

March 9, 1948.

M. CAWEIN
TELEVISION IMAGE TUBE

2,437,418

Filed May 11, 1945

2 Sheets-Sheet 1

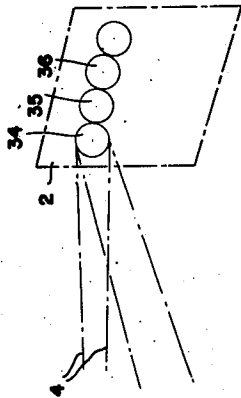


FIG. 2

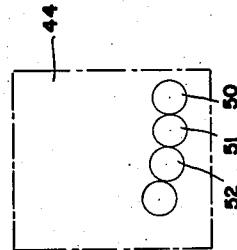


FIG. 6

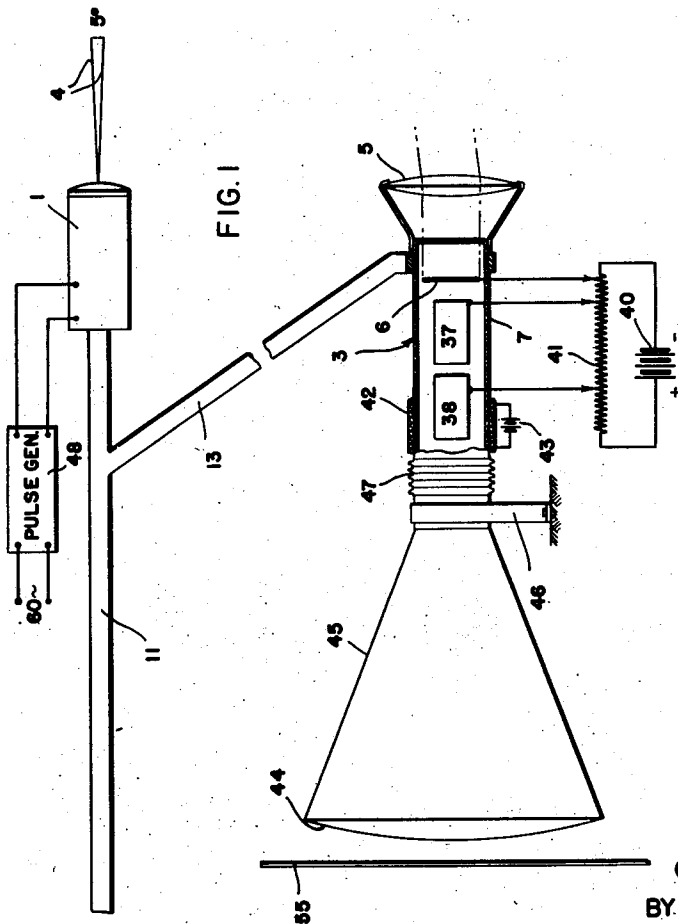


FIG. 1

INVENTOR
MADISON CAWEIN

BY *Edwin C. Martin*

ATTORNEY

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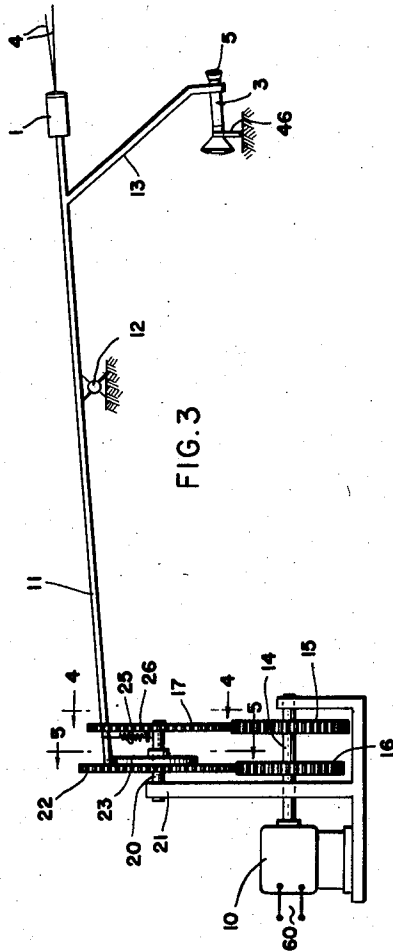


