

[54] **SHUTTERING APPARATUS FOR TELEVISION CAMERAS**

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[58] Field of Search 178/7.2, 7.7, 5.4, 5.4 CF,
178/DIG. 29, DIG. 33, DIG. 20, DIG. 21;
350/205, 206, 266, 274

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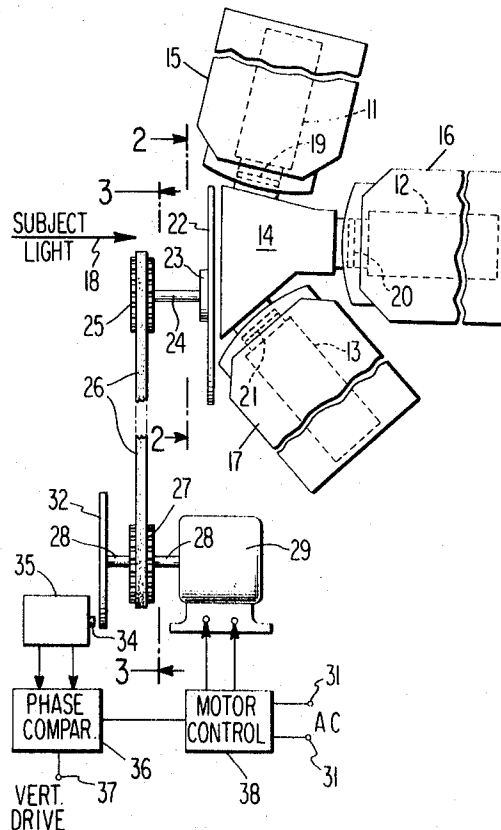
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Primary Examiner—Richard Murray
Attorney—Eugene M. Whitacre

[57] **ABSTRACT**

The apparatus is a generally opaque disc mounted in the camera tube light path for rotation about an axis vertically displaced from the light path and having two like, diametrically opposed and generally arcuate apertures with such configurations that different horizontal areas of the photosensitive target electrode of the tube are successively and equally exposed to light from a subject during each scanning field.

