

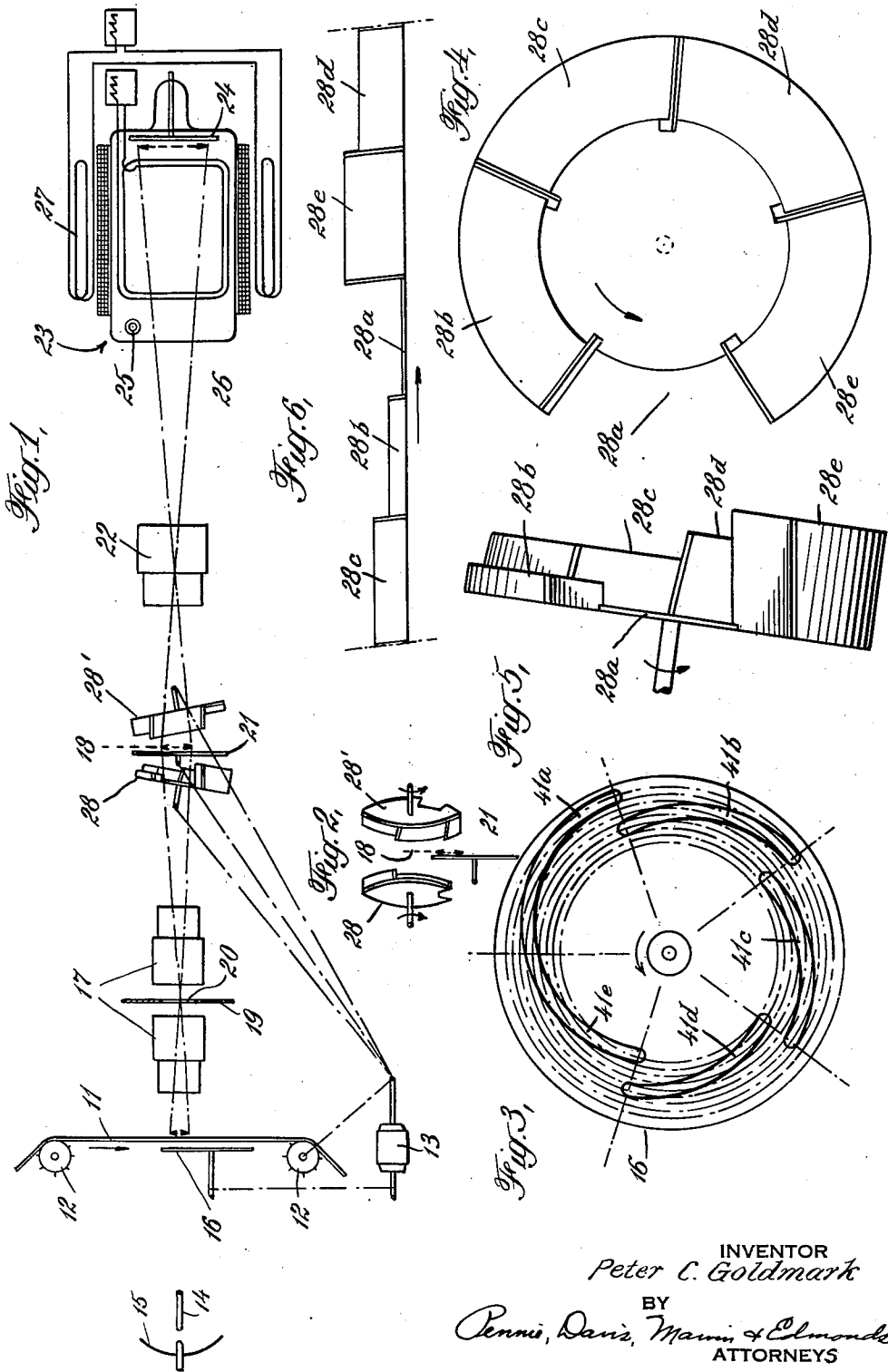
March 9, 1943.

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TELEVISION

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3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 8,

