

DESCRIPTION

**ELECTRICALLY CONTROLLED BIRIFRINGENCE LIQUID CRYSTAL DISPLAY HAVING MORE
DISPLAY AREAS AND METHOD OF DRIVING THE SAME**

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Technical Field

The present invention relates to a liquid crystal display apparatus and a method of driving the same, and, more particularly, to a liquid crystal display apparatus which displays color images using the birifringence of a liquid crystal.

Background Art

A liquid crystal display (LCD) panel for a color LCD apparatus generally has a liquid crystal (LC) cell, a pair of polarization plates sandwiching the LC cell, and a back light (illumination light source) located outside one of the polarization plates. The LC cell comprises a pair of transparent substrates with transparent electrodes formed on the opposing surfaces of the transparent substrates, and a liquid crystal sandwiched between the transparent substrates. One of the transparent substrates is provided with a color filter.

Conventional LCD apparatuses are driven by enabling or disabling the drive voltage to be applied between the opposing transparent electrodes to control the alignment state of the liquid crystal and causing the light from the back light to or not to transmit the LCD panel. When passing the color filter, the light from the back light is

colored to the color of that color filter, displaying a color image.

The light transmittance of the color filter is low, so that the conventional color LCD apparatus suffers a large
5 light loss at the color filter, making the display darker.

In a reflection type LCD apparatus which employs a reflector in place of the back light, in particular, the incident light is absorbed by the color filter twice, before and after it is reflected at the reflector. This
10 absorption darkens the display. It is therefore difficult to employ a color-filter using color LCD panel in the reflection type LCD apparatus.

Under this circumstance, recently has been developed an electrically controlled birifringence (ECB) type LCD
15 apparatus which can display color images without using any color filter.

Since this ECB type LCD apparatus employs a different coloring method from that of the LCD apparatuses using a color filter, it cannot be driven directly by using an RGB
20 signal which is used to drive an ordinary color LCD device using a color filter. Accordingly, the conventional ECB type LCD apparatus disregards color information and uses luminance information to provide the two-color (ON and OFF) display.

25 As another possible approach, the applied voltage may be altered in accordance with a display color which is specified by an RGB signal may be discriminated. This method, however, requires a process of temporarily

developing a display image in a frame buffer and then changing the applied voltage according to the display color. This method therefore needs a relatively large-capacity frame buffer and involves complex data processing.

5 Disclosure of Invention

Accordingly, it is a primary object of the present invention to provide an LCD apparatus capable of presenting multi-color display without using color filter, and a method of driving the same.

10 It is another object of this invention to provide an LCD apparatus which can set display colors on the apparatus side, and a method of driving the same.

It is a further object of this invention to provide an LCD apparatus capable of presenting gradation (color) display without using a large-capacity frame buffer, and a method of driving the same.

To achieve the above objects, a liquid crystal display apparatus according to the first aspect of the present invention comprises:

20 a liquid crystal display panel (3) for displaying
different colors in accordance with an applied voltage, the
liquid crystal display panel (3) having at least two
display areas (3b, 3c);

designations means (301 to 304) for respectively
25 setting display colors in the at least two display areas
(3b, 3c); and

drive means (400) for generating drive signals
respectively to the at least two display areas (3b, 3c) in

accordance with display colors specified by the designation means (301 to 304) and applying the drive signals to the liquid crystal display panel (3), thereby displaying colors, specified by the designation means (301 to 304), on
5 the at least two display areas (3b, 3c).

The at least two display areas (3b, 3c) include a first display area (3b) for displaying an image comprising a plurality of pixels and a second display area (3c) for displaying an image comprising at least one pixel. In this
10 case, the designation means may include means (301, 303, 304) for specifying a display image, a display color and a display position for the first display area (3b) and means (302) for specifying a display color for the second display area (3c).

15 The first display area (3b) may have a dot matrix display area, and the second display area (3c) may have a pictograph display section.

The first display area (3b) may have character display areas for displaying a plurality of characters each
20 comprising a plurality of pixels; and the second display area (3c) may have an image display area for displaying an image comprising at least one pixel. In this case, the designation means specifies characters to be displayed, display colors and display positions to the drive means
25 (400) with regard to the character display areas (3b), and specifying a display color of an image with regard to the image display area (3c).

The designation means (301 to 304) may specify, for

each of the plurality of characters, the character, display color and display position and specifying the display color for each pixel constituting the image.

