June 20, 1939. S. L. CLOTHIER ET AL 2,163,540

METHOD OF AND APPARATUS FOR TELEVISION SCANNING

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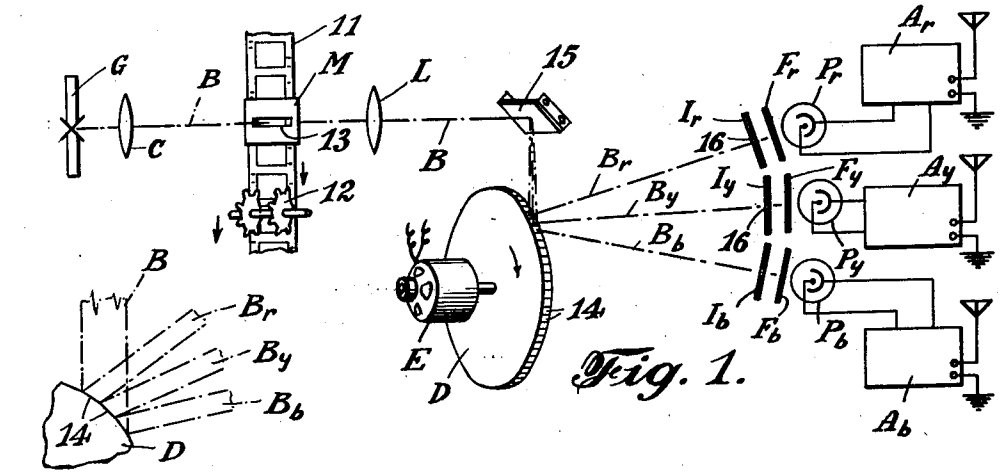
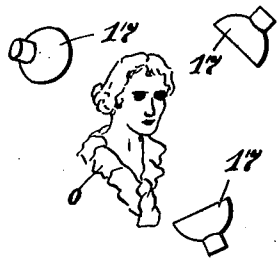


Fig. 1.

Fig. 2.



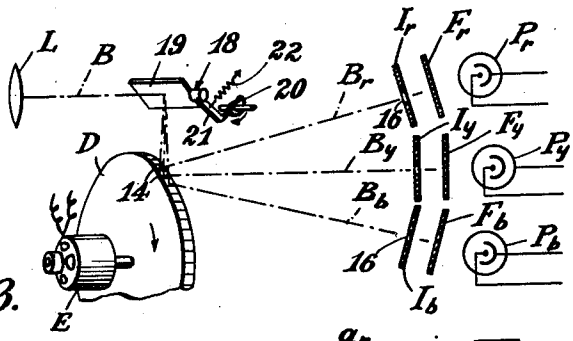


Fig. 3.

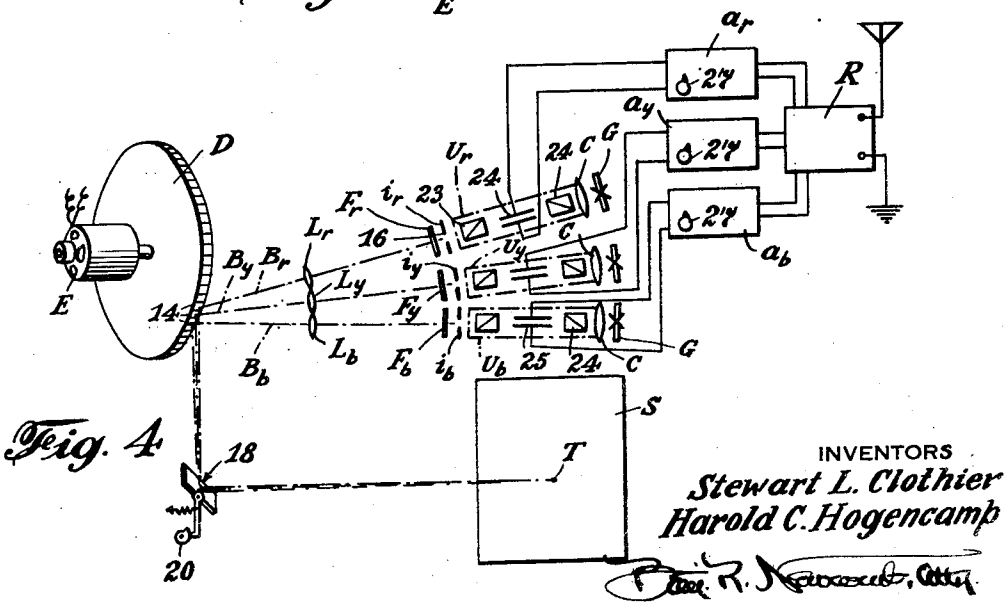


Fig. 4.