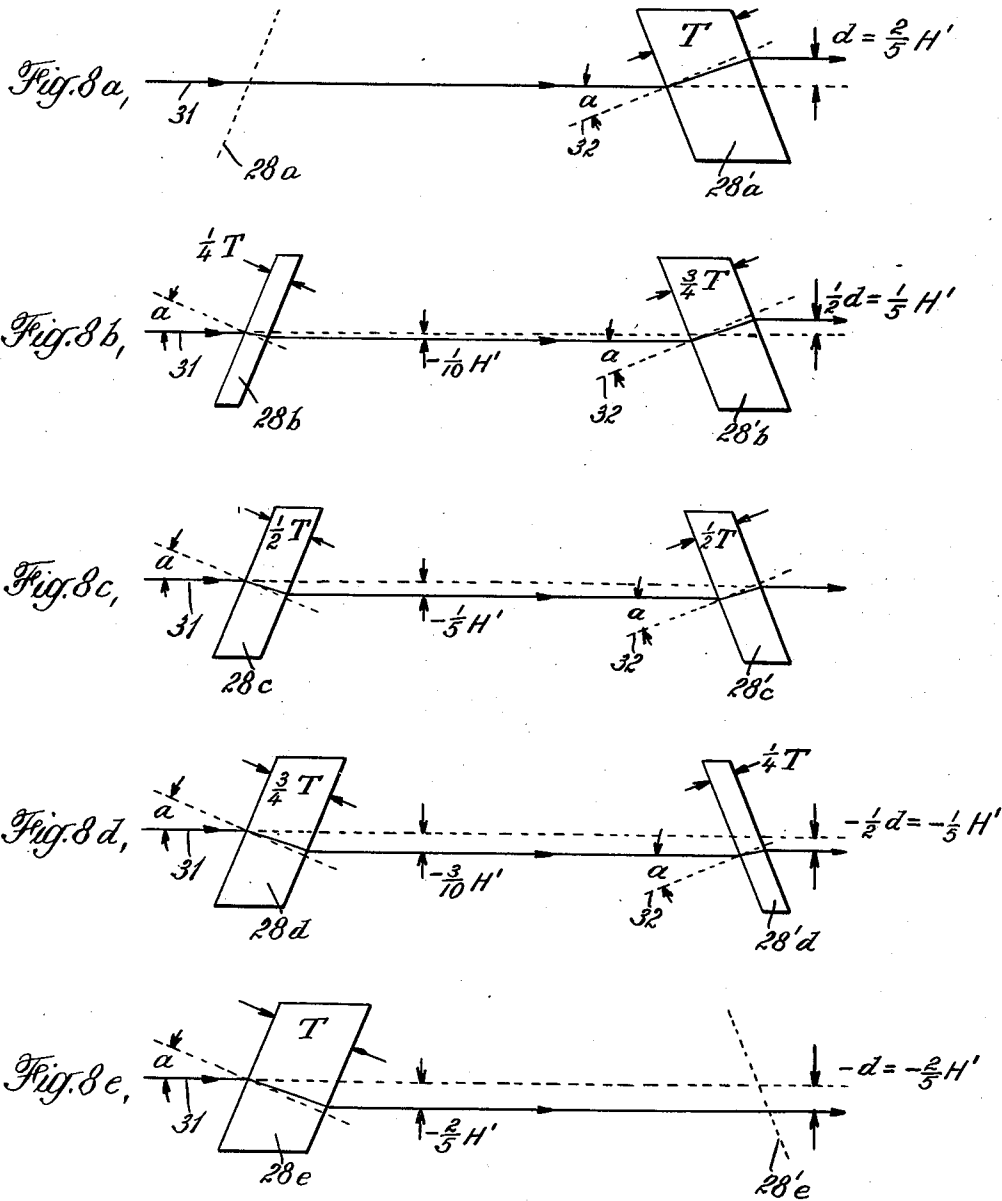
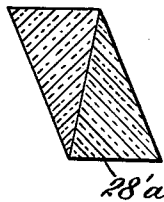


Fig. 9.



