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July 13, 1965

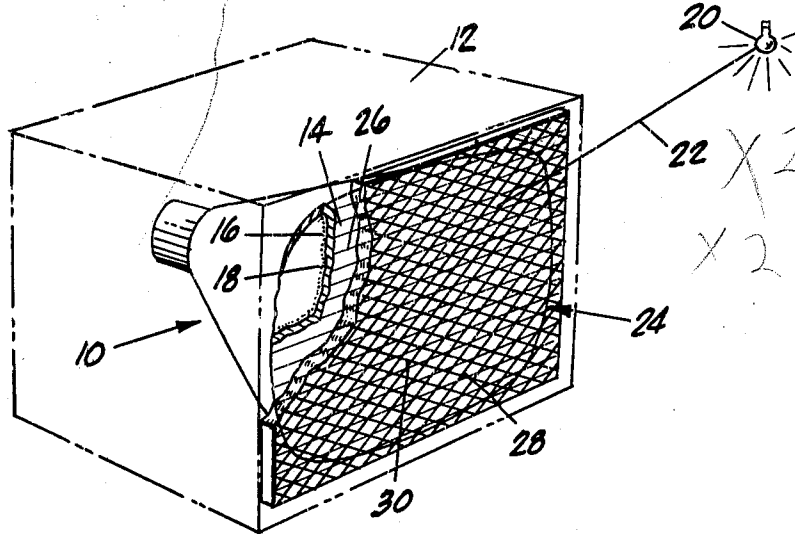
V. E. HAMILTON

3,194,885

AMBIENT LIGHT TRAPPING FILTER FOR CATHODE RAY TUBES

Filed Sept. 4, 1963

2 Sheets-Sheet 1



X 2578
X 2653

Fig. 1

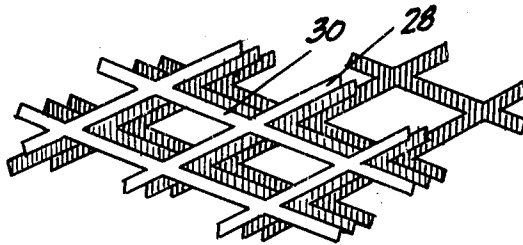


Fig. 2

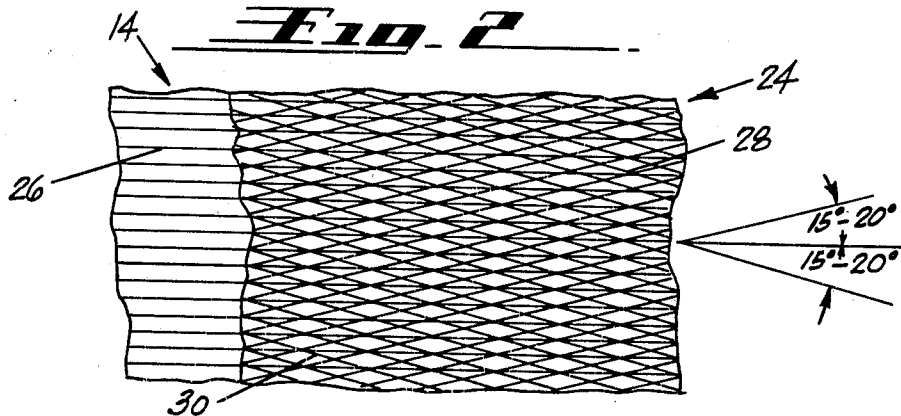


Fig. 3

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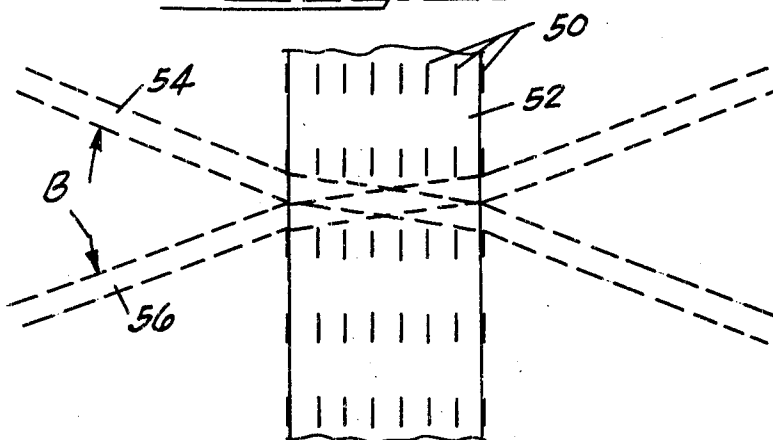
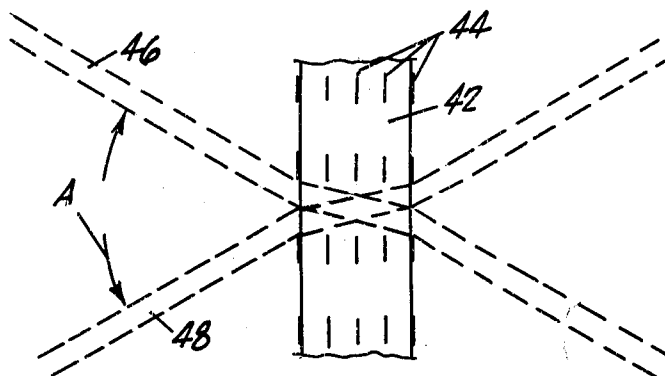
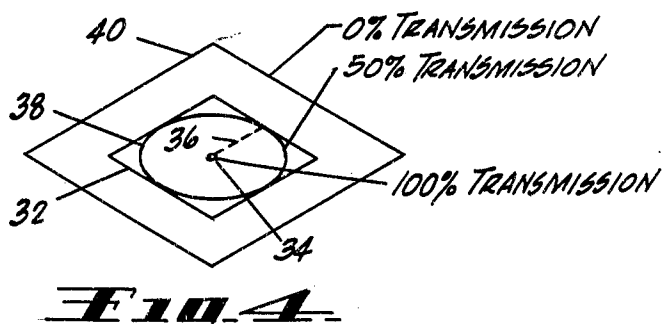
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1

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AMBIENT LIGHT TRAPPING FILTER FOR CATHODE RAY TUBES

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12 Claims. (Cl. 178-7.82)

This invention relates to a light ray filter for use primarily with a diffuse radiant screen presenting reproduced images, and is directed particularly to such filter which will trap ambient light rays angularly directed toward such screen. The filter traps both diffuse and concentrated light, thus preventing all off-axis light from striking the screen and degrading the image contrast, and consequently improving the quality of the image which is viewed. This application is a continuation in part of my application, Serial No. 230,644, filed October 15, 1962, which in turn is a continuation in part of my application, Serial No. 138,855, filed September 18, 1961.

Cathode ray tubes are typical examples of diffuse radiant screens and are particularly susceptible to the effects of being struck by ambient light rays. As is generally known, a cathode ray tube has a glass front wall, the inner surface of which is coated with phosphors which are caused to glow momentarily when struck from the rear by electrons from one or more electron guns in a selective manner to produce an image of some sort. When ambient light rays strike the front surface of