United States Patent

Loughlin

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[45] **Feb. 8, 1972**

[54] FLARELIGHT COMPENSATOR

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[73] Assignee: **Hazeltine Corporation**

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[52] **U.S. Cl.** ....**178/7.5 R**
[51] **Int. Cl.** **H04n 5/14**
[58] **Field of Search** ....178/7.5 E, 7.5 DC, 5.4

[56] **References Cited**

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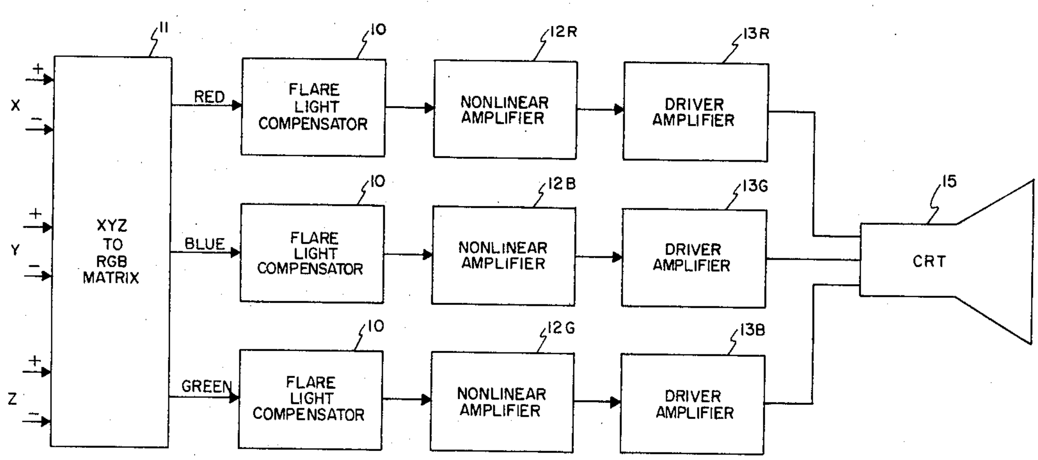
[57] **ABSTRACT**

Disclosed is apparatus which compensates for the undesirable effect of flarelight in a graphic arts process simulator containing an image display device actuated by an image representative video signal. The effect of such flarelight is most perceptible when displaying high key images containing small dark areas, since in these images flarelight from the brighter parts of the image will illuminate the dark areas making them appear somewhat lighter than is indicated by the corresponding amplitude of the video signal. To compensate for this effect in one embodiment of the invention, signals are supplied to the display through a circuit which has less effective DC coupling than AC coupling in other words it has a DC to AC transmission ratio less than unity. Thus the reference level for each signal, as applied to the display, is modified in relation to its average amplitude and therefore in relation to its average brightness. Signals representing high average brightness images (i.e., high key images) are established at a somewhat darker reference level than normal in order to tend to make the dark areas in the resulting displayed image darker than originally indicated, by an amount which offsets the effect of flarelight which tends to brighten these areas.

