Aug. 19, 1941. J. C. WILSON 2,253,312

TELEVISION SIGNAL-REPRODUCING SYSTEM

Filed March 2, 1939

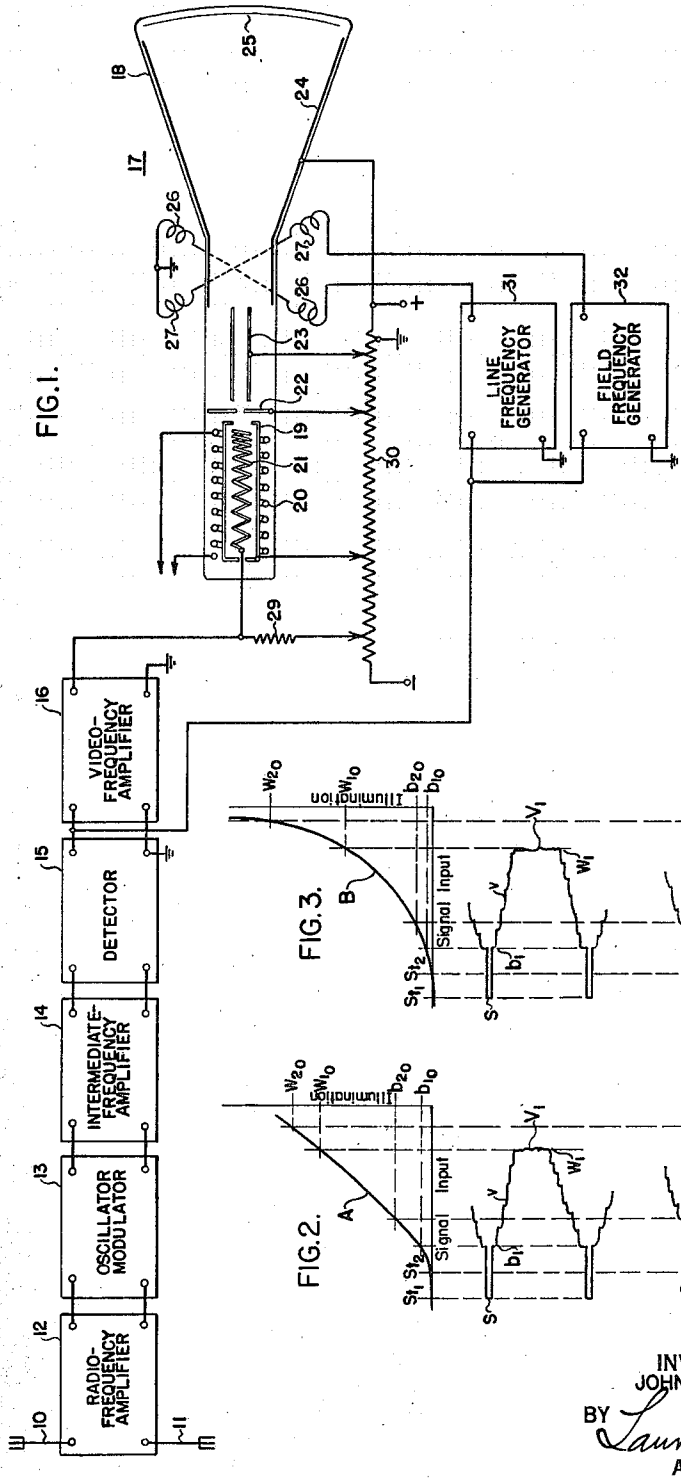


FIG. 1.

FIG. 3.

FIG. 2.

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Patented Aug. 19, 1941 2,253,312

UNITED STATES PATENT OFFICE

2,253,312

TELEVISION SIGNAL-REPRODUCING SYSTEM

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Application March 2, 1939, Serial No. 259,380

4 Claims. (Cl. 178—7.5)

This invention relates to television signal-reproducing systems and especially to such systems by means of which images may be faithfully reproduced irrespective of certain operating conditions tending to impair the fidelity of reproduction.

