

Jan. 5, 1943.

A. N. GOLDSMITH

2,307,210

TELEVISION SYSTEM

Filed Nov. 30, 1940

2 Sheets-Sheet 1

Fig. 2.

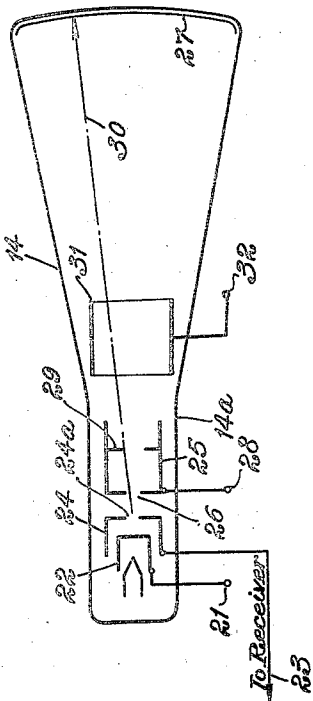


Fig. 1.

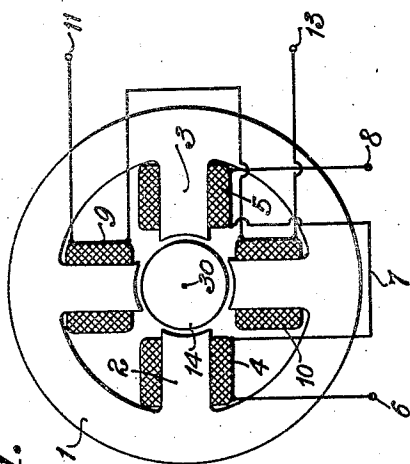


Fig. 4.

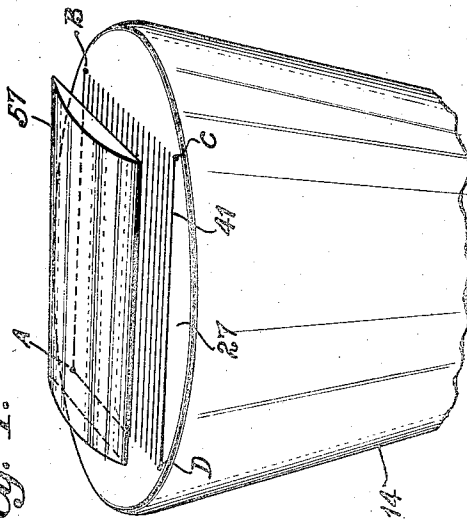
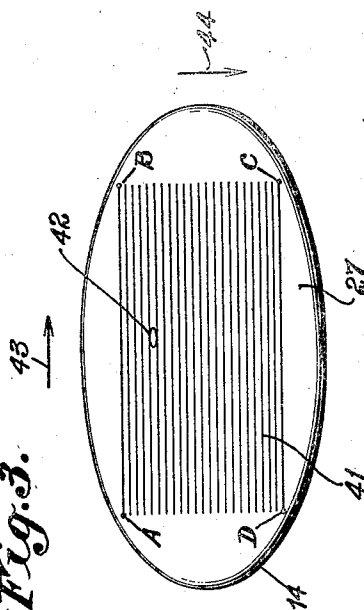


Fig. 3.



INVENTOR
Alfred N. Goldsmith
BY H. S. Srover
ATTORNEY

Jan. 5, 1943.

A. N. GOLDSMITH

2,307,210

TELEVISION SYSTEM

Filed Nov. 30, 1940

2 Sheets-Sheet 2

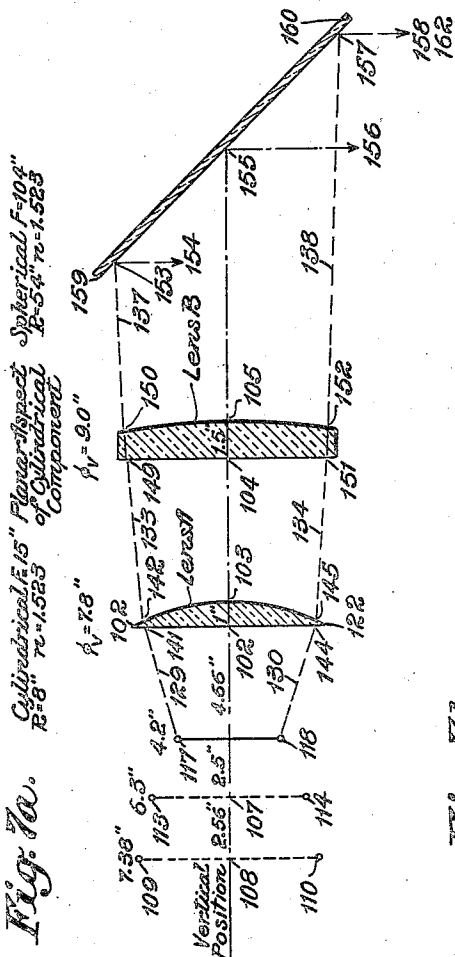


Fig. 7a.

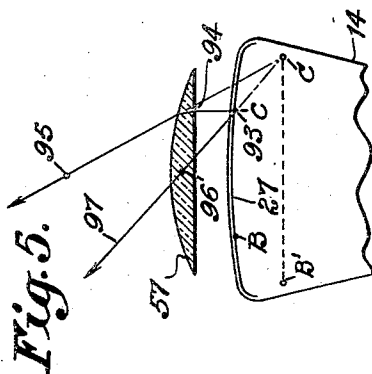


Fig. 5.

