

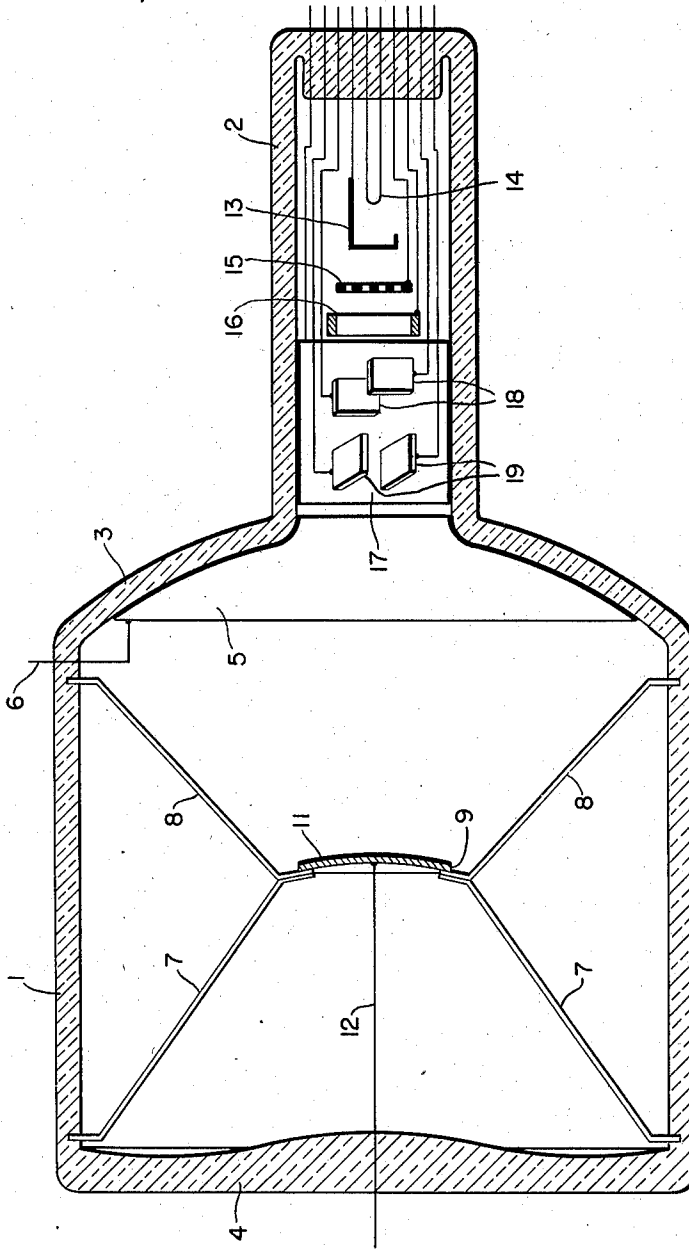
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IMAGE ANALYZING TUBE

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IMAGE ANALYZING TUBE

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This invention relates generally to electro-optical apparatus and more particularly to electronic television image tubes. This application is a division of a co-pending application of Madison Cawein, Serial No. 489,869, filed June 5, 1943.

According to conventional practice, numerous optical arrangements have been employed heretofore for increasing the photo efficiency of electronic television image analyzing and image reproducing tubes. As is well known, each type of image tube functions to translate energy from one form to another. For this purpose each of these tubes utilizes an energy translating element. In an image analyzing tube of the dissector type the energy translating element is a photoelectric cathode, whereby light energy is translated into electronic energy. In the iconoscope and orthicon types of image analyzing tubes the energy translating elements are mosaic surfaces, whereby light energy is translated into electronic energy. In an image reproducing tube the energy translating element is a fluorescent screen, whereby the electronic energy which impinges thereon is translated into light energy.