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3 Sheets-Sheet 3

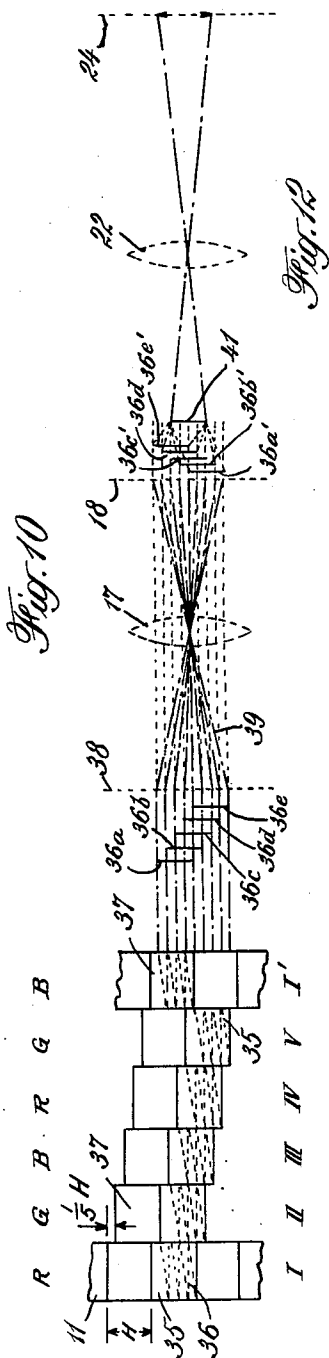


Fig. 12

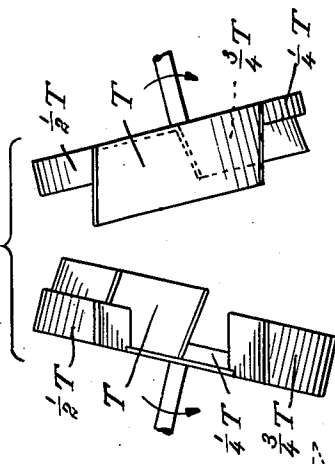


Fig. 11

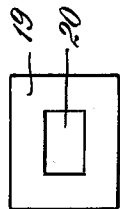
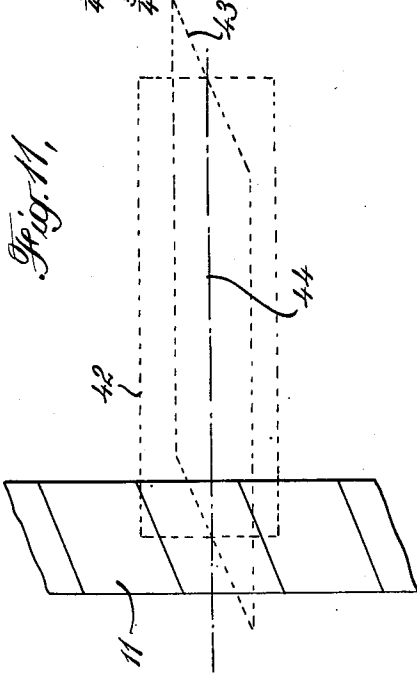


Fig. 7

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TELEVISION

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Application July 26, 1941, Serial No. 404,168

6 Claims. (Cl. 178—5.4)

This invention relates to television scanning apparatus, particularly to film-scanning apparatus used in television transmitters. The invention especially relates to a method and apparatus for scanning film-frame areas of a continuously moving film at a field-scanning frequency different from the film-frame frequency.

At the present time the televising of program material recorded on film is of considerable practical importance. It is contemplated that for some time at least, ordinary sound-motion-picture film will be employed as well as sound motion pictures especially recorded for television purposes. Present television standards for black and white pictures, in the United States, require the transmission of images at the rate of 30 pictures per second, double interlaced. Thus the component field scansions are produced at the rate of 60 fields per second. In motion picture practice, however, sound films are recorded and projected at the rate of 24 pictures per second. To coordinate these two different standards, the present widely adopted practice is to scan successive film frames alternately two and three times at the rate of 60 field scansions per second. In the frames scanned three times, the third scansion is a duplicate of one of the other two. Thus, 24 frames of the film are transmitted in a second but 60 field scansions are employed for doing so, thereby properly coordinating the motion picture and television standards.

Intermittent film scanners have been employed which operate in accordance with this system by moving the film intermittently at the alternate rates of 30 frames per second and 20 frames per second. Also, film scanners operating under this system but employing a continuously moving film have been disclosed in my co-pending application Serial No. 210,607, filed May 28, 1938. As explained in that application, the scanning pattern at the film must be displaced with respect to the path of travel of the film for successive field scansions to compensate for film movement and cause successive field scansions to register with respective film-frame areas. Accordingly, that application discloses inter alia the use of five fixed lenses or five fixed mirrors, or a single mirror intermittently moved to each of five positions to yield the proper scanning.

In other systems heretofore suggested, a plurality of stationary prisms, particularly wedge-shaped prisms, have been employed.

At the present time considerable attention has been directed toward the transmission and reproduction of television images in natural color.

Although direct pick-up devices have been constructed which operate very satisfactorily, it is expected that direct pick-up will be supplemented by transmission from color films, for example, films of the "Kodachrome" or "Technicolor" type in which the images on the film are in natural colors. In one type system found to give satisfactory results the color images are successively scanned in a plurality of different primary colors. With a continuously moving film, this requires a displacement of the scanning pattern with respect to the path of travel of the film to compensate for the movement of the film between successive scansions of the same film frame areas.

The apparatus of application Serial No. 210,607, supra, may be employed in such color systems as well as in black and white systems. However, the present invention provides a different apparatus in which the required displacement of the scanning pattern at the film is produced in a different manner. The specific embodiment described hereinafter is designed for the transmission of film in natural colors. However, it will be understood that the apparatus can be employed in the transmission of black and white pictures, the required modifications being in part pointed out hereinafter and in part obvious to those in the art.

In accordance with the invention, an optical system including a rotatable disk having a plurality of transparent segments spaced therearound is positioned between a continuously moving film and a scanning device so that as the disk rotates the segments are successively interposed in the path of the image rays between the film and the scanning device. The transparent segments have plane parallel faces and are inclined in the longitudinal axial plane of the image rays so that they produce a shift of the image rays in the longitudinal direction. It is contemplated that the faces of the segments will be parallel to the plane of the disk and the disk inclined in the longitudinal axial plane of the image rays, the thicknesses and refractive indices of the segments being correlated with the angle of inclination to produce a plurality of shifts of the image rays. Ordinarily it is contemplated that each segment will remain in operation throughout a field-scanning period and the shift produced by successive segments will be selected to compensate for film movement between successive field scansions. Thus, successive segments cooperate with the remainder of the optical system to render a plurality of spaced fixed areas in the path of travel of

the film successively conjugate with substantially the same area of the scanning device.

