

[54] APPARATUS FOR MAKING LIGHT
ATTENUATING FILTERS
[75] Inventor: Yong S. Park, Roselle, Ill.
[73] Assignee: Zenith Radio Corporation, Chicago,
Ill.
[22] Filed: June 10, 1974
[21] Appl. No.: 478,007

[52] U.S. Cl. 118/49.1
[51] Int. Cl.² C23C 13/08
[58] Field of Search 118/504, 301, 48-49.5;
117/106-107.2, 38, 8.5; 250/511, 512, 229,
234; 356/320, 201

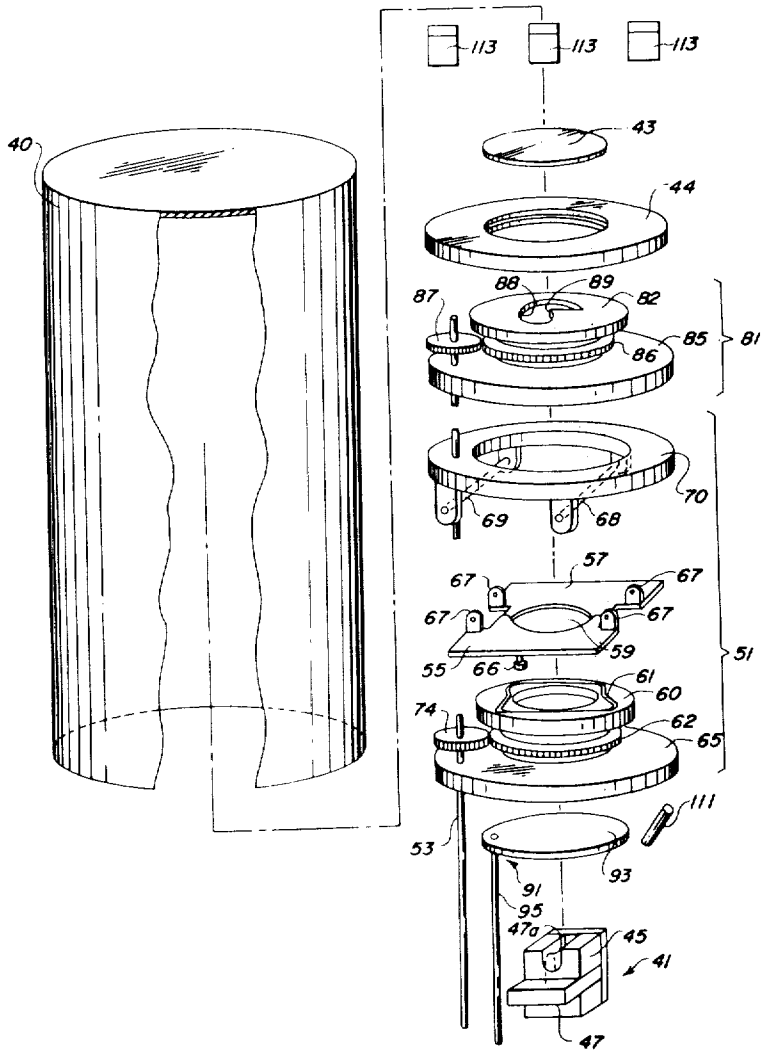
[56] References Cited
UNITED STATES PATENTS
2,160,981 6/1939 O'Brien 118/504 X
3,115,580 12/1963 Brewer 250/511
3,117,885 1/1964 Pohm et al. 118/504 X
3,193,408 7/1965 Triller 117/38
3,287,561 11/1966 Ingles 250/511 X

3,348,962 10/1967 Grossman et al. 118/504 X
3,404,282 10/1968 Walker 250/229 X
3,502,878 3/1970 Stewart et al. 250/512 UX
3,561,993 2/1971 Geffcken 117/38
3,617,331 11/1971 Illsley et al. 117/38 X
3,773,541 11/1973 Ng et al. 117/38 X

Primary Examiner—Morris Kaplan
Attorney, Agent, or Firm—John H. Coult

[57] ABSTRACT
Method and apparatus for making light attenuating filters used in screening cathode ray tubes. A patterned coating of light attenuating material is deposited on a transparent substrate from a vapor beam emitted by a source of appropriately vaporized, light attenuating material. The portion of the vapor beam permitted to impinge on the substrate is limited by means which define a non-circular aperture of time-varying size between the vapor source and the substrate. Means for varying the size of the aperture as a predetermined function of time are also included.