10 Claims, 14 Drawing Figures



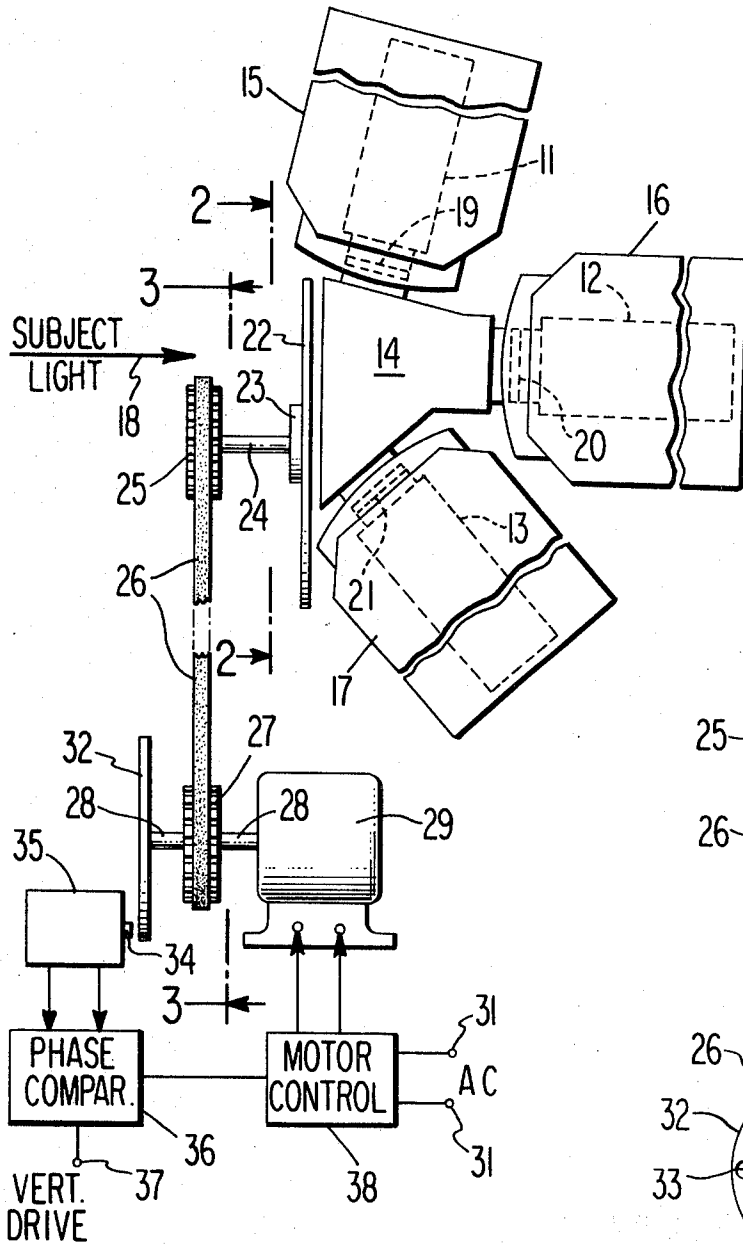


Fig. 1.

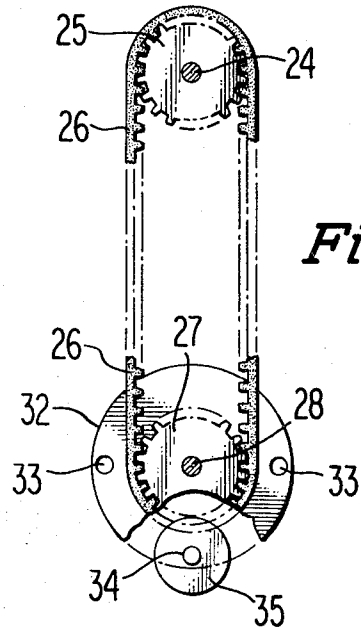


Fig. 3.

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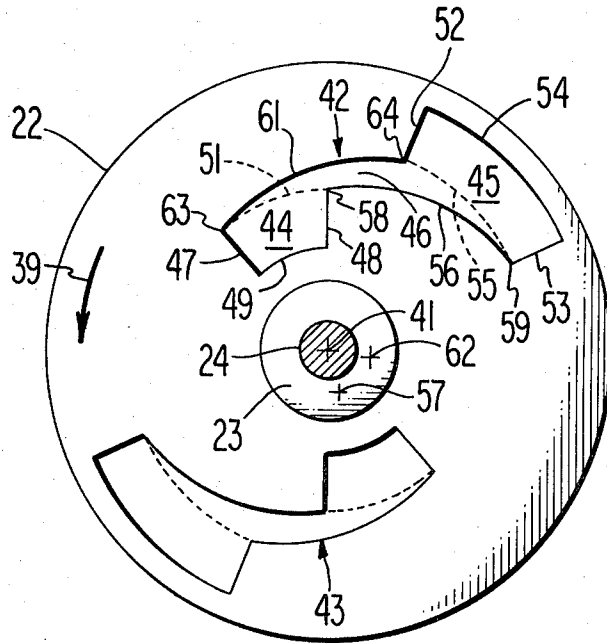


Fig. 2.

