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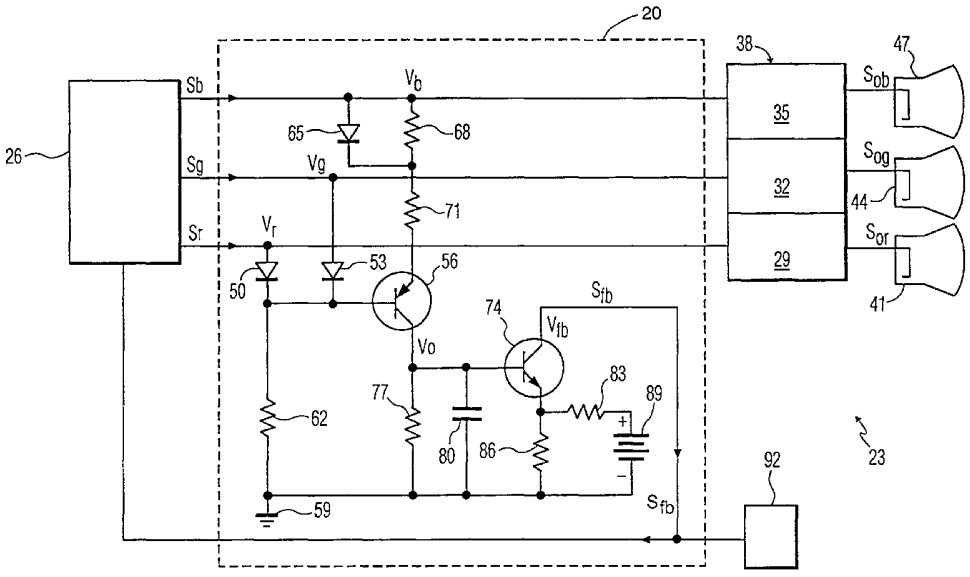

(57) Abstract: A cathode current limiting circuit (20) and method for use with projection color television display systems (23) to prevent overheating and possible cracking of the blue cathode ray tube (CRT) (47) when a continuous blue background is presented. The circuit (20) monitors differences between the respective low level red, green, blue (RGB) (Vr, Vg, Vb) signals sent from the video signal processor (26) to the CRT drive (38) which produces the respective RGB cathode or beam currents. When the low level blue signal (Vb) exceeds both of the red (Vr) and the green signals (Vg) by a predetermined value, the circuit (20) sends a feedback signal to the video signal processor (26) to limit the blue signal (Vb) and thus the cathode current from the CRT drive (38).

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CATHODE CURRENT LIMITING CIRCUIT FOR PROJECTION TELEVISION DISPLAY SYSTEMS.

FIELD OF INVENTION

The present invention is directed generally towards cathode current limiting circuits for video displays, and more particularly towards a cathode current limiting circuit for projection television display systems.

BACKGROUND OF THE INVENTION

A projection television display system includes three individual cathode ray tubes (CRTs), each having a different screen phosphor corresponding to one of red, green, and blue (RGB) colors. Each CRT emits a respective RGB light image responsive to a received television signal of the system, which light images are reflected from a mirror and merged onto the rear of an opaque screen for viewing as a single full color image. High level RGB video drive signals are coupled to respective cathodes of the electron guns of the CRTs from respective drive amplifiers or "drivers" which amplify the respective low level RGB video signals produced by a video signal processor. In response to the respective video drive signals, the CRTs generate electron beams at a cathode or beam current, which beams strike the respective screen phosphors within the CRT causing them to emit light outputs of particular wavelengths corresponding to the respective color emitted by the CRT. The light outputs produced by the CRTs are transmitted by an optical system to a screen where a composite color image is reproduced.

In such projection television display systems, having the three separate cathode CRTs for producing RGB light, certain signals such as a high level flat field in an individual primary color can result in that respective CRT providing much more than its nominal share of light. Unfortunately, many video accessory devices such as video games, cable television, etc. provide a blue flat field when no program content is being provided. While it is common practice to sense and limit the total beam current under such flat field conditions, one CRT may draw most if not all the beam current ordinarily allocated for all three CRTs. The CRT may overheat and fracture if such flat fields are allowed to remain displayed continuously.