FIG. 3

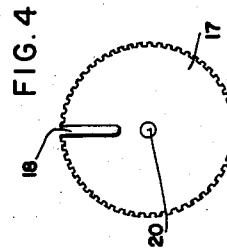


FIG. 4

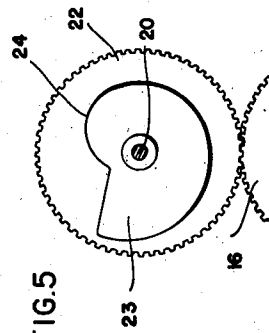


FIG. 5

INVENTOR
MADISON CAWEIN

BY

ATTORNEY

UNITED STATES PATENT OFFICE

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TELEVISION IMAGE TUBE

Madison Cawein, Fort Wayne, Ind., assignor, by
 mesne assignments, to Farnsworth Research
 Corporation, a corporation of Indiana

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10 Claims. (Cl. 178—6.8)

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This invention relates to a television system, and particularly relates to a television system for and method of reproducing a distant object.

It is frequently desired to reproduce an image of a distant object during total darkness or when insufficient illumination is available to reproduce the object in television fashion. Such conditions arise, for instance, when it is desired to televise outdoor games during periods of low light levels, such as during the late afternoon. The television system of the invention has also utility for spotting aircraft or detecting ships at night or at a distance during periods of daylight. In these cases it is necessary to illuminate the object to be reproduced with a light spot generated, for instance, by a search light. For practical reasons the angle of view which can be covered with a search light beam is not much larger than approximately 5 degrees. This is caused mainly by the fact that it is not possible to concentrate sufficient light over a wide angle of view. Thus, when it is desired to reproduce an image of an object having a larger angle of view than the illuminating light beam, the light beam has to scan the object to successively illuminate the entire area of the object. An image of the object is then reconstructed from the light reflected from the object.

It is an object of the present invention, therefore, to provide a television system where a distant object is illuminated with a comparatively narrow angle light beam and reproduced by utilizing narrow angle optical means cooperating with an image tube to derive a visible image representative of the object and composed of adjacent extended image areas.

Another object of the invention is to provide a system arranged for reproducing an image of a distant object which is insufficiently illuminated by intermittently projecting a light beam upon individual overlapping object areas to reconstruct an image of the object comprising extended overlapping image areas.

A further object of the invention is to reproduce an image of a distant object during total darkness by a television system that is very simple and does not require electronic scanning, while revealing the fine structure of the object.

In accordance with the present invention, there is provided a television system for reproducing an image of an object comprising means for generating a beam of light and for projecting it upon the object. An image tube comprising a photosensitive member is associated with optical means arranged for projecting the light reflected by the

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object upon the photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by the light beam. Common means are provided for moving the light beam, the image tube and the optical means in unison to sweep the object with the light beam in accordance with cyclically recurring scanning patterns and to direct at each instant the optical means towards the illuminated object area. Means are further provided for developing a light image on a screen, the light image being composed of extended adjacent image areas whereby each image area is representative of an instantaneous electron image.

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

In the accompanying drawings:

Fig. 1 is a schematic representation of a television system including a light source and an image tube in accordance with the invention;

Fig. 2 is a schematic view in perspective of a distant object illuminated by the light source and reproduced by the image tube of Fig. 1;

Fig. 3 is a schematic side elevational view of an apparatus for moving the light source and image tube illustrated in Fig. 1 in accordance with a predetermined scanning pattern;

Fig. 4 is a front elevational view taken on line 4—4 of Fig. 3 and illustrating a slotted gear;

Fig. 5 is a front elevational view taken on line 5—5 of Fig. 3 and illustrating a cam and associated gears; and

Fig. 6 is a front elevational view of the luminescent screen of the image tube of Fig. 1.

Referring now more particularly to Figs. 1 and 2 of the drawings, there is shown a television system including light source 1 arranged to project a beam of light upon a distant object, schematically indicated at 2, and image tube 3 arranged for reproducing object 2. Light source 1 generates light beam 4 subtending an angle of approximately 5 degrees which is substantially smaller than the angle of view of the entire area of object 2. Preferably, light source 1 generates infra-red light which may be within the wave length range of 8,000 to 10,000 Angstrom units. Optical means, such as lens system 5, is provided for projecting the reflected light of beam 4 onto translucent photosensitive member or photocathode 6 arranged in envelope 7 of image tube 3. Photocathode 6 may consist of a translucent pho-

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to sensitive layer arranged on the inner surface of envelope 7 instead of an electrode, as shown in Fig. 1. Lens system 5 is rigidly connected to envelope 7 as indicated. The angle of view of optical system 5 may substantially equal the angle subtended by light beam 4. Image tube 3 develops a visible image of object 2 in a manner to be explained hereinafter.