It is preferred to employ segments having substantially the same refractive index, and obtain different shifts by making the segments of different thicknesses. However, as will be shown hereinafter, the refractive index also affects the degree of shift so that a combination of different thicknesses and different refractive indices, or the same thicknesses and different refractive indices in a suitable case, may be employed if desired.

While a single image-shifting disk may be employed, in accordance with a preferred embodiment of the invention a pair of disks inclined in opposite directions in the longitudinal axial plane of the image rays are employed. These disks are rotated in substantial synchronism and the combined thicknesses of each cooperating pair of segments is selected to yield substantially equal optical lengths of path for different pairs. In this manner, aberrations due to different lengths of glass and air paths in successive pairs of segments are avoided.

The use of a rotating disk inclined in the longitudinal axial plane of the image rays and having plane parallel segments spaced therearound possesses many advantages. Even though the disk turns through a considerable angle while a given segment is operating, the shift remains substantially constant in magnitude and direction. Only one set of lenses need be employed in conjunction with the disk, so that the same set of lenses functions for all the field scansions. Suitable lenses of desired quality are commonly available. The aperture of the lens system can be made relatively large so that adequate light with a source of relatively small intensity can be obtained. Moreover, successive segments of the rotating member occupy substantially the same position in the optical path during the intervals they are in operation, thereby facilitating the design of a suitably corrected optical system. Also, the use of a separate rotating shutter is unnecessary.

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

In the drawings:

Fig. 1 is a diagrammatic view in a longitudinal (vertical) plane of film-scanning apparatus employing a pair of oppositely inclined image-shifting disks;

Fig. 2 is a detail of the disks in a lateral (horizontal) plane;

Fig. 3 is a face view of the heat-shielding disk 16 of Fig. 1;

Figs. 4 and 5 are face and side views, respectively, of one of the image-shifting disks;

Fig. 6 is a development of one of the image-shifting disks;

Fig. 7 is a face view of the mask 19 of Fig. 1;

Fig. 8 is a diagram illustrating the manner in which different pairs of cooperating segments produce different image shifts;

Fig. 9 is a detail of one of the transparent segments;

Fig. 10 is a diagram illustrating the manner in which the image shifts function to render different fixed areas in the path of travel of the film conjugate to the same area of the scanning device;

Fig. 11 is a diagram illustrating the longitudinal and lateral axial planes; and

Fig. 12 is a view of a pair of disks having segments arranged for film scanning at the rate of 24 film frames and 60 fields per second.

Referring to Fig. 1, a film 11 carried on sprockets 12 is fed longitudinally with continuous uniform motion by motor 13. A source of light, here shown as an arc 14 and mirror 15, is positioned to illuminate the film 11. Between the light source and the film is positioned a heat-shielding disk 16, described more fully hereinafter.

A lens 17 is positioned to render a film in the film-feeding mechanism conjugate to a selected intermediate image plane 18. As here shown, the lens 17 is formed by two common lenses placed back to back, with a mask 19 having an opening 20 therein placed between the two lenses. Since the two component lenses cooperate to form an image on the film 11 at the plane 18, the two component lenses may be considered simply as a "lens."

A second lens 22 is positioned to render the intermediate image plane 18 conjugate to the scanning device 23. This scanning device may be of any suitable type. The embodiment of Fig. 1 employs a non-storage tube known as an "Image dissector" tube. Lens 22 focuses an image at plane 18 onto the photoelectric cathode 24 of the scanning tube. An electron image is thereby emitted from cathode 24 and is caused to sweep across the collecting anode 25 by the horizontal deflecting coil 26, vertical deflecting coil 27, and their associated saw-tooth oscillators. When convenient, the scanning pattern may be considered as formed at the cathode 24.

A rotatable color filter disk 21, driven by motor 13, is positioned in the path of rays to the scanning device. It is advantageously placed near the intermediate image plane 18 but slightly removed therefrom so that any imperfections in the filters will not be sharply focused at the scanning device. If desired, the disk may be placed at any suitable point between the source of light and the scanning device. The disk 21 has a plurality of different colored filter segments which are successively interposed in the path of the light rays.

In the path of the light rays from the film to the scanning device is positioned a pair of rotatable disks 28 and 28'. The disks could be designed to rotate in either direction, but it is preferable to have them rotate so that the dividing lines between segments traverse the image rays in the direction of low frequency scanning, thereby permitting relatively short segments and small disks to be employed. These disks are advantageously placed near the intermediate image plane 18 and on each side thereof as illustrated. In these positions the cross-section of the image rays at each disk is relatively small, thus permitting segments of relatively short circumferential length, and hence a small disk, to be employed without cutting off marginal rays. Also, the boundaries between segments are fairly sharply defined at the intermediate image plane 18, so that as the disk rotates the change from one operating segment to the next takes place quickly as the boundary between them traverses the image area.

Since both disks cannot be placed exactly at the intermediate image plane 18, the longitudinal length of the opening 20 in mask 19 may be selected to cut off marginal rays which would pass through segments adjacent the correct operating segment and impinge on por-

tions of the image as they are being scanned. Of course, if desired, the aperture of the lens 17 can be made small enough and the disks 18 and 18' made large enough so that the mask can be dispensed with. However, the use of a mask with the lateral dimension longer than the longitudinal dimension facilitates the design and also passes more light, since the radial dimensions of the segments can be made sufficient to utilize light from a wider portion of lens 17 than is permitted in the longitudinal direction, while retaining a disk of small size.

