Nov. 16, 1948. D. W. EPSTEIN 2,454,144

IMAGE PROJECTION SYSTEM

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Fig. 1.

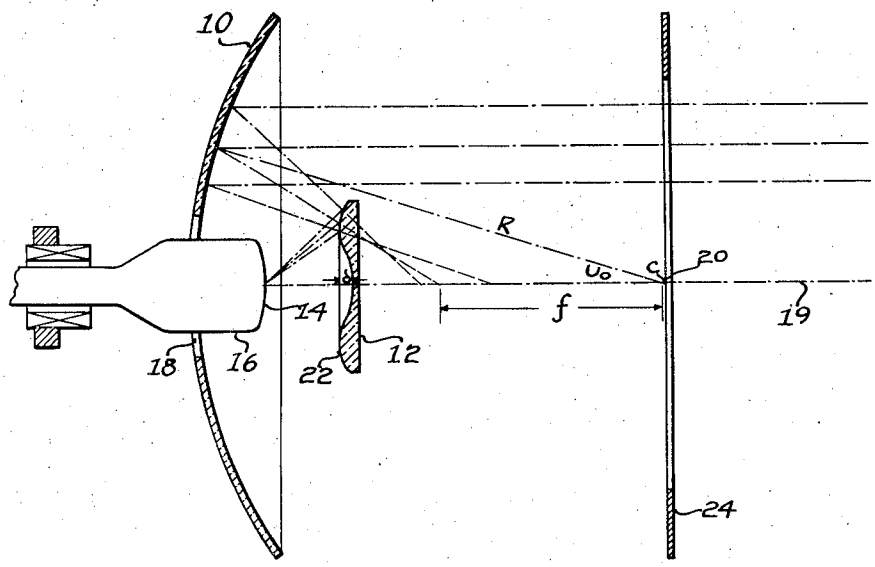
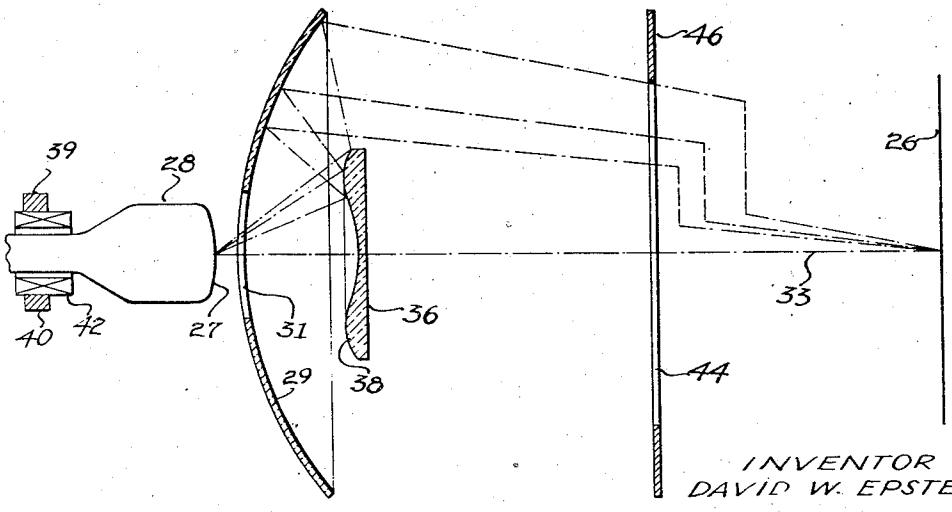


Fig. 2.



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Fig. 3.

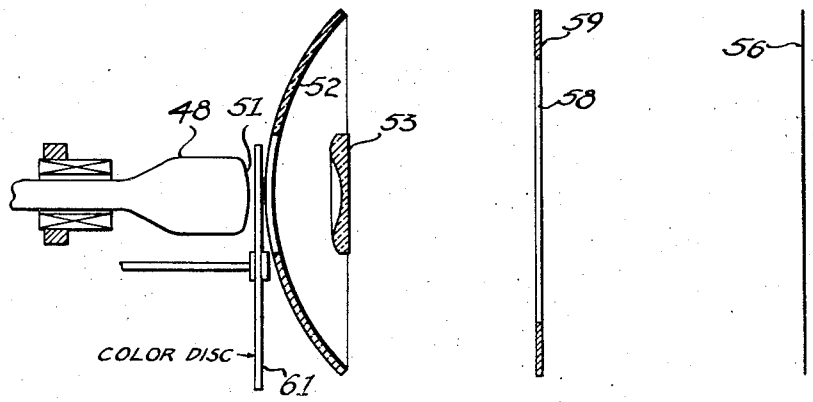


Fig. 5.