Typically, the share of the total cathode current drawn by all of the CRTs relative to that drawn by each individual CRT is determined by directly measuring the cathode ray current of each individual CRT. The overall cathode current is then controlled by feedback to control the gains of the RGB video signals thus limiting the maximum average cathode current in an individual electron gun of the respective CRT to a desired level. For example, the Philips/Magnavox Model GR-9D projection television display system directly measures the cathode current of the blue CRT. The gains of the RGB video signals are controlled in a feedback loop to limit the average blue cathode current to a safe level. However, the system requires the use of costly high voltage transistors as current sampling devices to directly sample the individual cathode currents, and furthermore introduces additional circuit complexity if the current sampling devices must also serve in an automatic "black current" AKB stabilization loop.

SUMMARY

It is an object of the invention to provide a cathode current limiting circuit, which reduces the problems of the prior art. The invention is defined by the independent claims. De dependent claims define advantageous embodiments.

In accordance with the present invention there is provided a cathode current limiting circuit and method of use for a projection color television display system. The display system is generally of the type having a video signal processor which feeds respective low level red, green, blue (RGB) signals to a cathode ray tube (CRT) drive which amplifies the low level RGB signals to high level RGB signals which drive separate RGB cathode ray tubes producing respective RGB beam currents. The circuit comprises a sensing, i.e., switching, device having inputs for receiving the respective low level RGB signals being fed from the video signal processor to the CRT drive. The sensing device is adapted to monitor differences between the low-level RGB signals and to produce an output signal at an output thereof when one of the RGB signals exceeds each of the other individual RGB signals. The output signal provides feedback to the video signal processor to adjust the low level RGB signals to limit the cathode beam current of the CRT having the highest level RGB signal.

The method of limiting the cathode current comprises the steps of 1) providing a cathode current limiting circuit of the type described above; 2) monitoring differences between the respective low level RGB signals being fed from the video signal processor to the CRT drive using the cathode current limiting circuit; and 3) producing an output signal using the cathode current limiting circuit when one of the RGB signals exceeds each of the

other individual RGB signals, which signal provides feedback to the video processor to adjust the low level RGB signals to limit the cathode beam current of the CRT having the highest level RGB signal.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be obtained from consideration of the following description in conjunction with the drawing in which: the sole figure shows an exemplary embodiment of a cathode current limiting circuit according to the present invention for providing feedback in a projection television display system.

DETAILED DESCRIPTION OF THE INVENTION

The sole figure shows an exemplary embodiment of a cathode current limiting circuit 20 according to the present invention in a projection television color video system 23. The cathode current limiting circuit 20 monitors differences between the low level red, green, and blue signals Sr, Sg, and Sb from a video signal processor 26 to respective red, green, and blue drivers 29, 32, and 35 of a CRT drive 38 of the video system 23. The limiting circuit 20 provides cathode current limiting feedback to the video signal processor 26 which limits the RGB cathode currents of the respective RGB drivers 29, 32, and 35 delivered to respective red, green, and blue CRTs 41, 44, and 47 of the video system 23.

In the exemplary embodiment shown, the separate RGB low level video signals, measured as respective RGB voltages Vr, Vg and Vb, are connected from the video signal processor 26 to the individual CRT drivers 29, 32, and 35 of the CRT drive 38 for amplification to a cathode current sufficient to drive the respective CRTs 41, 44, and 47. The green and red video signals are also fed through respective diodes 50 and 53 to be applied to the base of a PNP transistor 56. The base of the transistor 56 is also connected to a signal ground 59 through a resistor 62. The blue video signal is fed to the emitter of the transistor 56 through a resistor 68 and parallel diode 65, which are arranged in series with a resistor 71. The collector of the transistor 56 is connected to the base of an NPN transistor 74, and to a resistor 77 and capacitor 80 arranged in parallel and connected to ground 59. The emitter of the transistor 74 is connected intermediate a pair of resistors 83 and 86 arranged in series interconnecting a respective positive (+) and negative (-) bias voltage in the form of a battery 89. The positive (+) output of the battery 89 is connected through the resistor 83 to the emitter of the transistor 56, which is connected through the resistor 86 along with the negative output (-) of the battery 89 to ground 59. The collector of the transistor 74 is

connected to the video signal processor 26 as a feedback signal Sfb, which can also be input to one or more other feedback signal receiving devices 92.