The designation means (301 to 304) may comprise:

5 character code storage means (301) for storing character codes in association with positions at which the first display area (3b) of the liquid crystal display panel (3) displays the characters; character color data storage means (304) for storing display color data of characters in
10 association with the character codes stored in the character code storage means (301); and image color data storage means (302) for storing image color data to be displayed on the second display area (3c).

The image color data storage means (302) stores, for
15 example, individual bits of the image color data in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory area.

The character color data storage means (304) and/or the image color data storage means (302) may store p-bit
20 display color data for designating any of 2^p colors, where p is a positive integer; and the drive means (400) may include means for converting the p-bit display color data to q-bit display color data where q is a positive integer greater than p and means (400) for driving the liquid
25 crystal display panel (3) to display the display data in a display color corresponding to the q-bit display color data after conversion.

To achieve the above objects, a method of the second

aspect of the present invention is for driving a liquid crystal display panel which displays different colors in accordance with an applied voltage and has at least two display areas (3b, 3c).

5 The method comprises the steps of;

 respectively setting display colors in the at least two display areas (3b, 3c); and

 generating drive signals respectively to the at least two display areas (3b, 3c) in accordance with the display
10 color setting and applying the drive signals to the liquid crystal display panel (3), thereby displaying set colors on the at least two display areas (3b, 3c).

 The at least two display areas (3b, 3c) of the liquid crystal display panel (3) may include a first display area
15 (3b) for displaying an image comprising a plurality of pixels and a second display area (3c) for displaying an image comprising at least one pixel. In this case, the setting step may specify a display image, a display color and a display position for the first display area (3b) and
20 a display color for the second display area (3c).

 The first display area (3b) may have a dot matrix display area, and the second display area (3c) may have a pictograph display section.

 The first display area (3b) may have character display
25 areas for displaying a plurality of characters each comprising a plurality of pixels; and the second display area (3c) may have an image display area for displaying an image comprising at least one pixel.

The setting step specifies, for example, with regard to the character display areas, characters to be displayed, display colors and display positions, and with regard to the image display area, a display color of an image.

- 5 The setting step may specify, for each of the plurality of characters, the character, display color and display position and the display color for each pixel constituting the image.

- The setting step may store character codes in
10 character code storage means (301) in association with positions at which the liquid crystal display panel displays the characters, display color data of characters in character color data storage means (304) in association with the character codes stored in the character code
15 storage means (301), and image color data to be displayed on the second display area in image color data storage means (302). In this case, the driving step drives the liquid crystal display panel (3) based on data stored in the character code storage means (301), the character color
20 data storage means (304) and the image color data storage means (302).

- Individual bits of the image color data are stored, for example, in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory
25 area.

 The setting step may store in at least one of the character color data storage means and the image color data storage means, p-bit display color data for designating any

of 2^p colors; and the driving step may convert the p-bit display color data to q-bit display color data ($q > p$) and drives the liquid crystal display panel in such a way as to display the display data in a display color corresponding to the q-bit display color data after conversion.

The liquid crystal display panel (3) is comprised of a reflection type of liquid crystal display device which changes display colors by changing retardation of a liquid crystal by controlling an applied voltage.

10 Brief Description of Drawings

Fig. 1 is a cross-sectional view of an LCD panel of a color LCD apparatus according to one embodiment of this invention;

Fig. 2 is an exemplary plan view exemplifying the combination of the direction of the aligning treatment performed on an aligning film in the LCD panel according to this embodiment, the optical axis of a retardation plate and the transmission axis of a polarization plate for each constituting element;

20 Fig. 3 is a diagram showing the display area of the LCD panel according to this embodiment;

Fig. 4 is a block diagram showing the general structure of the color LCD apparatus according to this embodiment;

25 Fig. 5 is a block diagram showing the detailed structure of a drive controller according to this embodiment;

Fig. 6 is a diagram depicting the memory structure of

a DDRAM according to this embodiment;

Fig. 7 is a diagram depicting the memory structure of a pictograph (picto) RAM according to this embodiment;

Fig. 8 is a diagram depicting the memory structure of
5 a CGROM according to this embodiment;

Fig. 9 is a diagram depicting the memory structure of a CCRAM according to this embodiment;

Fig. 10 is a diagram illustrating the correlation between gradation data and the contents of palettes A, B, C
10 and D;

Fig. 11 is a diagram exemplifying picto display data which is displayed in different colors dot by dot;

Fig. 12 is a diagram showing an example in which gradation data in the picto display data in Fig. 11 is set
15 by a pair of data at the adjoining addresses;

Fig. 13 is a diagram exemplifying the setting of gradation data in the picto RAM by a pair of data at the adjoining addresses;

Fig. 14 is a diagram exemplifying the setting of
20 gradation data in the picto RAM by a pair of adjoining bits; and

Fig. 15 is a diagram illustrating the memory structure of the picto RAM which also serves as a CGRAM.