In accordance with present television practice, a transmitted signal comprises a carrier wave, modulated during successive intervals or trace periods by video-frequency and unidirectional components representative of variations in illumination of successive incremental areas of an image being transmitted and of its average background illumination, respectively. Between the trace periods, that is, during retrace intervals, the carrier wave has a predetermined amplitude level referred to as a blanking level and corresponding to a given shade, usually black, and is modulated during a part of this retrace period by synchronizing-signal components which correspond to initiations of successive lines and fields in the scanning of the image.

At the receiver, a beam is so deflected as to scan and illuminate a target or screen in a series of fields of parallel lines. The synchronizing-signal components of the received signal are separated from the other modulation-signal components and utilized to control the scanning apparatus of the receiver so as to synchronize its operation with that of similar apparatus utilized at the transmitter in developing the signal. The intensity of the beam is controlled by the light-modulation components, thereby to reconstruct the image.

Since the eye of an observer is responsive primarily to contrasts or ratios between illumination values rather than absolute value of any given shade of illumination of an object, such as black, it is important that the extreme values of illumination in the reproduced image corresponding to signal components representing white and black in the transmitted image have a constant ratio under all operating conditions. That is, the contrast ratio of the reproduced image should be maintained constant for a given amplitude of a signal to be reproduced irrespective of variations in the signal level corresponding to such given shade value.

To this end it is attempted in conventional television receiving systems so to control the system that the modulation signal is stabilized with respect to a particular shade value or level, such as the blanking level. More particularly, it is attempted so to control the system that a given signal level or amplitude corresponding to black, or any predetermined shade value, is effectively held fixed with respect to the signal-input brightness characteristic of the reproducing device of the system, in order that signal components representing any other given shade will at all times appear as the same shade in the reproduced image. However, due to various operating conditions, for example, variations in the average signal amplitude which are not compensated for, or to failure of the stabilizing circuits completely to fulfill their function, the signal level corresponding to black as applied to the reproducing device frequently is not maintained at a fixed value. Under these conditions, therefore, and in view of the fact that conventional television reproducing systems have either linear or logarithmic signal-input brightness characteristics, the contrast ratio tends to vary, thereby impairing the fidelity of reproduction. In general, the system should be controlled so that the light gradations or shades from black to white, represented by the various light-modulation components, are all faithfully represented in the reconstructed image, a given light gradation being represented by a constant contrast ratio under all operating conditions.

It is an object of the present invention, therefore, to provide an improved television signal-reproducing system whereby the contrast ratio for a given signal-input amplitude is maintained constant under all operating conditions.

In accordance with a feature of the present invention, there is provided a television signal-reproducing system which comprises signal-reproducing means together with means for developing and applying to the reproducing means a signal having an amplitude level related to black which is substantially fixed and having an amplitude level corresponding to black which varies in accordance with operating conditions in the system, which variations tend to effect undesired variations of the contrast ratio of a reproduced signal of a given amplitude. There are further provided means included in said reproducing means for imparting to the reproducing means an exponential signal-input brightness characteristic over the operating range of said sytem effective to provide a substantially constant contrast ratio for a reproduced signal of a given amplitude irrespective of the black-level variations.

Also in accordance with a feature of the invention, there is provided, in a television signal-reproducing system, a cathode-ray television signal-reproducing tube including an electron gun

for developing, accelerating and focusing an electron beam, a fluorescent target in the path of the beam, and a helical signal-input electrode included in the gun and having a nonuniform pitch providing an exponential signal-input-brightness characteristic for the tube.

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

In the accompanying drawing, Fig. 1 is a circuit diagram, partially schematic, of a television receiver including a signal-reproducing system embodying the present invention, while Figs. 2 and 3 are curves illustrating certain characteristics of the receiver of Fig. 1.

Referring now more particularly to Fig. 1 of the drawing, the system illustrated comprises a receiver of the superheterodyne type including an antenna system 10, 11 connected to a radio-frequency amplifier 12, to which there are connected in cascade, in the order named, an oscillator-modulator 13, an intermediate-frequency amplifier 14, a detector 15, a video-frequency amplifier 16, and a signal-reproducing system 17, which, in this embodiment, comprises a cathode-ray signal-reproducing tube 18. The cathode-ray tube 18 comprises the usual envelope provided with an elongated neck containing an electron gun, constructed in accordance with the present invention as hereinafter more fully described, including a cathode 19 having an external heater 20, an internal signal-input or control grid 21, a screen 22, a first anode 23, and a second anode 24. The tube also includes the usual fluorescent screen 25 on the enlarged end of the tube opposite the electron gun. Line-frequency and field-frequency scanning coils 26 and 27 are disposed about the neck of the tube for deflecting the beam in two directions normal to each other. The output circuit of the video-frequency amplifier 16 is connected to the control grid 21 by way of a leak resistor 29. Operating potentials for the several electrodes of the device 17 are supplied from a suitable source, as represented by the voltage-divider resistor 30.