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METHOD OF AND APPARATUS FOR TELEVISION SCANNING

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12 Claims. (Cl. 178—5.2)

This invention relates to methods of and apparatus for television scanning and more particularly to television transmission and reception of colored images.

Heretofore the successful transmission and reception of television signals in natural color has been attended by the use of extremely complicated apparatus which has been difficult to adjust and to maintain in satisfactory operating condition.

Accordingly one object of the present invention is to provide new and simplified methods and apparatus for exciting a plurality of photocells simultaneously with light impulses from the illuminated image or object.

A second object of the invention is to provide a new and improved method for exciting each of the photocells with a light beam of predetermined color.

A further object of the invention is to provide new and improved means for combining the respective colored beams at the television receiver so as to produce a single point of light of the desired color on the screen.

Further objects and advantages will become readiy apparent to those skilled in the art from the following description and the accompanying drawing which discloses apparatus embodying features of the invention.

In the drawing:

Fig. 1 is a diagrammatic view of a television film-scanning and transmitting apparatus operating according to the present invention.

Fig. 2 is a fragmentary view of the scanning disc showing in diagrammatic form the manner in which a beam of light is separated into a plurality of beams.

Fig. 3 is a diagrammatic view of a television scanning apparatus operating according to the present invention.

Fig. 4 is a diagrammatic view of a television receiving apparatus adapted to produce colored images on a screen.

In the drawing, like reference characters will be used to designate similar parts throughout the several views. Referring again to the drawing, and more particularly to Figs. 1 and 2, one form of apparatus embodying features of the invention comprises a concentrated light source G, as for example, an electric arc or incandescent filament. A film 11, which is to be scanned, is spaced from the light source G and is moved longitudinally in the direction indicated by an arrow at a continuous speed by means of sprockets or other similar means 12. If the apparatus is to be used for the transmission of colored images, the film 11 must be finished in color. Longitudinal or frame scanning of the film 11 is produced by means of the feeding motion of the film past a mask M which is provided with a transversely disposed slot 13 sufficiently long to cover the entire width of each frame. Means, such as a condensing lens, or prism C is provided to direct light from the source G into a single concentrated ribbon or beam of light B of sufficient size onto the slot 13 of the mask M. The single concentrated ribbon or beam of light B passes through the slot 13 and through the film 11 and is intercepted by a scanning disc D, provided with a plurality of scanning elements 14, arbitrarily shown in Fig. 1 as peripherally positioned mirrors. Each of the reflecting surfaces 14 is identical and each of said surfaces is in identical angular relation to the axis of the disc D. The disc D is positioned so as to scan at right angles to the direction of scanning produced by the longitudinal motion of the film with respect to the slotted mask M. The disc D is rotated, preferably at a high rate of speed, in the direction indicated by the arrow, as by an electric motor or other prime mover E. If desired the disc D may be made to rotate about a vertical axis so as to intercept the horizontal portion of the beam B directly; preferably, however, the disc D is rotated about a horizontal axis and the beam B is deflected onto its periphery by a suitably positioned stationary mirror 15, which is preferably of the first-surface type.

A plurality of aperture plates I_r, I_y, and I_b are disposed in equal spaced relation to the radius of the disc D, and are positioned so as to have formed thereon an image of a portion of the film 11, properly focused by means of a lens L adjustably situated between the mask M and the mirror 15. Three aperture plates are shown in the drawing, the images upon which are formed by the beam B reflected from three adjoining reflecting surfaces 14 on the periphery of the disc D. More or less aperture plates may be used, but it is to be understood that the beam of light B must be of sufficient cross section to span an equivalent number of reflecting surfaces on the disc D as indicated in Fig. 2. Throughout the description, the term "beam" will be used to designate a converging, diverging, or parallel collection of light rays. Each of the respective aperture plates is provided with a relatively small aperture or opening 16 through which light may pass. A corresponding plurality of photocells P_r, P_y, and P_b are positioned behind the respective aperture plates I_r, I_y, and I_b so as to receive light passing

