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VIDEO-FREQUENCY SIGNAL-TRANSLATING SYSTEM

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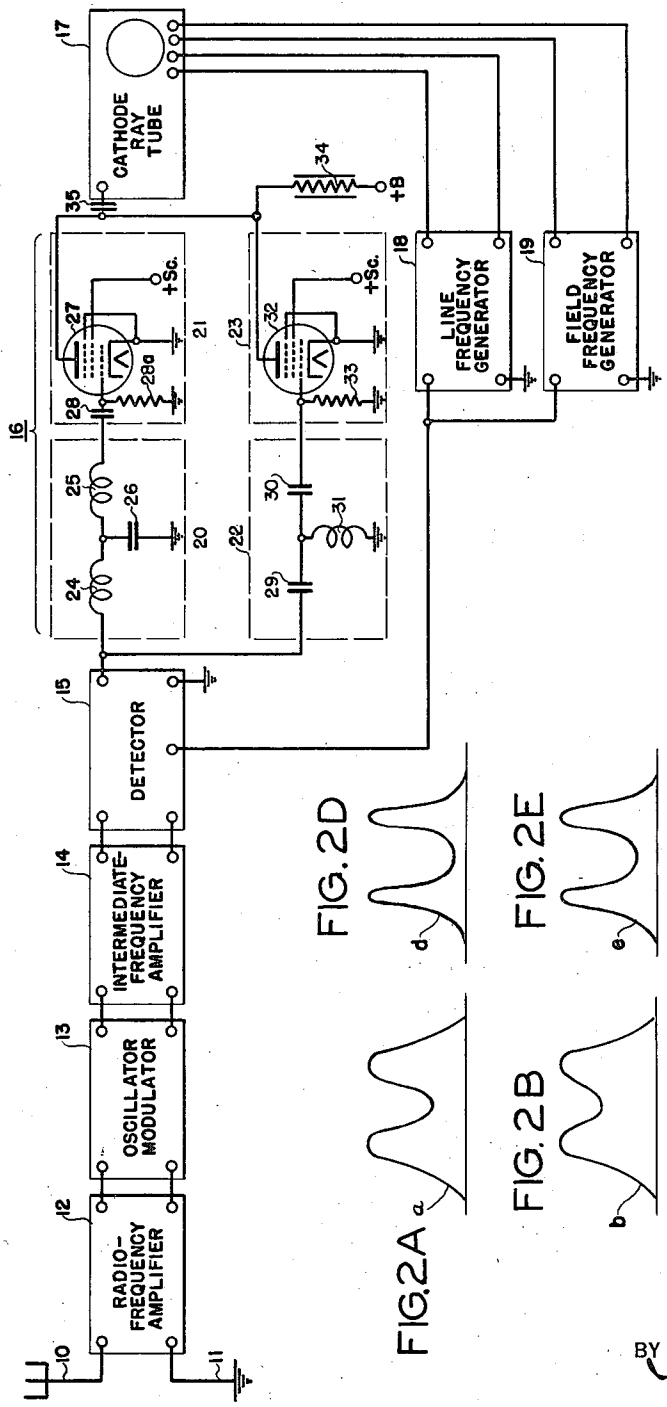


FIG. 1.

INVENTOR
PHILIP J. HERBST
BY Lawrence B. Dodds
ATTORNEY

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VIDEO-FREQUENCY SIGNAL-TRANSLATING SYSTEM

Philip J. Herbst, Bayside, N. Y., assignor to Hazeltine Corporation, a corporation of Delaware

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7 Claims. (Cl. 178—7.3)

This invention relates to television signaling systems and, more particularly, to improved video-frequency signal-translating systems useful in such television systems for improving the quality of a translated or reproduced television signal.

In accordance with present television practice, a television receiver generally includes a cathode-ray signal-reproducing tube which has, at one end of an elongated envelope, a plurality of electrodes conventionally referred to as an electron gun. These electrodes serve to develop, focus, and accelerate a beam of electrons or cathode ray toward a target disposed at the opposite end of the tube. The target usually comprises a fluorescent screen which, when scanned by the ray, becomes luminous. The intensity of the ray is modulated in accordance with the video-frequency components of a received television signal and the ray is deflected to scan the target horizontally at a relatively high frequency and vertically at a relatively low frequency so that series of parallel lines or fields, each representing a complete image, are successively traced on the target and the scene represented by the received signal is thus reconstructed on the fluorescent screen.

