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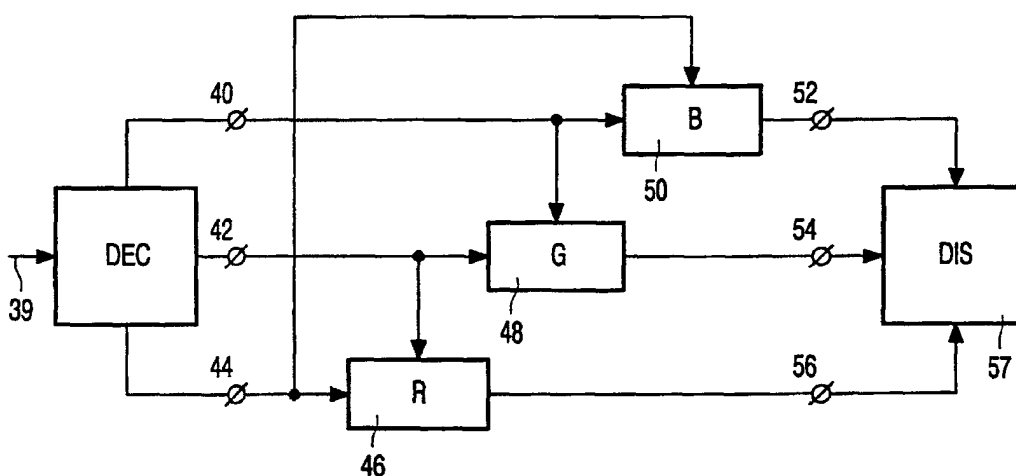
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(54) Title: INCREASING COLOR PURITY IN COLOR-SEQUENTIAL LIQUID CRYSTAL DISPLAY



(57) Abstract: A color-sequential LCD image display apparatus is operated through controlling an array of pixelized display elements for in each element rendering a plurality of colors in sequence. In particular, a compensating operation is executed against color impurities for a later color due to a non-instantaneous response of such elements as a result of an immediately preceding color for the element in question, under control of the combined color signals associated with both said immediately preceding color and said later color.

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INCREASING COLOR PURITY IN COLOR-SEQUENTIAL LIQUID CRYSTAL DISPLAY

A method and apparatus for generating a color-sequential LCD image display through controlling pixelized display elements for rendering a plurality of colors in sequence, whilst combining control signals for two successive colors against impurities from non-instantaneous response.

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BACKGROUND OF THE INVENTION

The invention relates to a system as recited in the preamble of Claim 1. Color sequential imaging systems generally use a single image element to create red, blue, green, and possibly white images sequentially in time for a particular pixel, although other color combinations have been used as well. If this image element, or the controlling mechanism in general has relaxation effects, the various color images may influence each other. In principle, an electronic pre-correction system may mitigate such effects, but this would require either introducing an additional image memory, or rather a higher bandwidth.

15 SUMMARY TO THE INVENTION

In consequence, amongst other things, it is an object of the present invention to effect such compensation at least in part, without needing additional expensive hardware. The inventor has recognized that in principle, the various colors are provided in parallel at a certain stage of the image generating.

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Now therefore, according to one of its aspects the invention is characterized according to the characterizing part of Claim 1. Generally, color sequential systems have lower system costs compared to systems wherein for each separate color a particular pixel would need a specific image element to be used in parallel for creating a color image. However, the most popular element in use today, to wit LCD, is relatively slow in reacting to control signals applied thereto. In a color-sequential application, such relaxation means that information displayed in a first color may "bleed" into another next-following color for the same pixel. If, for example, the sequence is red-green-blue-red-etcetera, information contained in the green image may be influenced by the immediately preceding red image. The effect can be mitigated by electrically pre-correcting the signal fed to the image element. However to do this, the pre-correction system

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must access the immediately preceding multicolor image. Converting a standard RGB image into a color sequential signal requires an image memory. Subsequent accessing of this information for color correction would then necessitate to double the bandwidth of the image memory, with associated cost increase. In contradistinction, according to the present invention the pre-correction is executed at an instant **before** converting from RGB to a color-sequential signal. At such earlier instant, the various color control signals would be available simultaneously. The optimum solution for an RGB sequence has the pre-correction of the green based on the red signal, and the pre-correction of the blue signal based on the red signal. Basing the pre-correction of the red signal on the blue signal from the previous frame would again require an image memory for one color, because this blue color image was then the most recent image sent to the image elements.