through the openings 16. When it is desired to employ the apparatus for the transmission of colored television pictures, a color filter is interposed preferably between each aperture plate and its corresponding photocell. These filters are preferably of transparent sheet material stained so as to pass only the desired color and to exclude from the photocells rays of predetermined colors. Any desired combination of color filters may be employed, but we prefer to employ filters F_r, F_y, and F_b capable of passing red, yellow, and blue rays respectively. For most efficient operation of the apparatus in the transmission of colored images, each respective photocell is especially sensitive to the particular color of light which falls upon it. For example, with a source G of substantially pure white light and a filter F_r capable of excluding light other than red, it is particularly desirable that the photocell P_r be especially sensitive to light rays in the red region of the spectrum. The electrical impulses from the photocells are amplified by the respective amplifiers A_r, A_y, and A_b, after which the signals may be sent to the receiving station in any conventional manner as by means of separate conductors, by the use of separate radio frequency transmitters operating at different frequencies, or by a single transmitter of proper design. In Fig. 1, separate radio frequency transmitters are diagrammatically shown associated with the amplifiers.

In the operation of the device shown in Fig. 1, the condensing lens C is adjusted so as to form single concentrated beam or ribbon of light at the slotted mask M for passage through the film. The mirror 15 and the lens L are then adjusted with respect to one another so that identical images of a portion of the film appear on each of the aperture plates I_r, I_y, and I_b. The lens C may then be readjusted so as to form an image of the crater or light source G on or near the periphery of the disc D. The respective aperture plates are then adjustably positioned so that the openings 16 are located on identical spots of each image. The sprockets 12 are then rotated so as to feed the film 11 longitudinally, producing frame or longitudinal scanning. The disc D is then set in motion by means of motor E so that linear scanning takes place at right angles to the longitudinal scanning. Since the beam or ribbon of light B reflected from the mirror 15 is of sufficient cross section to cover three reflecting surfaces 14 of the disc D, portions of the beam will be reflected from the disc D as three separate beams B_r, B_y, and B_b as seen in Fig. 2, which beams are then imposed upon the aperture plates. With the proper filter positioned behind each of the aperture plates, each photocell will be excited by the light passing through the filter and the image will be divided into its respective color components, the impulses from which are then separately transmitted by the respective photocells.

If desired, the arrangement of Fig. 1 may be used to transmit television signals of black and white film. In this event the respective filters F_r, F_y, and F_b are removed from behind the respective aperture plates so that each photocell receives a beam of white light through the respective opening 16. In this event, the photocells may be connected in parallel and the impulses amplified with a single amplifier. According to this method a plurality of reflecting surfaces are employed simultaneously and greater light efficiency from the scanning disc is obtained over that obtainable with a single reflecting surface and a single photocell.

In Fig. 3 of the drawing a slightly modified form of the invention is shown. In this arrangement an object O is illuminated with intense white light such as may be provided by a plurality of flood lamps 17 positioned so as to concentrate their rays upon the object. Light reflected from the illuminated object is concentrated by lens L into a single light beam, which beam is directed onto a first scanner 18 and subsequently to a second scanner comprising a disc D, both of which scanners are positioned so as to scan in mutually perpendicular directions. The first scanner may be of any conventional design such as a rotating prism having mirrored or other reflecting surfaces, or an oscillograph mirror actuated by any desired shape of wave form. Preferably, however, we employ an oscillatory mirror 19 operated by means of a cam 20 rotating in the direction indicated by an arrow. A cam follower 21 is secured in operative relation to the mirror 19 and is constantly urged against the cam by means of a spring 22. The scanner 18 and the disc D may be constructed according to an arrangement shown in our copending application Serial No. 50,316 filed November 18, 1935. The beam B formed by the lens L is reflected from the mirror scanner 18 upon a plurality of mutually adjacent reflecting surfaces 14 on the disc D. The beam B is dimensioned so as to cover two or more of the reflecting surfaces 14 on the disc D, and is divided by these surfaces into a plurality of separate beams B_r, B_y, and B_b equal in number to the number of reflecting surfaces covered. A plurality of aperture plates I_r, I_y, and I_b are spaced from the disc D at equal distances from the respective reflecting surfaces, the plates being arranged so as to be normal to the respective separate beams B_r, B_y, and B_b. Identical images of the scanned object O are formed on the surfaces of the respective aperture plates by proper manipulation of the scanner 18, the disc D, and the lens L. Each aperture plate is provided with an opening 16 of relatively small size so as to permit passage therethrough of elemental areas of the separate images. A plurality of photocells P_r, P_y, and P_b are disposed behind the respective aperture plates so as to be excited by the separate beams passing through the openings 16. When it is desired to employ this form of operation for the transmission and reception of objects in color, filters F_r, F_y, and F_b are interposed at a convenient point between the photocells and the disc D and serve to exclude from the respective photocells, light of predetermined colors. If desired, these filters may be placed in front of the respective aperture plates rather than as shown, between the plates and the photocells.