Since the video frequencies correspond in frequency and amplitude to the variations in illumination of successive incremental areas of the image, for a highly detailed image the video frequencies are correspondingly high. A faithfully reproduced image must include apparent variations in brightness corresponding to the high as well as low video frequencies. The area of the spot of illumination caused by impingement of the cathode ray on the fluorescent screen of the reproducing tube is usually such that there is an overlapping of successive lines. Moreover, since it is of no practical value to have greater detail in the horizontal direction than in the vertical direction, the frequency band usually employed in television systems is such as to provide approximately the same detail in the horizontal direction as is possible in the vertical direction.

Hence, the illumination spot size, as well as other limitations imposed by the electrical characteristics of such television systems, result in the suppression of the contrast between successive picture elements corresponding to the higher video-frequency signal components. For example, a video-frequency signal representing a scene with frequent changes in detail, such as a pair of closely spaced vertical white lines on a black background, is reproduced with substantially less contrast between the lines and the background than in the actual scene. Moreover, due to the fact that the response of the eye is logarithmic, the resultant visual sensation or apparent contrast is still less. For very high video frequencies the corresponding illumination contrast, and hence the perceptible detail, of the scene is frequently entirely lost.

It is an object of the present invention, therefore, to provide an improved video-frequency signal-translating system for use in a television signaling system, whereby signals representing illumination contrast between fine details of image structure may be faithfully translated or reproduced.

In this application the term "contrast" is employed to define the ratio of the illumination of one area of a scene to the illumination of an adjacent area thereof. The term "amplitude characteristic" defines the variation in the response with the amplitude of the stimulus of a particular device or group of devices. For example, the relation between grid-voltage input and anode-current output of a thermionic amplifier stage is its amplitude characteristic.

In accordance with the present invention, there is provided in a television signal-translating system a video-frequency signal-translating system including means having a linear transconductance characteristic for translating lower video-frequency signals, and means having a transconductance characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of the above first-mentioned characteristic for translating higher video-frequency signal components. The system includes means for combining the above-mentioned translated signal components, whereby the contrast in the fine detail structure of the television image is increased. In other words, the present invention provides a method of reproducing a signal in which the lower frequency signal components are translated with a predetermined amplitude characteristic, while the higher frequency signal components are translated with a predetermined relatively positively curved amplitude characteristic.

For a better understanding of the 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 schematic diagram of a complete television signal-receiving system including a video-frequency amplifier embodying the present invention, while Figs. 2*a*–2*f*, inclusive, are curves illustrating certain operating characteristics of the system of Fig. 1 to aid in the understanding of the invention.

Referring now more particularly to Fig. 1, the system there illustrated comprises a television receiver of the superheterodyne type including an antenna system 10, 11 connected to a radio-frequency amplifier 12 to which there is connected in cascade, in the order named, an oscillator-modulator 13, an intermediate-frequency amplifier 14, a detector 15, a video-frequency amplifier indicated generally at 16 and embodying the present invention, and a cathode-ray signal-reproducing tube 17. A line-frequency scanning generator 18 and a field-frequency scanning generator 19 are also coupled to the output of the detector and to the scanning elements of the cathode-ray tube. The stages or units 12—19, inclusive, excepting the video-frequency amplifier 16, 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 receiving system just described, 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 components of the signal are derived by the detector 15 and are supplied to the video-frequency amplifier 16 wherein they are amplified and translated by the apparatus of the present invention, as will be presently further described, and from which they are applied to a brilliancy-control electrode of the cathode-ray tube 17. The intensity of the electron beam of the tube 17 is modulated or controlled in accordance with the video-frequency voltages impressed upon the control electrode in the usual manner. The modulation components are also supplied to the generators 18 and 19, respectively, and the synchronizing components of the signals are utilized therein to synchronize the operations of these generators with the corresponding scanning apparatus at the transmitter. Saw-tooth current or voltage scanning waves are generated by the generators 18 and 19 and these waves are applied to the scanning elements of the cathode-ray tube 17 to produce scanning fields, thereby to deflect the ray vertically and horizontally so as to trace successive series of parallel lines or fields on the screen of the tube to reconstruct the transmitted image.