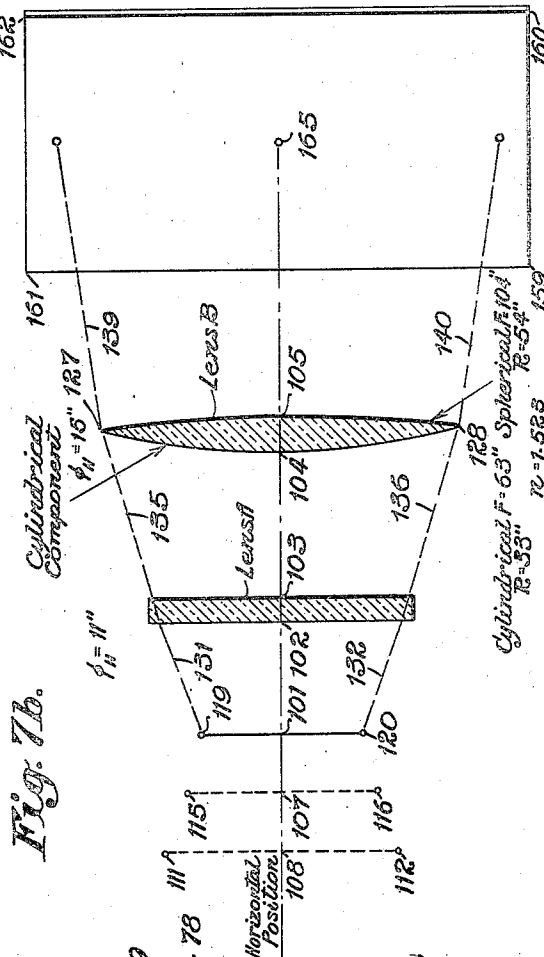


Fig. 76.

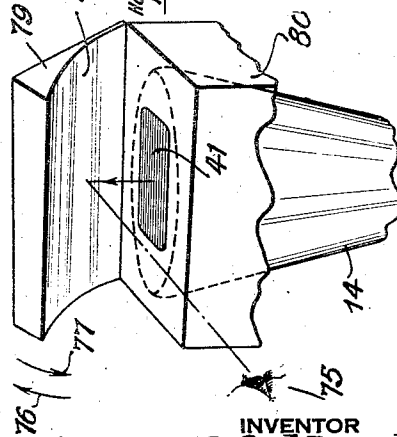


Fig. 6.

76

INVENTOR
Alfred N. Goldsmith
BY *H. S. Sower*
ATTORNEY

UNITED STATES PATENT OFFICE

2,307,210

TELEVISION SYSTEM

Alfred N. Goldsmith, New York, N. Y.

Application November 30, 1940, Serial No. 368,097

19 Claims. (Cl. 178—7.5)

This invention relates to television systems and particularly to the receiver end of such systems. Primarily the invention is directed to a television receiver system utilizing anamorphosis by which changes in the form or relative proportions or aspect ratio of the television pictures or electro-optical images, as well as the electrical and the optical processes therewith associated, are achieved.

In television receiver systems, as now customarily used, the electro-optical representation which is to be viewed directly, or through appropriately arranged optical enlarging systems, or in suitable viewing reflectors, is formed electronically from a series of substantially parallel lines produced by causing an intensity controlled cathode ray beam to traverse the luminescent target area of the cathode ray tube. In television systems recently used, such electro-optical representations usually result from tracing a cathode ray beam of substantially circular cross-section across the luminescent target area of a cathode ray tube in substantially parallel line traces, with the image formed from 441 line traces repeated thirty times per second. Such repetition rate is sufficient for the observer to sense continuity of image reproduction upon the viewing target because of optical persistence of vision. The produced images usually have an aspect ratio of such an order that the width of the resulting electro-optical image viewed on the end of the viewing tube has an aspect ratio or a width-to-height relationship of the order of 4 to 3. Thus, for instance, if the cathode ray tube upon which the electro-optical image is to be produced has a circular luminescent target area or end portion of the order of 12" in diameter, the size of the optical representation which is created by the impact of the cathode ray beam upon the viewing target will be approximately 7½" high by 10" wide.

Thus, it can be appreciated that the utilization of an image reproducing tube, of a diameter sufficiently great to enable a picture of the above suggested size to be produced, is quite substantial, so that the depth of the cabinet into which the tube is placed must also be substantial; consequently, a considerable amount of space from front to back is required for a television receiver. Such space requirement could be substantially reduced if it were possible to produce a television image on the tube in such manner that at least one of the above suggested dimensions, preferably the height, as it is viewed, because it affects the depth of the cabinet, could be reduced

so that the aspect ratio of picture width to picture height were other than the suggested 4 to 3 ratio, and yet provision could be made for enabling an observer to view the actual television image in the desired 4 to 3 aspect ratio.

Accordingly, it is an object of the invention herein to be described to provide a suitable system for compressing the television image in at least one of its two dimensions, and preferably its height as viewed, so as to enable the utilization of television receiver cabinets which are shallower from front to back than would be required if such television pictures had normal proportions prior to actual viewing.

It is also an object of this invention to provide cathode ray image producing tubes for television use, wherein a cross-section of at least the larger portions of the tube may be elliptical in nature, so that for the production of a television image of a certain predetermined maximum dimension, the tube will be shallower in the dimension perpendicular to the selected maximum than would be the case with the usual circular and conical construction of the flare of the image reproducing tube.

It is also an object of this invention to provide a television receiving and viewing arrangement for installation in a television receiver cabinet which will substantially reduce the space requirements for television apparatus and make possible greater ease in handling and shipping.

Another object of this invention is to provide a construction for a television receiver arrangement which may readily be adapted to systems utilizing either electro-static or electro-magnetic systems of deflection which shall function to distort the image in its initial production of the luminescent target of the cathode ray tube, so that the image resulting is compressed in at least one of its two dimensions in order to enable the use of a shallower television receiver cabinet.

