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(54) Method of processing a video signal for a display system using time modulation

(57) The present invention relates to a method of processing a video signal intended for a matrix display system such as a plasma panel in which the grey level applied to each pixel or cell is produced by using temporal modulation of the signal. The invention also relates to a circuit making it possible to implement this method. According to the method, the direction of motion of the transitions in the video signal is determined and a median filtering is carried out on N consecutive pixels, along the direction of motion.

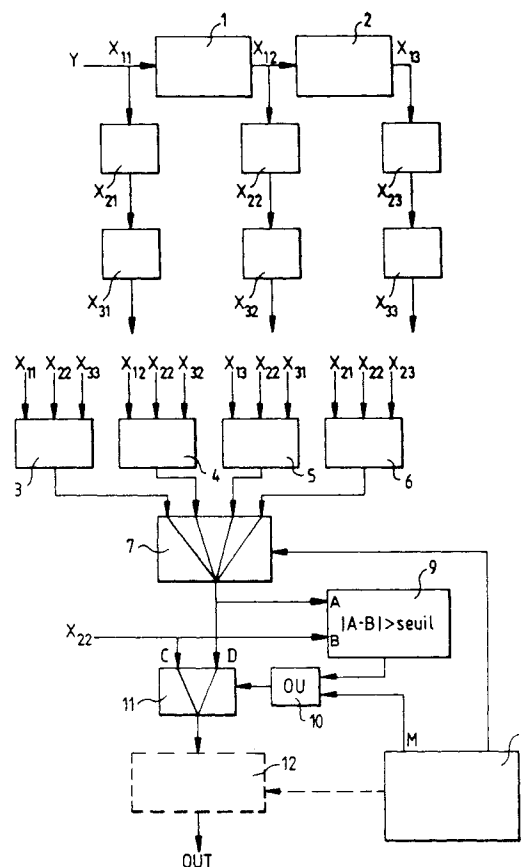


FIG.3

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Description

[0001] The present invention relates to a method of processing a video signal for a matrix display, more especially for a matrix display system in which the grey level applied to each pixel or cell is obtained by using width type modulation of the signal to be displayed. The present invention also relates to a device for implementing the above method.

[0002] Among matrix displays in which the grey level applied to each pixel is obtained by using width type modulation, plasma screens are more especially known. Accordingly, the present invention will be described whilst referring to this type of screen. However, it is obvious to the person skilled in the art that the present invention may also be applied to other matrix displays which use this type of width modulation, in particular devices of the micro-mirror type.

[0003] In a known manner, a plasma panel consists of two glass substrates onto each of which at least line electrodes and column electrodes, respectively, are screen printed. The number of line electrodes and column electrodes corresponds to the definition of the panel. Each crossover between a column electrode and a line electrode corresponds to a video cell which, in the case of a plasma panel, contains a volume of gas. In the case of a colour plasma panel, each cell is covered with a red, green or blue phosphor, a triple of red, green and blue cells defining a video pixel. Therefore, a colour plasma panel comprises three times as many column electrodes as pixels. On the other hand, the number of line electrodes is equal to the number of lines of the panel. Given this matrix architecture, it is sufficient to apply a potential difference to the crossover between a line electrode and a column electrode in order to excite a specific cell and thus obtain pointwise a gas in the plasma state. During the ionization of the gas, there is an emission of ultraviolet which will bombard the red, green or blue phosphors and thus give a red, green or blue illuminated cell. In fact, a cell possesses only two states, namely an excited or non-excited state. Therefore, it is not possible to carry out analogue modulation of the light level emitted, as in the case of cathode-ray tubes. Accordingly, in order to account for the various grey levels, width modulation of the duration of emission of the cell is used during the frame period referenced T. This frame period is divided into as many sub-periods n as bits used to code the video signal. From these n sub-periods, it must be possible, by combination, to reconstruct all the grey levels. In fact, the eye of the observer integrates these n sub-periods over a frame period T and thus recreates the grey levels. Thus, in the case of width modulation on 4 bits, each of the lines is addressed four times, the interval between two addressings defining the duration of the sub-scan. Hence may be distinguished an erase/write phase and a sustain phase.