Referring now more particularly to the portion of the system of Fig. 1 embodying the present invention for the purpose of increasing the contrast of fine detail structure in a reproduced image, the video-frequency amplifier 16 is provided with two separate signal-translating channels including a low-frequency channel and a high-frequency channel. The low-frequency channel comprises a low-pass filter 20 and an amplifier 21 and has a linear transconductance characteristic, while the high-frequency channel includes a high-pass filter 22 and an amplifier 23, as shown, and is designed to have a transconductance characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated and which has a slope which deviates positively from that of the transconductance characteristic of the low-frenquency channel.

The low-pass filter 20 comprises series inductance arms 24 and 25 with an interposed shunt arm comprising a condenser 26. The amplifier 21 preferably comprises a vacuum tube 27 of the pentode type having a mutual conductance characteristic which is substantially constant over the greater part of its operating range, a suitable grid condenser 28 and leak resistor 28*a* being provided.

The filter 22 may comprise series condenser arms 29 and 30 and an interposed shunt inductance arm 31. The amplifier 23 may also comprise a pentode vacuum tube 32 provided with a grid leak 33. In this case, however, the tube has a mutual conductance characteristic which is exponential over the greater portion of its operating range and the slope of which deviates positively with respect to that of the linear mutual conductance characteristic of the law-frequency signal-translating channel. The tubes 27 and 32 are provided with a common anode circuit including a suitable impedance 34 serving as a video-frequency load. The input circuit of the cathode-ray tube 17 is coupled across the impedance 34, by way of a blocking condenser 35, as shown.

In the operation of the amplifier 16, due to the conventional operation of the filter circuits 20 and 22, the lower video-frequency components of a received detected television signal are translated by way of the channel 20, 21 while the higher video-frequency components of the signal are translated by way of the channel 22, 23. The lower video-frequency components are translated linearly and without distortion due to the linear characteristic of the tube 27, while the higher video-frequency components are translated with a distortion of their wave shape due to the exponential characteristic of the tube 32.

The operating conditions within, and the results obtained by, the higher video-frequency channel may best be understood by reference to Figs. 2*a*–2*f*, inclusive. These curves illustrate the modulation signal wave form and reproduced image illumination characteristic of a signal representing an image comprising a pair of narrow closely-spaced white lines on a black field. In each case the abscissae represent either time or horizontal displacement and the ordinates, relative amplitude.

Curve *a* represents the video-frequency signal as it appears in the output circuit of the detector 15. Curve *b* illustrates the resultant actual illumination of the reproduced image on the screen of the cathode-ray tube if no loss-of-contrast compensation is provided. It will be apparent from this curve that, due to the size of the spot and other characteristics of the system, the contrast has been substantially impaired; that is, the valley between the two peaks representing the successive white lines is considerably less deep than the corresponding portion of the curve *a*. The part of the image between the two lines, therefore, is brighter than the corresponding area in the actual image; that is, the contrast has been compressed, which represents a loss in detail. Curve *c* represents the resultant visual impression or apparent brightness of the repro-

duced image. Due to the fact that the response of the eye is logarithmic, the reproduced image appears to have still less contrast between the white lines and the black background, as indicated by the broken lines X and Y. For frequencies near the upper limit of the band accommodated by the system, the fine detail contrast may be lost entirely.