A line-frequency generator 31 and a field-frequency generator 32 are coupled to the output circuit of the detector 15 for synchronization and are connected to the scanning coils 26 and 27, respectively, of the cathode-ray tube in the conventional manner. Suitable means are included in the generators 31 and 32 for separating the synchronizing pulses from the other modulation components and from each other. The stages or units just described, excepting the cathode-ray tube, may all be of conventional well-known construction so that detailed illustrations and descriptions thereof are unnecessary herein.

Referring briefly to the general operation of the system described above as a whole, television signals intercepted by the antenna circuit 10, 11 are selected and amplified in the radio-frequency amplifier 12 and supplied to the oscillator-modulator 13 wherein they are converted to intermediate-frequency signals which, in turn, are selectively amplified in the intermediate-frequency amplifier 14 and delivered to the detector 15. The modulation-signal components of the carrier wave are derived by the detector 15 and are supplied to the video-frequency amplifier 16 wherein they are amplified and from which they are supplied to the control grid 21 of the cathode-ray tube 17.

With proper operating potentials supplied from the source 30 to the electrodes of the tube 18, an electron beam is emitted from the electron gun, its intensity being controlled by the grid 21 in accordance with the video-frequency voltages impressed thereon and in a manner hereinafter explained in detail, which is in accordance with the present invention.

Saw-tooth current waves are generated in the line-frequency and field-frequency generators 31 and 32, which are controlled by the detected synchronizing pulses, and these waves are applied to the scanning elements 26, 27 of the cathode-ray tube 18 to produce electric scanning fields, thereby to deflect the ray in two directions normal to each other so as to trace a rectilinear scanning pattern on the screen of the tube and thereby to reconstruct the transmitted picture.

Referring now more particularly to the portion of the system of Fig. 1 in which the present invention is embodied, it will be appreciated that heretofore it was attempted to provide signal-reproducing systems or tubes with input-signal brightness characteristics which were substantially linear or which closely approached linearity. This characteristic of most conventional cathode-ray tubes actually has been a three-halves power curve. Furthermore, as has been stated, in the operation of television signal-reproducing systems, it frequently occurs that the level of the signal representing black, as applied to the reproducing means, is not maintained at a fixed value even though some other amplitude level related to black, such as the level representing the peaks of the synchronizing components, does remain substantially fixed. In such arrangements, therefore, black-level variations have effected undesired variations of the contrast ratio of the reproduced signal. These conditions are illustrated by the curves of Fig. 2 wherein curve A represents the signal-input brightness characteristic of a reproducing system of the type employed in the prior art. The wave forms of an applied input signal are shown at V_1 and V_2 which represent the same signal under different operating conditions, V_2 being identical with V_1 except that it is stabilized at the level St_2, while the signal V_1 is stabilized at the level St_1. In the wave forms V_1 and V_2, the portions S represent the synchronizing pulses which occur during the retrace periods of the wave while the portions V represent the video-frequency components, the levels indicated at b_1 and b_2 corresponding to black and the levels indicated at w_1 and w_2 corresponding to full white in the image being transmitted. Brightness values in the reproduced images corresponding to the levels b_1, b_2, w_1, and w_2 are indicated at b_{1_0}, b_{2_0}, w_{1_0}, and w_{2_0}, respectively. It will be seen that for the signal V_1 stabilized at St_1, the contrast ratio w_{1_0}/b_{1_0} is of the order of 10 to 1. However, for the signal V_2 stabilized at St_2, the contrast ratio w_{2_0}/b_{2_0} is substantially reduced, being of the order of 5 to 1. There is, therefore, a very appreciable distortion of the image reproduced from wave V_2 as it appears to an observer whose eyes are chiefly responsive to the ratio of the limiting brightness values, as distinguished from absolute values, as explained above.