[0004] The eye in fact integrates much faster than the frame duration and thus runs the risk of discerning, in cases of particular transitions of the addressing bits, variations in level which do not reflect reality. Contour defects or "contouring" may thus appear on the moving images. These defects may be compared with poor temporal restitution of the grey level. More generally, false colours appear on the object contours, each of the cells of a colour component possibly being subject to this phenomenon. This phenomenon is still more disruptive when it appears in relatively homogeneous zones. This phenomenon of "contouring" can be explained by referring to Figure 1. In this figure, the abscissa axis represents time and is subdivided into frame periods of duration T . Each frame period is divided into sub-periods whose duration is proportional to the weight of the various sub-scans thus making it possible to define a video level to be displayed on the plasma panel (1, 2, 4, 8...128) for a video signal quantized on 8 bits and addressing possessing 8 sub-scans. The ordinate axis represents the 0 or 1 logic level of the addressing bits during the frame periods corresponding to the unlit or illuminated state of a cell as a function of time for a given coding level.

[0005] Curve 1 corresponds to a coding of the value 128, curve 2 to a coding of the value 127 and curve 3 to a coding of the value 128 during the first frame and of the value 127 during the second frame and vice versa for the following two frames. The principle of width modulation of the grey levels involves a temporal splitting of the n bits coding the video signal into n sub-scans over the 20 milliseconds (T) of the frame. Taking a coding on 8 bits ($n = 8$), the transitions 127/128 and 128/127 entail a switching of all the bits. These 8 codes being split into 8 sub-scans over the 20 milliseconds of the frame, the eye, by integrating this information asynchronously, causes the appearance of the black zones (b) and the white zones (a) as represented in the Figure. This relates to a static description of the false-contour phenomenon taking into account the variations in coding from one frame to another for a given pixel. However, the straightforward static explanation of the phenomenon is not sufficient to describe it fully. It is also necessary to introduce a concept of the tracking of a contour by the eye in order to approximate what the observer actually perceives. It is therefore necessary to carry out a dynamic analysis of the problem introducing the concept of motion in the image.

[0006] The false-contour phenomenon therefore shows up in moving zones during strong transitions. However, the concept of strong transition does not correspond solely to strong variations in the video signal level but the expression strong transition is also used when there is switching of the bits of high weight. The false-contour phenomenon therefore appears when the variation in level between frames is small but corresponds to a significant switching in the level of the high weights, for example the 127/128 transition. In a uniform zone centred around these values 127/128 while the observer does not perceive any transition on a screen with a cathode-ray tube, he will see these false contours appear on a plasma panel during small movements. Moreover, some of the false contours may appear simply in relatively homogeneous zones such as the texture of the skin, by accompanied by noise. For example, a 127/128/127 transition with a movement of 3 pixels/image generates a fairly strong false contour as represented in Figure 2 in which curve 1

represents the position of the pixel with respect to the retina for 2 successive frames F_1 and curve 2 the appearance of the false contours at c and d. Thus, in the case of a colour screen, these false contours will be manifested by the appearance on the panel near these contours of "false colours", due to an erroneous interpretation of the RGB trio. Accordingly, studies of the false-contour phenomenon show that the straightforward static explanation of the phenomenon is not sufficient to describe the problem, but that it is necessary to introduce a concept of the tracking of the contour by the eye in order to approximate what the observer actually perceives. It is therefore necessary to carry out a dynamic analysis of the problem introducing the concept of motion in the image.

[0007] The objective of the present invention is therefore to propose a video signal processing method which takes into account the above observations and which makes it possible, in a single use, to eliminate some of the false contours or to make the corrections suitably in the case of the use of the known technique for adding equalization pulses.

[0008] The subject of the present invention is a method of processing a video signal intended for a matrix display system in which the grey level applied to each pixel or cell is produced using width modulation of the signal, characterized in that it comprises the following steps:

- determination of the direction of motion of the transitions in the video signal, and
- carrying out of a median filtering on N consecutive pixels, along said direction of motion.

[0009] Preferably, the median filtering is applied along four favoured directions, namely the horizontal, the vertical and the two diagonals.

[0010] Moreover, the median filtering is carried out with the aid of a median filter of odd size, preferably a one-dimensional filter of size 3.

[0011] The present invention also relates to a circuit for implementing the above method. This circuit comprises means for storing the current pixel and at least the neighbouring pixels along the direction of filtering and at least one median filter receiving the current pixel and the two neighbouring pixels along the direction of filtering. Preferably, the circuit comprises means for storing the current pixel and the eight pixels surrounding the current pixel, four median filters each respectively receiving the current pixel and two neighbouring pixels along the horizontal and vertical directions and along the two diagonals, and a switching circuit provided at the output of the four median filtering means and a means of selecting one of the filters as a function of the direction selected.