the glass they are refracted inwardly and strike a multiplicity of phosphors. The light energy is reflected diffusely from these phosphors whether or not they are being activated by the electron gun. The result is that many of the shadow areas or low lights are illuminated and approach the brightness of the highlights, thus degrading the contrast. The low lights may be made as bright as the highlights in some cases and the picture may be completely lost.

Various schemes have been devised to prevent ambient light rays from striking the cathode tube glass or phosphors, either of which may be considered as the "screen." Large hoods have been placed around the tubes extending toward the viewers but these are very clumsy. Honeycomb cores have been placed in front of the tube but the honeycomb walls are not perfect absorbers so they reflect the light rays onward to strike the screen anyway. My co-pending application for patent on Ambient Light Filter, Serial No. 230,644, filed October 15, 1962, discloses a novel construction which solves the problem.

Briefly, that novel construction comprises a filter body of transparent material in which are embedded a plurality of filter elements having a grid pattern. Each element constitutes a tier of alternating transparent and light absorbing material in closely spaced relation to constitute a multiplicity of light transmitting apertures bordered by light absorbing material. The grid pattern may be formed of generally parallel straight or wavy lines, or lines crossing each other to produce cells of varying shapes. The tiers are in generally parallel relation to each other and are spaced depthwise of the filter body with the light transmitting apertures in registry to constitute depthwise directed viewing cells. The axes of the cells may be normal to the plane of the filter body or at some other preselected angle, and may be parallel or divergent within limits.