To compensate for these undesired variations in the contrast ratio, therefore, the signal-reproducing device 18 is designed in accordance with the present invention. To this end, the cathode

19 of the electron gun of the tube 18, in the preferred embodiment illustrated in Fig. 1, comprises a sleeve of very small diameter centrally located in the end of the neck of the tube envelope. The cathode is preferably constructed of nickel and its inner surface is coated with suitable thermionic emissive material. The filamentary cathode heater 20 preferably comprises a helix of tungsten wire disposed externally around the cathode. For the purpose of controlling the intensity of the electron beam developed by the gun, the control electrode 21 is disposed within the cathode sleeve a small distance from its inner surface. This electrode comprises a helical grid having a nonuniform pitch, preferably a pitch which progressively increases throughout its length, or at least a portion thereof, as shown in the drawing.

The electron gun structure constructed as described above imparts to the tube 18 an exponential signal-input brightness characteristic such as illustrated by curve B of Fig. 3 and represented by the equation:

$$i=\epsilon^{e}$$

where

i=the illumination of the tube target and
e=the signal-input voltage.

That is, the electron gun includes means for imparting to the signal-reproducing tube an exponential signal-input brightness characteristic over the operating range of the system effective to provide a substantially constant contrast ratio for a reproduced signal of given amplitude irrespective of black-level variations thereof. This is clearly illustrated in Fig. 3 where the wave forms V_1 and V_2 are the same as those shown in Fig. 2 and similar designations are employed for the various signal components and brightness levels. It is seen that, due to the exponential signal-input brightness characteristic of curve B, the contrast ratio w_{2_0}/b_{2_0} for the signal V_2 is substantially the same as the contrast ratio w_{1_0}/b_{1_0} for the signal V_1, irrespective of the fact that the black level b_2 of the signal V_2 is considerably greater than the black level b_1 of the signal V_1.

It will be appreciated that, while a particular means has been shown as the preferred embodiment of the invention for imparting the desired signal-input brightness characteristic to the signal-reproducing system for compensating for the black-level signal variations, various other suitable means may be provided in accordance with the present invention for accomplishing this purpose. For example, instead of utilizing the novel type of cathode-ray signal-reproducing tube described above, the desired characteristic may be imparted to the signal-reproducing means by utilizing a conventional type of cathode-ray tube having an approximately linear characteristic and including in the reproducing means an amplifier tube having the required exponential characteristic and having a direct-current coupling to the cathode-ray tube.

While there has been described what is at present considered to be the preferred embodiment of this 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 signal-reproducing system comprising, signal-reproducing means, means for developing and applying to said reproducing means a signal having an amplitude level related to black which is substantially fixed and having an amplitude level corresponding to black which varies in accordance with operating conditions in said system, such variations tending to effect undesired variations of the contrast ratio of a reproduced signal of given amplitude, and means included in said reproducing means for imparting to said reproducing system an exponential signal-input brightness characteristic over the operating range of said system effective to provide a substantially constant contrast ratio for said reproduced signal irrespective of said black-level variations.

2. A television signal-reproducing system comprising an input circuit adapted to have a signal applied thereto having an amplitude level related to black which is substantially fixed and having an amplitude level corresponding to black which varies in accordance with operating conditions in said system and a cathode-ray signal-reproducing tube coupled to said input circuit, said black-level variations tending to effect undesired variations of the contrast ratio of a signal as reproduced by said tube, said tube comprising an electron gun having a control electrode to impart to said tube an exponential signal-input brightness characteristic over the operating range of said system effective to provide a substantially constant contrast ratio for said reproduced signal irrespective of said black-level variations.

3. In a television signal-reproducing system, a cathode-ray television signal-reproducing tube including an electron gun for developing, accelerating, and focusing an electron beam, a fluorescent target in the path of said beam, and a helical signal-input electrode included in said gun and having nonuniform pitch providing an exponential signal-input brightness characteristic for said tube.

4. In a television signal-reproducing system, a cathode-ray television signal-reproducing tube including an electron gun for developing, accelerating, and focusing an electron beam, a fluorescent target in the path of said beam, and a helical signal-input electrode included in said gun having a progressively increasing pitch throughout at least a portion of its extent providing an exponential signal-input brightness characteristic for said tube.

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