Another object of this invention is to provide a scanning cathode ray beam of elliptical cross-section capable of forming an elliptical scanning spot on the luminescent target or screen, the eccentricity of the ellipse being suited to the production of full and normal detail in the anamorphic image.

It is a still further object of this invention to carry on the reverse anamorphosis of the luminescent target image by optical reflecting or refracting means, so that the aspect ratio of the originally scanned field shall be restored in the picture image which is finally viewed, irrespective of the fact that electrical or mechanical means

function prior to viewing to distort the image deliberately in order to achieve the objective hereinbefore named.

It is another object of this invention to provide a television system and a viewing tube for viewing the television images where the tube target area is reduced so that the force exerted on the end of the tube by air pressure is reduced, and consequently, the tube is less subject to implosions.

It is a further object of this invention to provide an optical system suitable for producing enlargements of the television images where the enlargement is different in each of two directions because of the fact that an image of one aspect ratio is viewed as an enlargement in a different aspect ratio. In this way the invention provides for enlarging anamorphic television images so as to obtain a predetermined aspect ratio in the final image to be viewed by the observer where the original image was developed with an aspect ratio different from that originally viewed.

Other and further objectives will become apparent and at once suggest themselves to those skilled in the art to which the invention is directed by reading the following specification in connection with the accompanying drawings, wherein Fig. 1 illustrates schematically a yoke construction for use with cathode ray image producing tubes to provide for producing a distorted image in one direction. Fig. 2 represents in schematic form an electron gun for use in connection with a tube of the type shown by Fig. 1. Fig. 3 represents in schematic form the pattern traced on the target of the tube of Fig. 2, when there is incorporated with the arrangement of Fig. 2 a yoke construction of the type shown, for example, by Fig. 1, or its equivalent. Fig. 3 serves to illustrate schematically the electrical anamorphosis for compression of the picture or image being created on the viewing target of the tube. Fig. 4 illustrates one method of reversing the compression of the image so as to expand the observable image in one direction only. Fig. 5 illustrates schematically an alternative optical modification of the arrangement of Fig. 4. Fig. 6 schematically illustrates, by way of elementary diagrammatic representation, the manner in which the image produced on the luminescent target of the image reproducing tube may be enlarged or expanded in one direction, for example, in height. Fig. 7a illustrates in cross-section an optical system for enlarging anamorphic television images. Related Fig. 7b is a cross-section of the optical system of Fig. 7a taken in a direction at 90 degrees to the showing of Fig. 7a.

Now referring, for example, to the drawings, for a further understanding of this invention, it is to be understood that television (video or image or picture) signals combined with synchronizing signals, as is now well known in the art, may be received from any transmitting station. The signals are received, detected, amplified, and the synchronizing and controlling signals are separated from the picture or video signals. Separated synchronizing or control signals which are to be used for purposes of controlling the vertical deflection, the horizontal deflection and for other incidental controls, are then separated from each other after the initial separation from the picture or video signals.

One suitable form of receiver for accomplishing the foregoing result has been claimed and described in the Carlson U. S. Patent Reissue No. 20,700, dated April 19, 1938; but it is to be un-

derstood that various other forms of receiver instrumentalities may be utilized where desired. The present invention does not contemplate or require any special form of receiving circuit and is therefore flexibly applicable to substantially any normal television receiving circuit or system.

In any event, a television system for reproducing pictures will be assumed to embody apparatus wherein picture signals are received from any suitable form of transmitter, and after suitable amplification and detection, utilized in any appropriate manner to control the intensity of the luminescent effects observable on the viewing target of the cathode ray tube. Many and various effects for controlling the intensity of the observable effects are known, included among which are the so-called grid modulation schemes, velocity modulation schemes, beam size control schemes and various combinations of the foregoing.

The specific means to produce electro-optical effects upon the viewing target of the cathode ray image producing tube forms no specific part of this invention, only in so far as to become a part of the complete system in order to utilize the effect of suitable modulation on the viewing target by the cathode ray tube, it being understood that modulation here refers to all forms of intensity control above identified. There is customarily provided for any television system a suitable deflecting means for causing the developed beam to traverse the luminescent screen according to a bi-directional pattern of traversal. Such a pattern is initially formed by directing the beam back and forth rather rapidly in a transverse path relative to the luminescent target, and simultaneously to subject the developed cathode ray beam to a deflection across the luminescent viewing target in a direction normal to the first direction of deflection but operating at a much slower rate than the first deflection. For instance, if it be assumed that pictures are being reproduced so as to form thirty 441-line pictures per second, but interlaced at two picture fields per picture frame, it can be appreciated that the vertical deflection, that is, the slower of the two deflections, operates 60 times per second, whereas the horizontal deflection, that is, the more rapid of the two, operates at 13,230 times per second.

In order to control the deflection of the cathode ray beam developed within the cathode ray tube, an elliptical yoke for providing magnetic deflection of the electron stream or beam is preferably utilized. The elliptical shaping of the yoke is provided in view of the above mentioned elliptical shaping of the tube made possible by the production of the distorted initially produced image. However, a circular yoke can be used provided the pole faces for the two deflection means are brought suitably close to the circular cross-section of the cathode ray tube and provided the strengths of the two mutually perpendicular deflecting fields are appropriate and adequate to produce the desired vertical and horizontal deflections in the chosen anamorphic relationship.

To deflect the electron beam in one of its two directions of deflection, there are provided pole pieces 2 and 3 about which are suitably positioned deflecting coils 4 and 5, preferably connected in series by means of a conductor 7, which has the end terminals 6 and 8 energized from a suitable source of energy to produce a substantially saw-tooth current wave across the deflecting coils.