[0012] Other characteristics and advantages of the present invention will become apparent on reading the description below of a preferred embodiment of a circuit making it possible to implement the present invention, this description being given with reference to the drawings in which:

Figure 1 already described represents a timing diagram explaining the false-contour phenomenon,

Figure 2 already described represents various curves explaining the false-contour phenomenon in a spatio-temporal manner and,

Figure 3 is a diagrammatic representation of a circuit implementing the present invention.

[0013] Before describing the circuit of Figure 3 in detail, the definition of a median filter will firstly be recalled. A median filter is a non-linear filter of a so-called statistical nature. The median filter is of simple design with a good rate of calculation. The filters of this kind generally behave well in the presence of additive white noise and of Gaussian noise. They also exhibit properties of good preservation of edges and can be adaptive. The median filter is defined as follows:

[0014] The median of n samples x_i , $i = 1, \dots, n$ is denoted $\text{med}(x_i)$ and is defined by:

$$\text{med}(X_i) = \begin{cases} x(v+1) & n = 2v+1 \\ \frac{1}{2}(x(v) + x(v+1)) & n = 2v \end{cases}$$

where $x(i)$ is the element of statistical nature i. Generally, median filters of odd size n are used. Within the frame of the present invention, a one-dimensional median filter of size 3 is preferably used.

[0015] A one-dimensional filter of size 3 is defined by the following equation:

$$y(i) = \text{med}(x_{i-1}, x_i, x_{i+1})$$

[0016] Example with a string of samples $x_i = \{2, 3, 8, 4, 2\}$

$$y_0 \equiv 2(\text{boundary value})$$

$$y_1 = \text{med}(2, 3, 8) = 3,$$

$$y_2 = \text{med}(3, 8, 4) = 4,$$

$$y_3 = \text{med}(8, 4, 2) = 4,$$

$$y_4 \equiv 2(\text{boundary value})$$

[0017] Moreover, to eliminate some of the false contours, as explained in the introduction, it is preferable for the filtering to be carried out in the direction of motion of the transitions. Consequently, in accordance with the present invention, four directions of motion will be favoured along which a median filtering of size 3 will be carried out. These directions are the horizontal direction, the vertical direction and the two directions along the diagonals. A median filtering is therefore applied to each of these directions, the choice of appropriate filtering being performed by a motion estimator customarily used in the processing of video signals. This estimator provides moreover not only an indication of direction, but also an indication regarding the amplitude of motion detected.

[0018] However, this type of filtering must be limited. This is because it is not favourable to high frequencies and may eliminate fine details such as horizontal or vertical lines. Since, moreover, the corrections must be made solely in homogeneous zones, and as the filtering has to eliminate only low-amplitude noise, according to a supplementary characteristic, it is envisaged to control the action of the filter with respect to a threshold.

[0019] A preferred embodiment of a circuit implementing the method explained above will be described in greater detail with reference to Figure 3. As represented in Figure 3, the input video signal Y is sent to storage means making it possible to work on three lines in parallel, more particularly to two line memories 1, 2. The filtering is carried out by using the reference pixel X_{22} in Figure 3 as current pixel. In accordance with a preferred embodiment of the present invention, in which four directions of motion have been favoured, four median filters 3, 4, 5, 6 are used. Each median filter is a one-dimensional filter of dimension 3. As represented in Figure 3, the median filter 3 receives pixels X_{11} , X_{22} , X_{33} and corresponds to a motion along a first diagonal. The median filter 4 receives pixels X_{12} , X_{22} , X_{33} and corresponds to a motion along the vertical. The median filter 5 receives pixels X_{13} , X_{22} , X_{31} and corresponds to a motion along the second diagonal and the median filter 6 receives pixels X_{21} , X_{22} and X_{23} and corresponds to a motion along the horizontal. The output from the four median filters 3, 4, 5 and 6 is sent as input to a switching circuit 7 which chooses the output from one of the median filters as a function of the direction of motion given by a motion estimator 8. The motion estimator is a known circuit present in the system for processing the video signals to be displayed on a plasma type matrix screen. The motion estimator is used for the scan conversion and it provides an item of information regarding the presence or non-presence of motion along one of the four possible directions.

