

May 25, 1943.

J. N. DYER

2,319,803

TELEVISION

Filed Feb. 24, 1941

3 Sheets-Sheet 1

Fig. 1

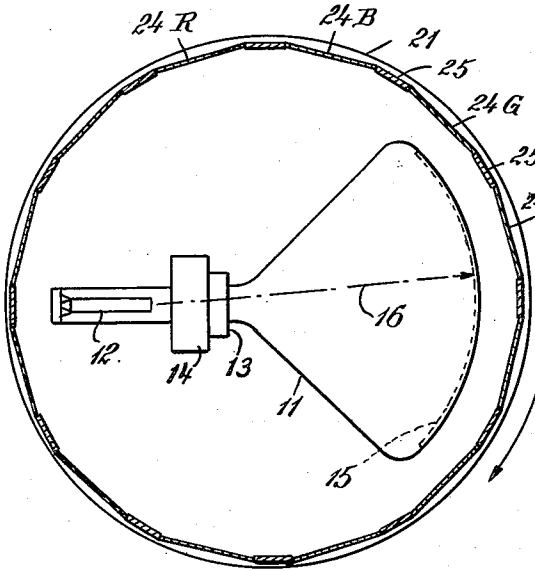
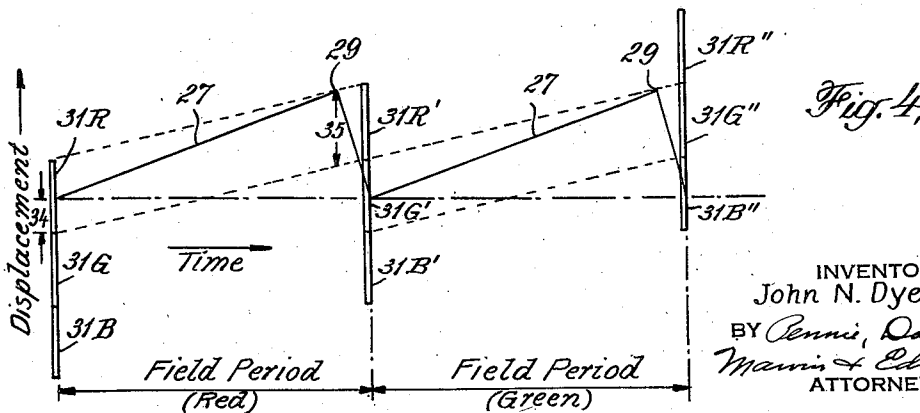
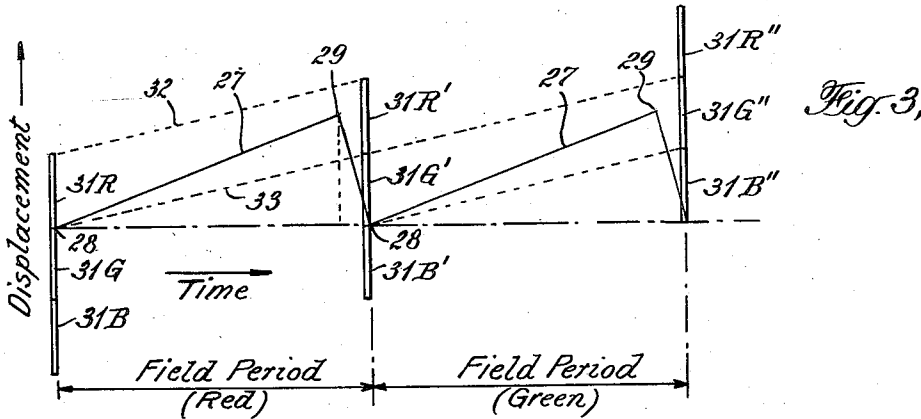
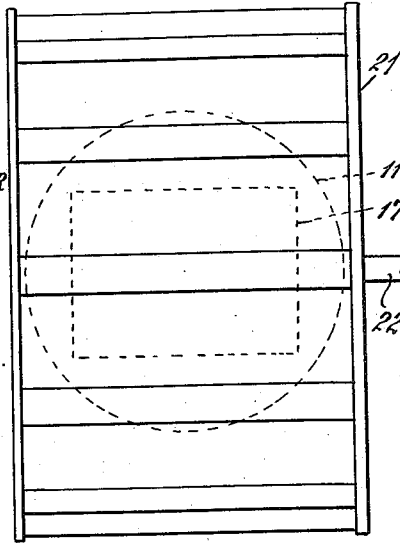


