METHOD AND APPARATUS FOR TELEVISION COMMUNICATION

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METHOD AND APPARATUS FOR TELEVISION COMMUNICATION

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2 Claims. (Cl. 178—7.2)

Our invention relates to improvements in methods and apparatus for television communication, and particularly to cathode-ray projection tubes for television reception and cathode-ray tubes for television transmission.

In television communication employing at the receiving station a cathode-ray tube having a fluorescent screen which is scanned by a ray of electrons, it has been proposed to make the construction and the various electrical conditions such that the fluorescent image be sufficiently brilliant for projection onto a larger, external screen. It has been found, however, that on account of the characteristics of the fluorescent screen, these tubes have definite limitations as to the brilliancy and sharpness of the image which can be produced for projection. For example, when operating at the relatively high intensities required, the fluorescent materials used heretofore no longer have a linear modulation characteristic. Furthermore, some screen materials which are purely fluorescent at moderate intensities become phosphorescent and even incandescent at the higher intensities of electron bombardment. These effects or characteristics result in pronounced blurring of the image, for the reason that at any elemental area of the screen, the period of time elapsing during excitation of the fluorescent material and decay to the point of extinction or invisibility, is substantially greater than the frame or field scanning period which is necessary to avoid flicker.

Development work along this line has accordingly centered on a construction for the screen whereby a more brilliant image can be obtained. One such construction comprises a thin sheet of metal which is maintained at red heat by current from an external source. In operation, as the ray of electrons is deflected to cause the screen to be scanned, any particular point is raised from red heat to higher values up to intense incandescence, depending upon the ray intensity. However, in these screens the period of decay is far in excess of that allowable if any particular point is to return from relatively intense incandescence to red heat within the frame or field period necessary to avoid flicker. Furthermore, on account of the relatively high coefficient of heat-conductivity of these screens, the heat of bright points flows in all directions to equalize the temperature, thereby causing adjacent points to become brighter than perhaps they should be, for good detail.

Another such construction is disclosed in Patent No. 2,097,594, issued November 2, 1937, to Harry E. Bamford, and comprises an incandescent screen composed of a plurality of closely mounted helices of very fine tungsten wire having their axes parallel, and normal to the plane of the screen. In operation, the impact of the ray of electrons on the screen raises the elemental areas thereof to incandescence at the point of contact, the degree of incandescence at any one point being proportional to the intensity of the electron ray directed at such point at the instant. In these screens, however, there is also the detrimental time lag, as in the others.

In order to avoid flicker, the frame frequency should be at least sixteen, and is preferably at least twenty-four. This means that in order to realize the desired operating action in screens of the character referred to, the decay period, whether it is one of radiation or one of conduction, must be no greater than one twenty-fourth of a second for good detail. Where interlaced scanning is employed, the field frequency may be as high as sixty, in which case the decay period must be no greater than one-sixtieth of a second if any degree of detail is to be obtained. Even at a frame frequency of sixteen, there would be blurring in the prior screens referred to on account of the time lag, and at a frame frequency of twenty-four, or at the high field frequency of sixty, these screens, if useful at all, would only be so for a still picture. Furthermore, in the screen construction proposed heretofore, selection of screen materials has necessarily been limited to those having a period of decay or a time lag sufficiently
low for a given frame or field frequency to avoid excessive blurring, so that use of more likely materials, such as phosphorescent or incandescent materials having a decay period many times the frame or field frequency, has not been possible.

With the foregoing in mind, an object of our invention resides in the provision of an improved method and apparatus for television communication whereby there is available at the receiver a sharply defined light source, modulated in accordance with the light intensity of the corresponding element of a still or moving image to be reproduced, and which has a substantially higher intensity than it is possible to obtain with the prior methods and constructions.

Another object of our invention resides in the provision of an improved construction of cathode-ray tube for television transmission which has advantages over those proposed heretofore in the way of greater efficiency and better operating action.

Other objects and advantages will hereinafter appear.