In television image tubes, whether they be analyzers or reproducers, it is desired to utilize the available light as efficiently as possible. For the present consideration image analyzing tubes, of which a charge storage tube is taken as an example, will be spoken of specifically, but it will be understood that the statements made herein will be equally applicable to other types of image analyzing tubes and to image reproducing tubes as well, for the reason that the optical problems are substantially similar. The only difference is that, in the case of the analyzing tube, the problem is to project the maximum quantity of light reflected from the subject upon the photoelectric cathode or mosaic, while, in a reproducing tube, the problem is to project the maximum quantity of light emitted by the fluorescent screen onto the viewing screen.

For maximum photoefficiency the optical system employed with a television image tube must have the optimum light gathering property compatible with the limitations imposed by the characteristics of the tube. The light gathering property of an optical system, such as a lens, is directly proportional to the square of the diameter of the lens aperture and is inversely proportional to the square of the distance which the light must travel from the lens to the focal plane. Thus, in a given interval of time, the ratio of the focal length of a lens to the diameter of the lens aperture is a measure of the light which may be projected

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upon a charge storage tube photoelectric electrode located in the focal plane of the lens. Therefore, it follows that, in a given interval of time, the smaller this ratio can be made the greater will be the light which is incident upon the photoelectric electrode to form the optical image. This ratio is commonly known as the f /number of the lens and designates the rapidity or speed thereof, the lower f /numbers being applied to the faster lenses.

With tubes having opaque energy translating elements, the optical systems which have been utilized heretofore have consisted of a lens or a system of lenses, necessarily disposed externally of the tubes by reason of the requirement that the scanning apparatus have unobstructed access to the sensitized surface of the energy translating element. Consequently, the aperture and focal length of such a lens are limited by the physical dimensions of the tube. The tube dimensions are determined primarily by considerations such as the focusing and scanning arrangements required for the operation of the tube. Hence, it is seen that the minimum f /number of the optical system is fixed by the tube dimensions. For example, in a charge storage tube, the fastest practical lens which may be used successfully is an $f/2.5$ lens.

In the operation of television image tubes the time during which an optical image is projected onto the energy translating element is determined by the frame scanning frequency. By reason of this limitation, only a relatively small quantity of light may be projected upon the photoelectric electrode of a charge storage tube to form the optical image thereon, when prior art optical arrangements are used. Since the exposure time of the electrode is limited by the frame scanning frequency, the only possible way of projecting more light upon the electrode is by utilizing an optical system having a speed greater than $f/2.5$. As previously indicated, such an expedient is prohibited where the optical system consists of a lens disposed exteriorly of a tube having an opaque electrode.

There remains, however, the alternative of disposing the optical system adjacent the end of the tube in which the energy translating element is located. By this means it is possible to shorten the focal length of the lens sufficiently so that it may be placed in such relative proximity to the photoelectric electrode that the distance required for the light to travel from the lens to the electrode is shortened materially. Such an arrangement permits the use of a much faster lens, say, for example, an $f/1.5$ lens. Since the quantity

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of light projected onto the electrode varies inversely as the square of the f / number, it is seen that, by the use of an $f/1.5$ lens, it is possible to project approximately three times as much light onto the photoelectric electrode than is possible with an $f/2.5$ lens.

There is, however, a disadvantage to this latter type of arrangement in that it requires the use of a translucent energy translating element. This, of course, is required since the light from the television subject is projected onto one surface of the electrode, while the electron image must be formed on the opposite side whereby to permit scanning thereof. It is well known that translucent structures of this character are difficult to form since they must be thin enough to render them semi-transparent and the photoelectric layer must be of uniform thickness in order not to introduce distortions. Obviously, a structure meeting these requirements has a low photo efficiency. As a result the gain in efficiency which is obtained by the use of the faster lens system is substantially counterbalanced by reason of the light loss introduced by the employment of the translucent energy translating element.

In view of the limitations and disadvantages of the attempts which have been made heretofore to increase the photo efficiency of a television image tube by means of optical systems disposed externally of the tube, it is apparent that any arrangement of this character will not produce an increase in efficiency sufficient ordinarily to render the use thereof of much practical value.