[0020] Preferably, so as to carry out the filtering only in homogeneous zones, while eliminating only low-amplitude noise, the circuit in Figure 3 comprises a comparator 8 making it possible to compare the value of the current pixel X_{22} minus the value output by the selected median filter, namely the value output by the circuit 7, with a threshold, by carrying out the function $IA - BI > \text{threshold}$, B being the value of pixel X_{22} and A the value output by the circuit 7. The output from the comparator 8 as well as the output from the motion estimator 9 giving an item of information regarding the presence or non-presence of motion are sent to an OR circuit 10. Furthermore, the output from the OR circuit 10 controls a second switching circuit 11 allowing switching between the value of the current pixel X_{22} on the first input C and the value output by the switching circuit 7 on its input D. The value output by the switching circuit 11 is sent directly to the circuit for 10-bit coding which is used for the address coding of a plasma panel, or to a circuit which gives equalization pulses and can be used to reduce certain false-contour effects. Such a circuit is known to those skilled in the art and is described for example in the article: A Motion-Dependent Equalizing-Pulse Technique for Reducing Gray-Scale Disturbances on PDPs, by Y.-W. Zhu, K. Toda, T. Yamaguchi, T. Shiga, S. Mikoshiba (University of Electro-Communications, Tokyo, Japan) and by T. Ueda, K. Kariya, T. Shinoda (Fujitsu, Ltd., Kawasaki, Japan) published in SID 97 DIGEST.

[0021] In accordance with the present invention, three processing circuits such as described above are used, one for each colour, red (R), green (G), blue (B). Moreover, the circuit described above has been positioned directly ahead of the circuit for 10-bit coding, namely after the customarily used gamma correction circuit, however it is obvious to the person skilled in the art that it may be used ahead of the gamma correction circuit.

Claims

1. Method of processing a video signal intended for a matrix display system in which the grey level applied to each pixel or cell is produced using width modulation of the signal, characterized in that it comprises the following steps:
 - determination of the direction of motion of the transitions in the video signal, and
 - carrying out of a median filtering on N consecutive pixels, along said direction of motion.
2. Method according to Claim 1, characterized in that the median filtering is applied along four directions, namely the horizontal, the vertical and the two diagonals.
3. Method according to Claim 1, characterized in that the median filtering is carried out with the aid of a median filter of odd size, preferably a one-dimensional filter of size 3.
4. Method according to any one of the preceding claims, characterized in that it comprises a detection of presence or absence of motion validating the filtering.
5. Method according to any one of the preceding claims, characterized in that it comprises a comparison of the correction value with a threshold validating the filtering.
6. Method according to any one of the preceding claims, characterized in that the method is applied to each colour, red, (R), green (G) and blue (B).
7. Circuit for implementing the method according to any one of claims 1 to 6, characterized in that it comprises means for storing the current pixel and at least the neighbouring pixels along the direction of filtering and at least one median filter receiving the current pixel and the two neighbouring pixels along the direction of filtering.
8. Circuit according to Claim 7, characterized in that it comprises means (1,2) for storing the current pixel and the eight pixels surrounding the current pixel, four median filters (3,4,5,6) each respectively receiving the current pixel and two neighbouring pixels along the horizontal and vertical directions and along the two diagonals, and a switching circuit (7) provided at the output of the four median filtering means and a means (8) of selecting one of the filters as a function of the direction selected.
9. Circuit according to Claim 8, characterized in that the switching circuit is connected to a motion estimator (8) giving the direction of motion of the transitions.
10. Circuit according to Claim 8, characterized in that the motion estimator sends a pulse of presence or non-presence of motion to a circuit making it possible to disable the filtering.
11. Circuit according to Claim 10, characterized in that the circuit making it possible to disable the filtering is a second switching circuit (11) receiving the current pixel on one input (C) and the output from the filtering circuit on the other input(D).
12. Circuit according to any one of the preceding claims, characterized in that it furthermore comprises a thresholding circuit (9) disabling the filtering circuit in respect of the non-homogeneous zones.
13. Circuit according to Claim 12, characterized in that the thresholding circuit carries out the function $|A-B| > \text{threshold}$, where A represents the output from the filtering circuit and B the current pixel.