To deflect the cathode ray beam produced within the tube in a direction perpendicular to the preceding, there is a second set of coils 9 and 10 positioned about pole pieces similar to the pole pieces 2 and 3. Energy is supplied to the last named deflecting coils by way of end terminal connections 11 and 13.

Where desired, the coils 9 and 10 on the one hand, and 4 and 5 on the other hand, may be mounted on the same yoke, or the coils may be mounted upon separate yokes, depending upon the reaction taking place between the vertical and the horizontal deflecting coils. In any case, the assembly of the yokes, which are shown schematically by Fig. 1, embrace a portion of the cathode ray image reproducing tube 14 through which the electron beam 30 passes after it has been projected beyond the termination of the electron gun from which it emanates (see Fig. 2).

The cross-sectional area of the cathode ray scanning beam, as it is projected through the cathode ray image producing tube and subjected to the influence of the deflecting coils, and thereafter, is preferably elliptical. Such an elliptical cross-section beam can be produced in a way which will be apparent from the gun construction shown by way of example in Fig. 2. In Fig. 2 there is represented a rather conventional illustration of a cathode ray tube 14, having a neck portion 14a in which is supported an electron gun formed from a suitable electron emitter, one or more accelerator electrodes, and such control and shielding electrodes as may be desired. In accordance with the applied modulation signals the cathode ray beam developed is caused to control the intensity of the luminescent effects resulting at the tube viewing target in accordance with the intensity or time of impact or the density per unit area of the impacting electrons.

Because of the fact that the image produced is distorted or compressed in one of its two directions during its initial production on the luminescent target of the tube, the cross-section of the cathode ray beam as it impinges upon the target also is preferably non-circular and has an elliptical configuration, as will herein be explained.

In referring now, for instance, to Fig. 2 of the drawings, there is contained within the neck 14a of the tube 14 a cathode element 22 which may be of the directly heated or indirectly heated type, and to which electrical connections may be made at the terminal point 21. When the cathode member 22 becomes heated, electrons are driven off and caused to flow through the tube under the influence of any accelerating fields.

Closely adjacent the cathode, according to known construction, the control electrode 24 is positioned. Control voltages, as determined by received signals, may be applied to the control electrode by way of the terminal connection 23. A first anode element 25, having a beam defining aperture 26, is then aligned with a similar aperture 24a of the control electrode 24. Suitable operating and accelerating voltages are applied (from a voltage source not shown) to the anode by way of the terminal connection 28. The aperture 26 is preferably elliptical in nature, so as to restrict the electron flow through the anode to a cross-sectional formation which is elliptical in nature, with the major axis of the ellipse parallel to the more rapid path of deflection of the cathode ray beam as it traverses the luminescent target 27 of the tube, that is, parallel to the scan-

ning lines, and also parallel to the direction in which the resultant image is not compressed. Under such circumstances, the major axis of the elliptical aperture 26 is of a length which coincides substantially with the diameter of the usually utilized circular aperture. The minor axis of the elliptical aperture 26 is related to the major axis in the ratio of compression or anamorphosis of the picture produced on the luminescent target 27 of the tube 14. In order to accelerate the developed cathode ray beam, conventionally represented at 30, after the beam has been deflected, there is provided a second accelerating electrode 31 to which positive voltages may be applied (from a source not shown) by way of the terminal connection schematically represented at 32.

By the use of the elliptical scanning spot herein described, the full picture detail or resolution is maintained along the scanning lines and also perpendicular thereto. Furthermore the scanned field or raster is smooth, that is, without visible overlap or gaps between adjacent scanning lines.

The diaphragm 29, included as a part of the first anode 25, preferably has an aperture opening which is substantially larger than that of the aperture 26, but the diaphragm serves to prevent interaction of disturbing fields upon the beam formation as it enters the first anode.

The deflecting system conventionally represented by Fig. 1 is preferably positioned about the neck 14a of the tube in a region intermediate the first anode 25 and the accelerating anode 31, or, where a tube of such high sensitivity is not required or where greater power to deflect the beam is available, the deflecting system of Fig. 1 may be located about the neck of the tube intermediate the second accelerating anode 31 and the target 27. When the deflecting system of Fig. 1 and the electrode assembly schematically represented by Fig. 2 are utilized for producing a cathode ray beam, and sweeping that cathode ray beam across the luminescent target area 27, the image pattern or raster traced upon the target may be conventionally represented by the raster pattern shown in Fig. 3 by the shaded lines 41 included within the boundary area A, B, C, D, with the scanning lines narrowed in proportion to the degree of distortion or anamorphosis to be produced, and the scanning spot 42 serving to represent in this pattern substantially the configuration of the aperture 26 in the electron gun assembly. As shown by Fig. 3 it will be noted that the image spot is elliptical with the major axis in the ellipse parallel to the pattern sides A, B and C, D.

For purposes of illustration, the arrow 43 represents the rapid or horizontal deflections of the cathode ray beam and the arrow 44 represents schematically the slow or vertical deflections of the cathode ray beam with the individual line traces of the raster being indicated by the lines 41.

From the foregoing it can be seen that if signals are received in a television receiver of the character hereinabove referred to, and these signals are utilized to apply modulating voltages to the control electrode 24 by way of suitable connections to the terminal 23, and if the beam is deflected across the target 27 by a suitable deflecting system (for example that of Fig. 1) there will result on the viewing target 27 a pattern which has one of its two dimensions, for example the dimension AB, undistorted and the

other of its two dimensions, for example the dimension BC, substantially changed or distorted, so that the observer viewing the target area 27 without the benefit of suitable means to restore the image to its true proportions would not see a true likeness of the field of view scanned at the point of transmission to produce the signals which are applied as modulations to the control electrode 24. It is herein to be understood that the distortion above mentioned is not a distortion of outline but rather of aspect ratio.