It is an object of the present invention, therefore, to provide an electro-optical device in which there is incorporated an optical system, whereby to increase the photo efficiency of the device.

Another object of the invention is to provide a television image tube incorporating an optical system having large light gathering properties, whereby to increase the photo efficiency of the tube.

Another object of the invention is to provide an improved charge storage tube such as an iconoscope having an opaque mosaic, and incorporating an optical system of a character to permit orthogonal scanning of the mosaic.

One optical system which possesses the characteristics required to increase the photo efficiency of a television image tube utilizing an opaque energy translating element is the so-called Schmidt optical system. Such a system has been employed heretofore in connection with astronomical telescopes and cameras. Briefly, such a system comprises a spherical reflector, opposite to which there is disposed in spaced relation, a lens having a configuration suitable to correct for the spherical aberration of the reflector. Approximately midway between the reflector and the correcting lens in the focal plane of the reflector, there is located a spherical member having its surface disposed parallel to the surface of the reflector. In the case where the system is employed in a telescope, the surface of the focal plane member is the screen upon which the image is projected and from which it may be viewed. In the case where the system is used with a camera, a photographic film is disposed in the focal plane of the reflector.

As is well known, the Schmidt optical system has a large light gathering property. Consequently, it may be used advantageously for applications requiring a wide-angle coverage together with an extremely small f / number. For example, a Schmidt optical system having a speed of

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$f/5$ may be constructed. Thus, the use of such an optical system in combination with a charge storage tube, for example, will increase the photo efficiency thereof to a marked degree over that obtainable with an $f/2.5$ lens, as in prior art systems. Since the light gathering property of an optical system varies inversely as the square of its f / number, it is seen that, by using a system having a speed of $f/5$ instead of a system having a speed of $f/2.5$, the light which is incident upon the photoelectric electrode of a charge storage tube is 25 times greater in the former case than it is in the latter case.

In accordance with the present invention, there is provided an evacuated envelope having a body portion and a stem portion affixed thereto. Adjacent to the wall of the body portion connecting with the stem portion, and within the envelope, there is provided an inwardly facing concave spherical reflecting surface. Preferably, this surface may be formed on the inside of a spherically shaped envelope wall. An aperture is formed in this surface to permit communication between the body and the stem portions of the tube. The wall of the body portion, opposite to the wall adjacent to the reflecting surface, is transparent and may be in the form of a lens which has a configuration suitable to correct for the spherical aberration of the reflecting surface. The correcting lens alternatively may be located externally of the envelope adjacent the transparent wall. There also is provided, within the envelope, an energy translating element having a convex spherical photoelectric surface, which is arranged parallel to the reflecting surface. The energy translating element of the tube is located between the correcting lens and the reflecting surface in the body portion of the tube. This element has a surface area which is small relative to the surface area of the reflecting surface. The energy translating element is disposed in alignment with the aperture formed in the reflecting surface.

There is mounted in the stem portion of the tube, electronic apparatus for cooperative operation with the energy translating element. Also, there is disposed adjacent to the stem portion of the tube envelope, suitable apparatus for effecting focusing and scanning, whereby to enable the electronic apparatus to perform its function. Also, suitable electrical connections are made through the tube envelope to the apparatus mounted herein.

In accordance with a specific embodiment of the invention, the energy translating element is a mosaic surface. The electronic means mounted in the stem portion of the tube envelope is an electron gun.

The focusing and scanning apparatus utilized in connection with a television image tube in accordance with the instant invention, may be electromagnetic and/or electrostatic, as desired.

For a better understanding of this invention together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the accompanying drawing, the single figure is a sectional view of an iconoscope or orthicon image analyzing tube embodying the invention.