The arrangement of the present invention compensates for the undesirable loss-in-contrast effects just described by means of the double-channel video-frequency amplifier arrangement including the higher video-frequency channel wherein the signal-translating characteristic is exponential. Here the video-frequency signal, representing the image under consideration, in the output circuit of the amplifier 23 has a wave form as illustrated by curve *d*. From this curve it will be apparent that, due to the exponential mutual conductance characteristic of the amplifier 23, the wave form of the signal has been distorted so that it now comprises peaks, the sides of which are substantially steeper than those of the curve *a* and the valley between which is substantially deeper. The actual illumination of the image resulting from this signal, therefore, is as illustrated by curve *e* in which the peaks are correspondingly steep and the valley is correspondingly deep relative to the respective characteristics of curve *b*. The apparent brightness in this case is as indicated by curve *f*. Comparing the lines X'—Y' of curve *f*, representing relative contrast, with the corresponding lines X—Y of curve *c*, the increase in contrast between the lines and the background, as seen by the eye, obtained by the system of the present invention is apparent. That is, with the system of the present invention, this contrast in the fine detail structure of a transmitted image is appreciably increased so that the image is more faithfully reproduced.

While in the foregoing description of a preferred embodiment of the invention certain suitable circuits designed for a particular use have been illustrated, it will be readily appreciated that various equivalent circuit arrangements may be employed for producing the desired effects for any desired purpose in accordance with the present invention. Thus, the invention in its broader aspect comprises reproducing the lower frequency components of a given signal with a predetermined amplitude characteristic and reproducing the higher frequency components thereof with a predetermined relatively positively curved amplitude characteristic and this may be accomplished by any suitable circuit arrangements, as will be readily appreciated by those skilled in the art.

While there has been described what is at present considered to be 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. In a television signal-translating system, a video-frequency signal-translating system comprising means having a linear transconductance characteristic for translating lower video-frequency signal components, means having a transconductance characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic for translating higher video-frequency signal components, and means for combining said translated signal components, whereby the contrast in the fine detail structure of the television image is increased.

2. In a television signal-translating system, a video-frequency signal-translating system comprising means having a linear transconductance characteristic for translating lower video-frequency signal components, means having a transconductance characteristic which is exponential within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic for translating higher video-frequency signal components, and means for combining said translated signal components, whereby the contrast in the fine detail structure of the television image is increased.

3. In a television signal-reproducing system, a video-frequency amplifier comprising amplifier means for translating lower video-frequency signal components having a first predetermined transconductance characteristic, separate amplifier means for translating higher video-frequency signal components having a second predetermined transconductance characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic, and means for combining said separately translated signal components, whereby the contrast in the fine detail structure of the television image is increased.

4. In a television signal-reproducing system, a video-frequency signal-translating system comprising a first channel including a low-pass filter and means having a first predetermined transconductance characteristic for translating signal components passed by said low-pass filter, a second channel including a high-pass filter and means having a second predetermined transconductance characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic for translating signal components passed by said high-pass filter, and means coupled to said translating means for combining the signal components passed thereby, whereby the contrast in the fine detail structure of the television image is increased.

5. In a cathode-ray tube television signal-translating system, a video-frequency amplifier comprising a lower video-frequency amplifying channel, a higher video-frequency amplifying channel, each of said channels including a vacuum amplifier tube, the tube of said first-mentioned channel having a mutual conductance characteristic which is substantially constant over the operating portion thereof and the tube of said second-mentioned channel having a mutual conductance characteristic which increases exponentially over the operating portion thereof and the slope of which deviates positively with respect to that of said first-mentioned charac-

teristic, a common parallel anode circuit for said tubes, and means for utilizing voltages developed in said anode circuit, whereby the contrast in the fine detail structure of the television image is increased.

6. The method of translating a video-frequency television signal so as to effect an increase in the contrast in the fine detail structure of the image represented by said signal, which comprises translating with a first predetermined amplitude characteristic lower video-frequency components of said signal, translating with a second predetermined amplitude characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic, higher video-frequency components of said signal, and combining said translated higher and lower video-frequency signal components.

7. The method of reproducing a television signal so as to effect an increase in the contrast in the fine detail structure of the image represented by said signal which comprises reproducing the signal components corresponding to low-frequency illumination variations with a predetermined amplitude characteristic and reproducing the signal components corresponding to high-frequency illumination variations with amplitude characteristic which is nonlinear within the amplitude range of the signal translated, which is independent of the average amplitude of the signal translated, and which has a slope which deviates positively from that of said first-mentioned characteristic.

PHILIP J. HERBST.