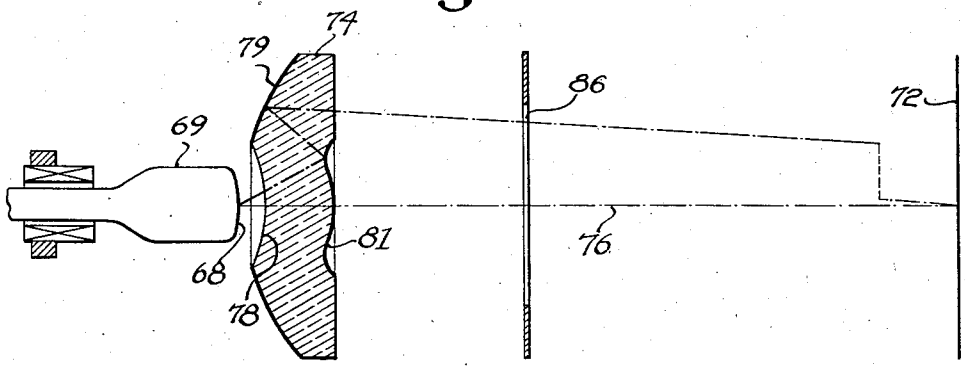
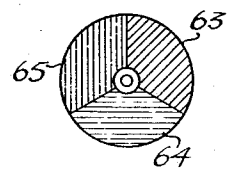


Fig. 4.



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IMAGE PROJECTION SYSTEM

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7 Claims. (Cl. 178—5.4)

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The present invention relates to an image forming or projection system, and more particularly to a novel optical train for television receivers of the projection type.

The invention is disclosed herein as being embodied in a system for projecting television images or the like in which the optical system is of the type comprising a spherical mirror and a spherical aberration correcting means. A system of this general type is disclosed and claimed in Patent No. 2,273,801, granted to Daniel O. Landis, February 17, 1942. In accordance with this invention, an aspheric correcting mirror is employed in a television image projector whereby the image producing tube and its associated parts may occupy a position which does not obstruct the light path of the system. In one aspect of the invention, reflection rather than light transmission and consequent refraction provides the necessary correction.

Accordingly, the primary object is to provide a television image projection system in which a spherical aberration correcting mirror is employed to eliminate substantially all spherical aberration.

Another object is to provide a television image projection system which does not rely upon refraction of transmitted light beyond the boundary of an optical element to correct for spherical aberration.

A further object of the invention is to provide a television image system employing a spherical aberration correcting mirror whereby only reflection occurs in the optical path rather than light transmission through different media with consequent refraction to provide the necessary correction.

Still another object is to provide a novel optical member having a correcting mirror surface.

Other objects and advantages of the invention will, of course, become apparent and immediately suggest themselves to those skilled in the art to which the invention is directed from a reading of the following specification in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic showing of an optical system which is referred to in describing principles of the invention;

Fig. 2 is a side view of a television image projection system embodying the invention;

Fig. 3 is a side view of a television image projection system embodying the invention in modified form;

Fig. 4 is a front elevational view of detail of Fig. 3 and

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Fig. 5 illustrates another modification of a television image projection system embodying the invention.

Referring to Fig. 1, there is shown illustratively a projection system for a specific case of infinite throw. Fig. 1 is illustrative of the manner of deriving the correcting mirror rather than as showing a preferred form of projector in accordance with the invention. The remaining figures of the drawing show the principle illustrated by Fig. 1 of the drawings applied in the production of a television image projection system. The system comprises a spherical mirror 10, a low power aspheric correcting mirror 12, and a light source such as the screen end 14 of a cathode ray tube 16. The tube 16 may project as shown through an opening 18 in the center of the spherical mirror 10. While a spherical mirror has no optical axis, the line 19, upon which the tube 16 and the mirror 12 are centered, will be considered an axis for the purpose of the following discussion. The center of the spherical mirror 10 is indicated at 20. The maximum depth δ of curvature of the reflecting surface 22 of the correcting mirror 12 is given by the relation:

$$2\frac{\delta}{R}=\frac{2f}{R}+\frac{1}{2f/R}-2$$

in which δ is the depth of the curve at the point clearly indicated on Fig. 1 along the line 19, and f is the focal length of the system. δ, as a function of f, for a radius of curvature of the mirror 10 of ten inches is given below:

f	δ
Inches	*Inches*
5.25	.0119
5.3	.0170
5.4	.0296

It will be observed in connection with Fig. 1 that the effect of the correcting mirror 12 is to bring the rays to a point focus.