As shown more clearly in Figs. 4 and 5, each disk comprises a plurality of transparent segments 28a, 28b, 28c, 28d and 28e, spaced around the disk. The segments are of different thicknesses in accordance with principles hereinafter described. Actually, in the specific embodiment shown, there are four glass segments and one open air segment 28a. As will be explained hereinafter, 28a might also be a segment of glass, and therefore the open air segment may be considered as a transparent segment of zero thickness. For convenience, segment 28a is represented by a double line, but will be understood to be entirely open.

The boundaries between segments are advantageously at an angle with respect to the axis of the disk, as shown in Fig. 5, so that the boundaries are substantially parallel to the axial ray as they traverse the image rays. This causes the boundaries to be more sharply defined at the image plane 18 and results in a quick change from one operating segment to the next as the boundary traverses a given area of the image plane 18.

As shown in Figs. 1 and 2, the disks are positioned so that as they rotate the segments thereof are interposed in the path of the image rays, the boundaries traversing the rays in the longitudinal direction. The disks are driven simultaneously and in phase by suitable means, here shown as motor 13, so that cooperating pairs of segments traverse the image field at the same time. Fig. 6 is a development of one of the disks, and shows the relative thicknesses of the segments.

The disks specifically illustrated contain five segments, in order to obtain the proper sequence of shifting hereinafter described in connection with Fig. 10. However, it will be understood that the number of transparent segments may be selected in view of the film-frame speed, field frequency of scanning, and the particular relationships selected, so as to produce the desired amounts and sequence of shifts.

From Figs. 1 and 2 it will be seen that the two disks are inclined in the longitudinal axial plane of the image rays in opposed directions. The term "longitudinal axial plane" will be understood by reference to Fig. 11, which shows the longitudinal axial plane 42 and a lateral plane 43, shown with respect to the film 11. The axis of the optical system is represented by line 44, and the longitudinal axial plane is a plane extending longitudinally of the film and containing the axis 44. In Fig. 1 the optical elements are arranged in alignment. If desired, the axis of the system may be bent through 90 degrees or in any other desired manner in order to secure a more compact or convenient arrangement. In such case it will be understood that the longitudinal axial plane will also be bent. In any case, the disks are so inclined

as to produce a shift of the image rays in the longitudinal direction.

The principles involved in the shifting of the image by the transparent segments is illustrated in Fig. 8. Fig. 8a illustrates a transparent segment 28a (open) of the left-hand disk of Fig. 1, cooperating with a segment 28'a of the right-hand disk. A ray of light 31 passes through the transparent segment 28a and of course is undeviated. The ray 31 impinges on segment 28'a, however, at an angle α with the normal 32 to the surface. In accordance with well known principles of optics, in passing through the glass plate the ray of light 31 undergoes an upward displacement d given by the following formula:

$$d = T \times \sin \alpha \left(1 - \frac{\cos \alpha}{\sqrt{\mu^2 - \sin^2 \alpha}} \right) \quad (1)$$

As indicated by the formula, the displacement d is a function of the thickness T of the glass plate, the angle of incidence α and the index of refraction μ . For a given μ and a given angle α , however, the displacement is directly proportional to the thickness T . For the scanning system described hereinafter in connection with Fig. 10, these factors are correlated to produce a displacement d equal to $\frac{1}{2}H'$, where H' is the height of a film frame as magnified or reduced by the optical system 17, as will be understood.

Fig. 8b shows the pair of cooperating segments 28b and 28'b. Here, the light ray 31 is displaced downwardly by the segment 28b, since the segment is of opposite inclination to segment 28'a of Fig. 8a. The ray emerges from segment 28b parallel to its initial direction but displaced therefrom. It then impinges on the segment 28'b at the same angle α as before, and is displaced upwardly. For the scanning sequence of Fig. 10 it is desired that the over-all displacement in Fig. 8b be one-half that of Fig. 8a. Furthermore, in order to avoid aberrations it is desirable that the lengths of path in glass be the same in 8b as in 8a. This may be obtained by using a thickness $\frac{1}{4}T$ for segment 28b and $\frac{3}{4}T$ for 28'b. This results in an initial displacement downwardly of $\frac{1}{5}H'$ by the first segment and an upward displacement of $\frac{3}{5}H'$ by the second segment, thereby yielding an over-all displacement of $\frac{1}{5}H'$ in the upward direction. In Fig. 8c the two segments are of the same thickness but of opposite inclination, thus yielding an over-all displacement of zero. In Fig. 8d the initial segment 28d has a thickness $\frac{3}{4}T$ and the second segment 28'd has a thickness $\frac{1}{4}T$. This is the reverse of Fig. 8b and results in a downward displacement of $\frac{1}{5}H'$. In Fig. 8e the thicknesses are the reverse of Fig. 8a, yielding an over-all downward displacement of $\frac{1}{5}H'$.