The cathode current limiting circuit 20 monitors the differences between the low level RGB video signals as RGB voltages Vr, Vg and Vb, and predicts when the cathode current of one of the three CRTs, the blue CRT 47 in the illustrated embodiment, can be expected to significantly exceed more than its nominal one-third share of the total cathode current. A feedback signal Sfb in the form of a feedback voltage Vfb generates a feedback current to the video processor 26. This feedback current reduces the voltage drive of the low level RGB video signals Vb, Vg and Vb in such a way that the appropriate high level RGB cathode current is delivered to the respective cathode guns of the RGB CRTs 41, 44, and 47. This limits the respective RGB beam currents to an acceptable level so as to not overheat the cathode gun or cause emission of x-rays by exceeding the x-ray threshold beam current level.

The cathode current limiting circuit 20 operates as follows. The low level RGB input voltages Vr, Vg and Vb each have nominally the same direct current (DC) and black/white (B-W) levels. The red and green input voltages Vr and Vg are applied to the base of the transistor 56 through the diodes 50 and 53, which prevent the reverse flow of current to the lesser of Vr and Vg. The blue input voltage Vb is applied to the emitter of the transistor 56, which is initially non-conductive, therefore there being no appreciable voltage drop across the diode 65, and the resistors 68 and 71 since there is no appreciable current flow therethrough. The non-linear resistor-diode network 65, 68 and 71 coupled to the emitter of the PNP transistor 56 renders the collector current of transistor 56 more accurately representative of the blue cathode current than does use of a single resistor. The final cathode current is I cathode exponentially related to the cathode drive voltage V_{drive} by the equation $I_{cathode}=m(V_{drive})^{2.5}$, wherein m is a constant.

Transistor 56 does not conduct until the level of the blue input voltage Vb is greater than each of the red and the green input voltages Vr and Vg, at which time the transistor 56 conducts to supply an output voltage Vo at the collector thereof (i.e. Vo = voltage across the resistor 77 and the capacitor 80, the opposite connections of each being grounded). The resistor 77 and the capacitor 80 function as an integrator which renders the output voltage Vo at the collector proportional to the average level by which the blue input voltage Vb exceeds the greater of the green and red input voltage Vg or Vr. Therefore with the input voltages Vr, Vg and Vb representing the average low level input signals or average voltage drive levels for the red, green, and blue colors:

$$Vo = k(Vb-Vg) \qquad \text{for } Vb>Vg>Vr$$

$Vo = k(Vb-Vr)$ for $Vb>Vr>Vg$

$Vo = 0$ for $Vb \leq Vg$ and $Vb \leq Vr$

The constant k is the proportion to the average level by which the blue input voltage Vb exceeds the greater of the green or red input voltage Vg or Vr, and is primarily controlled by the resistance value of the resistor 77, with the averaging function being primarily controlled by the capacitance of the capacitor 80. The output voltage Vo is maximum when the video is displaying a one- hundred-percent blue field. The emitter of the transistor 74 is negative-biased by the battery 89 through a voltage splitter formed by the resistors 83 and 86. When the output voltage Vo at the base of the transistor 74 versus the voltage at its emitter begins to exceed the turn-on for the transistor 74, the feedback signal Sfb in the form of a feedback current and resulting a feedback voltage Vfb at the collector of the transistor 74 is fed back to the video processor 26 to limit the levels of the low level RGB input voltage Vr, Vb and Vb to the respective RGB drivers 29, 32, and 35 of the CRT drive 38 to have an acceptable high level output signal S_{or}, S_{og} and S_{ob} to the respective red, green, and blue CRTs 41, 44, and 47. The feedback signal Sfb may be shared with additional drive limiting devices responsive to the total average beam current, such as the feedback receiving device 92. It is noteworthy that the cathode current limiting circuit 20 is insensitive to any common mode voltage level associated with the RGB voltages Vr, Vg and Vb, being sensitive only to differential voltage levels therebetween. Therefore, the cathode current limiting circuit 20 is readily adaptable to various projection television color video systems 23 wherein the respective red, green, and blue common mode voltages Vr, Vg and Vb are different since only the differential voltage levels are measured. Further adaptability and flexibility can be attained such as by making resistor 77 a variable resistor to change the constant k, and by replacing the source of a fixed biasing voltage such as the battery 89 with a variable source of biasing voltage to permit changing the point at which the feedback signal Sfb is sent from the collector of the transistor 74 back to the video signal processor 26.