The operation of the arrangement shown in Fig. 3 coincides very closely with that shown in Fig. 1. Light of high intensity is reflected from the object to be scanned and is formed or concentrated into a single beam by the lens L, which beam is intercepted successively by the first scanner 18 and the disc D operated so as to scan in mutually perpendicular directions. Preferably, the cam 20 is rotated and operates through the action of the cam follower 21 to oscillate the mirror 19 at constant angular velocity in one direction. When the cam reaches the point of maximum stroke the mirror is caused to fly back substantially instantaneously by means of the

pressure exerted by the spring 22, and by virtue of the shape of the cam.

The beam B is passed from the first scanner to the effective portion of the disc D, which in the present case constitutes the periphery, provided with the plurality of reflecting surfaces 14, each of these reflecting surfaces being identical and in identical angular relation to the axis of the disc. The beam B is dimensioned so as to cover as many of the reflecting surfaces 14 as is desired, the beam B being broken up into an equivalent number of separate beams B_r, B_y, and B_b reflected by the three consecutive reflecting surfaces. As previously described, the aperture plates I_r, I_y, and I_b are adjusted transversely so that the openings 16 coincide with an identical spot on the respective images formed on the plates. This last adjustment is preferably made with a still object, and with both scanners at rest. When both scanners are set in motion every portion of the image formed thereon, successively covers the opening 16 of each aperture plate, identical points being exposed simultaneously to the respective photocells P_r, P_y, and P_b. The filters F_r, F_y, and F_b serve to exclude undesirable colors from the respective photocells. The impulses from each photocell may be subsequently amplified in any convenient manner, for example, according to the manner disclosed in Fig. 1. If the color filters are omitted, the respective photocell terminal connections may be connected in parallel for subsequent amplification by a single amplifier.

In Fig. 4 of the drawing is shown a television receiving apparatus diagrammatically illustrating one manner in which signals may be received from an apparatus operating according to the disclosure of Fig. 1 or 3 so as to reproduce the image on a screen, and if desired, in its original color. If the electrical television impulses are sent by means of a radio frequency transmitter, use is made of a radio frequency receiver R having suitable antenna and ground connections. After the signals from the respective photocells have been detected, they are amplified by means of separate amplifiers a_r, a_y, and a_b according to the arrangement diagrammatically shown in Fig. 4. Each amplifier may be provided with a volume control 27 for adjusting the amplification of the impulses. A plurality of light-modulating units U_r, U_y, and U_b are positioned in spaced relation to a scanning disc D, which disc may be of a design identical with that used in the transmitting equipment. The respective light modulators may be of any convenient design, as for example, of a type employing a pair of Nicol prisms 23 and 24 between which a Kerr cell 25 is interposed. The terminal connections of each Kerr cell in the respective light-modulating units U_r, U_y, and U_b connect respectively with the output terminals of the amplifiers a_r, a_y, and a_b as indicated. Each light-modulating unit is provided with a source of intense white light such as an arc G. A condensing lens C is interposed between each light source and its respective light-modulating unit so as to concentrate the light rays into a pencil or beam of light. The light beam emanating from each of the light-modulating units first passes through the respective aperture plates i_r, i_y, and i_b, each of which is provided with an opening 16. Color filters F_r, F_y, and F_b are interposed in any desired place between the light source G and the disc D, and preferably on the side of the aperture plates closest to the disc D. If desired, the respective color filters may be positioned adjacent to each light source G. A plurality of projection lenses L_r, L_y, and L_b are adjustably disposed between the respective light-modulating units U_r, U_y, and U_b, and the disc D, in the path of the respective beams B_r, B_y, and B_b, so as to slightly converge the rays directed upon the disc D. An oscillatory or other suitable scanner 18 is positioned with respect to the disc D as indicated in Fig. 4 so as to scan in a direction perpendicular to that produced by the scanning disc D. The operation of the scanner 18 is identical with that shown in Fig. 3 and is operative through the action of cam 20 to produce vertical scanning of the screen S. The cam 20 is rotated by any convenient means at a speed preferably between 16 and 30 revolutions per second and in synchronism with the corresponding scanner at the transmitting station. A motor E of any conventional design rotates the disc D at a speed synchronized with the corresponding disc at the transmitting station.