Referring now to the drawing, there is illustrated an iconoscope or orthicon type of charge storage tube having a glass envelope surrounding the main or body portion of the tube and a

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stem portion envelope 2. The space enclosed by the envelopes is evacuated. One end wall 3 of the body portion of the tube is spherically shaped so that a concave surface is formed facing inwardly of the tube. The wall 3 is provided with a centrally disposed aperture, whereby to provide communication between the body and stem portions of the tube. The opposite end wall is formed by a transparent lens 4, the outer surface of which is flat and the inner surface of which has a configuration suitable to correct for spherical aberration. The center of curvature for the wall 3 is located approximately at the center of the lens 4.

A layer of light-reflecting material 5 is deposited on the concave spherical surface of the envelope wall 3. Preferably, this material is gold so that the surface formed is a good reflector of invisible light rays, such as the infrared rays. However, other materials such as silver may be employed with substantially equal facility within the scope of the invention. The reflecting surface 5 is deposited on the glass wall by sputtering or any other suitable process.

An electrical connection 6 is made to the reflecting surface 5 and may be extended through the tube envelope 1 as shown, or in any other well known manner.

In the main body portion of the envelope 1 a spider-like supporting structure may be employed for the photoelectric electrode. As illustrated herein, this structure comprises a plurality of small stiff wire members such as 7 and 8, the outer ends of which may be inserted in suitable recesses formed in the walls of the envelope 1. The ends of the supporting members 7 and 8 may be anchored in the envelope by fusing, cementing, or other suitable means. It is to be noted that this specific structure and the specified means of attaching it to the tube envelope are merely illustrative, since it is considered to be obviously within the scope of the invention to provide an equivalent structure of this or other form which may be anchored in any other well known manner.

Each of the supporting members 7 and 8 is angularly formed at the inner end thereof and serves to support the energy translating element. This element may be formed by attaching a suitable metallic backing plate 9 in any well known manner to the inner ends of the supporting members 8. The configuration of the backing plate is convex on the side thereof facing the reflecting surface 5 and is parallel thereto. A mosaic surface 11 may be applied to the spherically convex surface of the backing plate 9 by evaporation or other conventional process. A conductor 12 may be attached to the backing plate 9 as shown and passed to the outside of the tube through a suitable seal formed in the central portion of the correcting lens 4.

A conventional electron gun, electrostatic focusing apparatus, and electrostatic deflecting systems are mounted in the stem portion envelope 2. The electron gun comprises a thermionic cathode electron emitter 13 which is heated by a filament 14. The gun also includes a grid like structure 15 and a first anode 16, the latter of which is arranged for cooperative operation with a second anode 17, which is in the form of a wall coating on the tube envelope. The anode structure is for the usual purpose of focusing the electron beam. The deflecting system comprises a pair of horizontal deflecting plates 18 and a pair of vertical deflecting plates 19.

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Electrical connections to the electrodes mounted in the stem portion of the tube are made through the press portion of the stem, as shown.

Referring now to the operation of the embodiment of the invention illustrated, it will be assumed that light which is reflected from a subject is directed through the lens plate 4 from the left, as viewed in this figure. This light, when reflected from the spherical surface 5, forms an optical image on the mosaic surface 11, whereby the light energy is translated into electronic energy and creates an electrostatic charge image on the mosaic surface. In the case that such a tube is used as an iconoscope, a high velocity electron beam is caused to scan the mosaic surface under the control of the illustrated scanning apparatus. The television video signals thereby generated are applied to conventional amplifying apparatus (not shown) by means of the conductor 12 connected to the backing plate 9. In the case where the tube is to be employed as an orthicon, the mosaic surface 11 is scanned by a relatively low velocity electron beam in a well known manner effected by suitable modification of the deflecting system and the voltages applied thereto.

To those skilled in the art, it will be apparent that an image tube according to this invention possesses numerous advantages, irrespective of the type of tube. In all types of tubes the photo efficiencies thereof are increased to a marked degree. Also, tubes embodying the invention permit the use of solid or opaque energy translating elements with all of their inherent advantages.