Fig. 2



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Fig. 5,

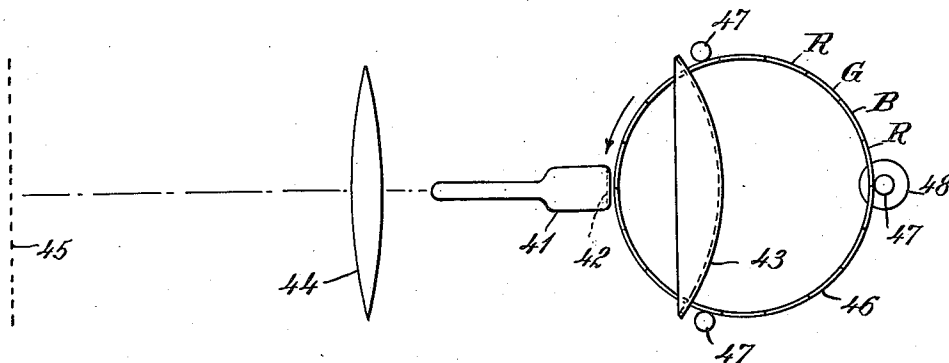


Fig. 6,

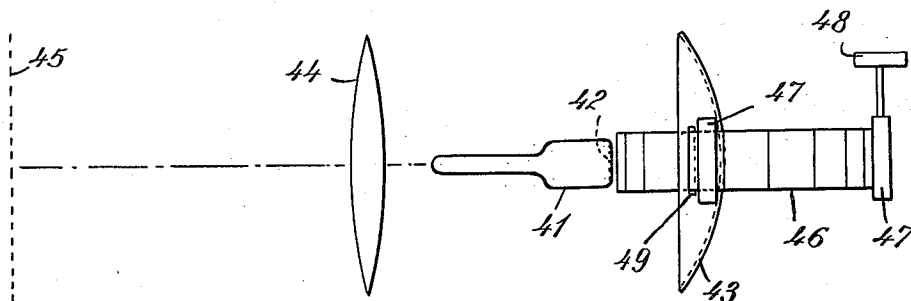
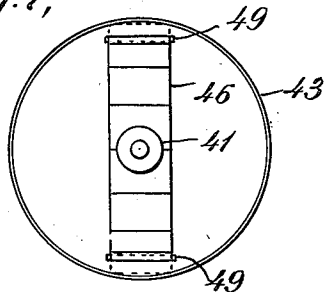


Fig. 7,



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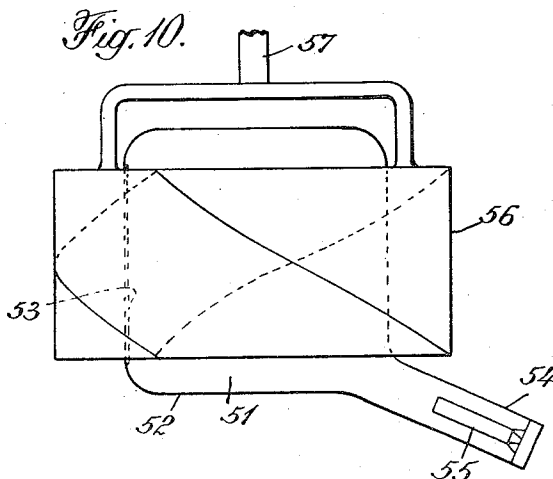
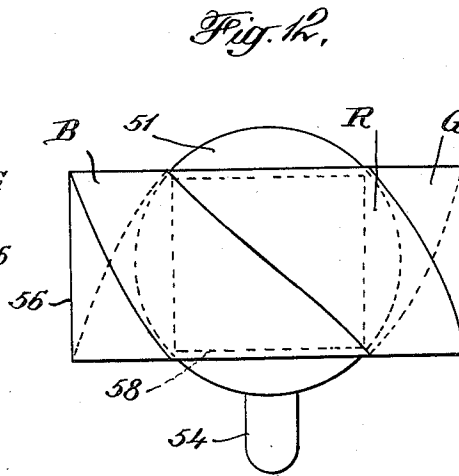
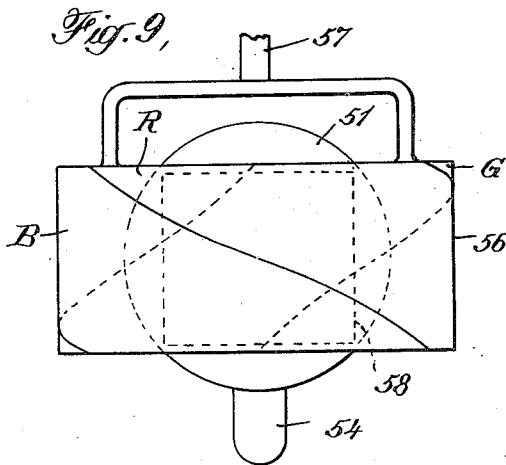
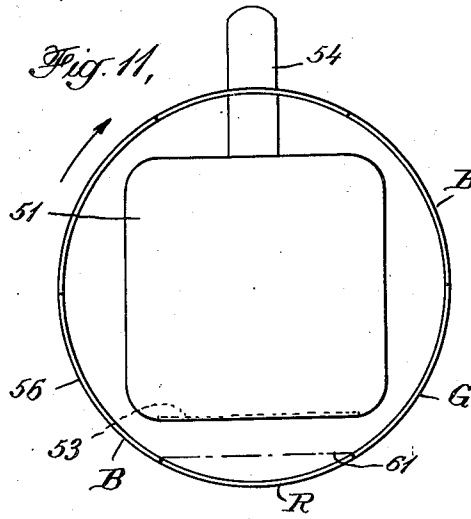
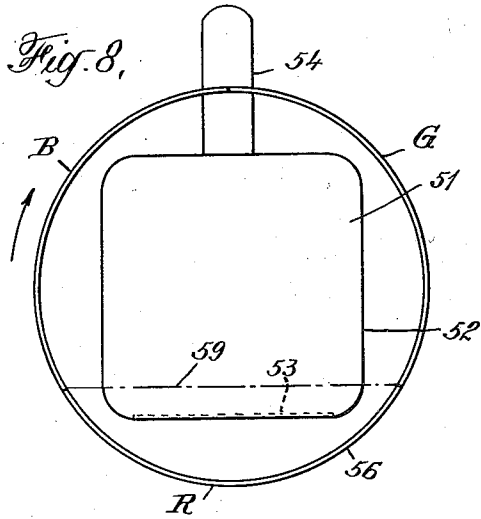
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3 Sheets-Sheet 3