6 Claims, 5 Drawing Figures



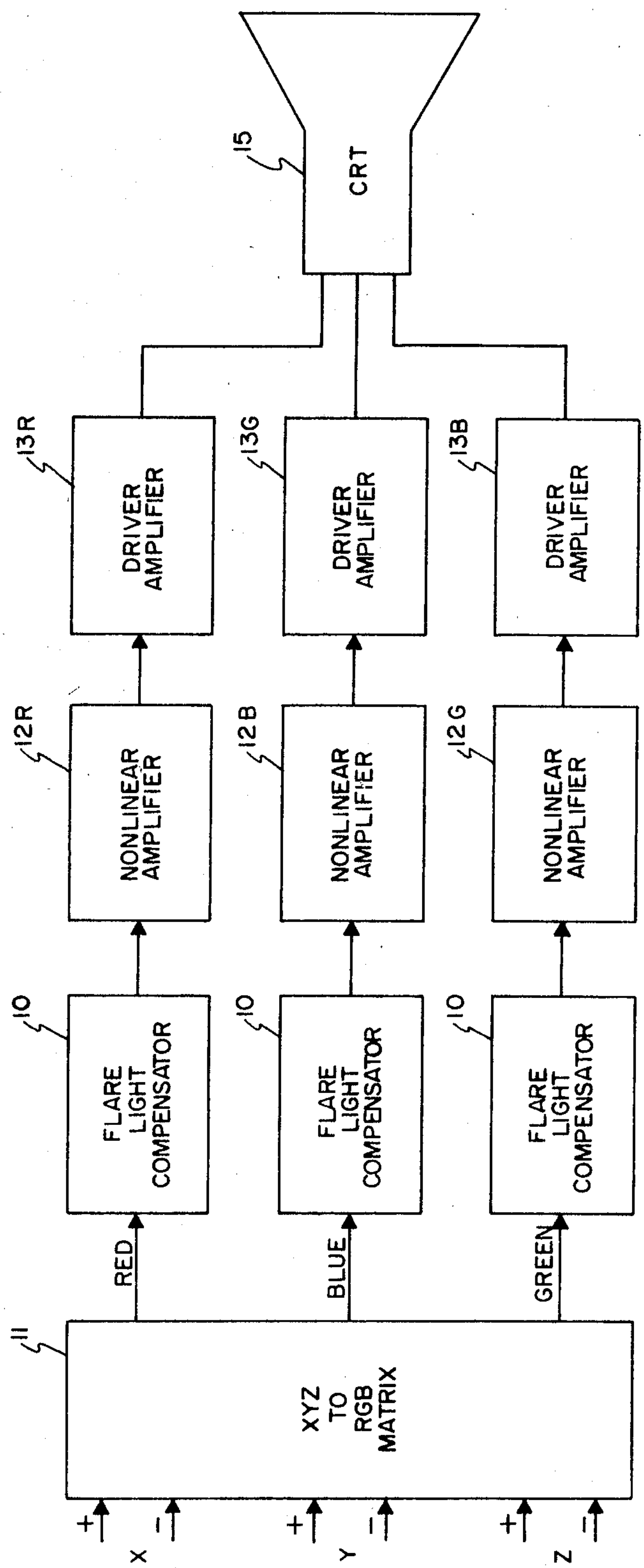

CRT
15
13R
DRIVER AMPLIFIER
13G
DRIVER AMPLIFIER
13B
DRIVER AMPLIFIER
12R
NONLINEAR AMPLIFIER
12B
NONLINEAR AMPLIFIER
12G
NONLINEAR AMPLIFIER
10
FLARE LIGHT COMPENSATOR
10
FLARE LIGHT COMPENSATOR
10
FLARE LIGHT COMPENSATOR
RED
BLUE
GREEN
11
XYZ TO RGB MATRIX
+
-
X
+
-
Y
+
-
Z

