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Jan. 5, 1943. A. N. GOLDSMITH 2,307,211

TELEVISION IMAGE ENLARGING SYSTEM

Filed Nov. 30, 1940 2 Sheets-Sheet 1

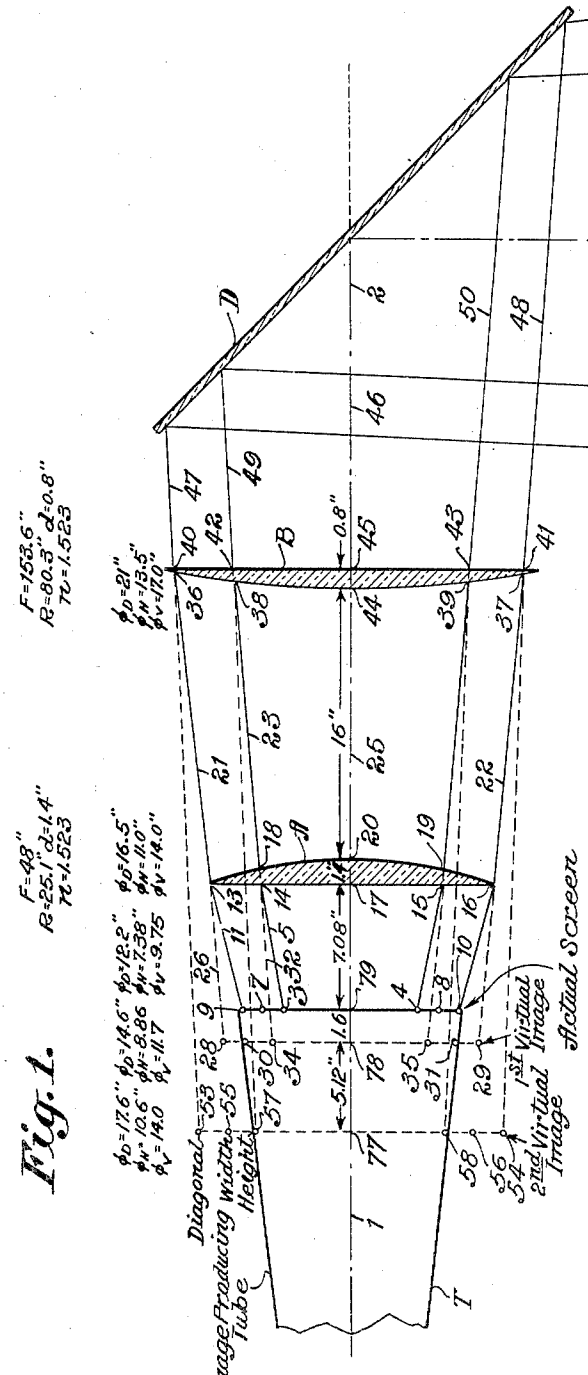


Fig. 1.

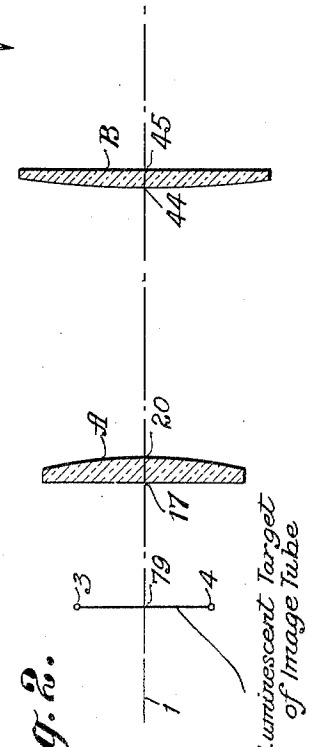


Fig. 2.

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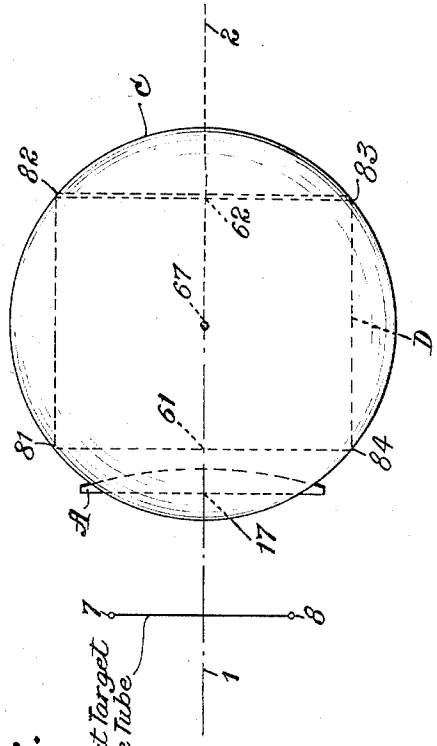


Fig. 3.