Therefore, in order to reverse the compression in question, there is provided in association with the tube 14 and the viewed target 27 a suitable optical system by which the image area ABCD may be expanded in at least one of its dimensions, that is, in the directions corresponding to the directions AD and BC, so as to transform the raster or pattern into a configuration of rectangular shape whose dimensions AB and BC shall be in the relation of 4 to 3, it being assumed that the desired aspect ratio of the viewed image is 4 to 3. At the same time, the expansion would, in effect, restore the scanning spot to its intended circular cross-section.

To accomplish this purpose in one way, there is placed at an appropriate distance from the end 27 of tube 14 upon which the image appears a cylindrical lens element 57, having dimensions adequate to cover the entire picture producing area of the tube, as shown, and with its directrices perpendicular to the direction of previous anamorphic compression of the picture image during its electrical production. It can be appreciated at once that a cylindrical lens of such character will not change the dimensions of the picture along the horizontal lines but will visibly enlarge the dimensions of the picture along vertical lines, which was above stated to be one of the objects of the invention. By suitably selecting the index of refraction and the curvature of the cylindrical lens element 57, the picture area ABCD will appear to the looker to be restored to its original proportions. Such a picture may either be viewed directly or, if preferred, through a plane mirror mounted in the receiver cabinet and tilted to an angle of approximately 45 degrees to the line of sight of the looker. Under such circumstances, the tube 14 is positioned vertically in the receiver cabinet and so mounted that the looker views normally a picture undistorted along the horizontal lines but distorted vertically. The reflecting mirror may be of the general type shown and claimed in U. S. Patent No. 1,870,702, granted to V. K. Zworykin on August 9, 1932.

With such an arrangement, if it be assumed that the lens 57 be mounted fairly closely adjacent the luminescent target 27 of the tube 14, so that the produced image in the direction between points B and C or between A and D of Fig. 4 is within the boundaries of the same letters on Fig. 5, it will be appreciated that the light from the point C, for instance, will follow the path indicated between point 93 through 94 to 95. Also, it is apparent that there will be a path of light, for instance, between point C and the central point 96 of the lens 57 which emerges along the path 97. Consequently, since a similar effect takes place from the point B, an observer will view through the lens 57 a virtual image between the points B' and C' which is an enlargement of line BC to the desired degree as indicated.

For convenient reference in this specification,

only two of all the existing light paths have been shown. The point C' is determined by the projection and intersection of the light paths 94, 95 and 93, 97, which is illustrated by the drawings as being at the point C'. Similarly, light emanating from the point B would produce light waves which would converge to form an image of that part at the point B'. It is accordingly quite evident that the image viewed will be an enlargement in one direction only, or in other words, the dimension of the image which has been compressed in its initial production is expanded along one dimension only.

Under such circumstances, it will be appreciated at once that the point 95 represents the principal focus of the cylindrical lens at the point and in the plane indicated, and that the light wave at the point C, or point 93, which passes through the optical center or optical central direction of the lens at 96, will continue on its way undeflected along the path 97. The other ray from the point C or 93, which is parallel to the optical axis of the lens will, after passage through the lens, pass through the focus 95 along the path between 94 and 95. Thus, if the rays are projected backward, it will be evident that a virtual image is formed, and to an observer the image of the line BC appears to be back and farther away from the optical axis than the point 93, which corresponds to the front-to-back magnification which was herein desired. However, in a direction or plane at right angles, the cross-section of the lens is merely an elongated rectangle, and consequently the cylindrical lens in this direction acts only as a parallel plate and produces no magnification. The result of this type of lens arrangement is that the image along all lines which are parallel to the line or side AB is unmagnified and undistorted.

In a modification of the invention, as shown by Fig. 6, an arrangement for reversing the image compression is schematically shown. In this figure, the image 41 radiates light, which is reflected by the cylindrical concave mirror 78, which is mounted in the lid 79 of the cabinet member 80. The axial distance of the image 41 from the mirror 78 must be less than the focal length of the mirror in that plane. The lid construction is preferably of the same general form, except for the concave feature, as shown by the Zworykin patent above mentioned. The concave mirror or reflecting surface 78 is arranged to be tilted about its back edge, in directions shown and conventionally indicated by the arrows 76 and 77, so as to be brought into a convenient position to be viewed by the observer or looker, conventionally represented at 75.

The remaining portion of the cabinet construction embodies the video receiver and synchronizing circuits, together with any desired sound reproducing apparatus, as disclosed by the above mentioned Zworykin patent. If now, for instance, the screen picture 41 is closer to the mirror 78 than the focal length of the mirror in that plane of its concavity, a virtual image will be produced thereby and this virtual image will be enlarged only from front to back, but not from left to right. Accordingly, by suitably selecting the radius of curvature of the mirror 78, the requisite degree of front-to-back expansion of the picture produced in the area 41 of the tube 14 may be accomplished.

In the arrangement disclosed by Fig. 6, the receiving instrumentality has been shown only in a conventional manner and preferably embodies

the general feature disclosed by the Carlson Reissue Patent No. 20,700 above named.

In further modifications of the invention, it is also possible to combine the general methods disclosed by Fig. 4 and Fig. 6, so that by using both a convex cylindrical lens near the end of the cathode ray image reproducing tube, and a concave cylindrical mirror further removed therefrom, the combination of these optical elements for producing the desired change in the aspect ratio of the picture may be provided. Under such circumstances, the optical elements in the case may be weaker or less powerful than with the use of individual lens and/or reflecting elements.

In a modified form, the foregoing invention is particularly applicable to the production of large size images by virtue of optical enlarging systems. Essentially, the optical enlarging systems comprise a multiplicity of spaced positive lens elements whose powers progressively and suitably decrease and whose apertures progressively and appropriately increase in relation to the separation of the lens elements from the object or image as it is produced upon the end of the cathode ray viewing tube.