Ambient light rays striking the surface of the filter body at acute angles other than normal are refracted into cells at an angle, striking one or another of the depthwise spaced lines of opaque or light absorbing material and are absorbed thereby. The success of such filter results from the fact that the cells are very small in at least one

2

lateral dimension and the lines forming the cell boundaries are extremely thin in the depthwise direction so that their edges present no appreciable grazing surface to reflect light rays onwardly. In fact, in a typical example the width of the apertures may be from .015 to .025 inch and the line width from .004 to .007 inch. The line thickness may vary from .0001 to .0002 inch and the depthwise spacing between lines may be of the order of .010 inch. Such a filter with six filter elements is only one sixteenth inch thick.

The home television set presents a particular problem for a light trapping filter because direct or reflected light sources may be anywhere in the room and the user expects the filter to eliminate their undesirable effects rather than require him to move the set or block some of the light sources. This means that the filter must trap most of the light coming from above eye level or even from floor level, and also must trap light from larger angles at each side. This, in effect, calls for a closed figure grid pattern. In addition, the raster of the television tube presents a series of alternating light and dark horizontal lines which are visible at all times when the tube is activated. The grid pattern must not combine with these lines to produce a moire effect. In fact it is highly desirable to break up the existing horizontal line pattern of the raster to improve the image.

The present invention provides a filter which overcomes both of these problems and greatly improves the image presented by the tube. In general, the filter is made up in the same way as those described in my previous application. The grid pattern of each filter element or tier is in the form of closed figures delineated by lines which are at substantial angles to a horizontal reference line or to the horizontal lines of the raster. In one form, a first set of spaced parallel lines extends diagonally in one direction and a second set of similar lines extends diagonally in another direction crossing the first set. Although they need not be at exactly the same angle to the horizontal it is preferable to make the angles the same to produce a uniform and more pleasing effect. The lines thus laid out present a repetitive pattern of diamonds, and the angles are chosen so that the width of a diamond is substantially greater than its height. In most cases the ratio is about two to one, or higher.

The useful limiting viewing angle is taken to be the angle at which the viewer receives fifty percent transmission, and it is determined by the depth and shape of the viewing cells. With diamond shaped cells the useful viewing angle becomes a substantially elliptical cone, the ratio of height to width corresponding generally to the dimensional ratio of the diamond. The vertical eye level position normally varies only from about three to six feet above the floor, requiring only a relatively small vertical angle of view, but it is desirable to allow the viewer as much horizontal shift as possible, approaching the range of good viewing of the unfiltered picture. Thus the elliptical cone of vision is basically the most desirable. Once a satisfactory ratio is determined, the absolute angle can be varied inversely with the depth of the cell. Adding more tiers of filter elements narrows the angle and removing tiers widens it.

With the diamond grid, all portions of all lines are diagonal with respect to the raster lines. At larger angles no moire effect is produced. The minimum angle below which the moire effect appears varies to some extent with the fineness of the lines, both on the grid and on the screen, but it has been determined that the minimum angle is of the order of fifteen degrees.

As indicated above, the arrangement described eliminates the moire pattern problem without sacrificing any of the improvement in contrast and clarity resulting from the use of the space lattice type filter. Another important

advantage is that the diamonds give the appearance of acting in combination with the horizontal raster lines to give a pleasing half-tone effect much the same as in newspaper and magazine printed pictures, and completely eliminate the displeasing effect of the horizontal lines in the raster.

Various other advantages and features of novelty will become apparent as the description proceeds in conjunction with the accompanying drawings, in which:

FIG. 1 is a front perspective view of a cathode ray tube of a television set with the filter of this invention, a part being broken away, mounted adjacent the tube, the housing being shown in phantom lines;

FIG. 2 is a greatly enlarged detail view in perspective of a portion of the filter of this invention;

FIG. 3 is an enlarged fragmentary front elevational view of the screen with raster lines thereon, partly covered by a portion of the filter with a diamond grid formation;

FIG. 4 is a schematic view in front elevation of a single cell of the diamond grid showing a polar diagram of transmission vs. viewing angle;

FIG. 5 is a schematic sectional view in elevation of a portion of a filter, illustrating a fifty percent transmission viewing angle with a selected number of filter elements; and

FIG. 6 is a similar view showing the change in viewing angle with a change in the number of filter elements.