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2,319,803

TELEVISION

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Application February 24, 1941, Serial No. 380,097

7 Claims. (Cl. 178—5.2)

This invention relates to television, especially to television in natural colors. The invention particularly relates to apparatus of the type employing rotating filter elements, and contemplates the provision of a form of rotating element and arrangement of the rotating element with respect to a cooperating scanning device which will yield a compact assembly adapted to be conveniently housed in a cabinet, etc.

In color television systems in which the object field is scanned successively in a plurality of colors and the signals transmitted to the receiver for reproduction, the use of rotating disks have heretofore been suggested. Suitable disks having segments of novel design are described in an application of Peter C. Goldmark, Serial No. 355,839, filed September 7, 1940, for "Color television." Such disks have been found to be quite satisfactory from the standpoint of operation. However, the diameter of the disk must in general be at least twice that of the scanning area, and the axis must be at one side of the scanning area. Hence this requirement is a limiting factor in the design of a cabinet. For example, in a receiver employing a cathode ray tube, the tube must be located at one side of the axis of the disk. If the cabinet is kept down to minimum dimensions, this means that the viewing area will be at one side of the cabinet. Also, the diameter of the disk determines the minimum width of the cabinet.

The present invention especially contemplates the provision of apparatus which will permit more freedom in the design of a compact, attractive cabinet.

The use of rotating filter drums instead of disks has been suggested in an application of Peter C. Goldmark, Serial No. 370,008, filed December 13, 1940, and entitled "Television." The present application discloses various improvements in the design and construction of color filter drums or, more generally, endless color filter elements, and also in their assembly with cooperating scanning devices.

In accordance with one feature of the invention, the endless color filter element or band, preferably a drum, is arranged to encircle part or all of an electronic scanning device. In the case of a receiver, a specific embodiment discloses a color filter drum encircling a cathode-ray tube and rotating about a horizontal axis. With such a construction and arrangement the width of the filter element need be only slightly greater than that of the scanned area, and hence the cabinet may be made much narrower than when

disks are employed. Also, the viewing area may be disposed on the vertical center line of the cabinet, if desired, rather than to one side thereof. Furthermore, by disposing the cathode-ray tube within the drum, not only is space conserved but also, for a drum of given diameter and a scanning area of given height, the vertical viewing angle is greater than with the cathode-ray tube outside the drum due to the concave surface of the drum being toward the scanning area. This latter feature is important since it is highly desirable to keep the components as small as possible without sacrificing viewing angle or other tolerances.