In view of the fact that the area of object 2 is appreciably larger than the cross-sectional area of light beam 4, light source 1 is arranged to scan object 2 in accordance with cyclically recurring scanning patterns to successively illuminate all portions of object 2. In order to move light source 1 as well as image tube 3 in accordance with a predetermined scanning pattern, there is provided apparatus illustrated in Figs. 3 to 5. For the purpose of controlling light beam 4 to scan object 2, there is provided electric motor 10 which may be a synchronous motor connected to a 60 cycle power source as indicated.

Electric motor 10 is arranged to move lever 11 as well as lever 13 in accordance with a spiral scanning pattern. Lever 11 is pivoted in ball and socket joint 12 and has one end secured to light source 1. Lever 13 has one end rigidly connected to lever 11 and its other end secured to envelope 7 of image tube 3. Electric motor 10 is arranged to drive shaft 14 having secured thereto gears 15 and 16. Gear 15 engages gear 17, shown particularly in Fig. 4. Gear 17 is provided with radial slot 18 through which the free end of lever 11 extends. Slotted gear 17 is secured to shaft 20 journaled in bearing 21. Gear 16 meshes with gear 22 having secured thereto cam 23, shown particularly in Fig. 5. Gear 22 and cam 23 have a sliding fit on shaft 20 so that gear 22 may be driven at a different rate than gear 17. Lever 11 is urged into engagement with control surface 24 of cam 23 by spring 25 secured to lever 11 and to pin 26 on gear 17.

The arrangement illustrated in Figs. 3 to 5 operates as follows. Gear 15 driven by motor 10 drives slotted gear 17 so that the free end of lever 11 extending through slot 18 is rotated about ball and socket joint 12 acting as a pivot. When gear 22 driven by gear 16 rotates at the same speed as slotted gear 17, the free end of lever 11 will always be in engagement with the same point of control surface 24 on cam 23 so that the free end of lever 11 follows a circular path. However, assuming that cam 23 has a relative rotation with respect to gear 17, cam 23 will move relatively with respect to slot 18 in gear 17. Thus, the free end of lever 11 will be moved up and down in slot 18 depending upon the shape of control surface 24 and its relative rotation with respect to gear 17.

By suitably shaping control surface 24 of cam 23 and determining the relative rotation of gear 22 with respect to gear 17, the free end of lever 11 may be made to move through a predetermined spiral path. It will be obvious that light source 1 will repeat the spiral movement of the free end of lever 11. Envelope 7 of image tube 3, being rigidly connected to lever 11 by the intermediary of lever 13, carries out the same movement as light source 1. Thus, light source 1 and image tube 3 may be made to scan object 2, for example, in accordance with a spiral scanning pattern or it may be made to move along horizontal lines, as is conventional in the television art. Preferably, the apparatus of Fig. 3 is arranged to be moved in unison so that light source

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1 may be directed towards any object such as 2.

If at any instant lever 11 is arranged parallel to shaft 20, light beam 4 will describe a circle on object 2 which has a diameter determined by the distance of lever 11 from shaft 20. When object 2 is arranged at a distance from light source 1, light beam 4 will cover an appreciable area of object 2 and thus light beam 4 will produce a spot of light on object 2 which rotates in itself. This effect, however, can not be observed. Assuming now that lever 11 forms an angle with shaft 20, light beam 4 will describe a circle or actually, in view of the varying position of cam 23, a spiral on object 2. Image tube 5 exactly follows the movements of light source 1 and hence image tube 5 will be directed at any instant at the same spot on object 2 as is light source 1.

Light source 1 and image tube 3 are aligned so that optical system 5 secured to image tube 3 focuses at any instant the light of beam 4 reflected from object 2 onto photocathode 6.

Since the angles subtended by light source 1 and optical system 5 are the same, an optical image is formed on photocathode 6 which may, for instance, correspond to area 34 of object 2. After a certain time interval, light beam 4 has moved to illuminate area 35 on object 2 and hence an optical image of object area 35 appears on photocathode 6. After another interval of time, light beam 4 will illuminate object area 36, an image of which then appears upon photocathode 6, and so on.