If also applying the correction mechanism to the **first** color control signal for the current image, the usage of an additional image memory is obviated by not using the blue signal of the previous frame, but rather the blue signal of the current frame or image. For static images, the correction mechanism will now be perfect. For non-stationary images however, some motion-induced color artefacts may occur. These small effects would introduce some bleeding of one color into another color. The worst case occurs when a saturated blue object moves over an almost black area. The pre-correction will now give a result that is slightly mislocated. Certain user tests have however found that the resultant effect is generally overlooked, inter alia, because the human eye/brain combination tends to be less sensitive for many temporal changes.

The invention also relates to an apparatus being arranged for practicing a method as claimed in Claim 1. Further advantageous aspects of the invention are recited in dependent Claims.

BRIEF DESCRIPTION OF THE DRAWING

These and further aspects and advantages of the invention will be discussed more in detail hereinafter with reference to the disclosure of preferred embodiments, and in particular with reference to the appended Figures that show:

Figure 1, a sequence of single-color frames for producing a full-color frame;

Figure 2, time-sequential organization of various color signals;

Figure 3, the nature of executing color compensation;

Figure 4, a hardware set-up for executing such compensation.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a sequence of single-color frames for producing a full-color frame. At left, an exemplary sequence 20 of blue-green-red-blue-green-red single-color frames are shown, of which each time three blue-green-red frames combine to a respective multi-color RGB

frame 22, 24. An additional white frame may be used for raising the brightness of the picture, sometimes at a cost of having a somewhat narrower color palette. The sequence of the one-color frames may be different, but is generally uniform in time. The physical nature of the rendering of colors on the display elements is standard in the art, and will not be further discussed.

5 Figure 2 shows a time sequential organization of various color signals. Although not to be considered as a restriction, in the Figure each signal has a uniform duration, as indicated by the associated BGR indications. Generally, lengthening the duration of a color period will raise the intensity of that color. Now, Figure 3 shows the nature of executing color compensation. By way of example, the intended intensities of the respective colors have been shown as drawn
10 lines, and for explanatory purpose, the control signal amplitude is supposed to be generally proportional to the associated color intensity. Figure 2 shows the effect of the relaxation, that in fact represents a kind of low-pass filter, the initial part of the color signal being displaced in the direction of the immediately preceding amplitude. Both the time constant and the intensity of the relaxation effect depend on the actual display element technology, and on the size and direction
15 of the step between successive control signals. Figure 3, therefore, also shows applicable control signal amendments, as being represented in interrupted lines: the blue signal is attenuated somewhat, and the red signal is amplified somewhat. It is noted that a negative control signal, which would be necessary for the green signal, is impossible in practice; however, the inaccuracy caused by this restriction is generally quite small. Note that Figures 2, 3 represent only an
20 example for a particular color mix.

Now, the **red** signal amendment is controlled by the immediately preceding **green** signal, so that the eventual control signal is governed by the combined control signals for two directly successive colors. Likewise, the **green** signal amendment is controlled by the immediately preceding **blue** signal. The size of the necessary control signals has not been
25 considered herein any further, inasmuch as it would be fully determined by the particular technology of the display apparatus. Now however, amending the **blue** signal through the immediately preceding **red** signal would imply taking recourse to the **red** signal (the last one) of the preceding image, and the providing thereof for effectively amending would either necessitate an image buffer, or rather necessitate raising the actually used bandwidth, because two accesses
30 would be necessary. By way of simplification and cost reduction, the present invention allows therefore to take the *succeeding red* signal of the same image as reference. For stationary or slow-moving images, the difference between the two approaches is well-nigh invisible. Only for fast-moving images, or upon camera jumps and the like, a brief disturbance would exist. Due to the perceptual nature of the human eye, the visibility of such disturbance is generally slight.