Numerous modifications to and alternative embodiments of the present invention will be apparent to those skilled in the art in view of the foregoing description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. Details of the structure may be varied substantially without departing from the spirit of the invention and the exclusive use of all modifications, which come within the scope of the appended claims, is reserved.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A cathode current limiting circuit (20) for use with a projection color television display having more than one cathode tube (41,44,47), comprising:

a first sensing device configured to receive a plurality of low level RGB signals (Vr, Vg, Vb) transmitted from a video processor (26) to a cathode ray tube drive (38), the first sensing device being adapted to monitor differences between the plurality of low level RGB signals (Vr, Vg, Vb) and to produce an output signal (Vo) when one of the plurality of RGB signals (Vr, Vg, Vb) exceeds all of the other ones of the plurality of RGB signals (Vr, Vg, Vb), the output signal (Vo) providing feedback to the video processor (26) to adjust the plurality of low level RGB signals (Vr, Vg, Vb) to limit a cathode beam current of the cathode ray tube (41,44,47) having a highest level RGB signal.

2. The circuit (20) according to Claim 1, further comprising an integrator (77,80) which renders the output signal (Vo) proportional to an average level by which the one of the low level RGB signals (Vr, Vg, Vb) exceeds the greater of the other individual low level RGB signals (Vr, Vg, Vb).

3. The circuit (20) according to Claim 2, further comprising a second sensing device configured to receive the output signal (Vo) from the first sensing device, the second sensing device monitoring the output signal (Vo) of the first sensing device and producing another output signal (S_{fb}) when the output signal (Vo) of the first sensing device exceeds a predetermined value, the other output signal (S_{fb}) of the second sensing device providing feedback to the video processor (26) after the predetermined value has been exceeded to adjust the low level RGB signals (Vr, Vg, Vb) to limit the cathode beam current of the cathode ray tube (41,44,47) having a highest low level RGB signal.

4. The cathode current limiting circuit (20) according to Claim 3, wherein the other output signal (S_{fb}) is produced only when a blue signal (Vb) of the low level RGB signals (Vr, Vg, Vb) exceeds each of a red (Vr) and a green signal (Vg) of the low level RGB signals(Vr, Vg, Vb).

5. The cathode current limiting circuit (20) according to Claim 1, wherein: the low level RGB signals comprise respective red, green, and blue RGB voltages (Vr, Vg, Vb):

the first sensing device comprises a PNP transistor 56 of which a collector delivers the output signal (Vo) and the base receives two of the RGB voltages (Vr, Vg, Vb) to be compared with a third of said voltages (Vr, Vg, Vb) which is input to an emitter, and the output signal (Vo) provides feedback to the video processor (26), when the third voltage at the emitter exceeds the greater of the two of the RGB voltage (Vr, Vg, Vb) at the base.

6. The circuit (20) according to Claim 5, wherein a pair of diodes permit the greater of the two RGB voltages (Vr, Vg, Vb) to be applied to the base of the PNP transistor (56).

7. The circuit (20) according to Claim 6, wherein the base of the PNP transistor (56) is coupled to ground potential through a resistor (62).

