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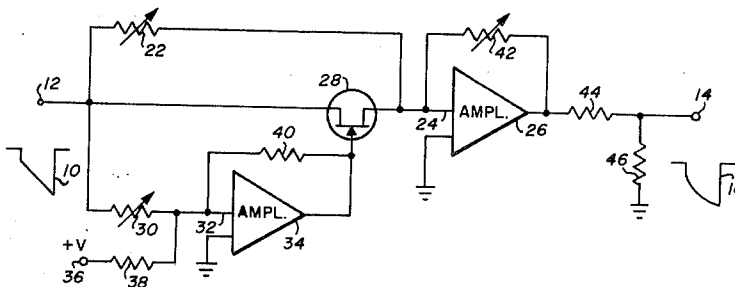
[54] **GAMMA CORRECTION CIRCUIT**
6 Claims, 4 Drawing Figs.

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178/DIG. 16, 178/72
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328/142, 143; 307/229, 230, 237, 253, 254

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ABSTRACT: In the exposure of film with a CRT, for example, the resulting recorded information density on the film is not proportional to the amplitude of the video signal applied to the CRT. That is, if a linear ramp function is applied to a CRT for the purpose of exposing film, the resulting exposed density on the film will be an exponential function. This response is defined as the gamma of the film and produces an error in recording an image on film. The disclosed embodiment of this invention is a circuit for correcting the error which results during the exposure of a photographic film or in the transmission of light through a layer of phosphor, such as found on the face of a CRT, due to the gamma characteristic thereof. The circuit is formed of an amplifier having a resistance feedback and a second resistance connecting the video signal to an input of the amplifier. In one embodiment, the input resistance is formed of a F.E.T., and in a second embodiment the feedback resistance is formed of an F.E.T. The operating characteristics of the F.E.T. establish the amount of correction provided to the video signal by the circuit. The operating characteristics of the F.E.T. in both embodiments of the invention can be varied by applying the video signal to a gate electrode of that F.E.T.



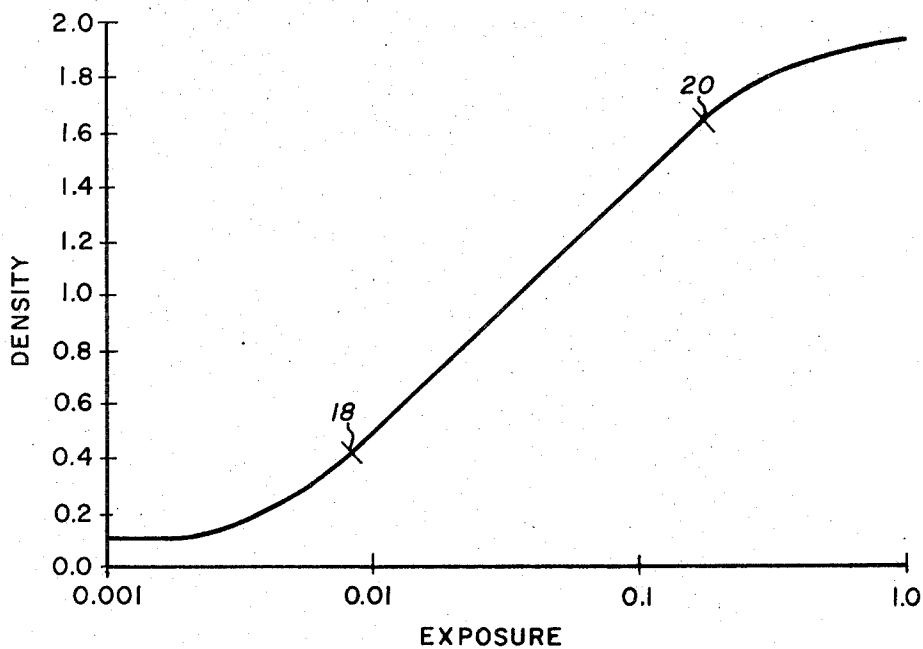
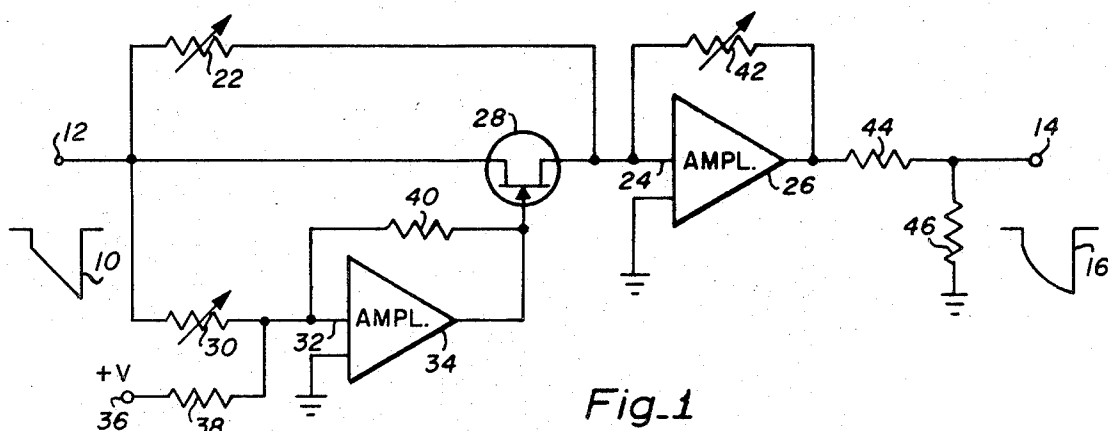