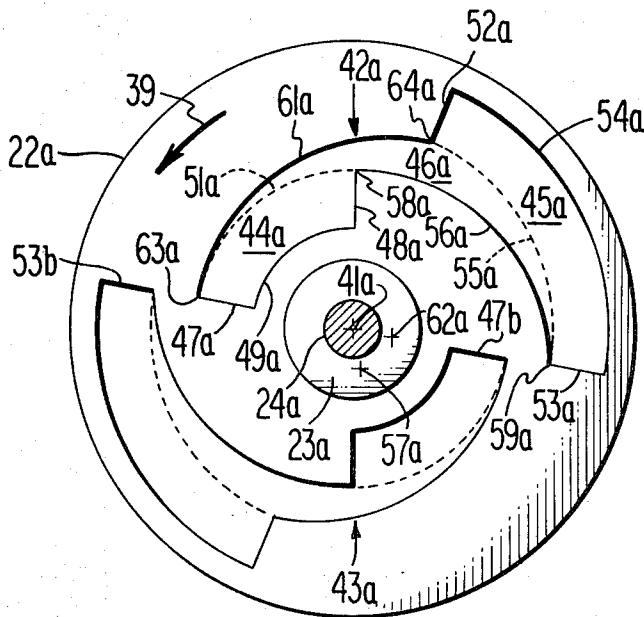
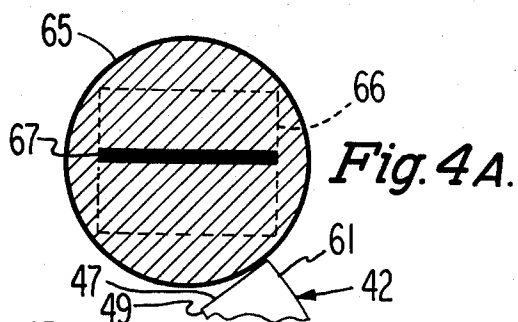
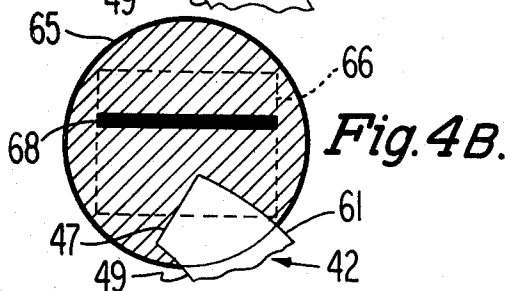
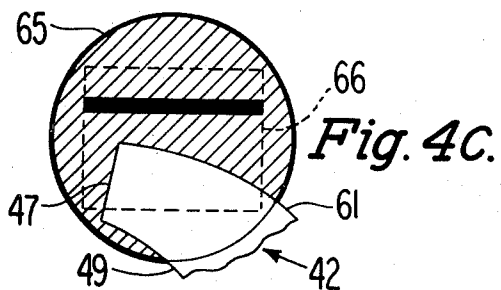
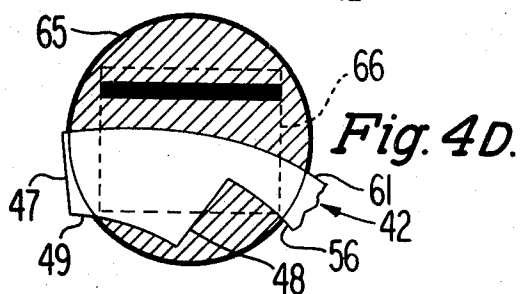
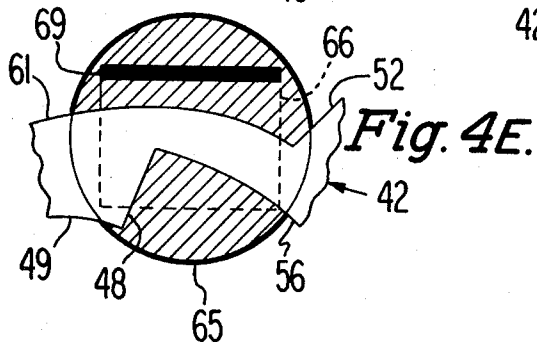
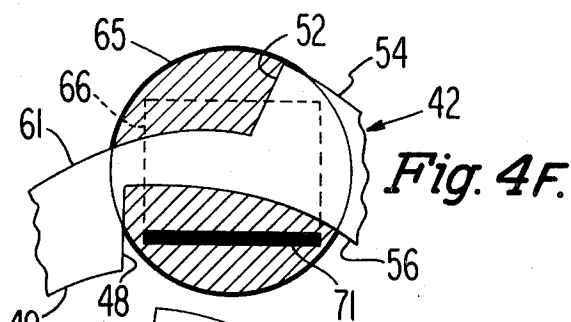
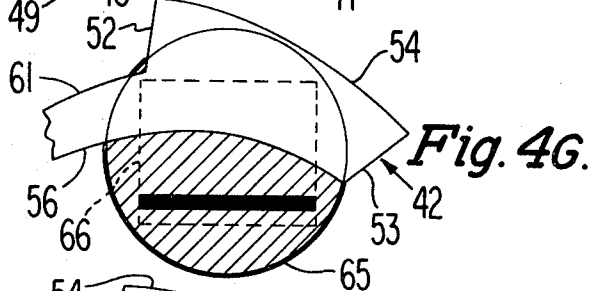
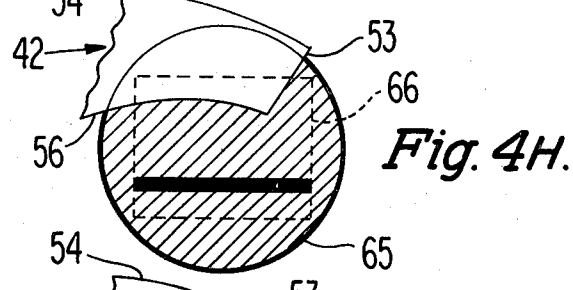
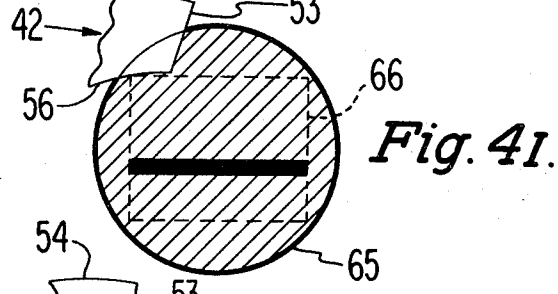
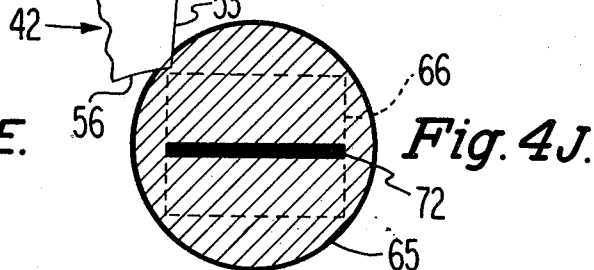