Best Mode for Carrying Out the Invention

25 A preferred embodiment of the present invention will now be described referring to the accompanying drawings.

Fig. 1 presents a cross-sectional view of an LCD (Liquid Crystal Display) panel of a color LCD apparatus

according to one embodiment of this invention.

As shown in Fig. 1, a color LCD apparatus 1 comprises an LCD panel 3 and a drive controller 5 which drives the LCD panel 3. The drive controller 5 controls the value of the drive voltage to be applied to the LCD panel 3 to display images in different colors in accordance with the value of the drive voltage.

The LCD panel 3, which is a reflection type, has an LC (Liquid Crystal) cell 30, upper and lower polarization plates 40 and 41 sandwiching the LC cell 30, a retardation plate 42 located between the LC cell 30 and the upper polarization plate 40, and a reflector 43 provided on the bottom of the lower polarization plate 41 (at the back of the LCD panel 3).

The LC cell 30 has a pair of transparent substrates 31 and 32 connected via a seal member 33, and a liquid crystal 34 sealed in the area defined by those substrates 31 and 32. Respectively formed on the opposing surfaces of the transparent substrates 31 and 32 are transparent electrodes (segment electrodes) 36 and 40 transparent electrodes (common electrodes) 38. Aligning films 37 and 39 are respectively formed on the transparent electrodes 36 and 38.

The aligning films 37 and 39, whose surfaces have undergone an aligning treatment like rubbing, restrict the aligning direction of the nearby LC molecules so that the lengthwise directions of the LC molecules are aligned to the direction of the aligning treatment. Accordingly, the

LC molecules 34a of the liquid crystal layer 34 are twisted toward the transparent substrate 32 from the transparent substrate 31 at an angle of 180 to 270 degrees. That is, the LC cell 30 is a super twisted nematic (STN) LC cell.

5 The retardation plate 42 causes the linearly polarized light having passed the upper polarization plate 40 to be elliptically polarized. The retardation plate 42 has its optical axis (phase-leading axis or phase-lagging axis) obliquely shifted from the transmission axis, 40a, of the
10 upper polarization plate 40 by a predetermined angle.

Fig. 2 is an exemplary plan view exemplifying the combination of the direction of the aligning treatment performed on the aligning film in the LCD panel according to this embodiment, the optical axis of the retardation
15 plate and the transmission axis of the polarization plate for each constituting element.

In the diagram, single-arrowhead lines 31a and 32a indicate directions of the aligning treatment performed on the aligning films 37 and 39, respectively. Double-
20 arrowhead lines 40a and 41a respectively indicate the transmission axes of the upper polarization plate 40 and the lower polarization plate 41. A line 42a shows the optical axis of the retardation plate 42. A line S indicates a reference line which is introduced for the sake
25 of descriptive convenience and extends horizontally.

As shown in Fig. 2, the aligning-treatment directions 31a and 32a are set to be inclined in the opposite directions to the reference line S by a predetermined angle

ϕ . Accordingly, the LC molecules 34a (Fig. 1) are twisted toward the upper transparent substrate 32 from the lower transparent substrate 31 in the direction and angle indicated by the arrow T.

5 The optical axis 42a of the retardation plate 42, which is, for example, the phase-lagging axis, obliquely intersects the reference line S by a predetermined inclination angle ψ . The transmission axes 40a and 41a, which are parallel to each other, are inclined to the
10 optical axis 42a by an inclination angle ϕ .

 The following will describe why a display image on the LCD panel 3 is colored.

 As external light passes the upper polarization plate 40, it is linearly polarized. As the linearly polarized
15 light passes the retardation plate 42, it becomes elliptically polarized by the birifringence effect according to the optical layout condition, such as the position of the retardation plate 42, and the value of the retardation. As this elliptically polarized light passes
20 the LC cell 30, it changes the polarized state by the birifringence effect according to the optical layout condition of the LC cell 30 and the retardation value.