For the purpose of illustrating our invention, an embodiment thereof is shown in the drawings, wherein

Figure 1 is a simplified, diagrammatic view, partly in section, of a television receiving system constructed and operating in accordance with our invention;

Figure 2 is an elevational view partly in section, the section being taken on the line 2—2 in Figure 1;

Figure 3 is a view similar to Figure 2, showing a modification;

Figure 4 is an enlarged, diagrammatic view, partly in section, of a television transmitting system constructed and operating in accordance with our invention;

Figure 5 is an enlarged, detail, elevational view, taken on the line 5—5 in Figure 4;

Figure 6 is an enlarged sectional view, taken on the line 6—6 in Figure 5;

Figure 7 is a view similar to Figure 4, showing a modification;

Figure 8 is a view similar to Figure 1, showing a modification;

Figure 9 is a detail, elevational view, taken on the line 9—9 in Figure 8;

Figure 10 is an elevational view partly in section, the section being taken on the line 10—10 in Figure 8; and

Figure 11 is a schematic diagram illustrative of the operating action in Figure 8.

In Figure 1 of the drawings, the reference numeral 10 designates a cathode-ray tube provided with an electron gun 11 of any suitable, conventional construction, for developing a ray 12 of electrons directed at the effective surface of the screen structure which is in the form of a drum 13, rotatably mounted in the tube. For this purpose, the drum 13 is fixed on a spindle 14 having a bearing at each end thereof in the wall of the tube, as shown. If desired, jewels may be used for these bearings. The effective cylindrical surface of the drum may be composed of any suitable fluorescent, phosphorescent, or incandescent material.

The drum 13 is rotated in the clockwise direction and at a uniform rate by a motor 15, the driving connection being effected by flux linkage between arms 16 of magnetic material fixed on the spindle 14 and a complementary, permanent or electromagnet 17 which is rotated by the motor.

A set of electrostatic deflecting plates 18 operates to deflect the ray 12 in one dimension only, and in a plane parallel to the axis of rotation of the drum 13. However, the ray 12 may be deflected electromagnetically, if desired, and a second set of deflecting plates 20 or other deflection means may be employed for vertical positioning of the ray.

In operation, deflection of the ray 12 in the one dimension effects line scanning, and movement of the screen surface in the direction transverse to this dimension effects frame scanning. With picture signals applied to the control electrode or grid 18 of the electron gun to modulate the ray intensity in accordance with the lights and shadows of the respective elemental areas of the image at the transmitter, a like and brilliant image is produced at the receiving end.

This image or series of images of course moves with the screen surface. The moving images are projected by a lens system 21 to a large external screen 22, the beam of light producing the large images being first reflected from the mirror drum 23, which effectively arrests the vertical motion of the large image.

Assuming that the frame frequency is to be twenty-four, the drum 22 can have twenty-four mirrors and be rotated at a constant rate of sixty revolutions per minute, so that twenty-four mirrors pass a given point at the periphery in one second. The diameter of the screen drum 13 in such case will be such that with this drum being rotated at a constant rate of sixty revolutions per minute, the screen surface may be composed of twenty-four frame areas which are scanned by the ray 12 and presented to the lens system 20 in succession and at the rate of twenty-four per second. From this it will be seen that repeated scanning of any one elementary line of the screen structure takes place only after an elapsed period of one second, which is far in excess of the time lag or decay period which the screen material might have. In our improved method and apparatus, therefore, there is always ample time for the screen material to decay from intense brightness to extinction before it moves around to be scanned again. If interlaced scanning is to be used, and the field frequency is to be sixty, with each of the drums being rotated at a constant rate of sixty revolutions per minute as before, the mirror drum 22 could have sixty mirrors and the diameter of the screen drum 13 could be such that the screen surface could be composed of sixty frame areas which would be scanned by the ray 12 and presented to the lens system 20 in succession and at the rate of sixty per second. Other figures and speeds can be used to obtain these same or other frame or field speeds.

The diameter of the screen-drum 13 is not critical. However, its peripheral speed, the frame frequency and the image size on the screen-drum surface are directly related. For example, having the desired size of the images at the screen-drum known, it is possible to fix the peripheral speed at a value determined by the product of
the frame frequency and the height of one screen-drum image.

The operating action may be analyzed in the following manner. With both the screen-drum 13 and the mirror or frame-drum 23 stationary, the result on the large screen 23 will be only a single, stationary, horizontal line. With the screen-drum 13 rotating and the mirror-drum stationary, the result is a series of images moving vertically downward on the large screen 23, and with the mirror-drum 23 rotating, the result is a series of images moving horizontally to the right. However, with the mirror-drum rotating at the proper speed and in the right direction, the vertical movement of the image series will be immobilized to cause the moving images to stand still on the screen 23 and the action of the subject to be reproduced.