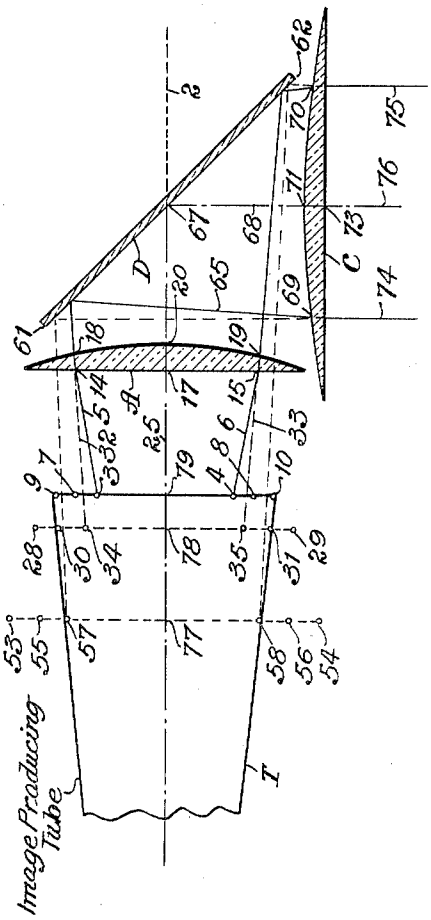


Fig. 4.

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Patented Jan. 5, 1943

2,307,211

UNITED STATES PATENT OFFICE

2,307,211

TELEVISION IMAGE ENLARGING SYSTEM

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Application November 30, 1940, Serial No. 368,098

7 Claims. (Cl. 178—7.5)

The present invention is related to image enlarging systems and finds a particular application to television systems. In such systems it is customary to produce an electro-optical replica of a scanned image on a cathode ray image reproducing tube so that the electro-optical replica results upon a luminescent target area of the cathode ray tube.

Many and various proposals have been heretofore made for enlarging television images, and these include the use of a lens element of relatively high power and large aperture arranged in cooperative relationship with the end viewing wall of a cathode ray tube and functioning customarily with a fairly high magnification of the image, and they also include other forms which are based upon the so-called Mangin mirror system and the so-called Schmidt optical camera. The resulting enlarged images are real, and inverted relative to the original image. The present invention is directed to a different form of system in that it is particularly related to the enlargement of television pictures which are already of sizeable dimensions and which require relatively limited enlargement (or magnification) to meet satisfactory requirements as to the ultimate size of the enlarged image. With the systems of the prior art it was usually customary to provide high voltage cathode ray tubes of small diameter to produce the initial image and such sizes of tubes were chosen especially in order to enable reasonably fast optical systems of high quality to be employed within at least feasible economic limits. In such systems the size of the picture to be enlarged and the speed and focal length of the enlarging lens are, of course, related to the cost of the optical system if the usual high magnification in the projection of a light image is employed, but in accordance with the presently proposed method different conditions obtain. Broadly speaking, the purpose of the present invention is largely directed to the whole picture field where a picture of moderate dimensions is to be viewed, although it is apparent that the invention is not of necessity restricted exclusively to such field. To recite a specific example, if the original picture to be enlarged is considered to be of a reasonable size—for instance, in the range between 6" and 12" in width—and the magnification ratio is to be kept reasonably moderate—for example, of the order of two or three to one or even less—it is possible to provide a relatively cheap optical system for enlargement which will have a high degree of efficiency. Furthermore, with the present invention the proposal and disclosure here made is that of producing the enlarged image as a virtual (and erect) image, which need not be projected upon any screen, but may be viewed as apparently located in space or in whatever surroundings the original picture occurs. Furthermore, the present invention is directed to an optical system wherein the heretofore experienced objections or defects of distortion and the like and of limited acceptable viewing angle have been overcome through the use of two lenses which are each of the positive type. In its preferred form the present invention comprises the use of two lenses, with the one of smaller aperture being placed relatively near the picture or object area to be enlarged and the second, of larger aperture, placed further from the original picture.