It will be noted that in each of the figures of Fig. 8 the combined thicknesses of each cooperating pair of segments is equal. However, the relative thicknesses of different cooperating pairs are selected so as to produce different longitudinal shifts of image rays.

Fig. 9 shows a transparent segment 28'a formed of two pieces of glass of slightly different refractive index so as to provide a suitable correction. Segments thus corrected may be employed for all the glass segments, or may be confined to only the thicker ones, as desired.

Referring now to Fig. 10, a scanning sequence is illustrated which is particularly adapted for the scanning of color motion picture film at the

rate of 24 film frames per second and 120 fields per second. Successive fields are scanned in successive primary colors, red, green and blue. It is contemplated that interlaced scanning will be employed. For example, the double-interlaced scanning sequence shown in Fig. 9 of my co-pending application Serial No. 355,840, filed September 7, 1940, may be employed. However, it will be understood that a different number of colors and a different number of interlaces may be employed if desired.

In Fig. 10 a fragment of film 11 is illustrated in the positions which it occupies at the beginnings of successive field-scanning periods I, II, III, IV, V and I'. With a film movement of 24 film frames per second and 120 field scansions per second, 5 field scansions take place during the interval that one film frame moves past a given point. Also, during each field scansion the film moves a distance of $\frac{1}{5}H$. It is preferred to scan the film longitudinally in a direction opposite to the film movement. Hence, the scanning pattern 36 at the film need be only $\frac{1}{5}H$ in height, the movement of the film during the field scanning period supplying the remaining $\frac{1}{5}H$ to scan completely the film-frame area. If desired, however, the apparatus could be designed to scan longitudinally in the direction of movement. As indicated, the scanning pattern consists of lines extending laterally of the film and displaced longitudinally thereof, forming a two-dimensional scanning pattern.

At the end of field scansion V the lower film-frame area 35 has been scanned in 5 field scansions, and at the beginning of the next field-scanning period I' the upper film frame area 37 occupies the same relative position in the film-feeding mechanism that the lower frame occupied at the beginning of the first field scansion I.

The vertical lines 36a, 36b, 36c, 36d, 36e represent the length of the scanning pattern in the longitudinal direction, and the successive displacements thereof by an amount $\frac{1}{5}H$ at the beginnings of successive field scanning periods. These patterns are actually formed in the plane 38, which is the plane of the path of travel of the film. The lines 36a, 36b, 36c, 36d, 36e are shown separated from plane 38 for clearness of illustration. The scanning areas represented by lines 36a, 36b, 36c, 36d, 36e are fixed with respect to the path of travel of the film, and are spaced with respect to each other. It will be understood that the term "spaced" applied to these areas includes the condition where the areas actually overlap, as is the case in Fig. 10.

The scanning areas 36a, 36b, 36c, 36d, 36e are rendered conjugate to the intermediate image plane 18 by lens 17, as explained in connection with Fig. 1. The respective positions at plane 18, prior to shifting, are indicated by the vertical lines 36a', 36b', 36c', 36d' and 36e'. The lines 39 represent rays from the extremities of the respective areas. The image-shifting disks 28, 28' at the intermediate plane 18 shift the image for successive field-scanning periods in the manner described hereinbefore. This causes all the intermediate images of the scanning areas to coincide successively at the area 41, also considered to be in plane 18, but shown displaced therefrom for clearness of illustration. Area 41 is then rendered conjugate to the plane 24 of the scanning device by lens 22.

In the actual embodiment of Fig. 1 the image shifting disks 28, 28' are not exactly at the intermediate image plane 18, but are on either side

thereof. Therefore the image rays are shifted by the segments of disk 28 before they reach the intermediate plane, and are further shifted by the segments of disk 28' after they pass the intermediate plane. However, for ease in understanding the principles of operation, the simplified arrangement of Fig. 10 has been resorted to.

From the foregoing explanation it will be understood that the image-shifting disks function to render a plurality of spaced fixed areas in the path of travel of the film successively conjugate to substantially the same area of a selected image plane 24. A scanning pattern at plane 24, provided by a suitable scanning device, need not be displaced longitudinally even though it is required to register with longitudinally displaced areas in the path of travel in the film. The disks perform this function. However, if desired, the usual slight displacement of the scanning pattern for interlaced scanning may be employed, as described in application Serial No. 210,607 mentioned hereinbefore.

As before mentioned, the heat disk 16 shown in Figs. 1 and 3 is provided to prevent the heat from the projection source from adversely affecting the film 11. With a scanning device of the non-storage type, such as the image dissector shown, it is necessary to illuminate a line of the film only at the time that particular line is being scanned. The heat disk therefore contains slots 41a, 41b, 41c, 41d and 41e, extending through equal central angles, one for each of the scanning areas 36a, 36b, 36c, 36d and 36e. For the specific case illustrated, slots 41a and 41e are continuations of each other. For a different specific embodiment this might not be true. The width of the slots is such as to expose only a fraction of the film frame to light from the projection source at any one time. In the limiting case this might be one line, but to avoid difficulties due to curvature of the slots and the necessity of maintaining very accurate phase relationships, the slots are preferably made wide enough to cover a number of scanning lines at a time.