In normal operation, if the screen-drum is run more slowly, the picture will remain on the projection screen, but it will be collapsed in height. If the screen-drum is rotated too fast, the picture will be stretched out in height, but it will remain fixed on the projection screen.

As shown in Fig. 3, in lieu of the magnetic flux coupling between the motor 16 and the spindle 14, one end of the latter may pass through the wall of the evacuated tube through a gasket, at which point there is a conical section 20 which is held seated in the gasket bearing by the atmospheric pressure. The use of such driving means is made possible by the slow speeds of rotation required.

From the foregoing it will be seen that in our improved method and apparatus, it is possible to use, for the screen, materials such as phosphorescent or incandescent materials, which, though more dextrous, could not be used in the prior methods and constructions on account of their relatively high time lag or decay period.

In our improved construction, furthermore, the greatest possible efficiency is obtained because of the fact that the image is taken from the same side of the screen surface which is scanned by the ray 12. Also, on account of the arrangement and operating action, there is no keystone and no variation in focus of the ray on the screen surface.

In cases where it is desired to use certain types of interlaced scanning, it may be desirable to cause a small amount of intermittent deflection of the ray 12 in a direction at right angles to the line-scanning dimension, in which case a second set of electrostatic plates or electromagnetic deflection coils may be used for this deflection.

In the transmitting system shown in Fig. 4, except for the following the construction and action is the same as in Figs. 1 and 2. The drum 13a, corresponding to the drum 13 in Fig. 1, is provided with a mosaic, photosensitive surface. A light image of the object 21, after reflection from the mirror drum 23a, is projected by the lens system 21a onto the photosensitive surface of the drum 13a. A collector electrode, which may be in the form of a metal plate 26 provided with a slot 29 as shown in Figs. 5 and 6, is supported close to the drum surface at the region thereof bombarded by the electrons of the ray 12a. The arrangement and size of the slot 29 being such that during normal operation the electrons of the ray can pass freely through the electrode 26 to the drum surface.

With the drum 13a rotating in the counterclockwise direction at the desired uniform rate, and with the mirror-drum 23a rotating at the proper speed and in the right direction according to the same principle in Fig. 1, there will be produced on the surface of the drum 13a a succession of complete, electron images of the object 21, each comprised of photoelectric charges corresponding respectively to the lights and shadows at the corresponding elemental areas of the object 27. Then, if desired, remain on the photoelectric surface for an appreciable time, which might be a period greater than that for one revolution of the drum 13a. There is therefore no loss in efficiency while any part of the drum surface rotates from light-image position to the position at the slot 26 of the collector electrode. As each elemental line 30 of the photoelectric surface of drum 13a moves across the slot 26, it is scanned by the ray 12a which is being deflected at line-scanning frequency by the plates 18a. Electrons of secondary emission, represented by the arrows 31, are thereby released, and in intensity of the respective photoelectric charges along the line 30 being scanned at the instant. On account of the close proximity of the electrode 26 to the drum surface, an appreciable percentage of the secondary emission 31 may be collected by this electrode and fed by the connection 26 to an amplifier and transmitter circuit, as shown. The current in the return circuit of the electrode 26 will consist of a certain direct-current component modulated by the video signals. The electrode 26 need be only slightly positive with respect to the adjacent photosensitive surface in order to collect the desired secondary electrons.

Since the electron path is relatively short, the output impedance of the collector electrode 26 is low as compared to such impedance in the various constructions and methods previously heretofore. This is advantageous where a wide band of frequencies is to be used, and results in a better signal-to-noise ratio.

After any line 30 passes beyond the collector electrode 26, there may still be some electron charges remaining on the mosaic surface, the purpose of removing such remaining charges, an erasing electrode 33 is employed. This electrode is supported close to the mosaic surface, and may be, for example, at about one hundred volts positive with respect to such surface. The mosaic surface, therefore, proceeds from the erasing electrode 33 to the re-exposure position in an uncharged and uniformly light-sensitive condition. Shading effects are thus eliminated.