6 Claims, 10 Drawing Figures



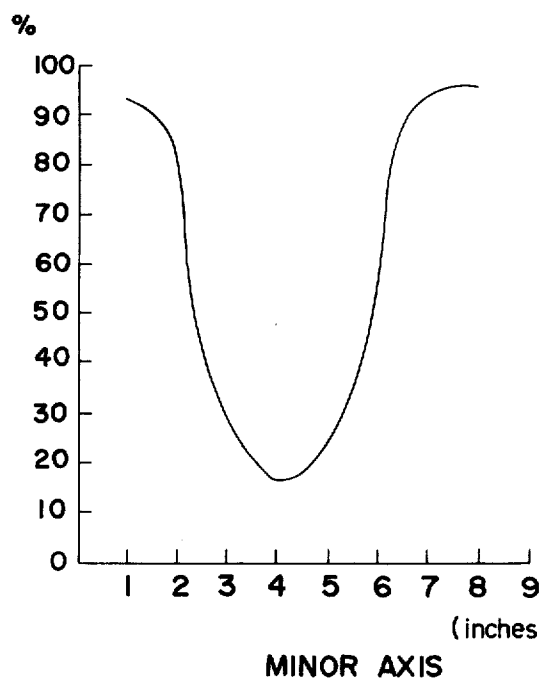
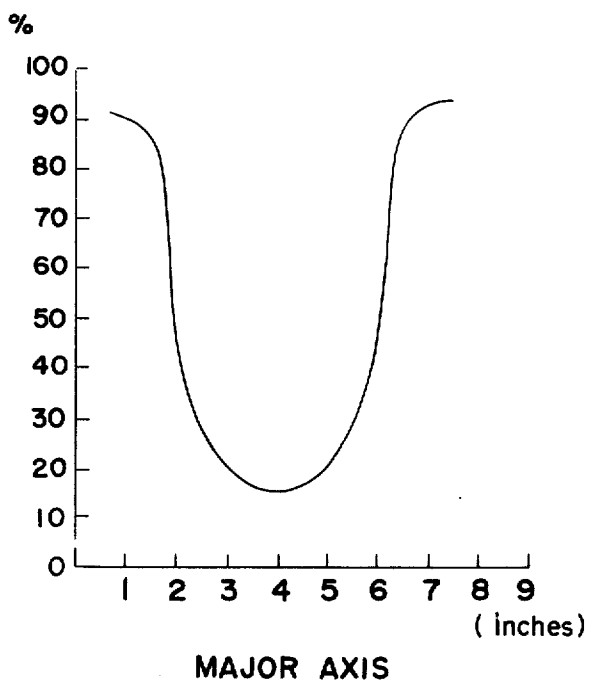
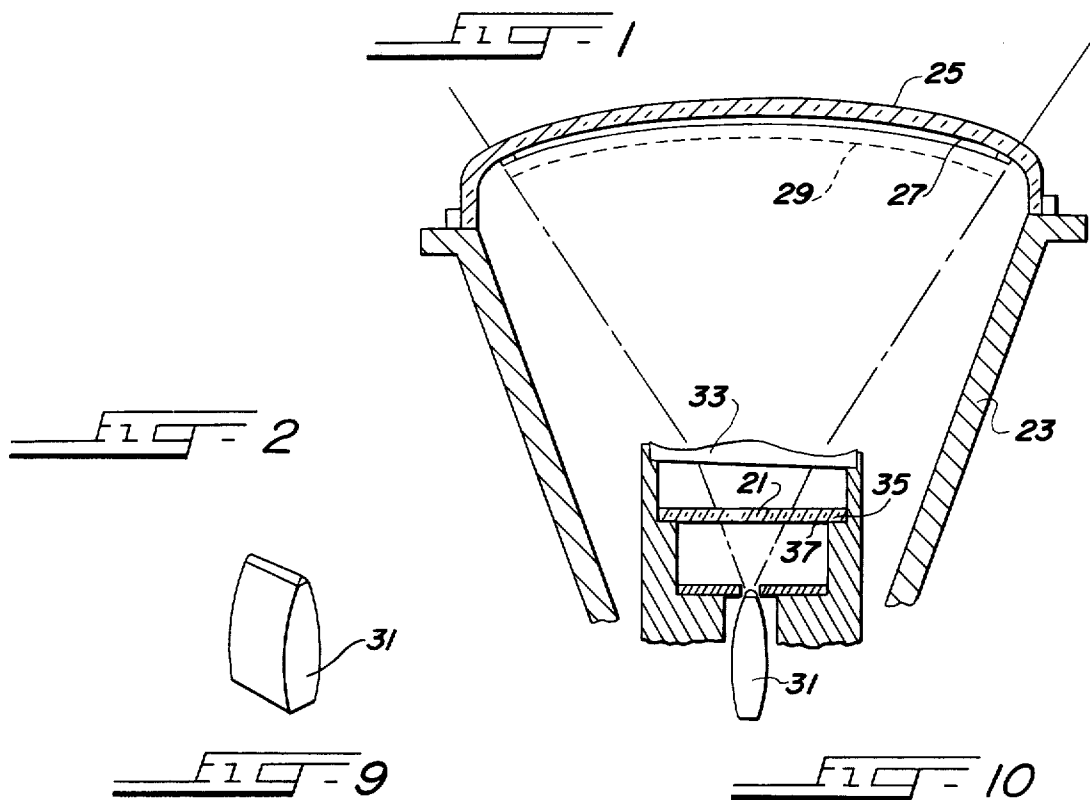
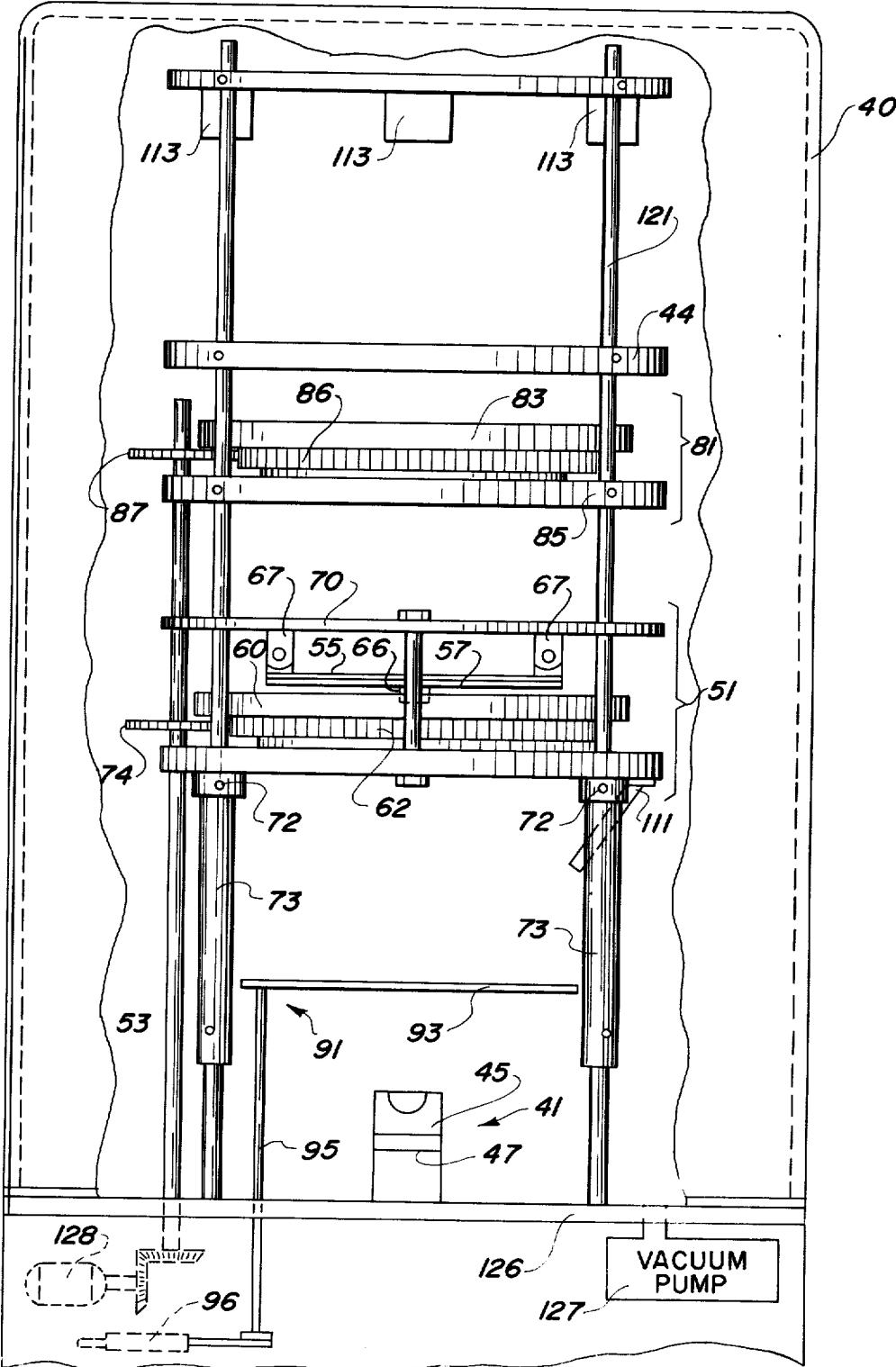