The dimensions of the drum and the number of filter segments may be selected so that the spacing between filters is equal to the height of the scanning area plus a distance to allow for the blanking period (about 10% at the present time). In such case, with proper phasing, the leading edge of a given filter segment may be made to traverse the scanning area at substantially the same speed as the scanning beam, and coincide therewith. However, it is found that with non-storage scanning devices, or scanning devices of the type in which the storage effect persists for only part of the scanning period, this relationship need not be maintained. If the dimensions of the drum or other moving filter element be properly selected so that the speed and height of the filter segments are properly correlated with the scanning, the height of the filter segments may be considerably less than the sum of the height of the scanning area plus an allowance for blanking. This permits the use of a greater number of filter segments for a given length of the moving element, and hence a reduction in the speed thereof. Such a reduction is highly advantageous to avoid noise.

In accordance with another specific feature of the invention, a drum is provided having filter segments arranged around the peripheral surface thereof in the form of helixes. With this construction the axis of rotation of the drum may be placed at right angles to the position it would have if the boundaries between segments were parallel to the axis. This permits a more convenient mechanical arrangement in some cases.

In accordance with a further feature of the invention, a combination of a filter drum, a mirror and a projection cathode-ray tube is provided for the projection of television images in color. The combination is arranged in a novel manner so

that the filter drum cuts off a minimum amount of light.

The invention will be more fully understood by reference to the specific embodiments illustrated in the drawings and the following description thereof. In the drawings:

Fig. 1 is an elevation of a specific embodiment in which a cathode-ray receiver tube is completely encircled by a color filter drum;

Fig. 2 is a front view of the embodiment of Fig. 1;

Fig. 3 is a diagram illustrating the principles on which the height of a filter and its speed of movement may be correlated with the vertical scanning so that the filter height is less than that of the scanning area;

Fig. 4 is a diagram illustrating further the principles of Fig. 3;

Fig. 5 is an elevation of a specific embodiment in which a rotating filter drum is combined with a cathode-ray tube, mirror and correcting lens for the projection of color images;

Figs. 6 and 7 are plan and front views, respectively, of the apparatus of Fig. 5;

Figs. 8, 9 and 10 are plan, front and side elevation views, respectively, of a specific embodiment employing a drum with helically shaped filter segments; and

Figs. 11 and 12 are plan and front views, respectively, of an embodiment similar to Figs. 8-10 in which a 6-segment drum is employed instead of a 3-segment drum.

Referring to Figs. 1 and 2, a cathode-ray receiving tube having an envelope 11, electron gun structure 12, horizontal and vertical deflecting coils 13, focussing coil 14 and luminescent screen 15 is provided. The scanning electron beam 16 is deflected by the deflecting coils to scan a scanning area 17 (Fig. 2) of the luminescent screen on the face of the tube in a series of horizontal side-by-side lines beginning at the top of the scanning area and progressing to the bottom (or vice versa) in a field scanning period. During a field scan the scanning lines may be contiguous so that all points of the area are covered, or they may be non-contiguous so that only a single interlaced set of lines is covered. The other sets of interlaced lines may then be scanned during succeeding field-scanning periods. Preferably, successive field scans correspond to different primary colors. For example, the systems disclosed in the application of Peter C. Goldmark, Serial No. 355,840, filed September 7, 1940, for "Color television" may be employed, in order that each set of interlaced lines may be reproduced in each color within a complete cycle. Of course, any other scanning system may be employed if desired, the present invention not being limited to any particular system.

Encircling the cathode-ray tube is a color filter drum 21. This drum is rotatable about an axis 22 and is driven in synchronism with the field scanning by suitable driving means (not shown). Any desired means may be employed for synchronizing the rotation of the drum with the field scanning.

Drum 21 is provided with a plurality of different color filter segments, 24R, 24G, 24B arranged around the peripheral surface of the drum. In the specific embodiment shown, the boundaries 25 between segments are parallel with the drum axis. For systems in which the images of successive field scans are exhibited in successively different colors, the number of filter segments and the speed of rotation are selected so

that the segments traverse the scanning area 17 at a frequency equal to the field-scanning frequency.

It has previously been suggested to make the spacing of the filter segments around the periphery of the drum (that is, the separation of corresponding points such as respective leading edges) equal to the height of the scanning area 17 plus an allowance for the blanking period (usually about 10% at the present time). In this manner the filter segments traverse the scanning area at substantially the same speed as the scanning beam in the low frequency direction so that, by proper phasing, the boundaries between adjacent filter segments may be made to coincide with the line being scanned so as to prevent color carry-over and permit equal exposure of all areas through a filter of given color. Of course, if the peripheral surface is not closely adjacent the scanning area, a suitable correction may be made, as will be understood by those in the art.