In an iconoscope or orthicon, it obviates the necessity of angular scanning. The mosaic may be scanned orthogonally and thus there is eliminated the heretofore employed arrangements for making a correction for the so-called keystone or perspective distortion.

The photo efficiency of a television image tube, or other device embodying the invention, not only is increased by the described arrangement, but also is maintained constant by reason of the fact that the concave light-reflecting member is sealed within an evacuated envelope. Thus, the reflecting surface is not subject to deterioration from such causes as dust, for example.

It should be noted that it is immaterial whether the outer, inner or both surfaces of the correcting lens be curved, so long as this member suitably compensates for the aberration of the reflecting member, whereby an undistorted image is formed.

While there has been described what, at present is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electro-optical device comprising, an envelope having two oppositely disposed walls, a concave light-reflecting member within said envelope adjacent one of said walls and facing the other of said walls, a light-refracting member mounted in spaced relation to said reflecting member, a photosensitive member capable of emitting electrons in accordance with light projected thereon mounted within said envelope in spaced relationship to said reflecting member

and facing it, electronic means for producing a cathode ray within said envelope disposed in cooperative relationship to said photosensitive member, and means disposed to produce within said envelope an electron-deflecting field having an intensity varying periodically according to a predetermined scanning pattern.

2. A television iconoscope comprising, an envelope having a transparent wall, a concave light-reflecting member in said envelope facing said transparent wall, a light-refracting member facing said reflecting member, a convex mosaic in said envelope disposed in spaced parallel relationship to said reflecting member, and an electron gun in said envelope disposed in cooperative relationship to said mosaic.

3. A television iconoscope comprising, an envelope having a transparent wall, a spherical light-reflecting member in said envelope facing said transparent wall, a lens to correct for spherical aberration of said reflecting member disposed in spaced relation to and facing said reflecting member, a spherical mosaic disposed in said envelope between said reflecting member and said transparent wall, and having the spherical surface thereof parallel to and facing said reflecting member, and an electron gun in said envelope disposed in cooperative relationship to said mosaic.

4. A television iconoscope comprising, an envelope having a body portion and a stem portion, said body portion having a transparent wall, a spherical light-reflecting member in said body portion facing said transparent wall, a lens to correct for spherical aberration of said reflecting member formed in said transparent wall, a spherical mosaic disposed in said envelope and having the spherical surface thereof parallel to and facing said reflecting member, an aperture formed in said reflecting member adjacent to

the stem portion of said envelope, an electron gun mounted in said stem portion, and electrostatic focusing and scanning means disposed adjacent to said electron gun.

5. A television iconoscope comprising, an envelope having a body portion and a stem portion, said body portion having two oppositely disposed walls, an inwardly facing spherical light-reflecting member formed in one of said walls, a lens to correct for spherical aberration of said reflecting member formed in the other of said walls, a spherical mosaic disposed in said envelope between said walls and having the spherical surface thereof parallel to and facing said reflecting member, an aperture formed in said reflecting wall member to provide communication between the body and stem portions of said envelope, and mounted in said stem portion, an electron gun, an annular electrostatic focusing electrode and electrostatic scanning elements comprising horizontal and vertical pairs of parallel arranged spaced plates.

6. A television charge storage image-analyzing tube comprising, an envelope having a transparent wall, a concave light-reflecting member in said envelope facing said transparent wall, a light-refracting member to correct for aberration produced by said reflecting member disposed in spaced relation to said reflecting member, a mosaic electrode in said envelope disposed in spaced relationship to and facing said reflecting member, an electron gun in said envelope disposed in cooperative relationship to said mosaic electrode for directing a cathode ray onto said mosaic electrode, and means for deflecting said cathode ray over said mosaic electrode to generate video signals representative of an optical image projected onto said mosaic electrode by means of said reflecting member.

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