A conventional type of television set is rather schematically illustrated in FIG. 1 by a cathode ray tube 10 mounted in a housing 12 shown in phantom lines. The tube includes a front wall 14, on the inner face 16 of which is the usual phosphor layer 18. Electrons streaming from the electron gun, not shown, at the rear of the tube strike the phosphors selectively to produce image signals which pass through the glass wall of the tube and are emitted forwardly, or to the right as viewed in FIG. 1. Any light source, such as source 20, emits light rays in all directions and those such as ray 22 strike the front face of the tube and are refracted inwardly, if the angle is acute enough, to strike the phosphor screen. As explained in more detail in my previously filed case mentioned above, the refracted rays are reflected by the phosphors and degrade the image contrast. Rays striking at the more obtuse angles are reflected off the surface of the tube wall, and some of these latter travel toward the viewer and further degrade the image.

To overcome these disadvantages an ambient light trapping filter 24 is provided in the form of a generally planar panel of transparent material mounted in front of the tube face, substantially normal to the tube axis, and in proximity to the tube wall 14. The panel may be a single sheet of material but in the presently preferred form it is made up of a plurality of layers cemented together in a unitary manner. Each layer is provided on one or both faces with a filter element consisting of a tier of alternate transparent and highly light absorbent areas in a grid-like pattern forming a multiplicity of light passages. The grid patterns of the various layers are in depthwise registry to produce a multiplicity of depthwise directed viewing cells. Off-axis light rays such as 22, striking the front face of the filter and refracted into the viewing cells, strike the light absorbent material at nearly normal angles and are absorbed thereby. The material at the margins of the viewing cells is so thin as to present substantially no grazing surface, so the rays are not reflected onwardly toward the screen.

Because of the scanning operation of the tube a series of horizontally extending light lines and dark lines 26 appear on the screen 18 at all times when the tube is activated. This is commonly referred to as a raster. When a space lattice type ambient light trapping filter is employed which includes horizontal lines in its grid pattern, these horizontal lines combine with the horizontal raster lines to produce a moire effect which is annoying and confusing and tends to distort the image which is being viewed. A filter

for a home television set must overcome this difficulty and also put minimum restrictions on the location of light sources while allowing maximum range of viewing positions both vertically and horizontally. The filter 24 shown in FIG. 1, and in more detail in FIGS. 2 and 3, produces an optimum solution to all of these problems.

Each of the tiers of filter elements as shown comprises a series of spaced, generally straight and generally parallel lines 28 of highly light absorbent material extending diagonally in one direction and another series of similar lines 30 extending diagonally in a second direction to cross the first series. For uniformity the lines in each set or series are at the same acute angle to a horizontal reference line, which is comparable to any of the horizontal raster lines. The result is a pattern of uniformly sized and shaped diamonds covering the entire area of the filter element. The filter body or panel is made up of a plurality of layers cemented face to face with a transparent cement and with the diamond shaped light passages in depthwise registry to produce a multiplicity of diamond shaped viewing cells extending depthwise of the body or panel. The cells are usually substantially parallel to each other though they may be convergent or divergent for special purposes, and the viewing axes may be normal or at a selected angle to the general plane of the panel.

It will be noted, as well shown in FIG. 3, that with the arrangement described all of the filter grid lines 28, 30, are at angles to the horizontal raster lines 26. Since slight divergences from the horizontal do produce a moire effect it is necessary to incline lines 28 and 30 at substantial angles. The minimum angle varies to some extent with the width and spacing of the grid lines and the raster lines but it has been determined that with the present lines and spacing the minimum angle is of the order of 15 degrees. Thus the first problem of the moire effect is taken care of with the inclined grid lines.

The second problem of minimum restriction on the location of light sources is also well handled by the present construction. The diamond grids are closed figures and therefore light rays approaching the screen from any vertical or horizontal direction at sufficient angularity will be refracted into contact with some portion of the light absorbent grid material and will be trapped. Of course these angles must be greater than those selected as the maximum viewing angles, and it is also to be understood that rays approaching at the more obtuse angles will be largely reflected.

The third important consideration is that of providing a maximum range of viewing positions, both vertically and horizontally, compatible with the light trapping function. From experience it has been determined that a reasonable standard for the "maximum useful viewing angle" is that angle off-axis at which the eye of the viewer receives 50 percent of the total on-axis image signal transmission. Except for extreme cases the vertical range of eye position that must be accommodated is from about three feet to six feet above the floor while the desired horizontal range is considerably more, usually two to three times as great. Thus, a generally elliptical cone of useful viewing angles is optimum, with the longitudinal axis extending horizontally.