The drum of Fig. 1 may be constructed in the foregoing manner, in which case the assembly illustrated has the advantages of being more compact and more suitable for commercial assemblies than the arrangements heretofore suggested. However, with cathode-ray tubes in which the period of afterglow is brief, or decays to a negligible value in a fraction of a field-scanning period, it has been found that the spacing between successive filters may be less than that required above, thus permitting more filters to be arranged on the peripheral surface of the drum and hence requiring a lower speed of rotation.

Referring to Fig. 3, the saw-tooth waves 27 represent the displacement of the scanning beam in the vertical or low frequency direction, plotted against time. The scanning beam starts at 28, corresponding to the line at the top or bottom of the picture as the case may be. It progresses over the lines of the scanning area until it reaches point 29, whereupon it returns abruptly to its initial value. The vertical distance between points 28 and 29 therefore represents the height of the scanning area 17 (Fig. 2). Of course, in interlaced scanning the scanning beam will not return to exactly the same line at the end of each scanning period, but the difference may be disregarded for present purposes.

Three filter segments 31R, 31G and 31B are illustrated at the beginning of the field period corresponding to a red image. These same filter segments are illustrated at 31R', 31G', 31B' at the end of the same field period. In order that the filter segments may occupy the same position relative to the scanning area at the beginning of their respective field periods, the distance a filter moves in a field scanning period should equal the distance between successive filter segments. With no allowance for the width of the boundaries, this is equal to the height of the filter segments, as shown in Fig. 3. The traversal of the scanning area by a given filter is substantially linear, so that the dotted lines 32 and 33 indicate the position of the leading and trailing edges of the red filter at any instant in the field scanning period. Since line 27, representing the position of the scanning beam, lies between the dotted lines 32 and 33 throughout the field period, the line being scanned will always be presented through the red filter.

A similar procedure obtains for the next succeeding field period in which the line being

scanned is always presented through the green filter.

In Fig. 3 the red filter is always somewhat in advance of the line being scanned, the difference varying from a maximum at the beginning of the scanning period (equal to the height of the filter segment) to a minimum at the end of the scanning period. In order to allow for a short period of after-glow, the filter disk may be retarded in phase with respect to the scanning beam, as shown in Fig. 4.

Fig. 4 is similar to Fig. 3 except that the filter segments are retarded in phase so that the leading edge of the filter coincides with the line being scanned at the end of the scanning area represented by point 29. Thus the scanning lines continue to be presented through a filter of given color by a period varying from that represented by the distance 34 to that represented by the distance 35.

It will be apparent that by changing the height of the filter segments, the separation thereof and the speed of travel thereof, a given scanning line may be obscured by a filter of given color for any desired fraction of a field period. With the proportions illustrated in Figs. 3 and 4, the phase of the filter segments with respect to the scanning beam may be varied between the position shown in Fig. 3 and that shown in Fig. 4. With tubes of little or no after-glow, this tolerance permits adjusting the phase so that the picture can be viewed from various angles above and below the scanning area, and also avoids the necessity for precise phasing. With tubes possessing after-glow, the distance 34 may be made sufficient to provide for the after-glow and other desired tolerances.

Generally, in order that, with proper phasing, each line of the scanning area may be obscured by a filter of given color as that line is scanned, the sum of the height of the filter segment plus the distance the segment moves in a field period should be equal to or greater than the sum of the height of the scanning area plus the allowance for blanking. If greater tolerances for after-glow, phasing, etc. are obtained. This applies for uniform movement of the filter segments and linear scanning, with the filter segments closely adjacent the scanning area. If these conditions are departed from, the necessary variations may be taken into account by plotting diagrams similar to Figs. 3 and 4 in which the actual positions of the filter segments and scanning beam at each instant are indicated.

While particularly applicable to a rotating filter drum, it will be appreciated that the principles of Figs. 3 and 4 may also be applied to other endless filter bands, disks, etc.

It will be noted that the vertical height of the observer's point of view determines the particular portion of the luminescent screen which he sees at any instant through a given filter segment. By placing the cathode ray tube inside the filter drum rather than outside thereof, so that the concave surface of the drum is toward the tube, the tolerance in the vertical viewing angle is increased. This is a considerable advantage since a color filter element is unavoidably rather bulky and every effort is made to reduce the size without sacrificing correct operation.