FIG. 3



1 - 4

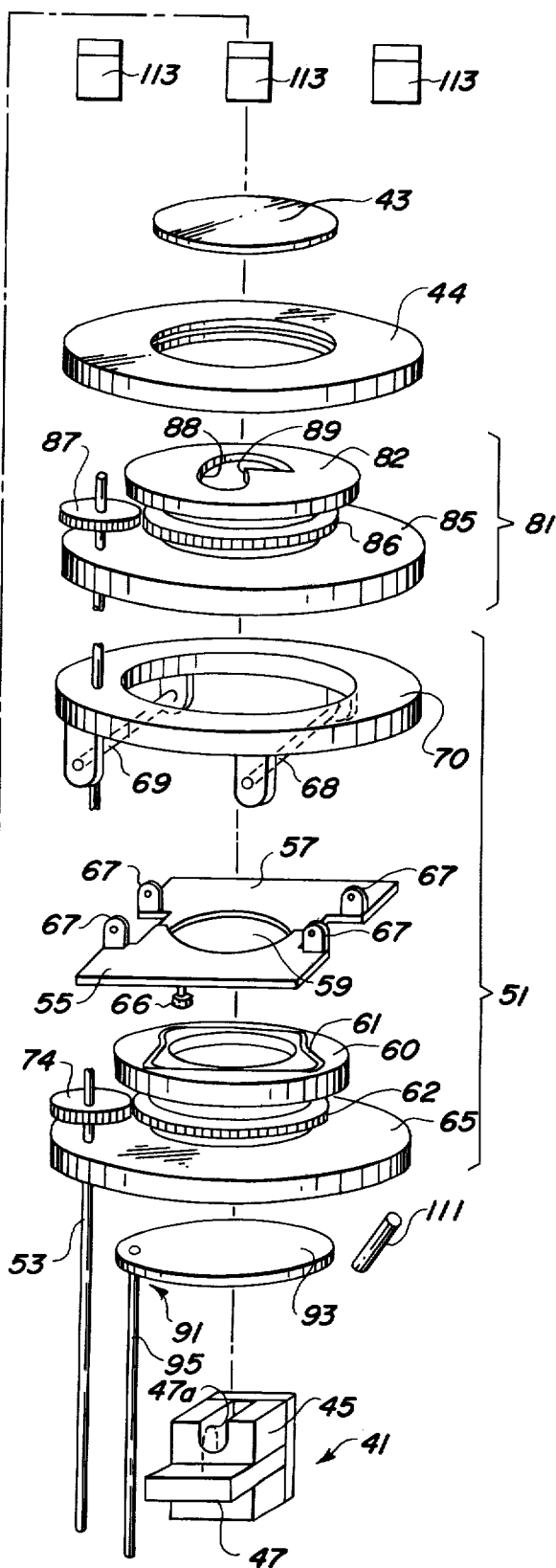
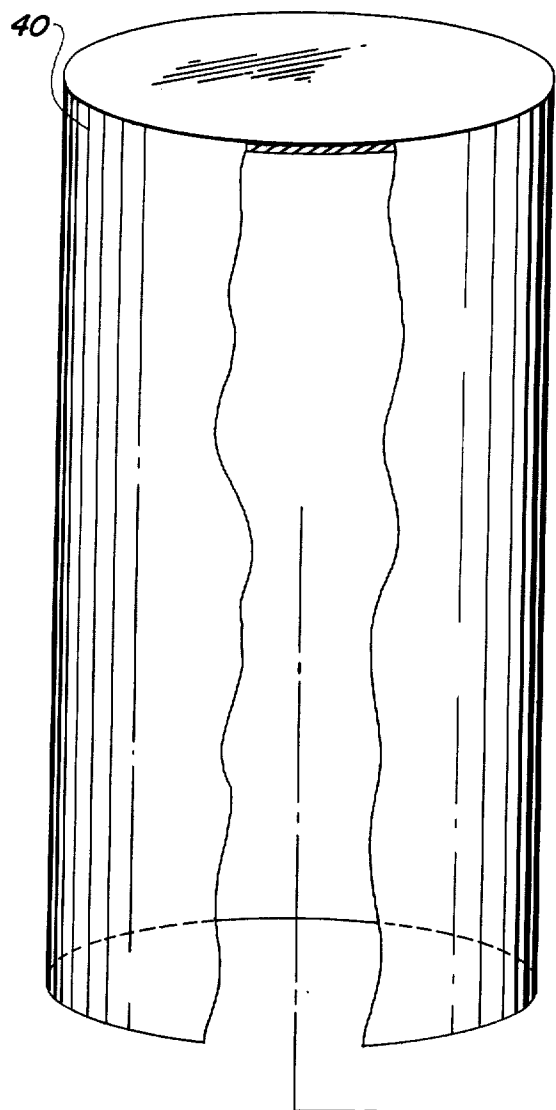
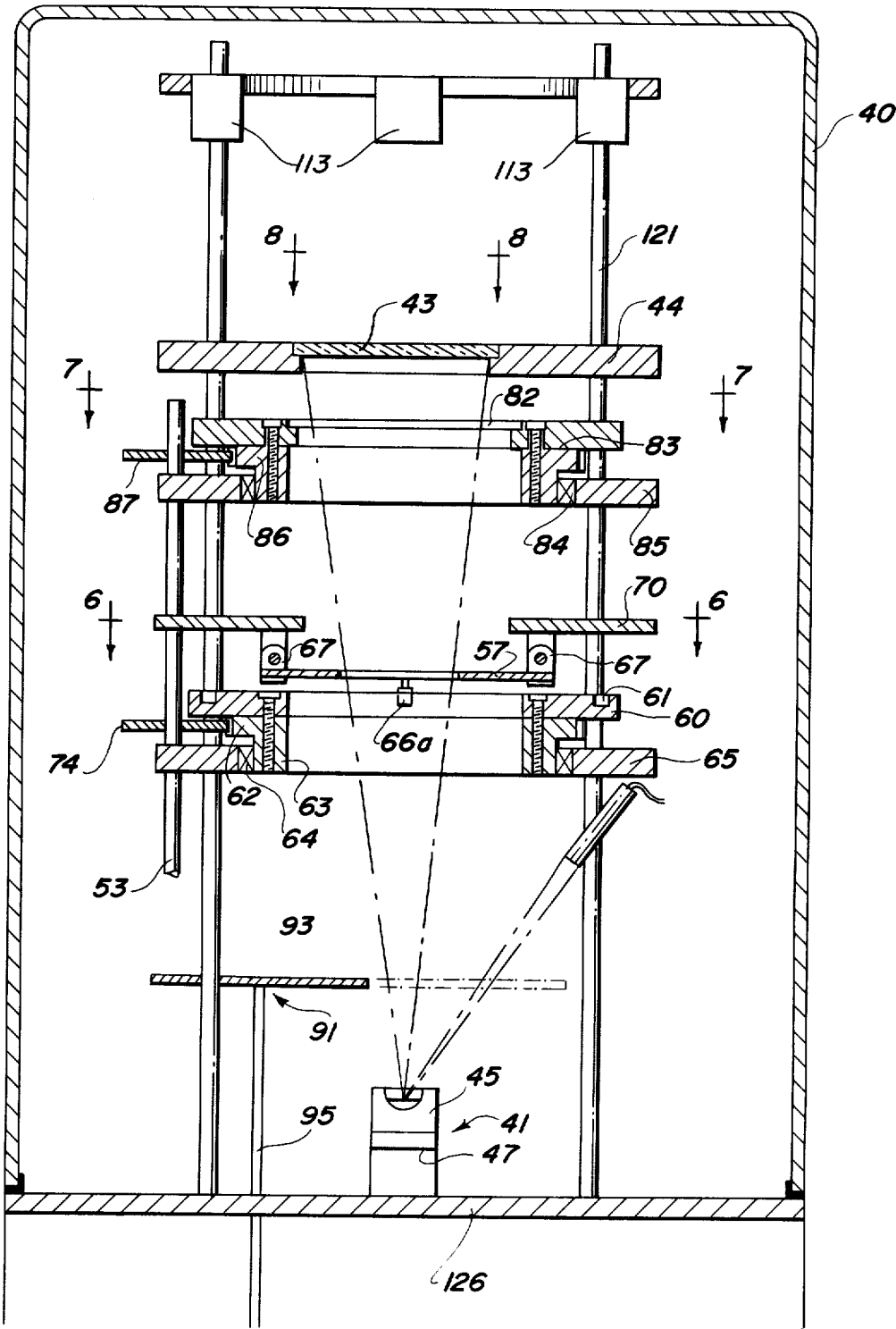