Fig. 5.

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SHUTTERING APPARATUS FOR TELEVISION CAMERAS

BACKGROUND OF THE INVENTION

Most black and white and color television cameras presently in use have storage type pickup tubes. The photosensitive target electrodes of such tubes are continuously exposed to light from a subject and scanned for a period of approximately one-thirtieth second for each complete frame of the picture occurring in two 1/60 second line-interlaced scanning fields. Any significant movement of the subject that occurs during the scanning periods causes the charge image, representative of the subject that is accumulating on the target electrode, to be blurred along the line of such movement. When the target electrode is scanned by an electron beam the video signals will represent the blurred charge image, and the resultant picture that is reproduced from such signals will be correspondingly blurred.

It has been proposed to place a shutter in the light path between the subject and the camera tube with an opening (or openings) to expose each of successive horizontal areas of the target electrode for a relatively small percentage of each scanning field period. It has been found that any significant motion in the subject is unlikely to occur in such a short time. The successive areas of the target electrode are scanned by an electron beam after their exposure to develop video signals representative of the charge image of the subject stored by the target electrode.

In systems in which line-interlaced scanning is effected by an electron beam which unavoidably partially scans line areas of the target electrode adjacent to the intended line it has been found that such a shuttering arrangement produces some discontinuity (i.e., multiple images) in the picture reproduced from the resulting video signals. The picture portions reproduced from the video signals that are developed from that part of the target electrode which is scanned in the interval between the beginning and end of the exposure period have the greatest discontinuity. It has been found, however, that by reducing the target electrode exposure to a relatively low percentage of the total field period (e.g., 25 percent) and by optimizing the exposure time to occur symmetrically around the vertical blanking interval the subjective effects of such multiple image production are substantially minimized. Of the 25 percent of the field scanning period centered about the vertical blanking time approximately 10 percent is taken by the blanking interval so that only the remaining 15 percent occurs during the active scanning time, and that is about equally divided at the beginning and end of that time. Thus, any multiple image discontinuity that is produced in the picture occurs at the top and bottom thereof where it is least objectionable.

In such proposed systems, the apertured shutter was located at a non-focal point of the optical apparatus and was rotated about an axis horizontally displaced from the optical axis so that apertures with radial sides traversed the light path in substantially horizontal portions thereof. Such a shutter was mounted on the outside of the television camera where the light path from the subject to the pickup tube is of appreciable dimensions. Hence, the shutter had to be of an inconveniently large size. While it would appear that a shutter of

similar design but of considerably smaller size could be similarly mounted inside of a camera where the light path is of reduced dimensions, it was found that the necessary physical arrangement of the internal apparatus of some cameras, particularly color cameras presently in widespread use, makes such mounting impossible.