Fig. 2

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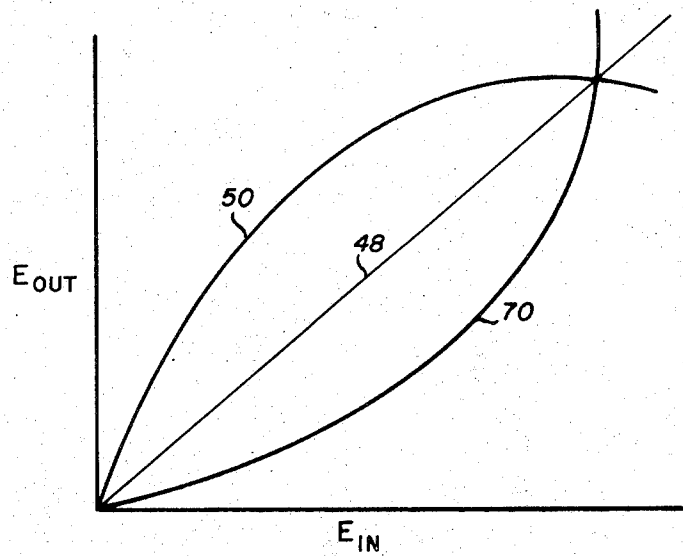


Fig-3

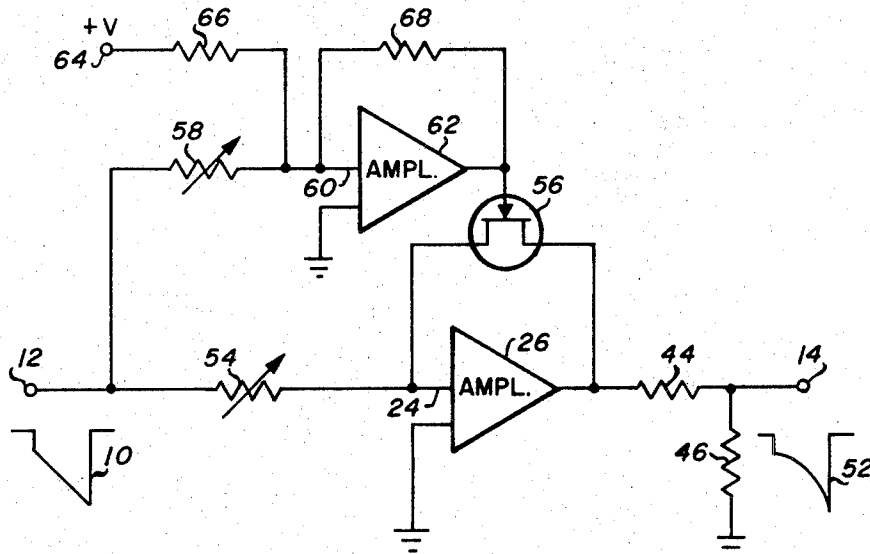


Fig-4

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GAMMA CORRECTION CIRCUIT

This invention relates to a circuit for correcting the recording error caused by the nonlinear response of a photographic film to the luminous energy impinged thereon by a recording device. The present invention also has application in the enhancement of images recorded on film or displayed on the face of a CRT.