The invention also contemplates the use of reflector arrangements for varying the direction of viewing, and in its preferred form such reflectors may be placed beyond the second lens or intermediate the first lens and a second lens in a somewhat displaced relationship with respect to the first lens. The invention is also to be understood as being related to a system wherein anamorphotic television images may be appropriately enlarged, as set forth and claimed in my copending application entitled "Television systems," which has been filed concurrently herewith.

The present invention in one of its preferred forms is schematically illustrated by the several figures of drawings accompanying the specification, in which Figure 1 is a rather general schematic view and in which Figures 2 and 3 represent cross-sections of the arrangement of Figure 1, Figure 2 being a cross-section through the optical axis in a plane perpendicular to the surface of the viewing plane which intersects the original image along its height and through its center, while Figure 3 is a similar view in a plane normal to that of Figure 2 and intersecting the original image through its center and along its width, and Figure 4 illustrates schematically a modification of the general system of Figure 1 provided for viewing at an angle by means of a suitable image reflecting element. Referring now to the schematic arrangement of Figure 1, the optical axis of the system in indicated schematically as along the path 1, 2 with the object picture which is to be enlarged centered at the point 79. This object picture may be assumed as being the electro-optical image produced from the transmitted television signals as received and caused to produce luminous effects upon a target area at one end of the tube T. The height of

the produced electro-optical image, which will here be termed the picture for purposes of example, may be assumed as being between the points 3 and 4, with the width of the picture assumed as being embodied in the space between the points 7 and 8, and the diagonal of the picture will be assumed to be between the points 9 and 10. If, for instance, the picture were to be reproduced upon the luminescent target of the usual 12" type cathode ray tube, it can be appreciated the picture height as embodied between the points 3 and 4 will be approximately 7.38". The picture width, which is embodied between the points 7 and 8, will be approximately 9.75", and the picture diagonal will be approximately 12.2" (this being because the tube actually may exceed the so-called 12" diameter by some slight extent). Under some conditions, however, the picture diagonal will be less by a slight amount than that indicated between the points 9 and 10 because the picture corners are slightly rounded, and it will be seen from what is stated above that the dimensions of the picture suggested solely for purposes of illustration correspond substantially to those experienced in practice when the image is reproduced upon the usual 12" cathode ray tube as used in practice. For the purpose of enlargement two lenses A and B have been provided to constitute the optical system. On Figure 1 of the drawings there is supplied immediately above each of the lens elements A and B certain data serving to illustrate the lenses' characteristics. It will be seen, for instance, that the focal length of the lens A is assumed to be 48". The lens has its left face 13, 14, 17, 15 and 16 planar and its right face 13, 18, 20, 19 and 16 is convex with a radius of curvature of approximately 25.1" and a thickness at its center between the points 17 and 20 of 1.4". The index of refraction for the perpendicular glass or other medium chosen for the lens is assumed to be 1.523. This provides a maximum aperture for the lens element A of 16.5", which it can be seen corresponds to the diagonal of the object picture, but actually the lens may be made of appropriate rectangular cross section 14" wide and 11" high, with rounded corners homologous to those of the object picture. Considering now the image produced upon the cathode ray tube, the light rays 12, 6, 5 and 11, which emanate from the picture, after passage through the lens proceed along the paths 22; 19, 39; 23; and 21, respectively. If these rays are now extended backward it will be seen that a vertical image is formed by the lens A between the points 34, 35 and 30, 31 and 28, 29, and that this image is centered at the point 78. In accordance with the calculation and assumed dimensions of the lens A this vertical image is 8.86" high, 11.7" wide, and 14.6" along its diagonal, neglecting, of course, the curved corner cut-off produced by the lens and the initially developed picture image. The second lens element B as indicated by the data about it on Figure 1 has a focal length of 153.6". The left surface 36, 38, 44, 39, 37 of the lens element B has a radius of 80.3" and its right face 40, 42, 45 and 41 is plane. The thickness of the lens element B at its center between the points 44 and 45 is 0.8" and its index of refraction corresponds to that of lens element A. Neglecting the corner cut-off, which may be permissible in most optical systems of this nature, the lens element B has a clear aperture of 21". But it may be made of rectangular outline so as to be 12.5" high, 17.0" wide and with rounded corners homologous to those of the object picture. The distance between the object picture on the plane of the points 7, 3, 78, 4 and 8 and the first lens element A is 7.08", and the distance between the lens elements A and B as indicated between the points 20 and 44 is 16". The light rays 22; 19, 39; 23; and 21, after passage through the lens element B proceed in the directions indicated by the light paths 48, 50, 49 and 47, respectively. If now these light rays are projected backward to the final or image picture which is actually viewed, it will be seen that there is developed a vertical image centered at the point 77, and as indicated by the data above the image in the plane of the point 77, the height measured between points 57 and 58 is 10.6", the width measured between the points 55 and 56 is 14.0", and the picture diagonal measured between the points 53 and 54 and neglecting the curved corner cut-off is 17.6". In accordance with the showing of Figure 1 it will be observed that the first vertical image formed with its center at the point 78 is approximately 1.6" to the left—that is, back of or beyond the object picture centered at 79 and produced upon the end of the cathode ray image reproducing tube. The final viewed vertical image which is centered at the point 77 shows approximately 7.2" beyond the original object picture formed upon the end of the cathode ray image reproducing tube. It thus appears to an observer that the final viewed image which is centered at point 77 lies 32" beyond the focal surface 40, 45, 43, 41 of the lens element B and is of dimensions which represent approximately an enlargement of 1.4 diameters. In some respects it will be noticed that the optical arrangement of the lenses A and B seems to resemble at least superficialy those of the well known Ramsden eye piece, which has heretofore been used for viewing small images produced in microscopes and the like for moderate enlargement and with an acceptable angle of viewing as well as a non-critical position of the eye pupil. However, the prior art arrangements have been so constituted that the dimensions and arrangements have been such as to permit only a single person to view with one eye the enlarged microscopic picture, but with the presently disclosed system the circumstances are quite otherwise, because in the first place a large image is further enlarged and in the second place the apertures of the lens elements A and B vastly exceed the pupil of the eye, and still further the system is so constituted that the image produced on the end of the cathode ray tube T when viewed from the right of the lens element B is so enlarged that a substantial number of people may view the enlarged vertical image without difficulty and with both eyes. It is of course, obvious that the exact focal lengths and positions of the lens elements A and B hereinabove described in connection with Figure 1 may be modified to a substantial extent without departing from the spirit and scope of the invention, and therefore it is to be understood that while exact calculated dimensions have been set forth in these specifications for the purpose of illustration, this has only been done to describe fully one form of practical system. In certain modifications of the invention the lens elements A and B may be bent to a slight extent, which is, for instance, provided by changing these lenses from the plano-convex type to the concavo-convex or the convexo-concave forms to provide for further corrections of optical aberrations of the resulting image. The dimensions of the lenses hereinabove described are