Referring now to Figs. 5-7, a specific embodiment is illustrated which is especially applicable

to the projection of images formed by a cathode-ray tube. A cathode-ray receiver tube 41, forming an image on the luminescent surface 42 thereof, is employed. This tube may be similar to that of Fig. 1, but is preferably of a type which produces a small but very brilliant image. Light from the projector tube 41 is received by the concave mirror 43 and reflected through the lens 44 to a suitably positioned screen 45. Lens 44 is designed to correct for the aberrations of the mirror 43. The mirror 43 and lens 44 thus function in a manner similar to that of the so-called "Schmidt camera," familiar in connection with astronomical instruments.

A filter drum 46 is positioned with its peripheral surface closely adjacent the scanning area 42 of the projector tube, and with at least a portion of its peripheral surface between the scanning area and the mirror 43. Although the drum could be positioned to encircle the projector tube 41, as illustrated in Fig. 1, in order to avoid impeding the light rays as much as possible, the invention contemplates positioning the mirror and drum so that the surface of the mirror extends within the drum. This arrangement is shown in Figs. 5-7.

As shown in Figs. 6 and 7, the filter drum impedes the rays of light through only a relatively narrow vertical band. The drum is preferably positioned so that the filters pass as closely as possible to the image so that all rays of light which reach the mirror will pass through the proper filter. It will be apparent that if the central portion of the mirror is reflecting, light rays therefrom will be reflected through various parts of the periphery of the drum lying within the mirror at any given instant. If the filter in front of the projector tube 41 is, say, red, such reflected rays which impinge on green or blue filter segments will be absorbed and hence will not impair the color reproduction. If the reflected rays impinge on a red filter, they will be partially attenuated and then allowed to pass. With a large number of filter segments this attenuation may not be objectionable. However, if desired, suitable stationary masks may be placed inside those portions of the drum lying between the mirror and the projector tube 41, so as to cut off rays which would otherwise pass through the periphery of the drum.

The number of filter segments may be selected as desired, six groups of three red, green and blue filters being specifically illustrated.

The drum may be supported and driven by suitable bearings 47 as shown. Driving power may be supplied to pulley 48, or in any other desired manner. Or, a vertical central slice may be cut out of the mirror to allow the periphery of the drum to be attached to a central axle, and supported and driven thereby. When such a slice is cut out, it will be understood that the surface of the mirror may still be considered to pass within the drum.

The mirror and drum may be proportioned so that the mirror lies entirely within the drum in the vertical plane, or the mirror may extend somewhat beyond the surface of the drum as shown in Fig. 5. In such case suitable slots 49 may be provided in the surface of the mirror. In either case, those portions of the mirror which extend laterally from the drum (see Fig. 6) will receive light rays from the projector tube and reflect them to the screen 45. If desired, the mirror may be wider than it is high so as to provide more light gathering power.

Broadly speaking, although a rotating filter drum such as illustrated in Figs. 5-7 is advantageous, any desired endless filter band may be employed.

Referring now to Figs. 8-10, a cathode-ray receiver tube 51 is employed comprising a bulbous portion 52 at one end of which is the luminescent screen 53, and an elongated neck 54 projecting at an angle from the other end of the bulbous portion. The electron gun structure 55 is arranged within the neck 54 for supplying a scanning cathode-ray beam. Suitable deflecting means (not shown) are of course employed, and causes the beam to scan the area 56 from top to bottom (or vice versa) in horizontal side-by-side lines. A color filter drum 58 is arranged to encircle the bulbous portion of the cathode-ray tube. This general construction and arrangement has been suggested by Peter C. Goldmark and is described in his copending application filed concurrently herewith.

In accordance with the present invention, the filter drum is arranged to rotate about a vertical axis 57 and the filter segments are arranged around the peripheral surface of the drum in the form of helixes. This helical arrangement of filter segments permits the drum to be rotated about a vertical axis while a given filter segment follows the line scanning in the vertical direction so that the lines are exposed through the proper filter segment as they are scanned. Also, the cathode ray tube can be arranged with its elongated neck 54 extending from the bottom of the drum (or the top, if desired), rather than from the side thereof. Thus the arrangement may be advantageous from the standpoint of mechanical design and cabinet design in many cases.

Any suitable number of filter segments may be employed as desired. For three color reproduction, multiples of three will usually be desirable. In general the number of segments and the angular twist of each segment should be such that as the drum rotates the scanning lines are covered progressively as they are scanned, and so that when one field scanning is completed a filter segment of different color is in proper position to begin the next scan. Although the arrangement and proportions of the helical segments may be varied widely to suit various conditions, the specific construction illustrated in Figs. 8-10 will be described for purposes of completeness.