 When the elliptically polarized light, which has undergone the birifringence effect caused by the
25 retardation plate 42 and the LC cell 30, hits the lower polarization plate 41, only the wavelength component of the elliptically polarized light which is parallel to the transmission axis 41a passes the lower polarization plate

41. Therefore, the light (linearly polarized light) which goes out from the lower polarization plate 41 becomes colored. The hue is essentially determined by the retardation of the retardation plate 42 and the retardation
5 of the LC cell 30.

The light having passed the lower polarization plate 41 is reflected by the reflector 43 and goes to the upper side of the LCD panel 3 in the opposite path to the above-described light path. The color of the outgoing light
10 presents color display.

The retardation of the retardation plate 42 is determined by the product, $\Delta n \cdot d$, of the refractive anisotropy Δn and the plate thickness d of the retardation plate 42. The retardation of the LC cell 30 is determined
15 by the product, $\Delta n \cdot d$, of the refractive anisotropy Δn and the layer thickness d of the liquid crystal layer 34 and the alignment state of the LC molecules 34a. By changing the value of the voltage to be applied to the LC cell 30 to alter the alignment state of the LC molecules 34a,
20 therefore, the retardation of the LC cell 30 changes and the degree of the birifringence effect of the LC cell 30 changes.

The above will be described more specifically. When no voltage is applied to the LC cell 30, the light incident
25 to the LCD panel 3 undergoes the birifringence effect of the retardation plate 42 and the birifringence effect according to the initial twist angle T of the LC molecules 34a and becomes elliptically polarized light according to

those birifringence effects. This elliptically polarized light passes the lower polarization plate 41 and is reflected by the reflector 43, and the reflected light travels in the opposite path to go out to the upper side of the LCD panel 3. The display color then becomes the color according to the retardation of the retardation plate 42 and the retardation of the liquid crystal layer 34 aligned at the initial twist angle T.

When a voltage is applied to the transparent electrodes 36 and 38, the LC molecules 34a gradually go upright from the initial twisted state as the voltage value increases. In accordance with the aligning state of the LC molecules 34a which have been aligned upright, the retardation of the LC cell 30 changes. The light incident to the LCD panel 3 undergoes the birifringence effect of the retardation plate 42 and the birifringence effect according to the varied retardation of the LC cell 30 and becomes elliptically polarized light according to those birifringence effects. The display color then differs from the one acquired in the above case where no voltage is applied to the LC cell 30.

When a voltage large enough to align the LC molecules 34a substantially upright is applied to the LC cell 30, the retardation of the LC cell 30 becomes approximately "0." Consequently, the birifringence effect of the LC cell 30 vanishes and the light incident to the LCD panel 3 is elliptically polarized only by the birifringence effect of the retardation plate 42. This elliptically polarized

light then passes the lower polarization plate 41, is reflected by the reflector 43, and travels in the opposite path to leave the LCD panel 3. The outgoing light is colored with the color according to the retardation of the retardation plate 42.

The display area of the LCD panel 3 will now be discussed.

The LCD panel 3 has 34 common electrodes 38 and 72 segment electrodes 36 as mentioned earlier, and has a plurality of pixels defined by the opposing portions of the common electrodes 38 and the segment electrodes 36.

As shown in Fig. 3, the upper area of a display area 3a of the LCD panel 3 constitutes a pictograph (hereinafter referred to as "picto") display area 3c, and the lower area constitutes a segment display area (character display areas) 3b.

The individual pixels of the segment display area 3b are shaped like dots. The segment display area 3b has a dot pattern of 72 dots x 32 dots by which it displays arbitrary characters (including numerals and symbols). The display positions and sizes of characters are fixed, and there are 4 lines by 12 digits of character display areas each having a size of 8 x 6 dots.

The individual pixels of the picto display area 3c are patterned in arbitrary shapes to form predetermined images. In Fig. 3, the display patterns are "Eng.", "Jap." and the frames surrounding the former two. Of the 72 segment electrodes 36, predetermined three segment electrodes 36

are patterned in those shapes. The first common electrode 38 faces the frame patterns and the second common electrode 38 faces the "Eng." and "Jap.".