based primarily upon an assumed viewing audience for the picture produced upon the end wall target of the cathode ray image reproducing tube with the audience typically seated so that, for instance, in the first row of lookers there would be two persons seated 28" apart and at a distance from the viewing image of approximately 64". In the second row of lookers there are assumed to be three persons each 42" apart so as to avoid viewing obstacles, and at a distance of 105" from the virtual viewing image. While it is readily apparent that the image produced on the end wall of the cathode ray tube T and situated above the point 79 may be viewed directly from the right of and in front of the lens element B, it is, of course, obvious in accordance with the teachings of Zworykin United States Patent No. 1,870,702 that an inclined mirror arrangement may be positioned to the right of the lens element B so as to intercept the bundle of rays included within the limit of the rays 47 and 48, so as to enable lookers to view the optical image from one side. Under such circumstances the optical axis 1, 2 may be vertical or slightly inclined, as disclosed by the aforesaid Zworkyin patent, so as to enable the cathode ray tube to be supported vertically or slightly inclined within the cabinet of a receiver. In another modification, as illustrated by Figure 4, further compactness of the structure may be provided by interposing a reflecting surface D between the lens elements A and B so that the light rays emerging from the lens A are caused to impinge upon the reflector D and to be reflected therefrom toward an observer positioned at approximately 90 degrees from the optical axis 1, 2. This provides for tilting the reflecting surface at an angle of approximately 45 degrees relative to the optical axis 1, 2. In the arrangement of Figure 1 where the reflecting element is shown as positioned to receive the light rays emerging to the right of the lens element B, it is, of course, apparent that the rays will be bent along a path conventionally represented as 65, while the other light rays will be bent along paths conventionally represented as 68 and 70. In the modified arrangement of Figure 4, the lens element B is moved from its position between the points 40 and 41, as in Figure 1, to a new position between the points 72 and 73, and such lens element has been indicated for illustrative purposes as the element C in Figure 4. Under such circumstances, it is again desirable that the optical axis 1, 2 be approximately vertical with respect to the television receiver cabinet so that the reflected axis 67, 76 will be approximately horizontal for convenient viewing. The apparently reduced dimension 69, 70 of the lens C as compared to the lens B of Figure 1, with which it is actually identical, is due to the fact that only the height of the picture need be taken care of in the direction 69, 70, since the lens aperture in this direction is capable of the reduction indicated without detriment to viewing. Under most circumstances the arrangement of Figure 4 is most convenient for use in practice. In Figures 2 and 3 there has been illustrated schematically the lens arrangement of Figures 1 and 4 combined and assumed to be turned at 90 degrees so as to provide the cross sections which would be observed in Figures 1 and 4 in a plane through the center of the object picture parallel to its height. In Figure 3 the cross section is in a plane through the center of the object picture but parallel to its width, and the lens element C as illustrated in outline in Figure 3 by the numeral 80 represents the maximum necessary dimension of the lens element B when it is shifted to the position shown by Figure 4. In the case where the reflecting element indicated by the boundary points 81, 82, 83 and 84 is interposed between the first and second lens elements, in the arrangements shown by Figures 2 and 3, no attempt has been made to illustrate the complete receiver arrangement because of the fact that these showings are merely additional views of the arrangements more completely disclosed by Figures 1 and 4.