The response or optical density of a film is, within certain limits, equal to the logarithm of the exposure. In sensitometry, the term "exposure" refers to the total amount of luminous energy which acts on the photographic material. The slope of the linear portion of a plot of density versus exposure is referred to as gamma." gamma." Because of this nonlinear response of film, when a light beam which is increasing linearly in luminance is swept across the film, the resulting information-density recorded on the film will not increase linearly, but exponentially across the film. If, for example, a CRT is employed for exposing a film, the response or optical density of the film will not be linearly proportional to the video signal applied to the CRT. As an example, if a linear ramp signal is applied to the CRT axis while the beam is scanning the film, the resulting information-density recorded on the film will increase exponentially with distance across the scanned portion of the film. As a result, the exposed image on the film is not a true replica of the image represented by the video signal.

The same condition exists in the emission of light from a phosphorous layer, such as on the face of a CRT, which is being impinged by an electron beam. The light emission from the phosphorous layer is not linearly proportional to the intensity of the electron beam impinging thereon. As in the case of the resulting image on film, the visible display on the face of the CRT is not a true replica of the image represented by the video signal applied thereto. The combined error when a CRT is employed to record on a film is also a logarithmic function.

The present invention overcomes the above described recording problems by modifying the video signal logarithmically. By proper selection of the amount of correction made to the video signal, portions of the resulting recorded image may also be enhanced. Such enhancement is desirable in photographs to be analyzing, such as may be required in aerial surveillance.

Accordingly, it is an object of the present invention to provide a circuit for correcting the recording error caused by the nonlinear response of a photographic film to the luminous energy impinged thereon by a recording device.

Another object of the present invention is to provide a circuit for correcting the error caused by the nonlinear response of a phosphorous layer to the energy of an electron beam impinging thereon.

Still another object of the present invention is to provide a circuit for modifying a video signal to correct for the nonlinear recording response of a recording material to that signal.

It is still another object of the present invention to provide a circuit which permits enhancement of images recorded on film or displayed on the face of a CRT.

Yet a further object of the present invention is to provide a circuit for modifying a video signal to correct the combined errors which exist in the nonlinear responses of a CRT-film-recording system.

A feature of the present invention resides in the provision of means for adjusting the amount of correction to the video signal to provide various corrections in accordance with various film characteristics.

These and other objects, features, and advantages of the present invention will be more fully realized and understood from the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a circuit diagram of one preferred embodiment of the present invention;

FIG. 2 is a plot of a typical characteristic curve of photographic film;

FIG. 3 is an approximate plot of the output voltage versus the input voltage of the gamma correction circuit of the

present invention and showing curves for various values of gamma; and

FIG. 4 is a circuit diagram of another embodiment of the present invention.

Like reference numerals throughout the various views of the drawings are intended to designate same or similar elements.

With reference to FIG. 1, there is shown a circuit for modifying a video signal to correct for the gamma characteristic of a film. If a ramp signal having a waveform 10 is applied to an input terminal 12, an output will be derived on terminal 14 having a waveform 16. In particular, the input video signal is modified logarithmically to provide an output video signal to the grid of a CRT.

The graph illustrated in FIG. 2 shows the relationship of density versus exposure on a photographic film. The slope of the straight line portion of the curve between points 18 and 20 is designated as "gamma." Because of the relationship between density and exposure, the video signal which drives the film exposing CRT must be modified.

The circuit illustrated in FIG. 1 performs this modification by employing the operating characteristic of an F.E.T. In particular, the input terminal 12 is connected through a variable resistor 22 to one input 24 of an amplifier 26. In addition, an F.E.T. 28 is connected with the drain electrode thereof to the terminal 12 and the source electrode thereof to the input 24 of the amplifier 26. The video signal on the input terminal 12 is also connected through a variable resistor 30 to one input 32 of an amplifier 34. A source of positive voltage on the terminal 36 is connected through a resistor 38 to the input 32 of the amplifier 34.

The amplifier 34 is provided with a feedback in the form of a resistor 40 connected between an output thereof and the input 32. The second input of the amplifier 34 is connected to the ground potential. The output of the amplifier 34 is connected to the gate electrode of the F.E.T. 28. The amplifier 26 is also provided with a feedback in the form of a variable resistor 42. The second input of the amplifier 26 is connected to ground potential. The output of the amplifier 26 is connected through a resistor 44 to the terminal 14, which is in turn connected through a resistor 46 to a ground potential.

In operation, the gain of the amplifier 26 is determined by the ratio of the resistance value of the variable resistor 42 and the resistance value of the input circuit formed by the combination of the variable resistor 22 and the F.E.T. 28. With a fixed bias, such as provided by the DC voltage on the terminal 36 applied to the gate of the F.E.T. 28, the effective resistance of the F.E.T. 28 varies approximately logarithmically with a signal applied to the drain electrode thereof. The effective resistance of the F.E.T. is further modified by a video signal applied to the gate electrode thereof via the resistance 30 and amplifier 34.