Image tube 3 serves for developing electron images representative of the optical images projected upon translucent photocathode 6 and for transforming the electron images into visible images. To this end first anode 37 and second anode 38 are arranged in envelope 7 for accelerating the electron images, each being composed of photoelectrons liberated from translucent cathode 6 by the action of the light projected thereon. A suitable source of potential such, for example, as battery 40 connected across potentiometer 41 is provided for supplying operating potentials to cathode 6 and anodes 37, 38 by means of suitable taps. Anode 37 may, for instance, be supplied with a potential of approximately 150 volts positive against that of cathode 6, while anode 38 may be maintained at a potential at approximately 1000 volts positive with respect to cathode 6. Focusing coil 42 energized, for example, through battery 43 is arranged for focusing the electron images upon luminescent screen 44, arranged opposite cathode 6 in envelope 45 forming an extension of envelope 7. Conical envelope 45 is fixedly supported by means of clamp 46, while portion 7 is moved in unison with light source 1. Bellows 47 provides a flexible connection between envelope portion 7 and conical envelope 45.

Light beam 4 illuminates successive object areas, such as 34, 35 and 36, and is preferably interrupted by pulse generator 48 in synchronism with the scanning pattern. Hence, pulse generator 48 may be connected to the same 60 cycle power source as is motor 10 for synchronizing pulse generator 48 with motor 10. Light source 1 may, for instance, be interrupted periodically by pulse generator 48 in such a manner that light beam 4 intermittently illuminates adjacent or overlapping object areas, such as 34, 35 and 36. Preferably, the rate of interruption is such that the illuminated object areas overlap. By interrupting light beam 4 periodically a greater light

intensity may be obtained, because a larger current may be passed through light source 1 when the current is interrupted than when the current flows continuously. This is particularly important if light source 1 projects infra-red light.

Let it be assumed that light beam 4 scans object 2 in accordance with a spiral scanning pattern, as described in connection with Figs. 3 to 5. In that case the scanning rate may be assumed to be one revolution in one-half second and four revolutions for scanning the entire area of object 2 which, therefore, requires two seconds. Assuming that light beam 4 has a cross-sectional area of 5 degrees, while the angle of view of the entire area of object 2 is 30 degrees. In that case thirty-six adjacent object areas, such as 34, 35 and 36, will cover the entire area of object 2. If light beam 4 intermittently illuminates overlapping object areas we may have, for example, sixty overlapping object areas which cover the entire area of object 2. Hence, during each time interval of two seconds there should be sixty light pulses so that pulse generator 48 interrupts light source 1 at intervals of $\frac{1}{30}$ second. Accordingly, during each revolution of light beam 4 across object 2 there will be fifteen light pulses. Gear 17, illustrated in Fig. 3, thus should be rotated at a speed of two revolutions per second or hundred twenty revolutions per minute. On the other hand, cam 23 should be rotated by gears 16 and 22 at the rate of thirty revolutions per minute relatively to gear 17, that is either at 150 or at 90 revolutions per minute.

The light reflected, for instance, from object area 34 is projected upon photocathode 6 to develop an electron image. If light beam 4 consists of infra-red light, translucent photosensitive cathode 6 should be predominantly responsive to infra-red light. The electron image thus developed is accelerated and focused upon luminescent screen 44 through the action of anodes 37 and 38 and focusing coil 42. Thus, the light image focused on luminescent screen 44 is greatly intensified due to the acceleration of the photoelectrons.

Focusing coil 42 is arranged so that the electron image is focused at a predetermined point with respect to moving envelope 7. When envelope 7 moves in unison with optical system 5 and light source 1, the point of focus of the electron image will be shifted with respect to stationary luminescent screen 44 to follow the same scanning pattern as that formed on object 2 by light beam 4. In this manner a light image is developed on screen 44 which is composed of extended adjacent image areas which will overlap when light beam 4 is interrupted so that it covers less than its own width before the next light flash is projected on object 2. The persistence time of luminescent screen 44 should, preferably, match or equal the time of one complete scanning period so that all the partial images representative of all object areas can be seen simultaneously. If object 2 is scanned once in two seconds, as explained hereinabove, the persistence time of luminescent screen 44 should be two seconds. Each area of the light image developed on screen 44 will reveal substantially all the detail of the object area illuminated by light beam 4.

The image seen on luminescent screen 44 is illustrated in Fig. 6. As indicated schematically, the image is composed of individual image areas 50, 51, 52, and so forth, corresponding to object areas 34, 35 and 36. These image areas may overlap, as explained hereinabove, although

they have been shown as adjacent areas to avoid confusion. Thus, an intense light image is obtained on screen 44 of a distant object 2 even during total darkness with a visible or invisible light beam. It will be observed that the image reproduced on screen 44 is reversed with respect to the original object. However, a true image may be obtained therefrom by means of lenses or mirrors, as is well known in the art.