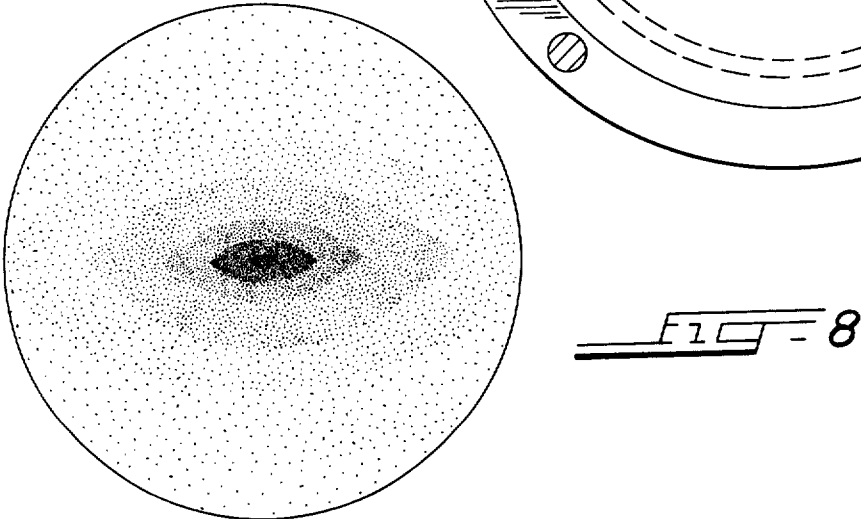
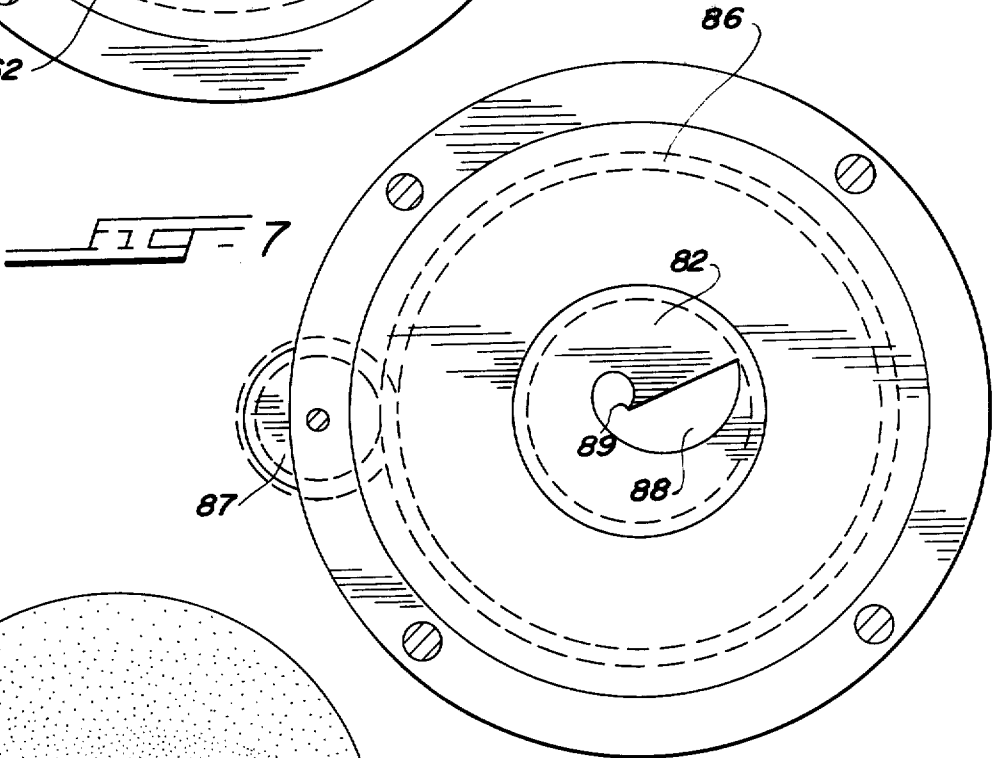
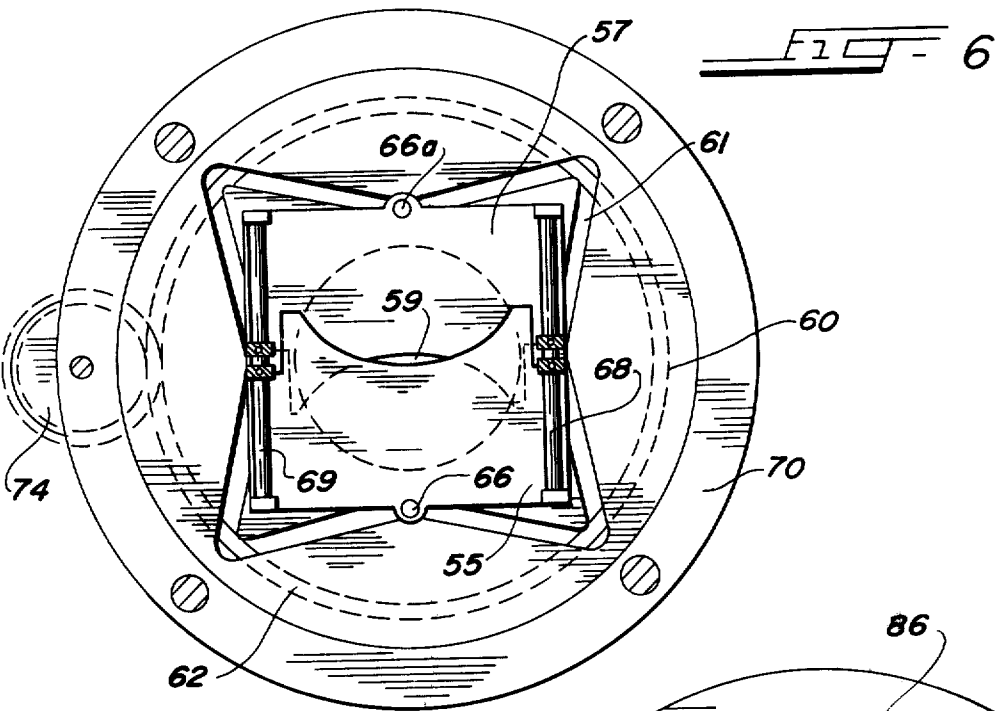