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 for enlarging a real image developed upon the luminescent target of a cathode ray tube comprising a multiplicity of spaced positive lenses 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 the said area.

2. A television picture enlarger for enlarging a real image developed upon the luminescent target of a cathode ray tube comprising a multiplicity of spaced positive lenses of progressively decreasing powers and progressively increasing apertures in relation to their separation from the real image producing area, at least two of said plurality of lenses being positioned with their axes mutually perpendicular one to the other, and 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, so that an observer may view in the optical system a virtual and enlarged image of said real image.

3. A television picture enlarger comprising a cathode ray image reproducing tube for producing upon the luminescent target area thereof a real optical image, a multiplicity of spaced positive lenses positioned in predetermined spaced relationship relative to the said target area of said tube, said lenses being of progressively decreasing powers and progressively increasing apertures in relation to their separation from the target area to form a virtual and enlarged image of the said target area, the spacing between the lens elements from each other and from the target area of the tube being substantially less than the respective focal lengths of the lenses.

4. The combination claimed in claim 3 comprising, in addition, a reflecting element intermediate at least two of the lens elements and positioned in a plane at approximately 45 degrees relative to the optical axis of the first lens element, the apertures of said lenses being greater than any linear dimension of the target area.

5. The combination claimed in claim 3 comprising, in addition, a planar reflecting element positioned at approximately 45 degrees to the optical axis of the lens system.

6. A television picture enlarger comprising a cathode ray tube for reproducing an electro-optical image upon a target area thereof, a first positive lens element of predetermined power and predetermined aperture positioned to receive the light emerging from the target area of said tube along a direction substantially normal to the plane of the target area, a reflecting element positioned to receive the light emerging from said

lens element said reflecting element being positioned in a plane substantially 45 degrees to the optical axis of said lens element, a second positive lens element positioned in a plane substantially 90 degrees to the plane of the first lens element and arranged to receive the light reflected from said reflecting element, said second lens element having an aperture greater than that of the first lens element, said second lens element being spaced from the first lens element along an optical path which is substantially less than the focal length of the said second lens element.

7. A television picture enlarger comprising in combination a cathode ray image reproducing tube having a substantially convex luminescent target area upon which a real, electro-optical image is adapted to be produced, a multiplicity of spaced positive lens elements positioned adjacent the luminescent target area of said tube and with predetermined spacing therefrom, said lens elements being of progressively decreasing powers and of progressively increasing apertures in relation to their spacing from the said target area, with the spacing between the successive lens elements of the multiplicity being such that the space between the tube target and the first lens element, and the first lens element and the second lens element, is each substantially less than the respective focal length of the lens elements.

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