SUMMARY OF THE INVENTION

The shuttering apparatus in accordance with the present invention comprises a generally opaque disc that is mounted for rotation in the light path from a subject about an axis displaced vertically from the subject representative light path. The disc has at least one transparent aperture divided into a plurality of generally arcuate sections located respectively at different radial distances from the rotation axis. In a particular aperture configuration having three sections an intermediate section is contiguous on one side to an inner leading section and on the other side to an outer trailing section. The aperture configuration is such that three different substantially one-third horizontal areas of the camera tube electrodes are exposed progressively between the top and bottom portions thereof about equally to light from the subject. The disc rotation rate and phase relative to the vertical (i.e., field) blanking interval are such that the electrodes are traversed by the aperture ahead of its scansion.

In a presently preferred embodiment of the shuttering apparatus the disc is provided with two diametrically opposed apertures of identical configurations so that the disc needs to make only one revolution for each picture frame (i.e., two fields). Also, in this preferred embodiment the disc apertures have such generally circumferential dimensions as to expose each of the one-third horizontal areas of the target electrodes for about 25 percent of the time of a field scanning period. In cases where less rapid movements in the subject are expected the circumferential dimensions of the disc apertures may be lengthened so that the electrodes are exposed for about 45 percent of a scanning field period.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more specific disclosure of the invention reference may be had to the following description of a number of illustrative embodiments thereof which is given in conjunction with the accompanying drawings, of which:

FIG. 1 is a side view of that portion of the inside of a color television camera with which the shuttering apparatus of the invention is associated and shows the mechanism by which the apparatus is operated;

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1 and shows the configuration of the apertures of one form of shutter disc in accordance with the invention;

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 1 and shows the shutter disc driving and phasing apparatus;

FIGS. 4A through 4J illustrate different stages of the exposure and scansion of the camera tube target electrode by means of apparatus in accordance with the invention; and

FIG. 5 shows the configuration of the apertures of another form of shutter disc according to the invention.

DESCRIPTION OF THE INVENTION

In FIG. 1 the camera includes red, green and blue pickup tubes 11, 12 and 13 respectively mounted in a generally vertical array and grouped around a component color selective light splitter 14. The respective tubes 11, 12 and 13 are enclosed in housings 15, 16 and 17 in which also are mounted auxiliary apparatus such as deflection yokes, focusing coils and the like (not shown) for the operation of the tubes. As is commonly known in the color television camera art the light splitter 14 has the peculiar shape illustrated in order to perform its function in the most efficient manner. Because of such a configuration it is necessary to locate the red camera tube 11 in such a way that its housing 15 extends forward of the front plane of the light splitter. The significance of this will be apparent presently.

Light from a subject enters the camera along a path indicated by the arrow 18 and, after separation into the component colors of the subject by the light splitter 14, is projected onto the appropriate photosensitive target electrodes 19, 20 and 21 of the respective camera tubes 11, 12 and 13. A shutter disc 22 in accordance with the invention is interposed in the light path 18 immediately in front of the light splitter at which point the focusing of subject representative light is such that the shadow of the shutter appears in the optical images formed on the camera tube electrodes. It can be seen that it is not possible to locate a simple shutter of the prior art type for rotation about an axis displaced horizontally from the subject light path 18 because of the projection of the red tube housing 15 forwardly of the front plane of the light splitter 14. Hence, the shutter 22 is attached by its hub 23 to a shaft 24 extending parallel to, and vertically displaced from, the light path 18 on the under side thereof removed from the red tube housing 15.

The shutter 22 is rotated by means of a toothed pulley 25 that is attached to the shaft 24 and is engaged by a toothed belt 26. The belt also engages a toothed driver pulley 27 (see also FIG. 3) that is affixed to a shaft 28 of a motor 29. The motor is energized from a source of alternating current (AC) at terminals 31. The speed of the motor 29 is accurately controlled so that the shutter 22 exposes the target electrodes 19, 20, and 21 of the camera tubes 11, 12 and 13 respectively once per scanning field. Also, the desired phasing of the shutter 22 is achieved by the speed control of the motor 29.