The schematic representation of FIG. 4 constitutes a polar diagram of percentage transmission vs. viewing angle. Diamond 32 represents a head-on view of one diamond shaped viewing cell. The dot 34 represents a center line of vision down the axis of the cell and can be designated as 100 percent transmission. If the viewer moves in such direction that the center or axis of the cell at the far end effectively moves in the direction of dotted line 36 until it reaches the wall of cell 32 the visible signal transmission is reduced to 50 percent. The same is true of movement in the other three directions parallel to the sides. Between these points, because of the diamond shape, the 50 percent point follows a curved path resulting in an approximate ellipse 38. The polar

5

diagram of zero percent transmission is the larger diamond 40. The result is a generally elliptical cone of useful viewing angles with the ratio of width to height being a function of the included angles of the diamonds. It will be seen therefore that one of the important steps in the manufacture of the filter is the adjustment of the included angles of the diamond grid to produce an elliptical cone of vision with the best ratio of vertical to horizontal angles for the intended purpose.

Once this ratio is determined, the absolute angles will be a function of the effective depth of the filter; i.e., the overall distance from the innermost filter element to the outermost one, as will be observed by reference to FIGS. 5 and 6. In each of these figures the sizes and shapes of the diamonds are the same. In FIG. 5, panel 42 includes five filter elements 44. Two bundles of rays 46 and 48 are shown, each having a thickness corresponding to half of the width of the viewing cell in the plane of the section. These rays therefore represent the limits of vision with 50 percent transmission and the angle A between them is the maximum useful included viewing angle.

FIG. 6 is similar to FIG. 5 but here the number of filter elements 50 in panel 52 has been increased to eight. The depth of the cell is correspondingly increased and the angle of the 50 percent bundle of rays is noticeably decreased. Thus the angle B between the limiting rays 54 and 56 is considerably less than angle A of FIG. 5. It will be seen that a second important step in the manufacture of a filter of this type is in varying the number of filter elements, or the thickness of the filter body, to achieve the necessary or desirable useful included viewing angle.

In the course of design other features may be varied alone or in conjunction with those mentioned above. To increase the absolute axial transmission, for instance, the light passages may be enlarged or the lines narrowed, or both. The viewing angle can be kept approximately the same by making the filter body appropriately thicker.

It will be seen that the present invention provides a light trapping filter of optimum characteristics in which the vertical and horizontal useful viewing angles can be tailored individually to give maximum viewing compatible with maximum light trapping. Of course it is obvious that one must be sacrificed for the other to some extent since any light source within the viewing angle will produce some detrimental effect on the image being viewed. However, because of the closed figure grid pattern the restrictions on light source location are minimized and a very satisfactory viewing range is achieved.

It will be apparent to those skilled in the art that various changes and modifications may be made in the construction and arrangement of parts and in the method of manufacture without departing from the spirit of the invention and it is intended that all such changes and modifications shall be embraced within the scope of the following claims.

I claim:

1. The combination of a viewing screen from which image light emanates with a space lattice type ambient light trapping filter mounted in front of and in proximity to said screen, the general planes of said screen and said filter being substantially parallel; said screen, when activated, presenting a series of alternating light and dark horizontal lines constituting a horizontal raster; said filter comprising a thin, transparent panel bearing, throughout its thickness, a plurality of depthwise spaced tiers of filter elements, each in the form of a light trapping grid pattern of highly light absorbent material; said grid pattern consisting of narrow lines arranged to form a multiplicity of adjoining polygonal frames, each enclosing a transparent area serving as a light passage; each frame being oriented so that all of its sides are at sufficient angles to the horizontal lines of the raster pattern to prevent formation of a moire effect between the grid lines and

6

the raster lines; the light passages of successive grid patterns being in depthwise registry to provide a multiplicity of depthwise directed viewing cells; said depthwise spaced grid lines acting individually to trap and absorb off-axis ambient light rays entering said cells at various angles and striking said grid lines at nearly normal angles.

2. The combination as claimed in claim 1; the minimum vertical angle between said grid lines and said raster lines being about 15 to 20 degrees.