Figure 4 shows a hardware set-up for executing the compensation according to the present invention. Inputs 40, 42, 44 receive the respective blue, green and red signals in parallel with each other, as they have been derived in parallel from the compound color signal received. For simplicity, such color decoder DEC has been represented by a single block to receive a compound color signal on input 39. Now, the blue signal is coupled into amending element 48 for amending the green signal that in the sequential organization of Figures 2, 3 comes later. The green signal is coupled into amending element 46 for amending the red signal that in the sequential organization of Figures 2, 3 comes later. Finally, the red signal is coupled into amending element 50 for amending the blue signal that in the sequential organization of Figures 2, 3 comes earlier in the instant frame organization. The amount of amending may be controlled by any of various mechanisms that have been in use for generating color control signals, such as a color-look-up table CLUT, a calculating mechanism based on an expression, or other. For brevity, the respective electronic realizations of the attenuating, calculating and amplifying operations in blocks 46, 48, 50 have been suppressed as being straightforward developments for a person skilled in the art. The outputs 52-56 are coupled to the actual mechanism 57 for effecting the pixel-organized coloring. This mechanism may contain an image memory, that needs reading only in synchronism with the sequential displaying of the pixel colors, but no faster. For brevity, no further details have been shown in the Figure.

CLAIMS:

1. A method for operating a color-sequential LCD image display apparatus through controlling an array of pixelized display elements for at each element rendering a plurality of colors in sequence,

5 said method being characterized by executing a compensating operation against color impurities for a later color due to a non-instantaneous response of such elements as a result of an immediately preceding color for the element in question, under control of the combined color signals associated with both said immediately preceding color and said later color.

2. A display apparatus for generating a color-sequential LCD image through an array
10 of pixelized display elements, each element being arranged for rendering a plurality of colors in sequence,

characterized by having compensating means (46, 48) for executing a compensating operation against color impurities for a later color due to a non-instantaneous response of such elements as a result of an immediately preceding color for the element in
15 question, through developing a secondary control signal (54, 56) from the combined primary color signals (42, 44) associated with both said immediately preceding color and said later color.

3. An apparatus as claimed in Claim 2, wherein said compensating means (50) is operative for a first color within a frame as based on another succeeding color signal (44) in the
20 same frame.

4. An apparatus as claimed in Claim 2, wherein such display element (57) is operative for displaying all colors pertaining to an associated pixel element.

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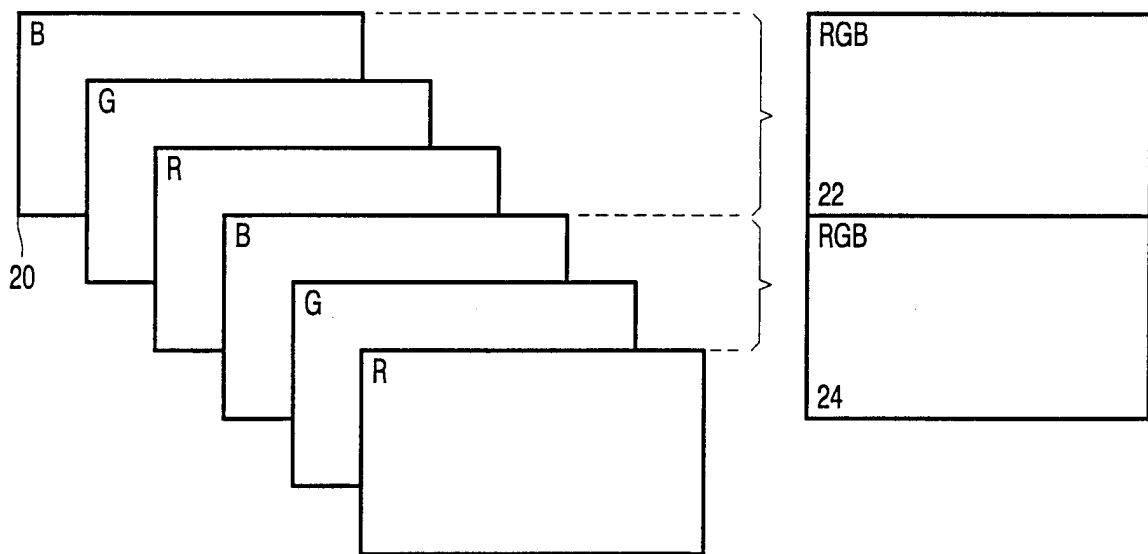