FIG. 5





APPARATUS FOR MAKING LIGHT ATTENUATING FILTERS

BACKGROUND OF THE INVENTION

This invention relates to light attenuating filters used in the manufacture of cathode ray tubes. Light attenuating filter is used herein to describe a coated optical medium of substantially neutral density for attenuating, in a predetermined, spatially varying manner during lighthouse exposure processes, radiation actinic to photosensitive coatings. The term "neutral density" indicates that the spectral distribution of the radiation is unaffected.

Screening of color cathode ray tubes is well known and understood in the art. Briefly, a cathode ray tube face panel is coated with material whose solubility is altered by actinic light energy. The coating is then illuminated with radiation actinic to the coating emanating from an appropriate source through a shadow mask disposed adjacent to the coating and which has a predetermined pattern of apertures formed therein so as to impress on the coating a corresponding pattern of latent aperture images. The sizes of the images, or the sizes of the ultimate phosphor deposits on the faceplate, are a function of exposure intensity and duration.

Due to source characteristics and variations in radiation path length, the light intensity distribution at the screen is non-uniform and requires correction which is usually provided by an attenuating filter located between the radiation source and the face panel coating. Such attenuation filters generally comprise a glass plate or other transparent substrate having a deposited metal of micron thickness for attenuating the exposure rays in a predetermined manner. These filters provide light attenuation which varies over the surface of the plate and have iso-attenuation contours appropriate to attain uniformity of light intensity on the photosensitive coating.