It is also feasible to connect screen 44 rigidly to envelope 7 so that screen 44 moves in unison with light source 1 and image tube 3. In that case each object area, such as 34, 35 and 36, appears at the same spot on screen 44. The thus obtained individual image areas are all projected in different directions in accordance with the scanning motion of light source 1 and image tube 3. Thus, the image areas may be projected on another stationary screen, such as indicated at 55 spaced from screen 44, to build up a picture of the object composed of individual image areas in the manner explained hereinabove. Screen 44 should have a short persistence time so that each image area has disappeared when the next image is projected thereon.

It is to be understood that light source 1 may also be arranged stationary while light beam 4 is scanned across object 2 by means of a moving mirror system or another suitable optical system as is conventional.

While there has been described what is at present 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 it is, therefore, 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. A television system for reproducing an image of an object comprising means for generating a light beam and for projecting it upon said object, an image tube comprising a photosensitive member, optical means for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, a screen, and means for developing a light image on said screen composed of extended adjacent image areas, each being representative of an instantaneous electron image.

2. A television system for reproducing an image of an object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said op-

tical means towards said illuminated area, a screen, and means for developing a light image on said screen composed of extended adjacent image areas, each being representative of an instantaneous electron image.

3. A television system for reproducing an image of an object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, means for periodically interrupting said light beam in synchronism with said scanning pattern to impulsively illuminate adjacent overlapping object areas, a screen, and means for developing a light image on said screen composed of extended overlapping image areas, each being representative of an instantaneous electron image.

4. A television system for reproducing an image of an object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, a stationary target, and means for focusing said electron image upon said target, thereby to develop an image on said target that is composed of image areas representative of said object.

5. A television system for reproducing an image of an object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, a stationary target, means for focusing said electron image upon said target, and means for accelerating said electron image towards said target thereby to develop an amplified image on said target that

is composed of image areas representative of said object.

6. A television system for reproducing an image of an object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, means for periodically interrupting said light beam in synchronism with said scanning patterns, a stationary target, and means for focusing said electron image upon said target, thereby to develop an image on said target that is composed of image areas representative of said object.

7. A television system for reproducing an image of a distant object comprising means for generating a beam of infra-red light subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, means for periodically interrupting said light beam in synchronism with said scanning pattern to impulsively illuminate adjacent overlapping object areas, a stationary target, and means for focusing said electron image upon said target, thereby to develop an image on said target that is composed of overlapping extended image areas representative of said object.

8. A television system for reproducing an image of a distant object comprising means for generating a light beam subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, a stationary luminescent screen having a persistence time that substantially equals the time required for one scanning cycle, and means for focusing said electron image upon said screen, thereby to develop

an image on said screen that is composed of image areas representative of said object.

9. A television system for reproducing an image of a distant object comprising means for generating a beam of infra-red light subtending an angle smaller than the angle of view of the area of said object and for projecting it upon said object, an image tube comprising a photosensitive member, optical means associated with said tube and subtending substantially the same angle as said light beam for projecting the light reflected by said object upon said photosensitive member to develop an electron image representative of the brightness values of the area of the object illuminated by said beam, common means for moving said light beam, said image tube and said optical means in unison to sweep said object with said light beam in accordance with cyclically recurring scanning patterns and to direct at each instant said optical means towards said illuminated area, means for periodically interrupting said light beam in synchronism with said scanning pattern to impulsively illuminate adjacent overlapping object areas, a stationary luminescent screen having a persistence time that substantially equals the time required for one scanning cycle, and means for focusing said electron image upon said screen, thereby to develop an image on said screen that is composed of overlapping ex-

tended image areas representative of said object.

10. In a television system for reproducing an image of an object, an image tube comprising a photosensitive member, a first envelope portion surrounding and supporting said member, means for projecting an optical image of said object upon said photosensitive member to develop an electron image, means for moving said first envelope portion to scan said object, a screen forming part of said image tube, a second envelope portion surrounding and supporting said screen, means for keeping said second envelope portion stationary, a flexible air tight connection between said envelope portions, and means for focusing said electron image upon said screen, thereby to develop an image on said screen that is representative of said object.

MADISON CAWEIN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,725,710	Hammond	Aug. 20, 1929
1,781,799	Baird	Nov. 18, 1930
1,936,514	Lengnick	Nov. 21, 1933
2,270,232	Rosenthal	Jan. 20, 1942