8. The circuit (20) according to Claim 5, further comprising an integrator (77,80) which renders the output signal (Vo) proportional to an average level by which the third voltage exceeds the greater of the two RGB voltages (Vr, Vg,Vb) input to the base of the PNP transistor (56).

9. The circuit (20) according to Claim 8, further comprising an NPN transistor (74) having a base as an input for receiving the output signal (Vo) from the PNP transistor (56), an emitter as an input for a biasing circuit comprising a voltage source (89) and a pair of resistors (83,86) in the form of a voltage splitter, and an output comprising a collector, the NPN transistor (74) being configured to monitor the output signal (Vo) of the PNP transistor (56) and to produce a feedback signal (S_{fb}) at the collector when the output signal (Vo) of the PNP transistor (56) exceeds a predetermined value, the feedback signal (S_{fb}) providing feedback to the video processor (26) after the predetermined value has been exceeded to adjust the low level RGB signals (Vr, Vg, Vb) to limit the cathode beam current of the cathode ray tube (41,44,47) having the greatest low level RGB signal (Vr, Vg, Vb).

10. The circuit (20) according to Claim 9, wherein the base of the PNP transistor (56) is coupled to a ground potential through a resistor (62).

11. A method of limiting the cathode current of a projection color television display system (23), comprising the steps of:

monitoring differences between a plurality of low level RGB signals (Vr, Vg, Vb) being transmitted from a video processor (26) to a cathode ray tube drive (38) using a cathode current limiting circuit (20), the limiting circuit (20) including a sensing device having inputs for receiving the plurality of low level RGB signals (Vr, Vg, Vb) and being configured to monitor differences between the low level RGB signals (Vr, Vg, Vb) and to produce an output signal (Vo) when one of the RGB signals (Vr, Vg, Vb) exceeds each of the other ones of the plurality of RGB signals (Vr, Vg, Vb), the output signal (Vo) providing feedback to the video processor (26) to adjust the low level RGB signals (Vr, Vg, Vb) to limit the cathode beam current of the cathode ray tube (41,44,47) having the highest level RGB signal; and

producing an output signal (Vo) using the cathode current limiting circuit (20) when one of the RGB signals (Vr, Vg, Vb) exceeds each of the other plurality of RGB signals (Vr, Vg, Vb), the output signal (Vo) providing feedback to the video processor (26) to adjust the low level RGB signals (Vr, Vg, Vb) to limit the cathode beam current of the cathode ray tube (41,44,47) having the highest low level RGB signal.