Referring now particularly to Fig. 7, there is disclosed an optical system for use in connection with the production of anamorphic television images. The disclosed optical system will serve for the enlargement of such pictures and will restore such pictures or images to normal aspect ratios. The system of Fig. 7 is broadly intended to accomplish two results, of which the first is to enlarge the image area upon the end of the cathode ray tube beyond its original size as it is viewed, and, at the same time, the optical system serves to restore such pictures to their original and usual aspect ratio.

The optical arrangement disclosed by Figs. 7a and 7b can be assumed, for example, as one by which the original image was 4.2" x 6.8", with the resultant enlarged image of 7.38" by 9.75". The original image with the system as disclosed by Figs. 7a and 7b is assumed to be produced with an aspect ratio of 1.62 and restored in enlarged form to an image having an aspect ratio of 1.33, as is customarily used.

Now referring particularly to Fig. 7a thereof, there is disclosed a cross-section of the enlarging system considered in a plane through the center of the original television picture and parallel to its height. The related drawing, namely Fig. 7b, is a cross-section of the optical system in a plane through the center of the original picture and parallel to the width thereof. In each part of Fig. 7 there is illustrated one lens system and dimensions which have proven practical. The illustrated lens system arrangement is to be understood as being descriptive of one suitable system, although some slight modifications might be made as, for instance, each dimension might be multiplied by choosing some constant multiplier for every dimension and thus provide for larger or smaller ultimate images.

In the showing of Figs. 7a and 7b the original picture may be considered as included between points 117 and 118 and having the above assumed aspect ratio of 1.62, so as to make possible the use of a shallower tube than is customarily adopted for more normal aspect ratios. The light rays from the television picture first pass through lens A. The lens A is a cylindrical lens with its cylindrical axis perpendicular to the plane of the

paper of the drawing in Fig. 7a, but parallel thereto in Fig. 7b.

The aperture 102, 122 of the lens A in the direction of the drawing Fig. 7a is assumed as being 7.8". The focal length of the cylindrical lens A, which is positive, is 15". One face of the lens is plane and the other has a radius of cylindrical curvature of 8", the index of refraction being 1.523. The thickness of the lens at its center is 1.0".

After light rays pass through the lens A, the light bundle 129, 130 is bounded, in the plane of the paper, between the rays 133, 134, which are directed backward to the first enlarged image at 107 and indicated between the points 113 and 114. This image need not be further considered at the present time for an understanding of the application, however, because the light bundle then strikes the cylindrical-spherical lens B, of which the planar aspect of the cylindrical component is schematically represented between the points 151, 104 and 149 in Fig. 7a, and on which the spherical portion is shown between the points 152, 105 and 150. The focal length of the spherical portion is 104", with a radius of curvature of 54", with the index of refraction of the glass also being 1.523 and the thickness of the lens at its center being 1.5".

The clear aperture of the lens B in the plane of the paper, as it is represented by Fig. 7a, is 9.0". As will be noted, the emergent light bundle or rays is indicated at 137 and 138 and appears to come from the final and enlarged virtual image of normal aspect ratio indicated at 108 and confined between the points 109 and 110 in one of its dimensions. This image has a height of 7.38" which, for the purposes of illustration, can be considered as the height of the normal picture produced on the luminescent end target of the usual 12" cathode ray tube.

In the showing of Fig. 7a, a plane mirror 159, 160 is indicated as being located in the path of the emergent light rays. This is shown solely for purposes of indicating convenience in viewing the resultant picture in the general manner suggested by Zworykin Patent No. 1,870,702. Furthermore, it should be understood, in connection with the showing of Fig. 7a, that while the mirror surface 159, 160 is indicated as having been placed beyond the lens B, it is to be understood that the optical system might readily be modified so as to locate the mirror intermediate the lens elements A and B without in any way departing from the spirit of the invention. As above mentioned, the various dimensions and spacings indicated by Fig. 7a are solely for purposes of illustrating one form of optical system which has proven to be satisfactory for the purposes hereinabove outlined.

Referring now particularly to the portion of the disclosure shown in Fig. 7b, which represents a cross-section through the center of the original picture and parallel to the width thereof, as above pointed out, the other two dimensions of the original picture appearing on the viewing end, which are represented at the points 119 and 120, may be considered as embodying the hereinabove suggested dimensions of 6.8". In this showing, the planar aspect of the cylindrical lens A is set forth, and it may be pointed out that its clear aperture in the plane of the paper is 11".

The cross-section of the lens B shows at its left the cylindrical component in cross-section. The lens in this direction has a focal length of 63" and a radius of curvature of 33", with the

glass index again being 1.523", as above noted. The right hand surface of the lens B, in Fig. 7b, as is represented between the points 128, 105 and 127, is a spherical cross-section, as hereinabove described. The clear aperture of lens B in the plane of the paper is, as shown in the drawings, 15". The other two dimensions of the reflecting mirror 159, 160 are shown at 161 and 162, which is the mirror shown by Fig. 7a, projected upon the plane of the paper, and point 165 represents a point thereon from which the light ray 156 passes perpendicularly from the plane of the paper, assuming the mirror 159, 160, 162, 161 to be inclined at an assumed angle of 45 degrees to the optical axis of the system (see particularly Fig. 7a).

Considering Fig. 7b still further, it will be noted that this optical system provides for enlarging an original picture of the size hereinabove suggested. The length dimension of the enlarged virtual image first produced by the lens A is represented only between the points 115 and 116; but the length dimension of the second or final virtual image produced by the combination of the lenses A and B is represented between the points 111 and 112. The light rays indicated at 131 and 132, which pass from the object area 101 to the lens A, correspond functionally to the light rays 129 and 130 of Fig. 7a; similarly, the light rays 135 and 136 and 139 and 140 correspond functionally or associatively respectively to the rays 133 and 134 and 137 and 138 of Fig. 7a.