FIG. 1

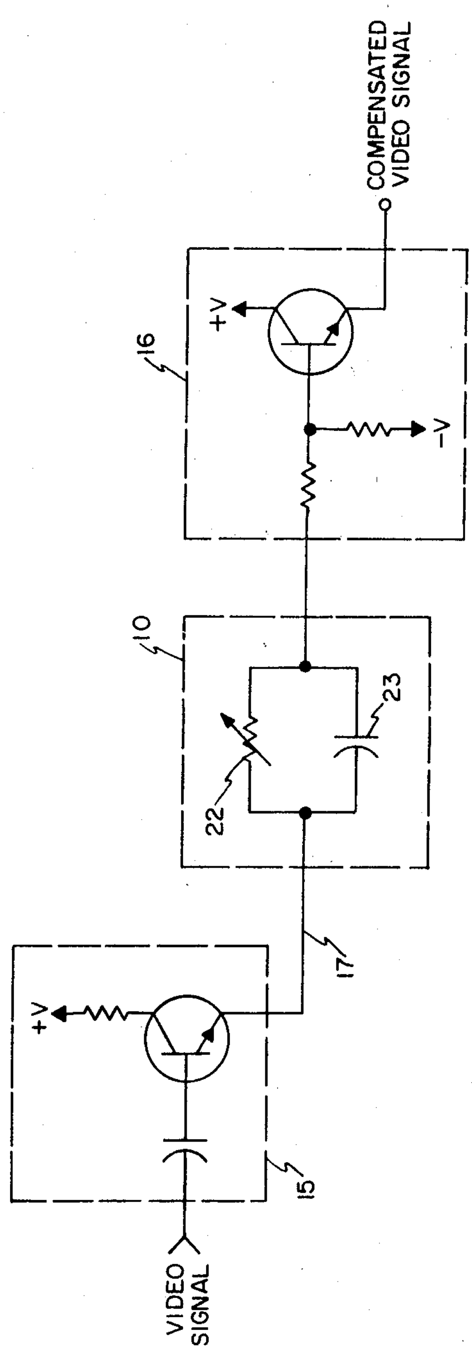


FIG. 2

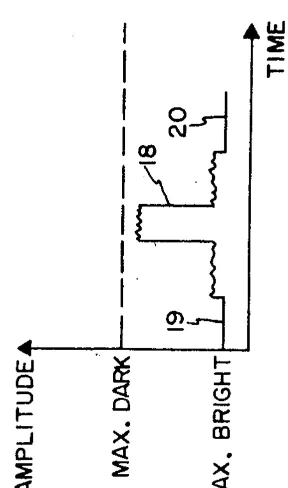


FIG. 3A

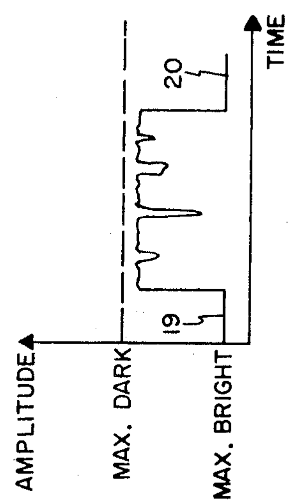


FIG. 3B

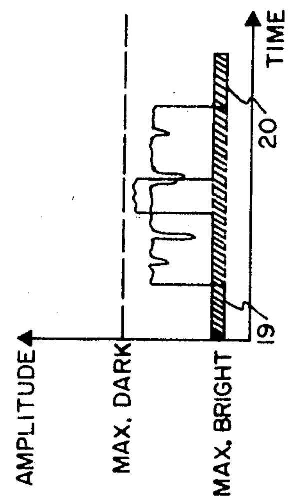


FIG. 4

FLARELIGHT COMPENSATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The present invention relates to image displaying and scanning systems such as those described in copending applications Ser. No. 874,550, filed Nov. 6, 1969 entitled "*Graphic Arts Process Simulation Apparatus*" *and Ser. No.* 887,850, filed Dec. 24, 1969, entitled "Flarelight Compensator," both of which are assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

This invention relates to novel flare compensation apparatus in an image display system such as the type described in the aforementioned copending application "Graphic Arts Process Simulation Apparatus". In normal TV applications, the effects of flarelight on modern picture tubes are low enough to be unimportant. However, in certain critical applications such as the graphic arts process simulator the effects of flarelight even with modern picture tubes can produce misleading results.

In the aforementioned copending application entitled "-Flarelight Compensator" one type of flarelight compensator is disclosed which compensated for the effects of flarelight in a cathode-ray tube (herein CRT) used as a flying spot scanner. In this system flarelight, for example that due to multiple reflections within the faceplate of the CRT, is made uniform, so that it is substantially equivalent to a DC signal, by increasing the thickness of the CRT faceplate. A pedestal signal proportional to this uniform flarelight is then subtracted from an image representative video signal to compensate for the effects of this flarelight.

With large image displays it is virtually impossible to make flarelight uniform as in the referenced application, because the required thickness of the faceplate would be impractical. Therefore in such displays flare compensation by a DC shift in the reference level of the video signal is only a first-order correction and being so the apparatus which performs this correction must be quite inexpensive to be cost effective.

The present invention is such an inexpensive flarelight compensator which provides an approximation to the compensation of the copending application and is particularly useful as a compensator in situations where a large image is displayed on a CRT. It will be recognized, however, that the invention may be employed to compensate for flarelight in any display device including a flying spot scanner if so desired.

SUMMARY OF THE INVENTION

Objects of the invention therefore are to provide a flarelight compensator capable of compensating for the effects of flarelight in a graphic arts process simulator containing an image display device; to provide such compensation for displayed images which are of high average brightness; and to provide such compensation which is inexpensive, and simple to install in systems of the type described in applicant's aforementioned copending applications.

In accordance with the invention, there is provided in a graphic arts process simulator which includes an image display device, an apparatus for compensating for the undesirable effect of flarelight in the display device. The apparatus includes means for supplying a video signal representative of the graphic arts image to be simulated, the signal having a DC component representing the average brightness of the image which varies between low key images and high key images. Further included is means, having a DC to AC video signal transmission ratio less than unity for supplied video signal by an amount which offsets the undesirable effect of flarelight normally generated in the display device when high key images are displayed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a color image display system with the present invention contained therein.

FIG. 2 shows a schematic diagram of an embodiment of the invention.

FIGS. 3A and 3B are graphical diagrams of portions of image representative video signals useful in understanding the embodiment of FIG. 2.

FIG. 4 is a graphical diagram of the output produced from the embodiment of FIG. 2 for the input signals of FIGS. 3A and 3B.

DESCRIPTION AND OPERATION OF THE INVENTION

In an image display system flarelight can result from many sources. One example is multiple light reflections within the display device and more particularly within the faceplate of a cathode-ray tube. In images of high average brightness, that is high key images, small dark areas are illuminated by this flarelight causing them to appear brighter to the eye than they would appear had the overall image been of a lesser average brightness (or had there been no flare), there being less average flare in low key (low average brightness) images.