Generally such filters are produced in a vacuum chamber by depositing a patterned coating of metal on a glass plate located vertically above a source of metallic vapor. The source emits a vapor beam which is spatially modulated by apertures of fixed size, some rotating and/or some stationary. U.S. Pat. No. 3,762,284, assigned to the assignee of this invention, shows spatial modulation of a light beam in a lighthouse by an aperture of non-fixed, time varying size, but the apparatus shown would not be suitable for meeting the objectives of the present invention. Typical prior art production of attenuating filters, U.S. Pat. Nos. 3,773,541 and 3,664,295 set forth a method and associated apparatus for making light attenuation filters used in lighthouse exposure of dot type tubes. Briefly, inside an evacuated chamber an appropriate metal is heated in a crucible to temperatures of about 2000°C so as to establish a metallic vapor beam propagating vertically toward a transparent substrate on which the light attenuating, metallic coating is deposited. Between the vapor source and the substrate a cardioid-shaped aperture of fixed size is rotated to modify the vapor beam passing there-through, thus causing to be deposited on the substrate a coating whose density is circularly symmetric and radially graded. More particularly, a family of concentric iso-attenuation contours are created which are circularly symmetric and decrease in magnitude of attenuation along any radius from center to edge. After depositing this initial coating, a non-rotating, lemniscular ap-

erture of fixed size is also introduced between source and substrate to further modify the vapor beam. Some of the resulting iso-attenuation contours remain circular and each of the remaining ones resemble the outline of a bow-tie. Each of the latter iso-attenuation contours includes substantially circular arcs of circles of different radii. Using a cylindrical coordinate system, the coating density, or filter attenuation, at filter surface locations corresponding to the lemniscular aperture could be described as a first function of radius only, independent of θ ; i.e., $f_1(r)$. At filter locations blocked by the mask defining the lemniscular aperture, the coating could be described as a second function of radius only, independent of θ ; i.e., $f_2(r)$ where $f_2(r) \neq f_1(r)$. The transition between these two density distributions, which would theoretically constitute a discontinuity, tends to be somewhat abrupt.

In the manufacture of stripe type tubes elongated light sources are often employed during lighthouse exposure which, if uncorrected, impose on a face panel a non-uniform light distribution characterized by iso-intensity contours which approximate ellipses. To attain uniformity of illumination, light attenuating filters having quasi-elliptical, iso-attenuation contours may be imposed between the screen and the radiation source.

Thus, it is an object of this invention to overcome the limitations of the prior art and to provide an improved apparatus for making light attenuating filters.

It is a further object of this invention to provide an apparatus for making light attenuating filters having iso-attenuation contours of which at least portions thereof are non-circular.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the 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, however, by reference to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a somewhat schematic, front sectional view of a lighthouse used in screening color CRT face panels — the lighthouse incorporates a light attenuating filter made according to this invention;

FIG. 2 is a perspective view of an elongated collimator;

FIG. 3 is a front plan view, partially cut away, illustrating the preferred embodiment of apparatus for making light attenuating filters according to this invention;

FIG. 4 is an exploded perspective view of parts of the FIG. 3 apparatus;

FIG. 5 is a front sectional view illustrating certain details of the preferred embodiment of the present invention;

FIG. 6 is a view taken along line 6—6 of FIG. 5;

FIG. 7 is a view taken along line 7—7 of FIG. 5;

FIG. 8 is a view taken along line 8—8 of FIG. 5 and very schematically represents a light attenuation filter made employing the principles of the present invention; and

FIGS. 9 and 10 are plots of percentage light transmission versus distance along the major axis (FIG. 9) and minor axis (FIG. 10) of a light attenuation filter made employing the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As previously mentioned, light attenuating filters are employed during lighthouse exposure processes of cathode ray tube manufacture in order to attain desired intensity distributions on the face panel-bearing photosensitive surface. A lighthouse, employing a filter 21 made according to this invention, is schematically illustrated in FIG. 1. For simplicity, certain mechanisms, such as those for indexing, cooling and adjusting, which are of no concern to the present invention, are omitted. Atop the lighthouse enclosure 23 rests a cathode ray tube face panel 25, whose inside surface bears a layer of photosensitive material 27. Mounted adjacent the face panel is a shadow mask 29 containing an array of apertures. Located toward the base of the lighthouse is a light source comprising an arc lamp (not shown) and a collimator 31 for channelling and directing light from the lamp toward the face panel. Located between the collimator 31 and the face panel 25 is a lens 33 for correcting misregistration errors and an attenuating filter 21 comprising a transparent substrate 35 bearing an appropriately patterned coating of light attenuating material 37.

As briefly mentioned earlier, in the lighthouse exposure of stripe type tubes elongated collimators similar to the one shown in FIG. 2 are used so that the mechanical supports in the shadow mask, known in the art as tie-bars, do not create shadows on the photosensitive layer on the face panel. Such collimators create intensity patterns at the face panel which have substantially elliptical iso-intensity contours. In such instance, an attenuating filter having substantially elliptical iso-attenuation contours is required to attain the desired uniformity of light intensity impinging on the photosensitive layer.

In accordance with a preferred embodiment of this invention, an attenuating filter 21 for use in the lighthouse of FIG. 1 and having substantially elliptical iso-attenuation contours is provided by modulating an appropriate vapor beam impinging on an appropriate substrate with an aperture of time-varying size whose boundary includes elliptical arcs. More specifically, the presently preferred method and apparatus incorporating the principles of the present invention are shown in the figures and described below.

Briefly, and as shown in FIGS. 3 and 4, the basic components include a vacuum chamber 40, a vapor source 41, a transparent substrate 43 for receiving the coating, and between the source and substrate a mechanism 51 for defining and time-varying the size of a non-circular aperture, and a gate 91 for blocking or releasing the vapor beam as remotely commanded. Also shown is a subassembly 81 providing a rotatable aperture of fixed size. As will be later explained, this subassembly 81 may, as an option, be omitted from the apparatus depending on the attenuating filter characteristics desired. Also shown: an electronic sensor 111 for automatically controlling the action of the gate 91, and electrical heaters 113 which warm the substrate 43 during vapor deposition. As shown in FIGS. 3 and 5 these basic components, except for the vapor source, are mounted, on and along a vertically disposed stand 121 inside vacuum chamber 40.