From the foregoing it will be apparent that the system herein described is utilized in combination with television image reproducing tubes and provides for enlarging the developed image in one direction only to produce a desired aspect ratio, or where desired, the image may be enlarged in two directions with the degree of enlargement or magnification different in each direction so that the desired aspect ratio of the viewed image is realizable.

In the foregoing description it has been assumed for purpose of illustration that the original image is produced on a viewing or target area which is planar in nature. However, in practice, and especially in the manufacture of cathode ray tubes for use in television image reproducers, the end surface of the cathode ray tube upon which the image is caused to appear is usually curved so that it is convex toward an observer or toward the lens system of the magnifier. Accordingly, in order to compensate for this curvature some slight modifications in the dimensions of the described optical system may be made in practice. However, such slight changes will not introduce any new distortions, and the convex surface facing toward the lens system is such that the distortion of the magnified image, as viewed, is actually less than if the image were formed upon a planar surface. This is because of the fact that the so-called pin-cushion distortion of the image which exists to some slight extent in such a magnifier system is reduced by the convexity of the original image toward the magnifying lens and optical system. Furthermore, with regard to the permissible angle of viewing the image as it is magnified, the foreshortening of the obliquely viewed image is no greater when using the magnifying system with a convex image than when viewing the image directly and without any magnifying lens system. Furthermore, because, in practice, the original image is usually produced upon a slightly convex surface toward the image enlarger, it makes possible a

somewhat better correction of image aberrations in the optical system than would be possible in the case of the planar image.

In the specific example of one form of optical system which has herein been set forth it will be understood that the optical system is substantially corrected for spherical aberration and distortion, such as "barrel" and "pin-cushion" effects, but not to any substantial extent for chromatic aberration or coma, which are each negligible in obtaining the degree of enlargement herein suggested. However, minor modifications in design will provide such correction where it becomes necessary due to increased enlargement or for other reasons.

It will, of course, be obvious that many and various modifications in the system may be made without departing from the spirit or scope of the invention as it is herein set forth and claimed.

What I claim is:

1. A television picture enlarger comprising an object area having an aspect ratio changed from a predetermined normal aspect ratio and at least one anamorphic optical element cooperatively associated with said image area for expanding said image in one dimension for restoring said aspect ratio to a normal value for viewing.

2. A television picture enlarger comprising a cathode ray tube having a viewing target area and means to produce therein an image area having at least one dimension thereof changed from normal size and an anamorphic optical means cooperatively associated with said tube for expanding said image in one dimension only for viewing.

3. In a television system, a cathode ray image reproducing tube having a viewing target area, means to produce on the target area an electro-optical bidimensional image having at least one division thereof reduced from normal viewing proportion relative to the other dimension and an anamorphic optical means cooperatively associated with said tube for enlarging said image by expanding said image in one of said directions to a greater degree than in the other direction to produce a viewed image of predetermined aspect ratio.

4. A television picture enlarger comprising a target area and means to produce thereon an electro-optical image area having at least one dimension thereof changed from normal viewing size and an anamorphic optical means cooperatively associated with said image area for enlarging said produced image by expanding said image during enlargement in one direction greater than in another direction.

5. In a television system, an electron tube for producing a bidimensional electro-optical image, means for distorting the image in its production in one of its two directions only, and at least one anamorphic optical means positioned substantially adjacent the produced image for distorting the developed image in a sense opposite to that of first distortion.

6. In a television system, an electron tube for producing a bidimensional electro-optical image, means for reducing the size of the produced image relative to normal viewing size in its production in one of its two directions only, and an anamorphic optical means positioned adjacent the produced image for enlarging the developed image in a sense opposite to that of first distortion.

7. A television system comprising a cathode ray tube having a luminescent target area, means

for producing an electro-optical bidimensional image upon the said target area, electrical means for distorting the image in its production in one of its two dimensions, a light reflecting element adapted to be positioned at an angle of the order of 45 degrees to the plane of the luminescent target for viewing the produced image, and an anamorphic lens element interposed between the reflecting member and the luminescent target for distorting the produced electro-optical image in a sense opposite to that of its distortion in production so that an observer views the image in predetermined normal proportions.

8. A television system comprising a cathode ray tube having a luminescent target area, means for producing an electro-optical bidimensional image upon the said target area, electro-magnetic means for distorting the image in its production in one of its two dimensions, a light reflecting element adapted to be positioned at an angle of the order of 45 degrees to the plane of the luminescent target for viewing the produced image, and an anamorphic lens element interposed between the reflecting member and the luminescent target for distorting the produced electro-optical image in a sense opposite to that of its distortion in production so that an observer views the image in normal proportions.

9. A television system comprising a cathode ray tube having a luminescent target area, means for producing an electro-optical bidimensional image upon the said target area, electrical means for distorting the image in its production in one of its two dimensions, a light reflecting element adapted to be positioned at an angle of the order of 45 degrees to the plane of the luminescent target for viewing the produced image, and an anamorphic lens element interposed between the reflecting member and the luminescent target for distorting the produced electro-optical image in a sense opposite to that of its distortion in production so that an observer views the image in normal proportions.

10. A television system comprising a cathode ray tube having a luminescent target area, means for producing an electro-optical bidimensional image upon the said target area, electro-static means for distorting the image in its production in one of its two dimensions, a light reflecting element adapted to be positioned at an angle of the order of 45 degrees to the plane of the luminescent target for viewing the produced image, and an anamorphic lens element interposed between the reflecting member and the luminescent target for distorting the produced electro-optical image in a sense opposite to that of its distortion in production so that an observer views the image in normal proportions.