FIG. 1



FIG. 2



FIG. 3

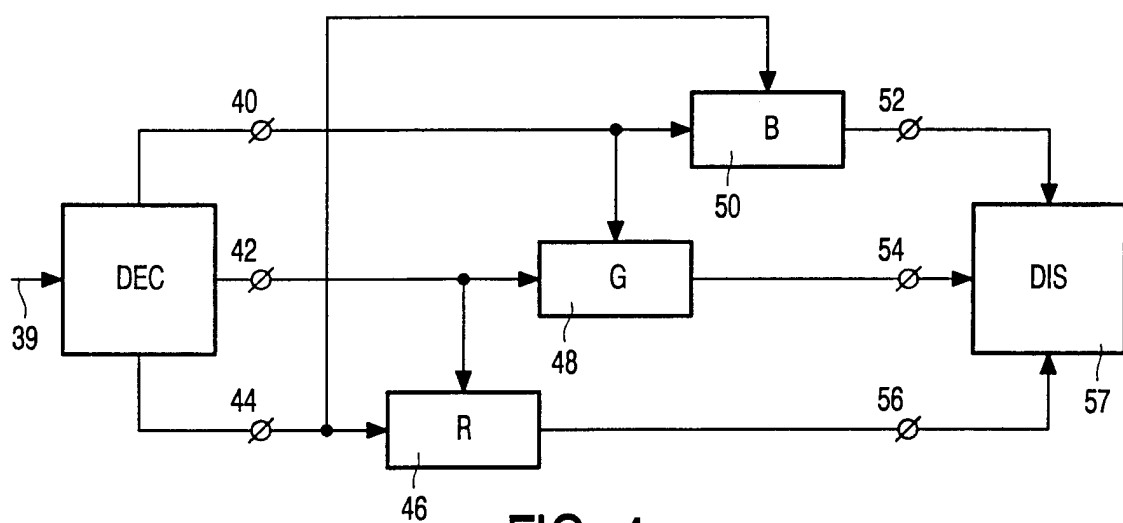


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/04929

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G09G3/36

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 G09G

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94 09475 A (LIANG JEMM Y ; PANOCORP DISPLAY SYSTEMS (US)) 28 April 1994 (1994-04-28) page 16, line 14 - page 20, line 9; figure 6A page 21, line 29 - line 33 -----	1-4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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- *E* earlier document but published on or after the international filing date
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T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

10 October 2000

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INTERNATIONAL SEARCH REPORT

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PCT/EP 00/04929

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9409475 A	28-04-1994	AU 5445894 A CN 1107233 A	09-05-1994 23-08-1995

专利名称(译)	增加色序液晶显示器的色纯度		
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优先权	1999201843 1999-06-10 EP		
外部链接	Espacenet		

摘要(译)

通过控制像素化显示元件阵列来操作彩色顺序LCD图像显示装置，以在每个元件中依次呈现多种颜色。特别地，在与所述元件相关联的组合颜色信号的控制下，由于这些元件的非瞬时响应，由于所讨论元件的紧接在前颜色的结果，对颜色杂质执行补偿操作以用于后续颜色。前一个颜色和后面的颜色。