass envelope **21** is shown in FIG. 1. Three electron guns **22** are disposed in the neck portion **25** of the cathode-ray tube envelope **22** and are arranged to emit respective electron beam components, only one such beam **23** being shown (greatly enlarged) for clarity. The electron guns are preferably disposed in a triangular or delta array but can be arranged in other suitable interrelationships, such as a collinear array, depending upon the other structural features of the tube construction. Alternatively a single electron gun can be used in conjunction with an auxiliary color switching deflection system for deflecting the electron beam to sequentially produce three separate electron beam components.

The electron beam is accelerated in a known manner to pass through a deflection field produced by scanning signals applied to a yoke member **26.** This deflection field changes the course of the electron beam in accordance with the instantaneous sweep signals applied to the yoke member **26.** Such a course change of the electron beam is gradual within the deflection field. After being deflected, the electron beam is directed through the apertures **31** in the color selection electrode or shadow mask **29** supported by frame member **36** to impinge on the scanning side (the side on which the electron beam components are incident) of a multi-color image screen **30,** disposed on the inside surface of the front plate **28** of the envelope **21.** The shadow mask **29** includes a plurality of apertures **31** in respective proper alignment with the elemental phosphor areas of screen **30.** Three interspersed similar groups of elemental phosphor areas, one for each primary color, are provided in the usual manner. Adjacent phosphor areas are separated by a light-absorbing material **27.** The elemental phosphor areas **24** are smaller than the apertures of the shadow mask and are completely illuminated by the electron beam **23.**

The relative size relationship of the apertures **31** of the shadow mask **29** and the elemental phosphor areas **24** is shown at larger scale, in FIG. 2 of the drawings. The elemental phosphor area **24** on screen **30** is surrounded by light-absorbing material **27.** The electron beam **23** is shown passing through aperture **31** in shadow mask **29** and impinging upon elemental phosphor area **24.** The cross-sectional area of electron beam **23** is larger than elemental phosphor area **24,** thus completely illuminating the elemental phosphor area.

In accordance with the invention, a new and improved method of manufacturing such a color cathode-ray tube comprises applying to the shadow mask a thin layer of transparent plastic material across the entire field of apertures with the transparent material extending within each of the apertures of the shadow mask to constitute individual optical lenses in registration with the respective apertures. A suitable transparent plastic material is a polyvinyl chloride homopolymer which is plasticized. Other materials such as styrene polymers,-cellulosic polymers and polyethylene polymers, to name a few, may also be used in conjunction with the suitable plasticizers. After the optical exposure process of the phosphor screen is completed the lenses are then removed from the shadow mask, and the shadow mask is ready for use in completing the tube assembly.

A lighthouse of a type well-known in the art but embodying the present invention for the formation of a multi-component phosphor screen with phosphor dots smaller than the shadow mask apertures is shown in FIG. 3. Light source **33** is situated in such a manner within the lighthouse that the actinic light which it emits provides continuous and uniform illumination over the back side of shadow mask **29.** The present invention provides an intermediate sub-assembly for this optical exposing process, which will produce optical exposure through the mask of image screen areas smaller than the apertures of the mask.

This intermediate sub-assembly is composed of the shadow mask **29,** supported by frame member **36,** and a sheet of transparent plastic material **34** in broad contact with the shadow mask **29.** The portion of the transparent sheet which overlies each of the apertures is configured to constitute an optical focusing lens **35** to converge the light passing through the apertures of the shadow mask **29** to optically expose image areas of the phosphor screen **30** smaller than the apertures of the shadow mask. The transparent plastic sheet preferably overlies the shadow mask on the side opposite the support frame **36,** to minimize or avoid optical aberrations in the light images projected onto the phosphor screen substrate.

More particularly, the lenses **35** are formed on the side of the shadow mask **29** opposite the support frame **36** so that the apertures will allow only the center portion of the lenses to conduct light. The focal length of a spherical lens (a lens with a constant radius of curvature as used here) varies from the center portions out to the fringe portions. A light ray impinging on the fringe portion of a spherical lens will converge to an image closer to the lens than a light ray impinging upon the center portion of a spherical lens. Therefore if the entire lens were permitted to be used, an image with a halo-like haze around it would result. Although this occurrence is tolerable, it is avoided by forming the lenses on the side of the shadow mask **29** opposite the support

frame 36 so that only the center portion of the lenses is allowed to conduct light. This results in a clear, well defined image upon the screen.