Assume that the height of the filter drum is equal to the height of the scanning pattern plus 10% to allow for blanking (present standards). Each helical segment is arranged to twist through an angle of 120° from the top to the bottom of the drum. Then, if the drum is rotated at a uniform speed through 120° during a field-scanning period, the lines of the scanning area 56 will be progressively covered by, say, the red filter R as the lines are scanned uniformly from top to bottom. At the beginning of the next field scan the green filter G will be in the position occupied by the red filter R in Fig. 9. Thus the lines will be progressively exposed through the green filter during that scanning period. By making the chord 59 subtended by a given filter somewhat greater than the width of the scanning area, suitable tolerances in lateral viewing angle, phasing, etc. may be obtained. Desired tolerances in the vertical direction may be obtained by increasing the height of the drum and prolonging the helical segments without changing the angular twist.

With three filter segments, the angular twist through which the filter extends in a scanning period can be other than that shown. For example, each segment could extend through 240°, in which case the drum would be rotated through 240° in a scanning period. With this arrangement, after a field scan with one filter has been completed, the next adjacent filter will not be in position for the beginning of a scan, but the second succeeding filter segment will be.

In general, it is believed preferable to arrange the filter segments so that in a height equal to that of the scanning area plus an allowance for blanking, each segment twists through an angle equal to the angle between adjacent filter segments. In this manner, the filter segments operate in succession, the speed of rotation is lowest, and maximum tolerances are obtained. However, for any given conditions the number of segments, degree of twist, speed of rotation, etc. can be selected to yield the desired result.

Figs. 11 and 12 illustrate a drum having six filter segments each twisting through $\frac{1}{6}$ of the circumference of the drum in a height equal to that of the scanning area plus a distance to allow for blanking. In this specific embodiment the chord 61 of the segments is made substantially equal to the width of the scanning area to keep the diameter of the drum as small as possible. In general it will be desirable to somewhat increase the diameter of the drum and circumferential length of the segments in order to provide desired tolerances.

When drums having helically shaped segments are employed with receiver tubes possessing substantial afterglow, the circumferential width of the segments may be made sufficient so that width of the scanning area viewed through the segment is greater than the length of a scanning line. This causes the full length of a number of lines to be observed simultaneously through the same filter, and provides a tolerance for afterglow, phasing, viewing angle, etc.

It will be apparent that the drums having helically-shaped segments are not confined to the particular assemblies shown. In general, any type of scanning device could be employed. If desired the drums could be arranged to completely encircle the tube as in Fig. 1, or arranged so that the tube is entirely outside the drum. They could also be employed with transmitter scanning devices such as electronic tubes. Also, instead of true helixes, approximate forms could be employed.

Broadly, the drum has helical segments of different optical characteristics, and is arranged so that the segments traverse the scanning area in a direction which makes a substantial angle with the direction of low-frequency scanning, and the boundaries between segments are at a substantial angle with respect to the direction of movement of the segments. Although a drum is preferred, other moving elements could be employed if desired.

In the preceding description the filter segments have been arranged to move fairly closely adjacent the scanning areas, so that there is little or no magnification between the segments and scanning area. If an arrangement is selected such that magnification is present, it will be understood that dimensions, speeds, etc., which are effective at the scanning area may be selected, and suitable correction factors employed to find corresponding dimensions, speeds, etc., elsewhere.

The foregoing specific embodiments describe

the use of drums in connection with receiver tubes. However, it will be apparent that similar arrangements may be employed in connection with transmitter tubes, the filter drum being arranged to encircle part or all of the tube. In the case of storage transmitting tubes, the dimensions may be selected so that the boundaries between filter segments substantially coincide with the line being scanned so as to avoid color carry-over, if desired.

The principles illustrated in Figs. 3 and 4 may be applied not only to the drum of Figs. 1 and 2, but also to the drums of the other figures as well. In general, features described in connection with one figure may also be employed with the others.

It will be understood that the present invention is not limited to the mere details of construction and arrangement of the parts disclosed, since many modifications may be made by those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. In natural color television, apparatus which comprises an electronic scanning device comprising an envelope having a two-dimensional scanning area therewithin, means for scanning said scanning area in two dimensions in a plurality of side-by-side lines at field-scanning frequency, a rotatable color filter drum having a plurality of different color filter segments on the peripheral surface thereof, said drum encircling at least a portion of said envelope and being positioned so that as the drum rotates said color filter segments successively traverse said scanning area, and means for rotating said drum at a substantially uniform speed such that the field of said scanning area is scanned during the period a filter segment traverses said scanning area.