The drive controller 5 performs the matrix driving of the entire common electrodes 38 and segment electrodes 36, i.e., the entire display area 3a, to display an image.

The drive controller 5 will now be described.

Fig. 4 presents a block diagram showing the overall circuit structure of the color LCD apparatus 1 according to this embodiment.

The drive controller 5 is connected between the LCD panel 3 and a display controller 10 which performs data processing to produce display data. The drive controller 5 produces an LC drive voltage (which will be discussed later) according to a display color in accordance with serial input data DATA, a serial interface shift clock signal SCK and a serial interface input enable signal STB, all input from the display controller 10. The drive controller 5 applies the LC drive voltage to the LCD panel 3 to display characters in multiple colors.

The drive controller 5 comprises a power supply section 51, an output interface circuit 100, a control section 200, a memory section 300 and an LCD driver 400, as shown in Fig. 4.

Fig. 5 is a block diagram showing the detailed structure of the drive controller 5.

As shown in Fig. 5, the power supply section 51 includes a supply voltage adjuster 511, a constant voltage

generator 512, a supply voltage booster 513 and an LCD voltage synthesizer 514.

The control section 200 includes an oscillator 201, a frequency divider 202, a timing synthesizer 203, an address counter 204, a plurality of status registers 205, a command decoder 206 and a power ON detector/reset circuit 207.

The memory section 300 includes a display data RAM (DDRAM) 301, a picto RAM 302, a character generator ROM (CGROM) 303 and a character color RAM (CCRAM) 304.

10 The LCD driver 400 includes a gradation PWM (Pulse Width Modulation) signal generator 401, a parallel/serial converter 402, a shift register 403, a common signal generator 404, a common driver 405, a latch circuit 406 and a segment driver 407.

15 A description will now be given of the power supply section 51.

The constant voltage generator 512 is comprised of a constant voltage source and generates a constant voltage from a supply voltage V_{DD} , a ground voltage V_{SS} and a
20 reference voltage V_{REF} . The supply voltage adjuster 511 adjusts the value of the constant voltage which is generated by the constant voltage generator 512. The supply voltage booster 513 boosts the constant voltage generated by the constant voltage generator 512. The LCD
25 voltage synthesizer 514 receives the supply voltage boosted ~~by~~ the supply voltage booster 513, combines a plurality of voltages needed to drive the segment electrodes, and supplies the resultant voltage to the segment driver 407.

The output interface circuit 100 converts the serial input data DATA, the serial interface shift clock signal SCK and the serial interface input enable signal STB, supplied from the display controller 10, to levels or data
5 which can be processed in the drive controller 5, and sends the results to the individual sections in the drive controller 5.

The control section 200 will be discussed below. The oscillator 201 generates a reference oscillation signal
10 from the serial interface shift clock signal SCK supplied from the display controller 10. The frequency divider 202 frequency-divides the reference oscillation signal from the oscillator 201 by a predetermined frequency-dividing ratio. The timing synthesizer 203 synthesizes acquires a timing
15 signal to drive the common electrodes from the frequency-divided signal from the frequency divider 202, and supplies the timing signal to the common signal generator 404.

The address counter 204 counts the addresses of data to be displayed, stored in the DDRAM 301 and the picto RAM
20 302, based on the serial interface shift clock signal SCK supplied from the output interface circuit 100. The address counter 204 sends out the counted addresses to the DDRAM 301 and the picto RAM 302.

The status register group 205 comprises a plurality of
25 registers for temporarily storing character data, color attribute data, display color specifying palette data and the like included in the serial input data DATA input from the output interface circuit 100.

The command decoder 206 decodes a command included in serial input data DATA from the output interface circuit 100 and controls the individual sections according to the decoded result.

- 5 The power ON detector/reset circuit 207 detects the power ON action of the color LCD apparatus 1 and resets the individual sections of the drive controller 5.

A description will now be given of the memory section 300.

- 10 The DDRAM 301 has a plurality of memory areas of 4 x 12 bits in association of the character display areas 3b of 4 lines by 12 digits, as shown in Fig. 6. Each memory area stores 8-bit character data (code data). The address of each memory area in the DDRAM 301 consists of six bits
- 15 (upper two bits (DDH1 and DDH2) and lower two bits (DDL1 to DDL4)). The memory addresses of the DDRAM 301 correspond to the character display positions of the character display areas 3b in a one-to-one relation. When a character "B" is to be displayed on the character display area 3b at the
- 20 first line and the second column as shown in Fig. 3, for example, 8-bit character data (code) of the character "B" is stored at the upper address (DDH2, DDH1) = 01) and the lower address (DDL1-DDL4) = (1000) in the DDRAM 301.