The transparent plastic sheet in broad surface contact with the shadow mask, and the portion of the sheet which overlies the apertures configured to constitute optically focusing lenses, is shown in greater detail in an enlarged view in FIG. 4. The optical lenses 35 have a double convex structure, each side having a different radius of curvature. The smaller radius of curvature 37 is on the side of the plastic transparent sheet which contacts the shadow mask. The light ray 32 created by the presence of the aperture 31 is converged by the optical lens 35 and is made to expose an elemental image screen area 24 which is smaller than the size of the aperture 31.

The provision of the sheet of transparent plastic material which overlies each of the apertures 31 to constitute optical focusing lenses 35 makes it unnecessary to vary the size of the apertures of the shadow mask before or after the optical exposing process. Possible damage to the shadow mask due to over-etching is eliminated with the present invention. Also, the aperture shapes will never be altered.

A preferred method for the manufacture of a color cathode-ray tube embodying the intermediate subassembly is made clear by FIGS. 5*a* and 5*b* of the drawings. FIG. 5*a* shows the apparatus before the sheet of transparent material makes contact with the shadow mask. The plastic transparent sheet 34 is reeled off of roll 38 over roller 40 and then is held in position extending over the field of apertures of the shadow mask by clamps 41. The shadow mask support frame 36 is pre-heated to approximately 180° Centigrade by heating elements 39. The apparatus is then rolled into the oven 43 as shown in FIG. 5*b*. Infrared heating elements 42 then bake the plastic transparent sheet 34 until the transparent plastic sheet 34 becomes softened (the precise temperature is not critical) at which time vacuum piston 44 causes the transparent plastic sheet to be pulled in contact with the surface of the shadow mask. The portions of the plastic transparent sheet which overlie the apertures of the shadow mask, being presoftened, then sag into the apertures under the influence of the earth's gravitational field. The sagging of the plastic transparent material into the apertures produces a stress differential between the edge of the individual apertures and the top surface of the transparent plastic material. This stress differential causes the transparent plastic material which overlies the apertures of the shadow mask to be bunched up over these areas forming the convex side with the larger radius of curvature of the double convex lens produced. The thermal forming of the lenses takes approximately 40 seconds. After the thermal forming has been completed the apparatus is then rolled out of the oven and the transparent plastic material is then allowed to harden for 30 seconds. After the transparent plastic material has hardened, the excess transparent material is cut away around the edges of the shadow mask and then the intermediate sub-assembly is ready for use in the optical exposing process previously described. Once the optical exposing process for the formation of the multi-component phosphor screen has been completed the plastic sheet, including the lenses, is then peeled off from the surface of the shadow mask. There is an important advantage to having the plastic transparent sheet in contact with the shadow mask during the screen exposing process. The plastic sheet prevents dirt particles and other contaminants, which may later cause damage to the tube or tube performance degradation, from being deposited on the shadow mask. When the plastic sheet is peeled off of the shadow mask, it takes with it these undesired particles. The shadow mask is then ready for assembly with the other tube components in the usual way.

While it is preferred to form the lenses by thermal sagging of the transparent material under the influence of a gravitational field, as described, it may also be possible to form the lenses in situ by spraying the plastic in liquid or vapor form or by the use of an external force which pulls or blows a presoftened transparent material into each aperture. Also, by using a volatilizable plastic, it may be possible to eliminate the need for peeling the lens sheet from the mask, relying instead on volatilization during final bake-out and exhaust.

While a particular embodiment of the invention has 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. An intermediate sub-assembly for use in the formation of a multi-component phosphor screen by an optical exposure process wherein a shadow mask extends between said phosphor screen and a source of actinic radiation, for use in a color cathode-ray tube, which sub-assembly comprises:

a shadow mask having a plurality of apertures disposed in a predetermined array corresponding to that of the individual phosphor components of said screen, with the apertures individually of a corresponding shape but of larger size than such individual phosphor components;

and a sheet of transparent plastic material overlying said aperture array and in broad surface contact with the phosphor screen side of said shadow mask, the portion of said sheet which overlies each of said apertures being configured to constitute an optical focusing lens to provide for optical exposure through said mask of image screen areas smaller than said apertures, said optical focusing lenses being double-convex with each side having a different radius of curvature, and in which the smaller radius of curvature is on the side of sheet which contacts the shadow mask.

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