Both speed and phase control of the shutter 22 are effected by means including a motor control disc 32 attached to the motor shaft 28. In the embodiment of the invention illustrated in FIG. 1 the motor control disc has two diametrically opposite apertures 33 that pass adjacent the pole piece 34 of an electromagnetic pulse generator 35 (see also FIG. 31). The pulses generated by the movement of the apertures 33 past the generator pole piece 34 are impressed upon a phase comparator 36 in which they are compared in phase with a series of vertical drive pulses supplied at a terminal 37. The vertical drive pulses control the vertical deflection of the electron scanning beams of the camera tubes 11, 12 and 13. Hence, they accurately represent the scanning field repetition rate and the timing of the vertical blanking interval. The signals resulting from this comparison are impressed upon motor control apparatus 38 to regulate the speed of the motor 29

suitably to effect proper exposure of the camera tube target electrodes 19, 20 and 21 by the shutter 22. The desired phasing of the electrode exposure in relation to vertical electrode scansion is achieved initially by suitable angular placement of the motor control disc 32 on the motor shaft 28 in relation to the angular placement of the shutter 22 on the shaft 24. Such relationship is accurately maintained by means of the toothed pulleys 25 and 27 and the toothed belt 26.

FIG. 2 illustrates a presently preferred form of the shutter 22 that rotates in the direction of the arrow 39 about an axis 41. The shutter has two generally arcuate apertures 42 and 43 that are disposed on diametrically opposite sides of the axis 41. Because the apertures are identical to one another the details of only one will be described. The aperture 42 has a radially leading inner section 44, a radially outer trailing section 45 and an intermediate section 46 that is contiguous to both leading and trailing sections.

The leading section 44 is bounded, on its ends, by straight front and rear aperture edges 47 and 48 that extend radially from the rotation axis 41 at an angle of substantially 45° to one another. The section 44 is bounded, on its inner side, by an arcuate aperture edge 49 centered at the rotation axis 41 and, on its outer side, by an imaginary arcuate edge represented by a broken line 51 also centered at the rotation axis 41.

The trailing section 45 is bounded, on its ends, by straight front and rear aperture edges 52 and 53 extending radially from the rotation axis 41 at an angle of substantially 45° to one another. The section 45 is bounded, on its outer side, by an arcuate aperture edge 54 centered at the rotation axis 41 and, on its inner side, by an imaginary arcuate edge represented by a broken line 55 also centered at the rotation axis 41.

The intermediate section 46 is bounded, on its inner side, by the imaginary arcuate edge 51 and an arcuate aperture edge 56 centered at an off-axis point 57 and extending from the radially outer end 58 of the rear edge 48 of the leading aperture section 44 to the radially inner end 59 of the rear edge 53 of the trailing section 45. On its outer side the intermediate section 46 is bounded by the imaginary arcuate edge 55 and an arcuate aperture edge 61 centered at an off-axis point 62 and extending from the radially outer end 63 of the front edge 47 of the leading section 44 to the radially inner end 64 of the front edge 52 of the trailing section 45.

The centers 57 and 62 of the eccentric arcuate aperture edges 56 and 61 are such that any point on one arcuate edge has the same angular spacing about the rotation axis 41 from a corresponding point on the other arcuate edge as the angular separation of the front and rear straight edges 47-48 and 52-53 of the leading and trailing aperture sections 44 and 45 respectively. For example, the extreme leading ends 58 and 63 respectively of the eccentric arcuate edges 56 and 61 are mutually spaced by substantially 45° the same as the straight sides 47 and 48 that they join at these ends. Similarly, the extreme trailing ends 59 and 64 of the respective eccentric arcuate edges 56 and 61 have the same 45° angular spacing about the rotation axis 41 as the straight edges 53 and 52 that they join. The same is true of all other intermediate corresponding points of the eccentric arcuate edges 56 and 61.

FIGS. 4A through 4J illustrate the manner in which the camera tube target electrodes 19, 20 and 21 of FIG. 1 are completely exposed in successive substantially horizontal portions to subject representative light by one-half a revolution of the shutter 22 of FIG. 2. The following description relates to the operation of shuttering apparatus of the invention in a television system in which each frame of the picture is produced by scanning the camera tubes in two line-interlaced fields of one-sixtieth second each. Thus, the time between each stage of FIG. 4 is one six-hundredth second in which the shutter rotates approximately 18°. Also, because the optical image of the subject appears inverted on the camera tube electrodes, these electrodes are scanned from bottom to top to develop video signals representing the subject from top to bottom. In these figures the shaded areas represent the portions of the light beam 65 that are occluded from the target electrodes.