In the transmitting system shown in Fig. 7, the object is in the form of a moving picture film 34 moved at a uniform rate in front of a mask 35 provided with a slit aperture 36. The rate of linear movement of the film may be the same as the peripheral speed of the drum 13a provided the lens 11b is arranged to give one to one image size, and this rate is determined by the desired frame frequency, as will be well understood. In operation, as the film moves at constant speed past the slit aperture 36, an image of this slit is projected onto the mosaic, photoelectric surface of the drum 13a, producing photoelectric charges thereon in accordance with the light and shade conditions along the respective linear element of the film. The operating action, otherwise, is the same as in Figs. 4, 5 and 6.
In Figs. 4 and 7, the ray may be positioned with respect to the slot 29 by the plates 2 a.

In the receiving system shown in Fig. 8, there is no mirror-drum as in Fig. 1, and a difference in the construction shown in Fig. 3 resides in the fact that the screen-drum 13 b is rotated intermittently by the motor 15 b through a Geneva gear mechanism 37 of any suitable, conventional construction. Also, in Fig. 8 a shutter 38 of a conventional construction is used, and is disposed between the lens system 21 b and the external screen 23 b. Both sets of deflecting plates are used in Fig. 8, so that the ray 12 b is deflected simultaneously at the line-scanning frequency and at the frame frequency to scan a frame area of the drum surface.

In operation, while the screen-drum 13 b remains stationary, a complete picture is scanned onto one frame area of its surface. At the end of one complete picture-scan, the screen-drum is rapidly moved, in the direction indicated by the arrow, a selected distance such that the scanned picture is in the field of the projection lens. During this movement of the screen-drum, the shutter 38 covers the projection surface of the lens. At the end of the intermittent movement, the drum 13 b is again stationary, and the shutter will have reached a position to permit passage of the beam to produce an enlarged image of the picture on the external, viewing screen 23 b. This image is projected for a period during which a second picture is being scanned onto a different and succeeding frame area of the stationary screen-drum.

If desirable, to eliminate flicker, the shutter 38 may be provided with a second blade, as shown in Fig. 9, and operated as in a motion picture projector, to quickly cover and uncover the picture while it remains motionless.

When the second picture has been completed, the drum 13 b is again moved and the above described action is repeated.

If 24 pictures are to be produced each second, the design of the Geneva gear mechanism 37 could be such as to cause the drum 13 b to remain stationary for about \( \frac{1}{4} \) of a second, and to be moved to its new position during the next \( \frac{1}{4} \) of a second, making a total time cycle of \( \frac{1}{2} \) of a second. Such operating action is illustrated in Fig. 11.

It will be understood that the shutter 38 may be driven, through suitable gearing, by the motor 15 b.

It is of course preferable to have the screen drum constructed with a minimum of weight and low movement of inertia to facilitate its intermittent motion without excessive driving power requirements.

In Fig. 7 the intermittent drive shown in Fig. 10 might be used, in which case a standard motion picture projector, with intermittent film movement and associated shutter, would be employed, and the two intermittent movements would be synchronized so that the drum and film would be stationary during the same periods. Likewise in Fig. 4 the mirror-drum could be omitted, and an intermittent and shutter employed as in Fig. 8.

It will be understood that various modifications, within the conception of those skilled in the art, are possible without departing from the spirit of our invention or the scope of the claims.

This application is a division of our prior application, Serial No. 195,939, filed March 15, 1938, now Patent No. 2,268,523, December 30, 1941.

We claim as our invention:

1. In a cathode-ray device for television transmission, a tube, screen structure in the form of a drum rotatably supported in said tube and having a photosensitive operating surface, means for developing a ray of electrons directed at said surface, means for deflecting said ray, an electrode supported in proximity to said surface at the region thereof bombarded by the electrons of said ray, and a connection from said electrode to a point exterior of said tube.

2. In a cathode-ray device for television transmission, a tube, photosensitive screen structure in the form of a drum rotatably supported in said tube, means for developing a ray of electrons directed at the effective surface of said screen structure, means for deflecting said ray, means for imparting rotary movement to said drum to cause said surface to be scanned by said ray, and means including a mirror drum for projecting a series of images of the view for transmission on said moving screen surface.

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