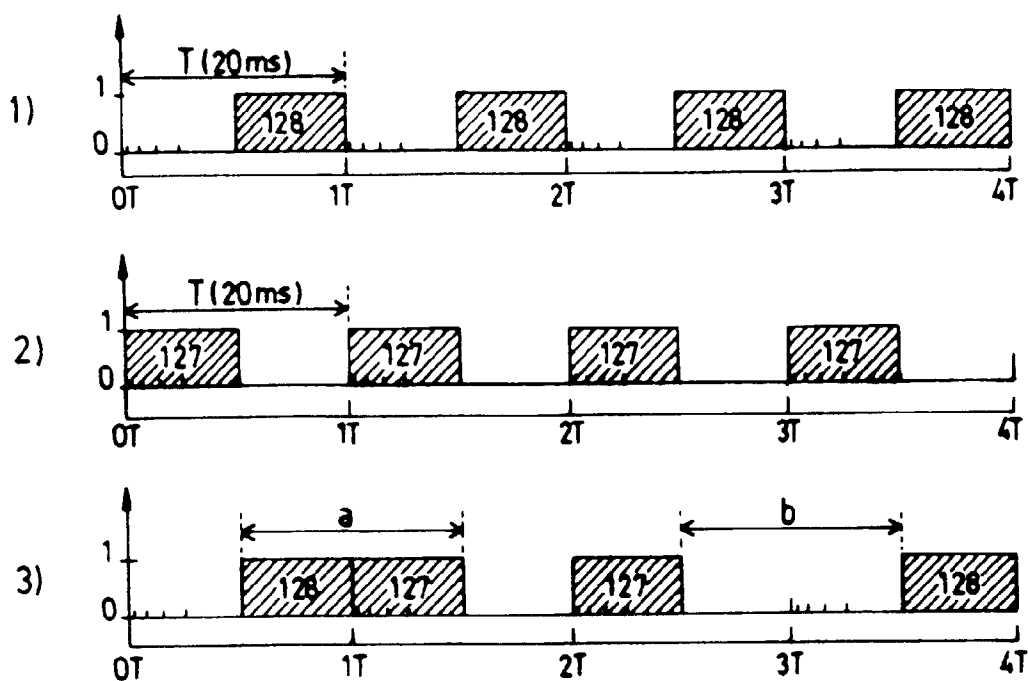


FIG.1

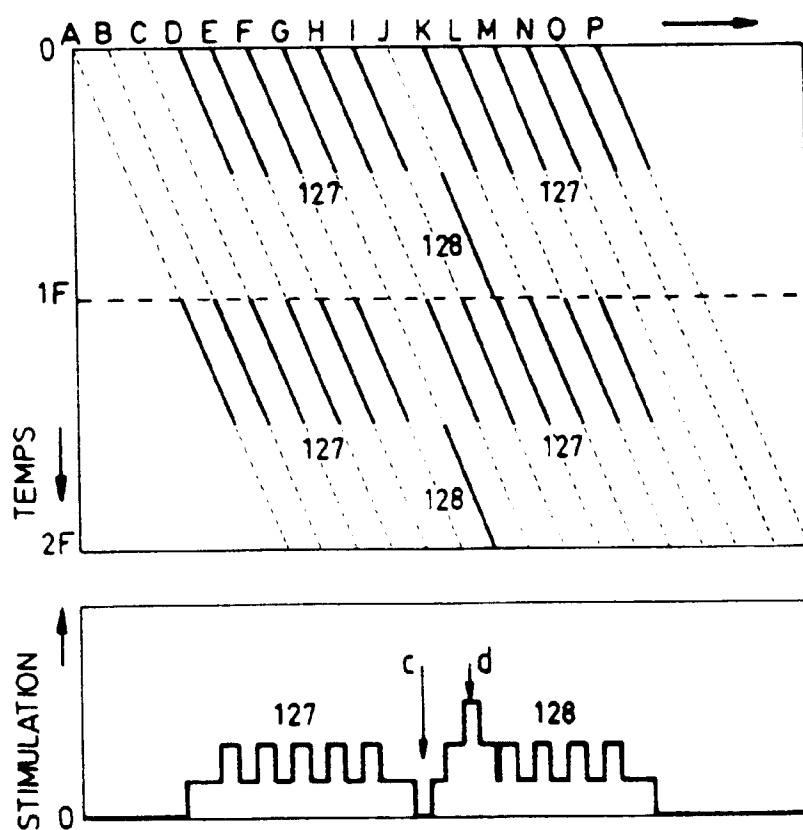


FIG.2

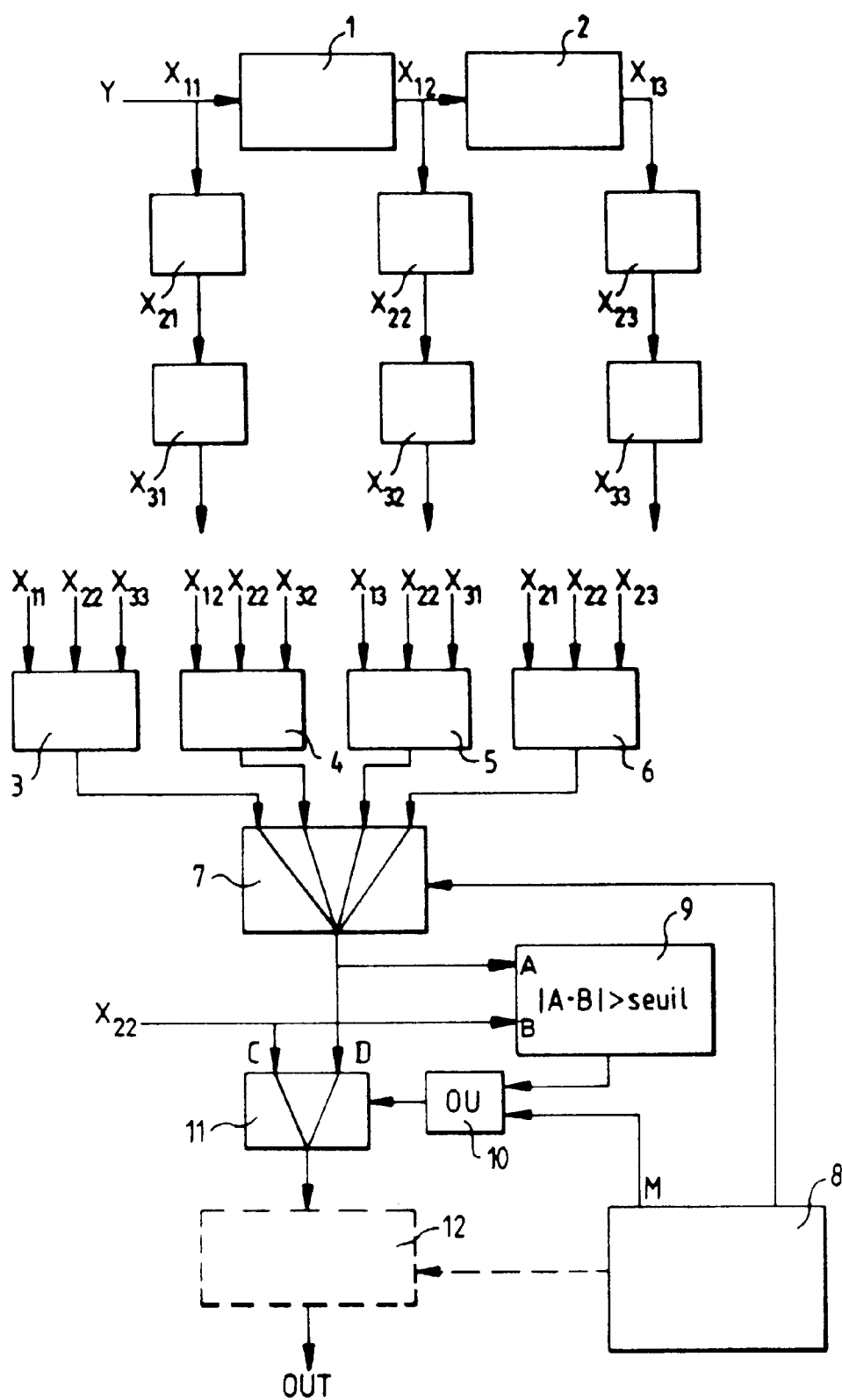


FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 99 40 0885

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A A A,D	EP 0 822 536 A (FUJITSU LTD.) 4 February 1998 (1998-02-04) * abstract * * page 2, line 14 - line 23 * * page 8, line 9 - line 22; figure 11 * --- EP 0 720 139 A (PIONEER ELECTRONIC CORP.) 3 July 1996 (1996-07-03) * abstract * * page 3, line 7 - line 15; figures 5-8 * --- ZHU Y -W ET AL: "15.3: A MOTION-DEPENDENT EQUALIZING-PULSE TECHNIQUE FOR REDUCTING GRAY-SCALE DISTURBANCES ON PDPS" 1997 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, BOSTON, MAY 13 - 15, 1997, no. VOL. 28, 13 May 1997 (1997-05-13), pages 221-224, XP000722692 SOCIETY FOR INFORMATION DISPLAY * the whole document * * abstract * -----	1,4,6,7, 9 2,3,5,8, 10-13 1-13 1-13	G09G3/28
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G09G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 3 August 1999	Examiner O'Reilly, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 40 0885

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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03-08-1999

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