An aperture, preferably located at the center of curvature of the mirror, which will accommodate the system optically is indicated on the drawing as being provided in a casing or cabinet 24, shown fragmentarily.

Fig. 2 of the drawings shows the optical system in accordance with the invention employed to project an image on a screen 26 of the luminous image produced on the screen end 27, for example, of a cathode ray television tube 28 or other luminous image source. A spherical mirror 29

is provided with an opening 31 toward which the tube 28 faces. As before, the line indicated by reference character 33 may be considered as the optical axis of the system since a correcting mirror 36, provided with a figured reflecting surface 38, is centered on this line as well as the tube 28. This optical system has a curved field approximately equal to the focal length of the system.

Supporting means of any desired type are provided for the image producing tube 28, such means being indicated conventionally at 39 and 40. These supports may be connected to or secured upon any portion of an associated television receiver. The deflecting yoke for the cathode ray tube is indicated at 42 which will be suitably connected or coupled to the deflection circuits of the associated receiver. An aperture 44 is indicated which may be provided in casing 46 of the associated television receiver so that the image may be projected on to the previously mentioned screen 26 or other suitable image viewing surface. The latter may, of course, be of translucent variety if desired. The aperture 44 is preferably located at the center of curvature of the mirror.

Fig. 3 of the drawings indicates the application of a system similar to Fig. 2 to reproduce television or other electrically produced images in colors. The tube 48 is or may be similar in all respects to either the tube 16 or the tube 28, provided that the colors which are to be combined to produce the colored image are present when the screen within the end 51 of the tube is activated. A spherical mirror 52 in combination with an aspherical correcting mirror 53 projects the image produced by the screen end of the tube 51 on to a screen 56 in the manner discussed above in connection with Fig. 2 of the drawings. The tube 48, it is understood, will be supported in the manner suggested above in connection with Fig. 2 of the drawings. An aperture 58 in a wall or the like of an associated cabinet or housing 59 permits projection of the image upon the screen 56 on to the appropriate image viewing surface. The aperture 58 is preferably located at the center of curvature of the mirror.

A rotary filter 61 is shown by way of example, and it will be noted that this filter, in accordance with this aspect of the invention, is positioned so that it chops and filters the light emitted by the tube 48 by means of the filter sections 63, 64, and 65 (Fig. 4). In the three-color television system selected by way of example for illustrating the application of this invention to color television, the filters normally used are colored red, green, and blue, and as the rotary filter 61 is rotated by a synchronized source of a mechanical power, such as an electric motor, (not shown), light of these different colors from the image is projected successively upon the screen 56.

The equipment for sequential scanning of the original in different colors is not disclosed herein since it does not form a part of the present invention. It will be understood that any system of scanning may be employed for applying a series of signals to the appropriate electrode or electrodes of the tube 48 in timed relationship with the presentation of the colored sectors 63 to 65 or their equivalent. An arrangement for effecting this purpose is shown in Patent No. 1,748,883, granted to Ray D. Kell, February 25, 1930. A cathode ray color television transmitter is shown in Patent No. 2,297,524, granted to E. I. Anderson, September 29, 1942.

Fig. 5 of the drawings shows a modification of the invention in which a produced image appearing on the end 68 of an image producing tube 69 is projected upon an image viewing surface such as that provided by a screen 72, by means of an optical system provided by a unitary optical part or member indicated in its entirety by reference character 74. The part or member 74 may be of glass, selected in view of its optical characteristics, a plastic such as "Lucite" (methyl methacrylate), "Polystyrene," or other suitable transparent substance which may be cast, ground, molded under pressure, or otherwise suitably worked to provide the necessary configuration of its light reflecting surfaces. The center line of the tube 69 is located on a line 76 which may be regarded as the optical axis of the projection system. The active face 68 of the tube 69, from which the luminous image is projected is opposite a depression 78 formed on one surface of the member 74. The depression 78 provides a boundary surface between two optical media, in this case, between air and the material of the member 74. The remainder of this surface is of spherical configuration so as to provide a spherical reflecting surface to serve as a spherical mirror 79. A central portion of the face of the member 74 opposite the mirror 79 is figured to provide an aspherical correcting mirror 81. This correcting mirror 81 corresponds in function to the correcting mirrors 12 and 36 of Figs. 1 and 2 respectively of the drawings. From the foregoing description of Fig. 5, taken in conjunction with the description of Figs. 1 and 2 of the drawings, it is believed that the function and use of the several optical components of the unitary device 74 will be clearly understood.