Except for mechanism 51, all the individual components and their functions are well known in the art and

thus will be described only briefly. The vapor source 41 preferably simulates a point source of vapor. It comprises means for creating and emitting an appropriate vapor beam, and typically includes a metal-holding hearth 45 adjacent which is located an electron beam source 47 which is capable of heating the metal to about 2000°C. A suitable electro-magnet may be suitably disposed adjacent the hearth to magnetically influence the direction of electron beam 47a onto the metal in the hearth. The metal employed should be capable of providing a substantially neutral density metal coating.

Gate 91 comprises a suitable plate 93 which is large enough to intercept the vapor beam which would otherwise propagate toward the substrate 43. Plate 93 is disposed transversely to the direction of the vapor beam and is mounted on a shaft 95 which rotates on command to move the plate either in or out of the beam path.

Sensor 111 is a solid state device which is disposed so as to continually receive portions of the vapor beam regardless of the position of gate 91. Sensor 111 is essentially an oscillator whose frequency of oscillation is dependent on the amount of vapor received and coating deposited thereon. An electronic system (not shown) detects these changes in frequency and outputs appropriate commands to the gate 91 via a solenoid type of electromechanical converter 96.

Optional subassembly 81 includes (see FIG. 4, 5 and 7) a substantially horizontally disposed stencil 82 borne by a rotatable stencil support plate 83 which in turn is journaled in a bearing 84 held by a stationary bearing support plate 85. For providing the rotational movement, the stencil support plate 83 includes a gear 86 in engagement with shaft mounted drive gear 87. The stencil is substantially rigid and as seen in FIG. 7, the fixed-size aperture 88 defined by the stencil 82 is approximately cardioid or comma-shaped, with vertex 89 preferably positioned at the center of rotation. Modifications of the aperture shape, by hybridizing and combining spirals and cardioids, to attain various gradings of coating on the filter are well known and understood in the art.

Substrate 43 is typically a flat, circular plate of substantially neutral density glass. It is typically between 7 and 8 inches in diameter and is held by a centrally apertured support 44. Heaters 113 should be capable of raising the temperature of the substrate 43 to about 300°C. Vacuum chamber 40 is typically a hollow cylindrical chamber closed at one end and open at the other. It seals against surface 126 and is capable of withstanding the degree of vacuum encountered during operation.

The mechanism 51 which incorporates departures from the prior art will be described in somewhat greater detail. (See FIGS. 3-6 collectively.) To briefly summarize, however, motor-induced rotational motion of drive shaft 53 is translated into rectilinear motion of cooperating templates 55 and 57 which define a non-circular aperture 59 of time-varying size. More particularly, a cam 60, comprising a rigid circular plate with a continuous channel 61 on one side is concentrically affixed to a gear 62 having an axially protruding collar portion 63 which is journaled in a bearing 64. The cam and gear form a rotatable combination inside bearing 64 which is in turn supported at the inner periphery of a stand-mounted, annular support plate 65. Coupling

from drive shaft 53 to cam 60 is accomplished by gears 62 and 74. In another preferred embodiment a second drive system and drive shaft, similar and in addition to the common drive illustrated, is employed to drive only the templates so that the movement rates of the templates and of the stencil can be independently controlled.

Immediately above the cam are the two templates 55 and 57 which cooperate to define the non-circular aperture 59 of time-varying size. Preferably the confronting edges of the two templates are concave and follow elliptical arcs. Also in the preferred embodiment the two templates are slightly vertically offset from one another to allow template overlap so that aperture 59 may be totally closed. Attached to the bottom surface of each template is a cam follower 66 and 66a, which rests and rides in the cam channel 61.

The templates are typically flat, rigid plates, each having mounted normal thereto and away from the aperture-defining edges, two eyelets 67 by which each portion hangs from template guide rods 68 and 69. Guide rods 68 and 69 comprise a horizontally disposed pair of parallel cylindrical rods affixed to the bottom of a stand-mounted support plate 70, and function to support templates 55 and 57 and guide their movement along linear horizontal paths.

Means are provided by which the aperture 59 may be located at various fixed positions along the path of the vapor beams. As shown in FIG. 3, set screws 72 and support collars 73 are employed to reposition mechanism 51 to various locations along vertical stand 121. Of course gear 74 is repositioned accordingly along drive shaft 53.

It should be apparent that all support devices, cams and gears disposed along the path of the vapor beam, whether they constitute part of mechanism 51, subassembly 81 or substrate support 44, are centrally apertured so as to permit the desired propagation of the beam therethrough.

In assembled and operational form, the following distance and dimensions are representative and typical of the preferred embodiment. The distance between the vapor source 41 and substrate 43 is approximately 17.5 inches; the distance between vapor source 41 and the variable size aperture 59 is approximately 14 inches; the distance between vapor source 41 and rotatable aperture 88 is approximately 17 inches.

In operation, a substrate 43 is positioned on its support 44 and an appropriate metal, typically Chromium or Inconel, is placed in hearth 45. Aperture 59 is positioned and located vertically so as to control the magnification of the image of the aperture 59 cast on the substrate. This adjustment may be used to effect coating density distribution and/or maximum size of the resulting coating pattern. With the vacuum chamber in place as shown in FIGS. 3 and 5, vacuum pump 127 is actuated so as to create a vacuum of about 2×10^{-5} torrs inside the chamber. Then the electron beam source 47 and substrate heaters 113 are also actuated. Since a readying or warm-up period is required before the vapor source can create and emit an appropriately distributed vapor beam, gate 91 is initially in a closed position to prevent spurious deposits on substrate 43. (Closed gate position illustrated by ghost lines in FIG. 5.)

Before gate 91 is opened, drive shaft 53 is set into rotation by activating drive motor 128. This rotational

motion is transformed into rotational motion of stencil 82 via engaging gears 86 and 87. The rotation of the drive shaft is also transformed into rotation of cam 60 via gears 62 and 74. As cam 60 rotates, cam followers 66 and 66a ride in the cam channel 61 and cause templates 55 and 57, since they are restricted to rectilinear motion by guide rods 68 and 69 along which they slide, to cyclically move toward and away from each other.

Sensor 111, in conjunction with remote equipment not shown, detects when the vapor beam is ready and initiates a command signal to electromechanical converter 96 which in turn rotates gate 91 out of the vapor beam path. As the vapor beam propagates toward the substrate, it is spatially modulated by the rectilinearly moving templates 55 and 57, and by rotating stencil 82.