In the operation of the device shown in Fig. 4, the light-modulating units U_r, U_y, and U_b are angularly positioned, in equal spaced relation to the periphery of the disc D so that the respective rays B_r, B_y, and B_b emanating therefrom fall upon three consecutive light reflecting surfaces 14, and are reflected upon the scanner 18. By means of proper adjustment between the lenses L_r, L_y, and L_b, and by proper positioning of the scanning disc D and the scanner 18, the three separate beams B_r, B_y, and B_b are focused while the scanners are at rest so as to produce an image of the illuminated aperture 16 of the respective aperture plates i_r, i_y, and i_b, in superposed relation as a single point T upon the screen S. The condensing lenses C are then adjusted so that an image of the light source G, or crater of each arc, is produced on or closely adjacent to the respective reflecting surfaces 14, formed on the periphery of the disc D. If the apparatus shown in Fig. 4 is intended to be used for the reproduction of images in color, the respective color filters are interposed between the light source G and the disc D so as to produce beams B_r, B_y, and B_b preferably having the respective characteristic colors of red, yellow and blue. It is understood, however, that other combinations of color filters may be used, but that in any case they must cooperate with those employed in the transmitting station to produce the desired color on the screen S. The respective volume controls 27 may be adjusted separately so as to regulate each color value and to combine them properly to produce the desired shade and color tone. With the foregoing adjustments properly made and the scanners D and 18 set in motion the single point T will successively cover every portion of the screen S and will be modulated both as regards intensity and color, so as to reproduce on the screen, a colored image of the object scanned.

By way of example, let it be assumed that at any one instant, a point on the image scanned has the characteristic color of orange. In the transmitter operating according to the form shown in either Fig. 1 or Fig. 3, only the photocells P_r and P_y, sensitive respectively to red and yellow, are excited. Accordingly, the electrical impulses from the cells are amplified by the amplifiers A_r and A_y after which they are transmitted to the receiving station, for example, over separate radio frequency channels. After the signals are detected by the receiver R, they are

amplified by the respective amplifiers a_r and a_y sufficiently to modulate the Kerr cells **25** in the light-modulating units U_r and U_y, and to permit passage therethrough of a red and yellow beam respectively. Since the beams are focused coincidently upon the screen S, the colors combine to produce an orange colored point on the screen to coincide with the point scanned on the object.

If desired, one or more of the filters may be removed, and the device operated to produce black and white images toned with one or more colors. Otherwise, the connections of one or more of the light-modulating units may be joined to different amplifiers so as to produce colors on the screen differing from those scanned at the transmitter. Obviously all of the filters may be omitted and the plurality of light-modulating units employed in cooperation with a plurality of reflecting surfaces on the scanning disc to increase the light intensity of the point T over that obtainable with a single light-modulating unit and a single reflecting surface. In this event, a single amplifier may be employed at both the transmitter and receiver for connection with the photocells and light-modulating units respectively.

It is obvious that other modified structures will immediately suggest themselves to one skilled in the art in view of the foregoing disclosure and it is to be understood that the arrangements herein disclosed are not to be construed in a limited sense as we contemplate any structure properly within the scope of the appended claims.

We claim:

1. In a television scanning apparatus, an optical system gathering light from a televised subject and concentrating the light into a beam forming an image of the subject in a desired plane, line scanning means interposed in the light path intermediate the optical system and image plane dividing the light beam into a plurality of beams each producing an image in a plane equally distant from said line scanning means, means in the image planes selecting identical elemental areas of the several images, means individually and simultaneously converting the light impulses of said elemental areas into electrical impulses, and means whereby the images in the image plane are moved in a direction substantially normal to the motion of the images produced by the aforesaid scanning means.