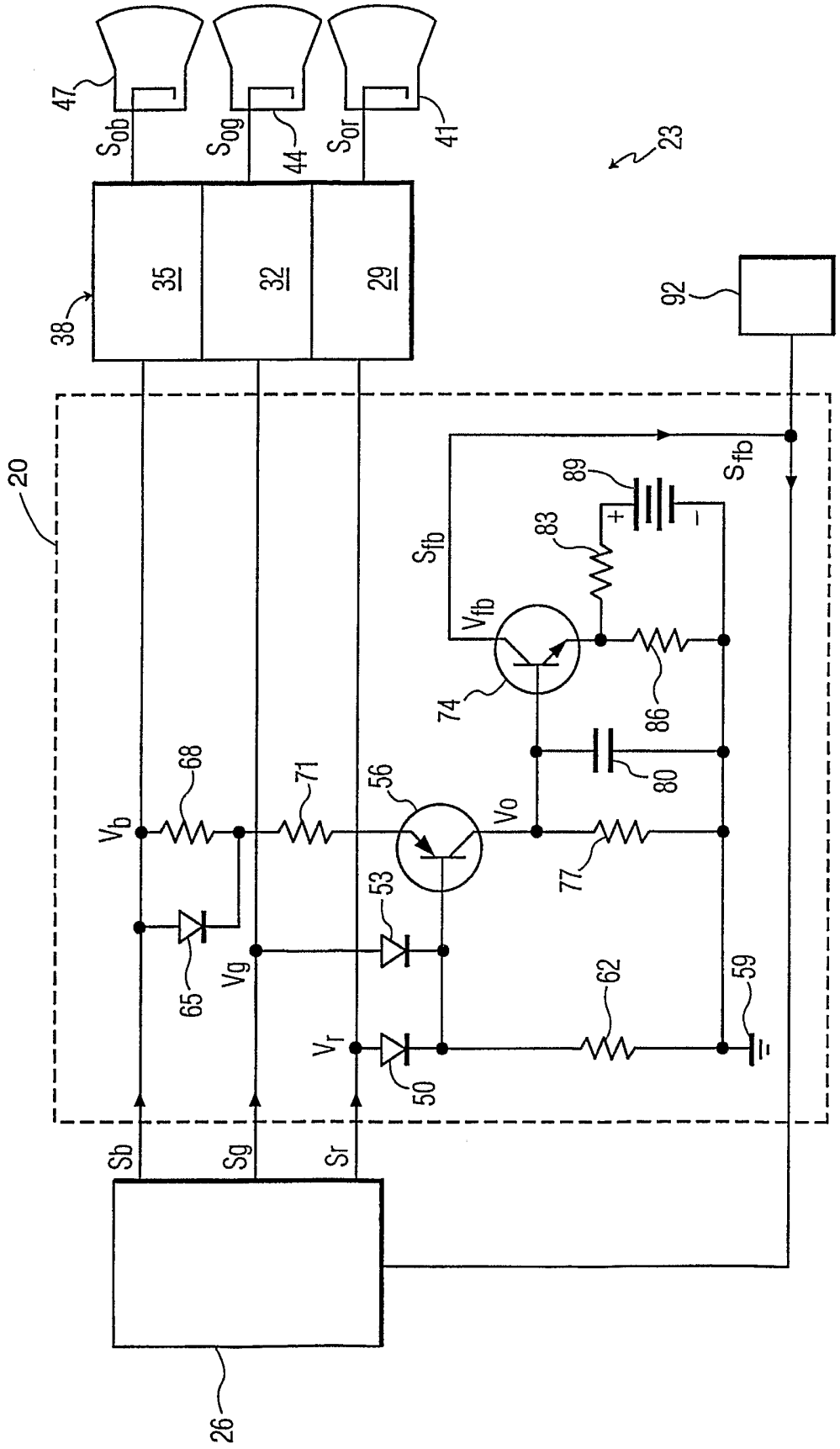
12. The method according to Claim 11, wherein the step of producing an output signal when one of the RGB signals Vr, Vg, Vb exceeds each of the other individual RGB signals Vr, Vg, Vb comprises producing an another output signal (S_{fb}) only when the equations Vb>Vr and Vb>Vg are both simultaneously satisfied.

13. The method according to Claim 12, wherein the sensing device includes an integrator (77,80) which maintains the output signal Vo of the sensing device proportional to the RGB signals Vr, Vg, Vb according to the equations:

$$Vo = k(Vb-Vg) \quad \text{for } Vb>Vg>Vr$$
$$Vo = k(Vb-Vr) \quad \text{for } Vb>Vr>Vg$$
$$Vo = 0 \quad \text{for } Vb\leq Vg \text{ and } Vb\leq Vr$$

where k is a proportionality constant, and further includes providing a second sensing device having inputs for receiving the output signal Vo from the first sensing device and a biasing voltage (89,83,86), the second sensing device being adapted to monitor differences between

the output signal Vo and the biasing voltage (89,83,86) to produce an another output signal (S_{fb}) when the output signal Vo also exceeds a predetermined value.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INTERNATIONAL SEARCH REPORT

Internati Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N9/64 H04N9/31

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 008 842 A (NAGATA KOICHIRO) 28 December 1999 (1999-12-28) column 2, line 60 -column 4, line 10 column 5, line 66 -column 6, line 41	1,11
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 06, 31 July 1995 (1995-07-31) & JP 07 087502 A (HITACHI LTD), 31 March 1995 (1995-03-31) abstract	1,11
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☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2003	24/01/2003

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In tion on patent family members

Internati pplication No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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