2. In natural color television, apparatus which comprises an electronic scanning device comprising an envelope having a two-dimensional scanning area therewithin, means for scanning said scanning area in two dimensions in a plurality of side-by-side lines at field-scanning frequency, a rotatable color filter drum having a plurality of different color filter segments on the peripheral surface thereof, said drum encircling at least a portion of said envelope and being positioned so that as the drum rotates said color filter segments successively traverse said scanning area, and means for rotating said drum at a substantially uniform speed selected to cause said filter segments to traverse the scanning area at substantially field-scanning frequency.

3. In a color television receiver, in combination, a cathode-ray receiving tube having a luminescent screen therein and means for successively reproducing images on said screen in a plurality of side-by-side lines, a rotatable color filter drum having a plurality of color filter segments arranged around the peripheral surface thereof, said drum encircling at least a portion of said cathode-ray tube and the peripheral surface thereof moving adjacent said luminescent screen whereby light from the screen passes through the portion of the peripheral surface adjacent the screen, and means for rotating said drum to exhibit reproduced images on said screen successively in different colors.

4. In a color television receiver, in combination, a cathode-ray receiver tube having a luminescent screen therein, means for repeatedly scanning said screen at field-scanning frequency to reproduce images thereon in a plurality of

side-by-side lines, a rotatable substantially cylindrical color filter drum having a plurality of color filter segments arranged around the peripheral surface thereof with the boundaries between segments substantially parallel to the drum axis, said drum encircling at least a portion of said cathode-ray tube and the peripheral surface thereof moving adjacent said luminescent screen whereby light from the screen passes through the color filter segments as the segments traverse the scanning area, and means for rotating said drum at a substantially uniform speed selected to cause said filter segments to traverse the luminescent screen in the low-frequency direction at substantially field-scanning frequency to thereby exhibit successive images in successively different colors.

5. In a color television receiver, in combination, a cathode-ray receiving tube comprising an envelope having a bulbous portion and an elongated neck extending therefrom, an electron gun structure in said elongated neck, and a luminescent image-reproducing screen in said bulbous portion opposite said elongated neck and substantially perpendicular to the axis thereof; means for deflecting an electron beam from said gun to successively reproduce images on said luminescent screen in a plurality of side-by-side lines at field-scanning frequency, a rotatable substantially cylindrical drum having a plurality of color filter segments arranged around the peripheral surface thereof with the boundaries between segments substantially parallel with the drum axis, said cathode-ray tube being positioned with said bulbous portion and neck within said drum and with said luminescent screen adjacent the periphery of the drum so that as the drum rotates the color filter segments successively traverse the luminescent screen and present images thereon successively in different colors, and means for rotating said drum at a uniform speed selected to cause said filter segments to traverse the luminescent screen at substantially field-scanning frequency.

6. Color television apparatus which comprises, in combination, an electronic scanning device comprising an envelope having a two-dimensional scanning area therewithin, means for scanning said scanning area in two dimensions in a plurality of side-by-side lines at field-scanning frequency, a rotatable color filter drum having a plurality of different transparent color filter segments arranged around the peripheral surface thereof and positioned so that said segments successively traverse said scanning area in the low-frequency direction, and means for rotating said drum at a substantially uniform speed selected to cause said filter segments to traverse said scanning area at substantially field-scanning frequency, the effective height of a filter segment at the scanning area being less than the height of the scanning area and the sum of said effective height plus the distance traversed by a filter segment over the scanning area in a field-scanning period being equal to or greater than the height of the scanning area.

7. In a color television receiver, in combination, a cathode-ray receiving tube having a luminescent screen therein and means for successively reproducing two-dimensional images on said screen in a plurality of side-by-side lines at field-scanning frequency, a rotatable substantially cylindrical color filter drum having a plurality of color filter segments arranged around the peripheral surface thereof with boundaries

substantially parallel to the axis, said drum encircling at least a portion of said cathode-ray tube and the peripheral surface thereof moving adjacent said luminescent screen whereby light from the screen passes through the portion of the peripheral surface adjacent the screen, and means for rotating said drum at a substantially uniform speed selected to cause the filter segments to traverse the image area at substantially field-scanning frequency to exhibit reproduced images on said screen successively in dif-

ferent colors, the effective height and speed of traversal of a filter segment at the image area being less than the height of the image area and the speed of traversal thereof by the scanning beam in the low-frequency direction, respectively, and the sum of said effective height plus the distance traversed by a segment in a field-scanning period being equal to or greater than the height of the image area.

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