2. In a television scanning apparatus, an optical system gathering light from a televised subject and concentrating the light into a beam forming an image of the subject in a desired plane, line scanning means interposed in the light path intermediate the optical system and image plane dividing the light beam into a plurality of beams each producing an image in a plane equally distant from said line scanning means, means in the image planes selecting identical elemental areas of the several images, means individually and simultaneously converting the light impulses of said elemental areas into electrical impulses representing a selected color for each image, and means whereby the images in the image plane are moved in a direction substantially normal to the motion of the images produced by the aforesaid scanning means.

3. In a television scanning apparatus, an optical system gathering light from a televised subject and concentrating the light into a beam forming an image of the subject in a desired plane, line scanning means interposed in the light path intermediate the optical system and image plane dividing the light beam into a plurality of beams each producing an image in a plane equally distant from said line scanning means, means in the image planes selecting identical elemental areas of the several images, means individually and simultaneously converting the light impulses of said elemental areas into electrical impulses representing a selected primary color for each image, and means whereby the images in the image plane are moved in a direction substantially normal to the motion of the images produced by the aforesaid scanning means.

4. Apparatus for scanning motion picture film which comprises a light source, means for projecting a single light beam through the film to be scanned, light scanning means dividing the light beam into a plurality of beams each producing an image in a plane equally distant from said line scanning means and for simultaneously moving the several beams to effect scanning in one dimension, means for continuously moving the film to effect scanning in a direction normal to the first direction of scanning, means for selecting identical elemental areas of the several images in the image planes, and means for then individually and simultaneously converting the said identical elemental areas into electrical impulses.

5. Apparatus as claimed in claim 4 including means whereby the identical elemental areas are converted into electrical impulses representing a different selected color for each image.

6. In combination, a plurality of light sources, a like plurality of light modulators including plates having substantially identical apertures, a screen, optical means for imaging said apertures on said screen, a mirror drum line scanner having substantially identical reflecting surfaces about its periphery, each in identical angular relation to its adjacent surfaces, a frame scanner, means for imparting motion to the line scanner and to the frame scanner, the whole combination being so positioned and arranged that light from adjacent apertures is directed on respectively adjacent mirror drum surfaces, the separation of the apertures and the divergence angles of the surfaces cooperating to cause the plurality of aperture images to coincide and be superimposed upon the screen.

7. Apparatus as claimed in claim 6 including a color filter interposed in the path of at least one of the light beams.

8. Television scanning apparatus comprising a plurality of light sources, a screen, individual optical means for concentrating light from each of said sources into a beam forming a scanning spot of elemental area on said screen, a rotating line scanning member comprising a plurality of identical plane reflecting surfaces in identical angular relation about its periphery, and a frame scanner operating to scan in a direction normal to the direction of line scanning, said light sources, optical means and line scanning member being so positioned and arranged that the plurality of light beams simultaneously cooperate with a like plurality of the identical reflecting surfaces, each beam cooperating with a different surface, in such manner that the plurality of scanning spots are coincidently superimposed upon the screen, and maintain this relation during the entire process of scanning.

9. Apparatus as claimed in claim 8 including means for individually modulating each of said beams in accordance with electrical fluctuations.

10. Apparatus as claimed in claim 8 wherein a

color filter is interposed in the path of at least one of the light beams.

11. Television apparatus including means gathering light from a televised subject and concentrating said light into a beam, a single line scanning means dividing the light beam into a plurality of beams each producing an identical image of the subject and simultaneously moving said images to effect line scanning, means in the image planes selecting identical elemental areas of the several images, means individually and simultaneously converting the light impulses of said elemental areas into electrical impulses and means whereby the images in the image plane are moved in a direction substantially normal to the motion of the images produced by the aforesaid line scanning means to effect frame scanning.

12. Television apparatus comprising a transmitter including means gathering light from a televised subject and concentrating said light into a beam, a single line scanning means dividing the light beam into a plurality of beams each producing an identical image of the subject and simultaneously moving said images to effect line scanning, means in the image planes selecting identical elemental areas of the several images, means individually and simultaneously converting the light impulses of said elemental areas into electrical impulses, and means whereby the images in the image plane are moved in a direction substantially normal to the motion of the images produced by the aforesaid line scanning means to effect frame scanning, and a cooperative receiver including light means modulated in accordance with the electrical impulses of the transmitter, a field of view, and means translating said modulated light into a visible reproduction of the televised subject.

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