The space between the tube face 68 and the area or depression 78 may, to advantage, be filled with a medium of approximately the same index of refraction as that of the tube 68, and optical system 74, or the tube face 68 may fit substantially perfectly into the depression 78 so that there is no air medium between them. An aperture, such as indicated at 86, located at the center of curvature of the mirror 79 will, in general, improve the operation of the optical system.

Various modifications of the invention shown and described herein by way of example are possible without departing from the spirit and scope of the invention described herein, and it is desired that any and all of such modifications be considered within the purview of the present invention defined by the hereinafter appended claims.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. An optical system for image projection comprising a cathode ray tube operative to produce a bi-dimensional optical luminous image, an aspherical correcting mirror positioned to receive light from said cathode ray tube, a light reflecting surface of revolution having its concave surface positioned to receive light reflected from said correcting mirror, said correcting mirror being axially aligned with said cathode ray tube and said reflector and having a surface configuration whereby to correct the spherical aberration introduced into the light rays reflected directly by said reflecting surface whereby a sharply focused image of the original luminous image

is developed at a plane located a finite distance from the reflecting surface.

2. A television image projection device comprising a cathode ray tube having a luminescent target area whereupon an optical image is produced, an aspheric correcting mirror axially aligned with said target area whereby to receive light therefrom, a spherical reflector having its concave surface area positioned to receive light reflected from said correcting mirror, said correcting mirror having its reflecting area of such curvature as to correct for spherical aberration due to the reflector so that a sharply focused enlarged image of the tube target area may be focused upon a viewing surface located at a finite distance from said spherical reflector.

3. In combination, a cathode ray tube operative to produce a luminous image, a spherical mirror having a central aperture to pass light produced by said cathode ray tube, a disc operative to rotate situated between said tube and said aperture and having a plurality of color filters thereon, and an aspheric correcting mirror in alignment with said tube and said aperture positioned to throw light from said tube upon said spherical mirror.

4. An optical system comprising an optical member having a surface which is of convex angular shape to provide a spherical mirror, a circular light transmitting portion in the center thereof, and another surface of said member which is of a circular shape to provide an aspheric correcting mirror having its reflecting surface facing interiorly of said optical member toward said spherical mirror and axially spaced therefrom, and an annular transparent portion surrounding said correcting mirror to transmit reflected light from said spherical mirror.

5. An optical system comprising an optical member having a surface which is of a shape to provide a spherical mirror, another surface of said member which is of a shape to provide an aspherical correcting mirror having its reflecting surface facing interiorly of said optical member toward said spherical mirror, a cathode ray tube having a screen structure positioned opposite the reflecting surface of said spherical correcting mirror and so located that effectively it

is substantially at a focus of the spherical mirror, and a surface of said member providing a light transmitting portion facing the screen structure of said tube.

6. An optical system comprising an optical member having a surface which is of a shape to provide a spherical mirror, another surface of said member which is of a shape to provide an aspherical correcting mirror having its reflecting surface facing interiorly of said optical member toward said spherical mirror, a cathode ray tube having a screen structure positioned opposite the reflecting surface of said spherical correcting mirror and so located that effectively it is substantially at a focus of the spherical mirror, and a surface of said member providing a light transmitting portion facing the screen structure of said tube and shaped to conform thereto.

7. An optical system comprising an optical member having a surface which is of convex angular shape to provide a spherical mirror, a circular light transmitting portion in the center thereof, and another surface of said member, a portion of which is of a shape to provide an aspheric correcting mirror having its reflecting surface facing interiorly of said optical member toward said spherical mirror and axially spaced from the first mentioned surface, said last named surface also having a transparent annular portion for transmitting light reflected from said aspherical correcting mirror and said spherical mirror.

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