3. The combination of a cathode ray tube having a viewing screen from which image light emanates with a space lattice type ambient light trapping filter mounted in front of and in proximity to said screen, the general planes of said screen and said filter being substantially parallel; said screen, when activated, presenting a series of alternating light and dark horizontal lines constituting a horizontal raster; said filter comprising a thin, transparent panel bearing, throughout its thickness, a plurality of depthwise spaced tiers of filter elements, each in the form of a light trapping grid pattern of highly light absorbent material; said grid pattern consisting of a first series of narrow, generally straight and generally parallel lines of highly light absorbent material separated by transparent areas and a second series of similar lines crossing the first series at an acute angle; the two series of lines being arranged to provide a multiplicity of adjoining diamond shaped frames with their major axes extending horizontally, the width of each frame being substantially greater than its height, and each frame enclosing a similarly shaped transparent area serving as a light passage; each frame being shaped and oriented so that all of its sides are at sufficient angles to the horizontal lines of the raster pattern to prevent the formation of a moire effect between the grid lines and the raster lines; the light passages of successive grid patterns being in depthwise registry to provide a multiplicity of depthwise directed viewing cells producing a cone of useful viewing angles of greater azimuth than elevation; said depthwise spaced grid lines acting individually to trap and absorb off-axis ambient light rays entering said cells at various angles and striking said grid lines at nearly normal angles.

4. The combination as claimed in claim 3; the minimum vertical angle between the sides of said diamond shaped frames and the horizontal lines of the raster pattern being about 15 to 20 degrees.

5. A space lattice type ambient light trapping filter adapted to be mounted in front of and in proximity to a viewing screen presenting, when activated, a series of alternating light and dark horizontal lines constituting a horizontal raster, comprising: a thin, transparent panel adapted to be mounted in a generally vertical plane; said panel bearing, throughout its thickness, a plurality of depthwise spaced filter elements; each of said filter elements comprising a generally planar tier of alternating loci of transparent and highly light absorbing material arranged to provide a multiplicity of light transmitting apertures in close proximity to each other and separated by grid lines of light absorbing material to form a grid pattern of polygonal frames, each enclosing a transparent area; each frame being oriented so that all of the lines forming its sides are at substantial angles to a horizontal reference line to prevent the formation of a moire effect between the grid lines and the horizontal raster lines of a viewing screen; the light transmitting apertures of successive grid patterns being in depthwise registry to provide a multiplicity of depthwise directed viewing cells; said depthwise spaced grid lines acting individually to trap and absorb off-axis ambient light rays entering said cells at various angles and striking said grid lines at nearly normal angles.

6. A filter as claimed in claim 5; the grid lines being so thin at the margins of said light transmitting apertures as to present substantially no grazing surface.

7. A filter as claimed in claim 5; said polygonal frames

7

being in the form of diamonds; the width of each frame being substantially greater than its height to produce a cone of useful viewing angles of greater azimuth than elevation.

8. A filter as claimed in claim 7; the absolute vertical and horizontal angles of view being an inverse function of the overall depth between the outermost and innermost tiers.

9. A filter as claimed in claim 5; the minimum angle between a horizontal reference line and the grid lines forming said frames being of the order of 15 degrees.

10. A space lattice type ambient light trapping filter adapted to be mounted in front of and in proximity to a cathode ray tube viewing screen presenting, when activated, a series of alternating light and dark horizontal lines constituting a horizontal raster, comprising: a plurality of thin filter body layers of transparent material laminated and cemented face to face with transparent cement to form a substantially unitary filter body panel; a filter element arranged between adjoining faces of each adjacent pair of layers; each of said filter elements comprising a generally planar tier of alternating loci of transparent and highly light absorbing material arranged to provide a multiplicity of light transmitting apertures in close proximity to each other and separated by grid lines of light absorbing material to form a grid pattern of polygonal frames, each enclosing a transparent area; each frame being oriented so that all of the lines forming its sides are at substantial angles to a horizontal reference line to prevent the formation of a moire effect between the grid lines and the horizontal raster lines of a viewing

8

screen; the light transmitting apertures of successive grid patterns being in depthwise registry to provide a multiplicity of depthwise directed viewing cells; said depthwise spaced grid lines acting individually to trap and absorb off-axis ambient light rays entering said cells at various angles and striking said grid lines at nearly normal angles.

11. A filter as claimed in claim 10; said grid pattern consisting of a first series of narrow, generally straight and generally parallel lines and a second series of similar lines crossing the first series at an acute angle; the two series of lines being arranged to provide a multiplicity of adjoining diamond shaped frames with their major axes extending horizontally.

12. A filter as claimed in claim 11; the absolute vertical and horizontal angles of view being an inverse function of the overall depth between the outermost and innermost tiers.

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