In stage 1 of FIG. 4A the shutter aperture 42 is about to enter the light beam 65 while a substantially rectangular raster 66 is being scanned in the area 67. FIG. 4B represents the conditions one six-hundredth second later in stage 2 when the aperture 42 is just starting to expose the lower parts of the target electrodes to the light beam 65 and target electrode scansion has proceeded upward to the raster area 68. As the shutter continues to rotate the aperture 42 exposes successively higher areas of the target electrodes to subject representative light until, three six-hundredths second after stage 2 of FIG. 4B, the aperture is in the position of stage 5 of FIG. 4E. At this stage the scansion of the target electrodes ends at the top area 69 of the raster 66 after which the vertical blanking interval of approximately one six-hundredth second begins.

After the end of the vertical blanking interval stage 6 of FIG. 4F is reached and, while the middle areas of the target electrodes are being exposed to the subject representative light beam 65 by the aperture 42, scansion of the target electrodes in the next field begins at the bottom area 71 of the raster 66. The exposure of the target electrodes by the aperture 42 and their scansion continues as described until, four six-hundredths second after stage 6 of FIG. 4F and nine six-hundredths second after stage 1 of FIG. 4A, stage 10 of FIG. 4J is reached. At this stage the light beam 65 again is occluded from the target electrodes and the raster 66 is being scanned approximately at the middle area 72. Stage 11 (not shown) of the operation occurs one six-hundredth second after stage 10 of FIG. 4J and is the same as stage 1 of FIG. 4A except that it is the aperture 43 that is about to begin exposure of the camera tube target electrodes to the light beam 65. The camera tube target electrode exposure and scansion continues as described with the scansion always being done in the areas shadowed by the shutter 22.

Pictures of materially improved resolution have been reproduced from video signals representing rapidly moving subjects and developed by use of the disclosed shuttering apparatus including the disc 22 of FIG. 2. As described, such apparatus effects the exposure of a camera tube target electrode to subject representative light for about 25 percent of the total field scanning time. The principle of this invention can be applied to shutter discs providing longer or shorter exposure

times. Practically, though, it should not be necessary to further shorten the exposure time because a 25 percent exposure time has been found to be quite satisfactory for most subjects. In order to utilize the available light in the most efficient manner it may be desirable, however, to lengthen the exposure time.

In FIG. 5 there is disclosed a shutter disc embodying the invention and designed to provide an exposure of 45 percent of the field scanning time. All parts of the disc 22a of this figure correspond (except for angles) to similar parts of the disc 22 of FIG. 2. Accordingly, they are identified by the same reference characters, followed by *a*, as those used to identify the parts of the FIG. 2 disc. In order to avoid needless repetition in the following description only those differences in the disc 22a from the disc 22 will be pointed out. The angular separation of the front edge 47a of the leading section 44a from the rear edge 53a of the trailing section 45a is increased to 180°. Thus, all of the arcuate edges 49a, 51a, 54a, 55a, 56a and 61a have increased lengths. The off-axis centers 57a and 62a of the eccentric arcuate edges 56a and 61a are slightly different from the corresponding centers of the FIG. 2 and disc 22.

In operation the shutter disc 22a of FIG. 5 performs substantially in the same manner as the disc 22 of FIG. 2. It differs only in starting the target electrode exposure at an earlier stage and ending it at a later stage. For example, about the time that the rear edge 53a of the trailing section 45a of the aperture 42a reaches a stage similar to that shown in FIG. 4G the front edge 47b of the leading section of the aperture 43a reaches a stage similar to that shown in FIG. 4A. Also, about the time that the rear edge 53b of the trailing section of the aperture 43a reaches a stage similar to that shown in FIG. 4J the front edge 47a of the leading section of the aperture 42a reaches a stage similar to that shown in FIG. 4D. The result of this is that the subject representative light beam is never completely occluded from the camera tube target electrodes as in stages 1 and 10 respectively of FIGS. 4A and 4J. While the improvement in the resolution of reproductions of moving parts of a subject made from video signals developed by using the shutter 22a of FIG. 5 is not as great as that produced by the shutter 22 of FIG. 2 it, nevertheless, is acceptable, particularly where the movement of such subject parts is not extremely rapid.