By adjusting the value of the resistance 30, the effect of video signal to DC voltage on the input 32 of the amplifier 34 can be varied. The effective resistance of the input circuit of the amplifier 26 can also be varied by adjusting the value of the resistance 22. The gain of the amplifier 26 will be affected by changing the effective resistance of the input circuit thereto, but such effect can be controlled and the gain of the amplifier 26 can be varied by adjustment of the variable resistor 42.

FIG. 3 is a plot of the voltage developed at the output terminal 14 versus the voltage applied to the input terminal 12. The straight-line curve 48 represents the relationship between the input voltage and the output voltage when no correction is made to the video signal, such as in the case when the F.E.T. 28 is inoperative or not connected in the circuit. The curve 50 represents one relationship between the input voltage and the output voltage when the F.E.T. 28 is operative in the circuit illustrated in FIG. 1. By adjusting the values of the resistors 22, 30 and 42, an entire family of curves or operating characteristics will be effected. In the normal application of the circuit illustrated in FIG. 1, the maximum value of the input

signal on the terminal 12 should coincide with the maximum point on the curve 50. This maximum point can, as explained above, be established by adjustment of the resistors 22 and 30. The portion of the curve 50 between the origin and the maximum point can be varied substantially to any configuration as required by the characteristics of the recorder and recording medium by judicious adjustment of the variable resistors 22 and 30.

If it is desired to enhance a particular gray-shade level in an image, the variable resistors 22 and 30 can be adjusted such that the maximum point on the curve 50 coincides with the value of the input signal corresponding to that gray-shade level. If the resistors 22 and 30 are so adjusted to provide such enhancement, the gray-shade levels which are darker than the particular gray-shade level to be enhanced will be exposed on the film as lighter gray-shade levels. As a result, the desired gray-shade level to be enhanced will be the darkest shade recorded on the film or recording media which is employed.

Other characteristics of the recording system may require correction of the video signal which is opposite to that provided by the circuit illustrated in FIG. 1. Such correction can be effected by the circuit illustrated in FIG. 4, wherein the effective resistance of the input circuit to the amplifier 26 is not variable in accordance with the video signal, but the feedback resistance is variable in accordance with the video signal. As a result, the output will have a waveform 52. The circuit illustrated in FIG. 4 includes a variable resistor 54 connected between the input terminal 12 and the input 24 of the amplifier 26. An F.E.T. 56 is connected in the feedback path of the amplifier 26.

The bias circuit for F.E.T. 56 is similar to the bias circuit for the F.E.T. 28 shown in FIG. 1. In particular, a variable resistor 58 is connected between the terminal 12 and one input 60 of an amplifier 62. A source of positive voltage on a terminal 64 is connected through a resistor 66 to the input 60 of the amplifier 62. A feedback in the form of a resistor 68 is connected from the output to the input of the amplifier 62. The other input of the amplifier 62 is connected to ground potential. The

output of the amplifier 62 is connected to the gate electrode of the F.E.T. 56. The output-voltage versus the input-voltage of the circuit illustrated in FIG. 4 is represented by a curve 70 in FIG. 3. By adjustment of the variable resistors 54 and 58, the input to output voltage relationship can be altered to provide any desired family of curves in the plot illustrated in FIG. 3.

The invention claimed is:

1. A signal-correction circuit comprising a signal-input terminal and a signal-output terminal, an amplifier having at least one input and an output, a first variable impedance means connected between said input terminal and an input of said amplifier, a second variable impedance means connected from the output of said amplifier to an input of said amplifier, one of said first and second impedance means having a main conduction path and a control member, and means connected between said input terminal and said control member to modify the impedance of said main conduction path in response to variations in the amplitude of signals applied to said input terminal.

2. The signal-correction circuit defined in claim 1 wherein said variable impedance means having the main conduction path and the control member comprises a means whose impedance varies nonlinearly with respect to the control voltage applied to the means connected to the control member.

3. The signal correction circuit defined in claim 2 wherein said variable impedance means having a main conduction path and a control member comprises a transistor.

4. The signal correction circuit defined in claim 3 wherein said means connected between said input terminal and said control member comprises a second amplifier having a second feedback path.

5. The signal-correction circuit defined in claim 1 wherein said first variable impedance comprises said impedance with the main conduction path and the control member.

6. The signal-correction circuit defined in claim 1 wherein said second variable impedance comprises said impedance with the main conduction path and the control member.

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