Slot 41a operates during field scansion I. The beginning of the slot exposes the lower lines of film frame 36 (Fig. 9) and as the heat disk rotates, slot 41a progresses toward the top of the film frame to expose areas as they are scanned. Since the film frame moves downward $\frac{1}{5}H$ during the film scanning period, the end of the slot need be displaced radially only $\frac{1}{5}H$ with respect to the beginning thereof. Successive slots operate in similar manner during successive field scanning periods. The beginning and end of slot 41b is displaced inwardly a radial distance of $\frac{1}{5}H$ with respect to the beginning and end of slot 41a, to compensate for the displacement of the continuously moving film during the first scansion period. Slots 41c, 41d and 41e are displaced inwardly in a similar manner to expose film-frame 36 during respective scansion periods III, IV and V. At the end of period V, slot 41a again comes into operation to expose the succeeding film-frame 37 during field-scansion I' of that film frame, etc.

As before noted, the number of segments of the image displacing disks and the thicknesses thereof may be selected to produce the displacements required by the scanning system employed. Fig. 12 illustrates a pair of disks suitable for use in conjunction with a film scanning apparatus in which film continuously moving at the rate of 24 film frames per second is scanned at the rate of 60 field scansions per second. As shown

in application Serial No. 210,607, supra, such a coordination of standards may be obtained by shifting the scanning pattern at the film through $+\frac{1}{2}H$, 0, $-\frac{1}{2}H$, $+\frac{1}{4}H$ and $-\frac{1}{4}H$. These displacements may be effected by arranging the segments in Fig. 1 in order around the left hand disk with thicknesses 0, $\frac{1}{2}T$, T , $\frac{1}{4}T$ and $\frac{3}{4}T$; and cooperating segments on the right hand disk with thicknesses T , $\frac{1}{2}T$, 0, $\frac{3}{4}T$ and $\frac{1}{4}T$, where a thickness T is selected to yield a displacement of $\frac{1}{2}H$.

For any other scanning system, the thicknesses and order may be suitably chosen to yield the desired displacements.

It will be understood that in the specific embodiments described herein the image of the film at the scanning device is continuously moving, since the lenses 17 and 22 are fixed with respect to the scanning device. However, the shifts produced by the disks cause longitudinally corresponding parts of the same and successive film-frame areas to be conjugate to the same area of the scanning device at corresponding instants in their respective longitudinal scanning periods.

In the specific embodiment described herein the film images are projected to the scanning device, which is the preferred arrangement, but it will be understood that a luminous scanning pattern could be formed by the scanning device, for example, on the screen of a cathode-ray tube, and the rays passed through the disks to the film and then to a photoelectric cell. The disks would still be between the film and scanning device, and the latter would be conjugate to each other.

The use of an intermediate image plane 18 (Fig. 1) is advantageous since if the size of the film frames change slightly due to shrinkage, etc., thereby rendering the displacements produced by the several pairs of segments of the disks slightly inexact, lenses 17 may be adjusted to change the magnification between film and plane 18 so as to restore the images at plane 18 to the size for which the disks were designed. If desired, however, the intermediate image plane could be dispensed with, with more or less success.

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 in the art without departing from the spirit and scope of the invention.

I claim:

1. In television, apparatus for scanning an object field which comprises an optical system for focusing an image of said object field at a selected plane, a pair of rotatable disks each having a plurality of transparent segments spaced therearound, said disks being positioned near said selected plane and mounted so that as the disks rotate cooperating pairs of segments are successively interposed in the path of the image rays, said plurality of segments having plane parallel faces substantially parallel to the planes of rotation of the respective disks and the planes of rotation being inclined in opposed directions so that segments of respective disks displace the image rays in opposite low-frequency directions, a scanning device positioned to receive the image rays after said displacing and adapted to scan the image in two dimensions at field-scanning frequency, means for rotating the disks in substantial synchronism with the

field scanning at a speed such that each cooperating pair of segments operates substantially throughout at least one field-scanning period, the combined effective thicknesses of each cooperating pair of segments being selected to yield substantially equal optical lengths of path and the relative thicknesses of different cooperating pairs being different so as to produce a plurality of different shifts of the image rays in the low-frequency direction.

2. Television film-scanning apparatus which comprises a film-feeding mechanism for feeding a film longitudinally with continuous uniform motion, an optical system for rendering a plurality of spaced substantially fixed areas in the path of travel of the film successively conjugate to substantially the same area of a selected image surface, said optical system including a pair of rotatable disks each having a plurality of transparent segments spaced therearound, said disks being positioned between said film and said image surface so that as the disks rotate the segments thereof are successively interposed in the path of the image rays, said plurality of segments having plane parallel faces substantially parallel to the planes of rotation of the respective disks and said planes of rotation being inclined in the longitudinal axial plane of the image rays in opposed directions so that segments of respective disks displace the image rays in respectively opposite longitudinal directions, means for rotating the disks in substantial synchronism, the combined thicknesses of each cooperating pair of segments being selected to yield substantially equal optical lengths of path and the relative thicknesses and refractive indices being correlated with the angles of inclination so that different cooperating pairs produce different longitudinal shifts of the image rays, and a scanning device positioned and adapted to provide a scanning pattern at said selected image surface.