It is to be understood that a shutter in accordance with this invention is not necessarily limited to any particular number of apertures of the character specified herein. Although it is desirable, for dynamic balancing purposes, that they be provided in pairs it is within the purview of the invention that the disc have any odd number of apertures such as one, for example. Hence, while specific angles have been given in the description of a two-aperture disc, it is to be understood that they are merely examples. In general the angular separation of the aperture edges 48 and 52 of FIG. 2 and the corresponding edges of FIG. 5 are functions of the angular rotation of the disc 22 in the time of one blanking interval. Similarly, the angular separation of the aperture edges 47 and 53 of FIG. 2 and the corresponding edges of FIG. 5 are functions of the angular rotation of the disc in the time of a scanning interval.

The shuttering apparatus of the invention is useful in all applications of both black and white and color

television cameras. It is particularly useful in those cameras employed in applications, such as sporting events for example, in which video recorders are employed for "stop action" and "slow motion instant replay" effects. The apparatus is of such a nature that not only can it be incorporated in television cameras during manufacture but it can also be fitted into cameras already in use.

What is claimed is:

1. In a television camera having a pickup tube with a photosensitive target electrode receiving light from a subject and productive of subject representative video signals during successive field periods respectively comprising alternating target electrode scanning intervals and blanking intervals, light shuttering apparatus for increasing the resolution of video signals representing moving parts of said subject, said apparatus comprising:

a generally opaque disc mounted in the light path between said subject and said electrode and rotatable about an axis displaced vertically from said light path,

said disc having at least one transparent aperture divided into a plurality of generally arcuate sections having such respective configurations that different horizontal areas of said electrode are exposed equally to light from said subject progressively between the top and bottom thereof; and means for rotating said disc about said axis so that the exposure of each area of said electrode by said aperture is effected ahead of scansion.

2. Shuttering apparatus as defined in claim 1, wherein:

said aperture has a radially inner leading section, a radially outer trailing section and a radially intermediate section, said respective sections providing substantially equal light exposures of said different electrode areas.

3. Shuttering apparatus as defined in claim 2, wherein:

said leading and trailing sections of said aperture are partially bounded by respective front and rear radially extending edges having the same separation angularly about said rotation axis, and the rear edge of said leading section being spaced angularly about said rotation axis from the front edge of said trailing section.

4. Shuttering apparatus as defined in claim 3, wherein:

said leading section is further bounded by spaced relatively short radius inner and outer arcuate edges concentric about said rotation axis, and said trailing section is further bounded by spaced relatively long radius inner and outer arcuate edges concentric about said rotation axis.

5. Shuttering apparatus as defined in claim 4,

wherein:

said intermediate aperture section is bounded, on its inner side, by said outer concentric leading section arcuate edge and a first eccentric arcuate edge extending between the rear edges of said leading and trailing aperture sections, and on its outer edge, by said inner concentric trailing section arcuate edge and a second eccentric arcuate edge extending between the front edges of said leading and trailing aperture sections, said eccentric arcuate edges being respectively centered such that any point on said first eccentric arcuate edge has the same angular spacing about said rotation axis from a corresponding point on said second eccentric arcuate edge as the angular separation about said rotation axis of the front and rear edges of said leading and trailing aperture sections.

6. Shuttering apparatus as defined in claim 5, wherein:

the angular separation about said rotation axis between the rear edge of said leading aperture section and the front edge of said trailing aperture section is a function of the angular rotation of said disc in the time of one of said blanking intervals.

7. Shuttering apparatus as defined in claim 6, wherein:

the angular separation about said rotation axis between the front edge of said leading aperture section and the rear edge of said trailing aperture section is a function of the angular rotation of said disc in the time of one of said scanning intervals.

8. Shuttering apparatus as defined in claim 7, wherein:

said disc has a second transport aperture like said one aperture with the respective sections thereof disposed substantially diametrically opposite to corresponding sections of said one aperture.

9. Shuttering apparatus as defined in claim 8, wherein:

the angular separation about said rotation axis of the front edge of the leading section of a first one of said two apertures from the rear edge of the trailing section of the second one of said two apertures is such that the exposure time of said target electrode is approximately 25 percent of each of said field periods.

10. Shuttering apparatus as defined in claim 8, wherein:

the angular separation about said rotation axis of the front edge of the leading section of a first one of said two apertures from the rear edge of the trailing section of the second one of said two apertures is such that the exposure time of said target electrode is approximately 45 percent of each of said field periods.

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