These images are displayed on the CRT in response to an image representative video signal which may for example have an amplitude which varies in accordance with the brightness of the image. In one form of graphic arts process simulator minimum signal amplitude represents maximum brightness and maximum signal amplitude represents minimum brightness (maximum darkness). In accordance with the present invention the effects of flarelight can be compensated for by adjusting the amplitude of video signals representative of images especially susceptible to this flarelight (high key images) so that the dark areas in these images are displayed darker than actually indicated by the original video signal thereby offsetting the brightening effect of flarelight in the system.

A novel apparatus **10** for accomplishing this is shown in FIG. 1 to be contained, in the image scanning system of aforementioned copending application "Graphic Arts Process Simulation Apparatus". The remaining blocks **11**, **12R**, **12G**, **12B**, **13R**, **13G** and **13B** and **14** are substantially the same as the corresponding blocks in FIG. 5 of the copending application and their functions are more completely described therein. A separate flarelight compensator **10** for each of the three colored channels (red, blue, and green) is employed since flarelight can be generated independently for each color displayed on the face of CRT **14**. If the display system employed was of the monochrome type then all compensation necessary could be accomplished by a single compensator **10**. Since all three compensators **10** and their operation are substantially identical, the description of the invention herein contained refers only to a single channel, for example the red (R) channel. The positioning of compensators **10** between the nonlinear amplifiers **12** and X, Y, Z, to R, G, B matrix **11** is selected at a point where the video signal amplitude linearly represents image brightness. It will be recognized that compensators **10** could be incorporated in other positions in the individual video signal paths of the display system where the video signal amplitude linearly represents image brightness. If a compensator **10** is used in a nonlinear portion of the signal path such as between nonlinear portion of the signal path such as between nonlinear amplifier **12** and driver amplifier **13**, the resultant compensation will not be as effective although in some cases this position may be more convenient. It will also be recognized that once compensation takes place the video signal should be DC coupled to the display tube since an AC coupling circuit may destroy the difference in reference levels of the video signals for high key and low key images.

Referring now to FIG. 2 which shows a detailed embodiment of a compensator **10** built in accordance with the invention and connected between an output amplifier **15** from the matrix **11** and an input amplifier **16** of nonlinear amplifier **12R**. There is supplied to compensator **10** via lead **17** an image representative video signal of the type hereinbefore described (maximum amplitude representing maximum darkness). A portion of one such signal is shown in FIG. 3A as having a small dark area, represented by narrow pulse **18**, and a large bright area, as represented by the remainder of the signal contained between blanking intervals **19** and **20**. A portion of a second signal is shown in FIG. 3B as having a relatively large dark area as represented by the high amplitude of the total signal between blanking intervals **19** and **20**.

Block **10** represents means, having a DC to AC video signal transmission ration less than unity for supplied video signals, for modifying the DC to AC ratio of said supplied video signal by an amount which offsets the undesirable effect of flarelight normally generated in the display device when high key images are displayed. This has the effect of establishing supplied video signals at a reference level which shifts slightly in proportion to their DC component, with signals representing high key images established at a higher and therefore darker reference level than signals representing low key images.

Referring now to FIG. 4, the output of block **10** is shown for the signals of FIG. 3A and FIG. 3B superimposed on one another. As can be seen from the drawing the signal portion of FIG. 3A is shown at a higher reference level than the signal portion of FIG. 3B the difference in reference levels being represented by the cross-hatched area of FIG. 4. The result when these signals are DC coupled to a display device, such as CRT **14** and in the embodiment of FIG. 1 through nonlinear amplifier **12R** and driver amplifier **13R** is as follows: The signal portion of FIG. 3B drives the appropriate electrode of the CRT (in this case red) in accordance with its amplitude variations, with maximum amplitude signals turning the electrode off completely, resulting in a maximum dark (i.e., black) display on the CRT. Since the average brightness of the image of FIG. 3B is low (average amplitude is high) there is no substantial flare problem in the displayed image and therefore a small dark area appears to be equally dark to the eye as does a large dark area. The signal of FIG. 3A on the other hand represents a high average brightness image in which as previously stated the flarelight may illuminate small dark areas such as the one generated as a result of pulse **18**. This flare illumination is offset by the apparent increase in amplitude of pulse **18** due to the higher reference level of the signal, allowing the small dark area to appear to have the same darkness as it would have had, had the average brightness of the image been low. Furthermore since the reference level is continuously shifted in proportion to the average amplitude (i.e., DC component) of the video signal, and therefore average brightness of the image, all video signals supplied will be established at a reference level which will provide compensation to a first order of magnitude for each image, since as average brightness decreases the flarelight decreases and therefore the amount of compensation necessary decreases. It will be noted that this type of compensation is only effective in the range where the amplitude of the uncompensated video signal is not great enough to turn the appropriate CRT electrode off by itself since in some configurations once maximum darkness has been reached there is no way of making the displayed image appear darker.