After a preset amount of coating has been deposited on sensor 111, it and its cooperating electronic hardware output a command signal to converter 96 which in turn rotates gate 91 back into its vapor blocking position.

It should also be pointed out that motor 128 provides a fairly constant RPM to drive shaft 53. Changes in the velocity of the templates along their paths of travel may be provided by reshaping cam channel 61. In the presently preferred embodiment the channel is symmetrically configured of co-joined, substantially straight line segments to impart to the templates a fairly constant velocity. Template movement is also cyclic at a rate of about 40 cycles per minute.

The vapor that reaches the substrate causes a coating to form thereon, and thereby results in a light attenuation filter as highly schematically characterized in FIG. 8. Whereas discrete bands of iso-attenuation are shown, it should be understood that the coating density actually varies smoothly and continuously. FIG. 8 is reasonably accurate however in showing that the coating density varies over the surface of the substrate so as to exhibit iso-attenuation contours whose shapes approximate ellipses. Toward the center of the substrate the ends of the quasi-elliptical contours may tend to be pointed depending on the exact contour of the confronting edges of the templates 55 and 57, and depending on the abruptness of the transition between the templates at the two aperture defining extremes.

Of course the coating density actually varies smoothly and continuously along any diameter of the filter. The iso-attenuation contours, depicted in FIG. 8 as the boundaries between bands, are intended only to represent the shape of a few contours selected from what in reality is a large family of contiguous and substantially concentric contours. For instance, typical of the variations along any diameter are FIGS. 9 and 10, which are plots of percentage light transmission along, respectively, the major and minor axes of a light attenuation filter made using the aforescribed apparatus and method. (The major axis is a central axis through the quasi-elliptical shapes substantially parallel to the direction of maximum dimension of the quasi-ellipses. The minor axis is an axis substantially perpendicular to the major axis.) FIGS. 9 and 10 also provide an indication of the ellipticity of the contours. For instance it is apparent that the same value of transmission is less radially displaced from center along the minor axis than along the major axis.

As earlier pointed out, the subassembly 81 providing the rotatable cardioid aperture may be omitted from the system. Modulation of the vapor beam by the tem-

plates 55 and 57 only will also produce attenuation filters exhibiting iso-attenuation contours which approximate ellipses. A primary effect of the rotating cardioidal aperture is to modify the ellipticity of the contours, i.e., modify the ratio of major axis dimension to minor axis dimension for any given iso-attenuation contour. The general tendency in the presence of the rotating cardioidal aperture is toward elongated contours as compared to contours in the absence of the rotating aperture.

Also in the preferred embodiment the distance between source and substrate, and the sizes of beam limiting apertures, are so chosen that the angular subtend of the part of the vapor beam permitted to impinge on the substrate does not exceed about 24° . The vapor source, instead of simulating an isotropic emitter, is fairly directional. Inside an angular subtend of about 27° the beam is fairly uniformly dense. Outside this angle, the beam pattern, or vapor distribution, substantially effects the distribution of the density of coating deposited on the substrate.

It should be apparent that although the above-described embodiment is preferred, a number of modifications are possible without departing from the principles of the invention herein. For instance, the variable size aperture could be created by two template portions which, instead of moving toward and away from each other, were hinged to operate much like a trap door. Of course appropriate changes to the driving mechanisms would be made accordingly.

Moreover, modifications of the image of the aperture of time-varying size could be accomplished by tilting the path of travel of the templates so that it would not be substantially normal to the path of the vapor beam.

Also, instead of using a rotating cardioidal aperture to elongate the quasi-ellipses, other shapes of aperture could be used to modify the iso-attenuation contours. For instance a rotating aperture comprising a sector of a circle with the sector apex located at the center of rotation could be used to "fatten" the quasi-ellipses.

Also, although the preferred embodiment provides a substantially constant velocity to the templates by means of the constant RPM drive shaft and the particular cam channel depicted, velocity of the templates may be caused to vary along their paths by either a variable speed motor or a cam with appropriately curved cam channel. By these means one may vary the distribution of coating density along a filter diameter.

Furthermore, the shape of the iso-attenuation contours need not be limited to quasi-ellipses. By changing the shape of the confronting edges of the templates to follow other non-circular loci of points, the shape of the iso-attenuation contours are changed accordingly. For instance, a diamond-shaped or hexagonal aperture

of time-varying size is readily achievable. Confronting template edges following parabolic or hyperbolic loci are possible. Moreover, the confronting edges of the templates need not be concave but could bow the other way so as to be convex.

Thus, 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.

What is claimed is:

1. In a light attenuating filter coating apparatus of the type wherein a patterned coating of light attenuating material is deposited on a transparent substrate from a vapor beam emitted by a source of appropriately vaporized, light attenuating material, the improvement comprising means defining a non-circular aperture of time-varying size between said vapor source and said transparent substrate for controlling the impingement of the beam on the substrate, means for varying the size of said aperture as a predetermined function of time, so that the resulting light attenuating filter is characterized by iso-attenuation contours of which at least portions thereof are non-circular, said means for defining said aperture of time-varying size comprising a pair of templates which are movable rectilinearly toward and away from each other along a path substantially parallel to said transparent substrate and the confronting edges of the templates are essentially concave.

2. Apparatus as defined in claim 1 wherein said confronting edges are essentially elliptical arcs.

3. Apparatus as defined in claim 1 wherein said means for varying the size of said aperture as a predetermined function of time includes means for moving said templates at a relatively constant velocity.

4. Apparatus as defined in claim 1 wherein said means for varying the size of said aperture as a predetermined function of time includes means for moving said templates in a cyclic mode.

5. Apparatus as defined in claim 1 and further including means for defining an aperture of fixed size between said vapor source and said substrate, and means for rotating said aperture of fixed size in a plane substantially perpendicular to said vapor beam.

6. Apparatus as defined in claim 1 wherein said aperture-defining means is adjustable along an axis substantially parallel to said vapor beam so that the aperture of time-varying size may be located therealong at various fixed locations.

* * * * *