3. Television film-scanning apparatus which comprises a film-feeding mechanism for feeding a film longitudinally with continuous uniform motion, a lens positioned to render an area of said film conjugate to a selected intermediate image plane, a scanning device, a second lens positioned to render said intermediate image plane conjugate to said scanning device, a pair of rotatable disks each having a plurality of transparent segments spaced therearound, one of said disks being positioned on each side of said intermediate image plane and mounted so that as the disks rotate said segments are successively interposed in the path of the image rays, said plurality of segments having plane parallel faces substantially parallel to the planes of rotation of the respective disks and said planes of rotation being inclined in the longitudinal axial plane of the image rays in opposed directions so that segments of respective disks displace the image rays in respectively opposite longitudinal directions, means for rotating the disks in substantial synchronism, the combined thicknesses of each cooperating pair of segments being substantially equal and the relative thicknesses of different cooperating pairs being different so as to produce different longitudinal shifts of the image rays, whereby a plurality of longitudinally displaced substantially fixed areas in the path of travel of the film are rendered successively conjugate to substantially the same area of the scanning device.

4. Television film-scanning apparatus for

scanning film-frame areas at a field frequency different from the film-frame frequency which comprises a film-feeding mechanism for feeding a film longitudinally with continuous uniform motion and selected film-frame frequency, a lens positioned to render an area of said film conjugate to a selected intermediate image plane, a scanning device for scanning areas of said film in two dimensions at a field-scanning frequency substantially different from said film-frame frequency, a second lens positioned to render said intermediate image plane conjugate to said scanning device, a pair or rotatable disks each having a plurality of transparent segments of different thicknesses spaced therearound with plane parallel faces substantially parallel to the planes of rotation of the respective disks, one of said disks being positioned on each side of said intermediate image plane and mounted so that as the disks rotate said segments are successively interposed in the path of the image rays, said planes of rotation being inclined in the longitudinal axial plane of the image rays in opposed directions so that segments of respective disks displace the image rays in respectively opposite longitudinal directions, means for rotating the disks in substantial synchronism at a speed such that cooperating segments traverse the image rays at substantially field-scanning frequency, the combined thicknesses of each cooperating pair of segments being substantially equal to yield substantially equal optical lengths of path and the relative thicknesses being correlated with the refractive indices and angles of inclination to longitudinally shift the image rays by amounts sufficient to compensate for film movement and cause longitudinally corresponding parts of the film-frame areas to be conjugate to substantially the same area of the scanning device at corresponding instants in their respective longitudinal scanning periods.

5. In a color television system, apparatus for scanning an object field which comprises an optical system for focusing an image of said object field at a selected intermediate image plane, a pair of rotatable disks each having a plurality of transparent segments spaced therearound, said disks being positioned one on each side of and near said intermediate image plane, and mounted so that as the disks rotate cooperating pairs of segments are successively interposed in the path of the image rays, said plurality of seg-

ments having plane parallel faces substantially parallel to the planes of rotation of the respective disks, said planes of rotation being inclined in opposed directions so that segments of respective disks displace the image rays in opposite low-frequency directions, a rotatable color-filter disk disposed between said pair of rotatable disks and adjacent said intermediate image plane, a scanning device positioned to receive the color-filtered image rays after said displacing and adapted to scan the image in two dimensions at field-scanning frequency, means for rotating the paired disks in substantial synchronism with the field scanning at a speed such that each cooperating pair of segments operates substantially throughout at least one field-scanning period, the relative thicknesses of different cooperating pairs being different so as to produce a plurality of different shifts of the image rays in the low-frequency direction.

6. In a television system, apparatus for scanning an object field which comprises an optical system for focusing an image of said object field at a selected intermediate image plane, a pair of rotatable disks each having a plurality of transparent segments spaced therearound, said disks being positioned one on each side of and near said intermediate image plane, and mounted so that as the disks rotate cooperating pairs of segments are successively interposed in the path of the image rays, said plurality of segments having plane parallel faces substantially parallel to the planes of rotation of the respective disks, said planes of rotation being inclined in opposed directions so that segments of the respective disks displace the image rays in opposite low-frequency directions, a scanning device positioned to receive the image rays after said displacing and adapted to scan the image in two dimensions at field-scanning frequency, means for rotating the disks in substantial synchronism with the field scanning at a speed such that each cooperating pair of segments operates substantially throughout at least one field-scanning period, the combined effective thicknesses of each cooperating pair of segments being selected to yield substantially equal optical lengths of path, and the relative thicknesses of different cooperating pairs being different so as to produce a plurality of different shifts of the image rays in the low-frequency direction.

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