A particularly effective and inexpensive method for establishing these video signals at the required reference level is by a partial DC coupler such as the parallel combination of variable resistor **22** and capacitor **23**. Briefly and by way of background AC coupling means that the DC component of the signal is blocked (usually by a capacitor). DC coupling means that the DC component of the signal is passed (usually by a resistor). Partial DC coupling has the effect of passing a portion of the DC component of a signal and blocking a portion of it. In other words the DC to AC transmission ratio is less than unity. In the embodiment illustrated this transmission ratio is determined by the relationship between the capacitance of capacitor **23**, the resistance of variable resistor **22**, and the output and input impedances of amplifiers **15** and **16**, respectively.

Referring again to FIG. 4 it can be clearly seen how the reference levels for each of the signals of FIG. 3 are established. The signal of FIG. 3A has a small DC component (average value) representative of its low average amplitude. It is therefore passed through the coupler (resistor **22** and capacitor **23**) substantially unaffected. The signal of FIG. 3B has a large DC component representative of its relatively high average amplitude. If the coupling was total AC the DC component of the signal would be completely blocked and the resulting video signal would be centered about its average value which would cause it to sag substantially below the signal of FIG. 3A. However if partial DC coupling is used, the resulting sag is only a portion of what it would be for total AC coupling and therefore the signal of FIG. 3B would only sag below that of FIG. 3A by this portion.

For example if resistor **22** and capacitor **23** were selected to provide 5 percent partial DC coupling, in other words a 95 percent DC to AC transmission ratio, the signal of FIG. 3B would sag below a signal having little or no DC component (such as the signal of 3A) by an amount approximately equal to 5 percent of its own average value. The larger the average amplitude of the signal and therefore the lower the average brightness of the the image, the larger will be the sag and in effect the lower the reference level at which such signals will be established. Signals established at the highest (darkest) reference levels will be those having little or no DC component (average value) and as previously stated are those which represent images susceptible to distortion due to flarelight and therefore are those which require compensation.

In order to properly adjust resistor **22** to a value which will provide adequate compensation over the entire range of possible supplied signals, the following procedure is suggested. First a large area of predetermined darkness and then a small area of equal darkness is viewed on the CRT. Resistor **22** is then adjusted until the larger dark area visually appears to be of the same darkness as the smaller area. This procedure has been used by viewing a full screen dark area and then viewing a dark two-inch square in the center of the CRT, both areas having been originally generated to have equal darkness.

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.

What is claimed is:

1. In a graphic arts process simulator which includes an image display device, apparatus for compensating for the undesirable effect of flarelight in said display device, comprising:
   means for supplying a video signal representative of the graphic arts image to be simulated, said signal having a DC component representing the average brightness of said image which varies between low key images and high key images,
   and means, having a DC to AC video signal transmission ratio less than unity for supplied video signals, for automatically modifying the DC to AC ratio of said supplied video signal in accordance with the average image brightness of said signal by an amount which offsets the undesirable effect of flarelight normally generated in the display device when high key images are displayed.

2. Apparatus in accordance with claim **1** wherein said supplied video signal has an amplitude which linearly represents image brightness.

3. Apparatus in accordance with claim **2** wherein said modifying means has a DC to AC transmission ratio of about 95 percent.

4. In a graphic arts process simulator which includes an image display device, apparatus for compensating for the undesirable effect of flarelight in said display device, comprising:
   means for supplying a video signal representative of the graphic arts image to be simulated, said signal having a DC component representing the average brightness of said image which varies between low key images and high key images and said signal having an amplitude which linearly represents image brightness;

and means, including a partial DC coupler having a DC to AC video signal transmission ratio less than unity for supplied video signals, for automatically modifying the DC to AC ratio of said supplied video signal in accordance with the average image brightness of said signal by an amount which offsets the undesirable effect of flarelight normally generated in the display device when high key images are displayed.

5. Apparatus in accordance with claim 4 wherein said partial DC coupler comprises the parallel combination of a resistor and a capacitor.

6. Apparatus in accordance with claim 5 wherein said resistor and capacitor are selected to provide a DC to AC video signal transmission ratio of about 95 percent.

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