11. In a television system, a cathode ray tube having included therein means to develop an electron beam and a target area upon which the developed beam is adapted to impinge to produce luminous effects, means to control the intensity of the electron beam whereby the intensity of the luminous effects is varied so that an electro-optical image representation results upon the luminescent target, deflecting means for causing the produced beam to traverse the target in bidimensional patterns, means to restrict the area of beam impact upon the target to one of substantially elliptical dimensions with the major axis of the ellipse corresponding substantially to the normal height of one picture line and the minor axis of the ellipse representing a compression in image production whereby there results an electro-opti-

cal pattern compressed in one dimension, and an anamorphic optical means for expanding the produced image in its direction of distortion to produce a virtual image of the initial image of predetermined aspect ratio for viewing.

12. In a television system, a cathode ray tube having included therein means to develop an electron beam and a target area upon which the developed beam is adapted to impinge to produce luminous effects, means responsive to received signals to control the intensity of the produced electron beam whereby the intensity of the resulting luminous effects is varied so that an electro-optical image representation results upon the luminescent target, deflecting means for causing the produced beam to traverse the target in bidimensional patterns, electrode means to restrict the area of beam impact upon the target to one of substantially elliptical dimensions, said ellipse having its major axis dimension corresponding substantially to the normal height of one picture line and its minor axis representing a compression in image production whereby there results upon the tube target an electro-optical pattern compressed in one of its two dimensions, and an anamorphic optical means for expanding the produced image in its direction of compression to produce a virtual image of the initial image of predetermined aspect ratio.

13. In a television system, a cathode ray tube having included therein means to develop an electron beam and a target area upon which the developed beam is adapted to impinge to produce luminous effects, means responsive to received signals to control the intensity of the electron beam whereby the intensity of the luminous effects produced is so varied that an electro-optical image representation results upon the luminescent target, means for causing the produced beam to traverse the target in bidimensional patterns, means to restrict the area of beam impact upon the target to one of substantially elliptical dimensions, said ellipse having its major axis dimension to correspond substantially to the normal height of one picture line and its minor axis to represent a compression in image production whereby there results upon the tube target an electro-optical pattern compressed in one of its two dimensions, an anamorphic optical system for enlarging the produced image in each direction and expanding the enlargement in the direction of initial compression to a degree greater than in the other direction to produce a virtual image of the initial image of predetermined aspect ratio, and reflector means in which to view the produced virtual image.

14. In a television system, a cathode ray tube for producing an electro-optical television image, means for compressing the television image produced in one direction only to produce an image having an aspect ratio substantially less than a predetermined normal aspect ratio, a multiplicity of spaced positive optical image-forming elements of progressively decreasing powers and progressively increasing apertures in relation to their spacing from the tube to form a virtual and enlarged image of the television picture area, at least one of said optical image-forming elements being of an anamorphic character to expand the produced optical image in one direction to convert the produced picture of less than normal aspect ratio into one of predetermined increased aspect ratio for viewing by an observer.

15. In a television system, a cathode ray tube for producing an electro-optical television image,

means for compressing the television image produced in one direction only to produce an image having an aspect ratio substantially less than a predetermined normal aspect ratio, a multiplicity of spaced positive optical image-forming elements of progressively decreasing powers and progressively increasing apertures in relation to their spacing from the tube to form a virtual and enlarged image of the television picture area, at least one of said optical image-forming elements being adapted to expand the produced optical image in one direction to convert the produced picture of less than normal aspect ratio into one of predetermined increased aspect ratio for viewing by an observer, and a reflecting element interposed between the image producing tube and the observer, said reflector being inclined at substantially a 45 degree angle to the optical path of the image initially produced.

16. A television receiver system comprising a cathode ray tube having means included therein for producing an electro-optical image having a predetermined aspect ratio between image height and image width, an optical system for enlarging the said image comprising a plurality of positive sphero-cylindrical and cylindrical lenses each separated one from the other by distances substantially less than their respective focal lengths, said lenses having progressively diminishing power and progressively increasing aperture in relation to their separation from the image area on the tube so as to form an enlarged erect vertical image of the electro-optical image produced upon the tube and to expand the enlarged image in one direction of width and height greater than in the other direction of width and height so as to transform the produced electro-optical image into a vertical image having an aspect ratio different from that initially produced.

17. A television system comprising a cathode ray tube having a luminescent target and means to produce upon said target an electro-optical

bidimensional image having a predetermined distortion in one of its two directions, in combination with an anamorphic light reflecting element adapted to be positioned at a predetermined angle to the plane of the luminescent target for providing for viewing the image produced upon said target, said anamorphic light reflecting element being adapted to distort the electro-optical image viewed upon the target in a sense opposite to that of its distortion in production, so that an observer of the said image in said reflector views an image of substantially normal proportions in each of its dimensions.

18. A television picture enlarger for enlarging a real image developed upon the luminiscent target of a cathode ray tube in a manner such that the real image is compressed in one direction only from its normal dimensions so as to provide an image having an aspect ratio substantially of a value other than a predetermined normal ratio, which comprises a multiplicity of spaced positive optical image-forming elements of progressively decreasing powers and progressively increasing apertures in relation to their separation from the real image producing area to form a virtual and enlarged image of said area, at least one of said optical elements having anamorphic properties for expanding the said observed image in one of said directions to an amount greater than the expansion in a direction normal thereto so as to convert the produced image into one having the selected normal aspect ratio.

19. The television picture enlarger claimed in claim 18 wherein at least two of said plurality of lenses are positioned with their optical axes mutually perpendicular one to the other, and comprising, in addition, a substantially planar reflecting element located intermediate the said two mutually perpendicular lens elements and in a plane at approximately 45° relative to the optical axis of each of said lens elements.

ALFRED N. GOLDSMITH.