- The memory contents of the DDRAM 301 can be set and
- 25 changed arbitrarily by the display controller 10 in accordance with the display contents.

Fig. 7 shows the memory structure of the picto RAM 302.

The picto RAM 302 stores 2-bit data (color attribute data) indicative of a picto display color to be displayed on the picto display area 3c of the LCD panel 3. The picto RAM 302 has eight memory areas of 8 x 6 bits so that
5 display colors of (8 x 6) x 4 patterns can be specified. It is possible to arbitrarily decide whether or not to actually use those memory areas, in accordance with the structure of the LCD panel 3.

In Fig. 3, for example, there are three segments
10 (patterns) of "Eng.", "Jap." and "frame". Therefore, only color attribute data (six bits) for three segments are stored and the other areas are empty and unconnected in Fig. 7.

Each memory area ((8 x 6) bits) of the picto RAM 302
15 is specified by a 3-bit upper address C1-C3 and one word (six bits in this case) in each memory area is specified by a 3-bit lower address L1-L3.

2-bit color attribute data for indicating the color of each segment is stored, separated at the relatively same
20 address positions in two adjoining memory areas of an odd-numbered address and an even-numbered address. Bit data with a weight "1" (2^0) is stored in the area at an even-numbered address, and bit data with a weight "2" (2^1) is stored in the area at an odd-numbered address.

25 For example, the color attribute data (00; background color) of the segment of the "frame" in Fig. 3 (first segment) is stored in the 0-th bits D0 at addresses "000000" and "001000" (C3-C1, L3-L1) in the picto RAM 302.

Likewise, the color attribute data (10; red) of the segment "Eng." in Fig. 3 is stored in the first bits D1 and the color attribute data (01; blue) of the segment "Jap." is stored in the second bits D1.

- 5 The color attribute data of each segment is allowed to be externally supplied by the display controller 10.

Fig. 8 depicts the memory structure of the CGROM 303.

The CGROM 303 serves to store character fonts, and has a memory area (10h to DFh) 303a for storing 208 character
10 fonts having a size of 5 x 8 bits, a memory area (E0h to FFh) 303b for storing 32 character fonts having a size of 6 x 8 bits, and a memory area (08h to 0Fh) 303c for storing 8 pictographs of 6 x 8 bits.

Those memory addresses each consist of eight bits
15 (upper four bits and lower four bits) and are associated with character codes stored in the DDRAM 301. It is to be noted that the address 00h to 07h is what is assigned to the above-described picto RAM 302 and the address 00h to 07h in the CGROM 303 is not used.

- 20 From the viewpoint of the hardware structure, the GCROM 303 is comprised of a backed-up RAM or the like, so that the use efficiency of the hardware becomes higher if the address 00h to 07h in the CGROM 303 is used.

Fig. 9 depicts the memory structure of the CCRAM 304.

- 25 The CCRAM 304 serves to specify the display colors of individual characters to be displayed on the character display areas 3b of the LCD panel 3, i.e., the display colors of the character codes stored in the DDRAM 301, and

stores color attribute data in association with display data to be stored in the individual memory areas in the DDRAM 301. The CCRAM 304 has 4 x 12 memory areas in association with the character display areas 3b which
5 display characters of 4 lines by 12 digit. As mentioned earlier, each color attribute data consists of 2 bits and each memory area has a size of 2 bits. Each memory address of the CCRAM 304 consists of six bits (upper two bits (CCH1 and CCH2) and lower four bits (CCL1-CCL4)). The memory
10 addresses of the CCRAM 304 correspond to the character display positions of the character display areas 3b and the memory addresses of the DDRAM 301 in a one-to-one relation.

The 2-bit color attribute data stored in the CCRAM 304 specifies the display color of the character code stored at
15 the same address position in the DDRAM 301.

The contents of the CCRAM 304 are also allowed to be externally set by the display controller 10.

The LCD driver 400 will now be described.

Based on the serial interface shift clock signal, SCK,
20 the PWM signal generator 401 generates a gradation setting PWM signal for the PWM driving of the segment electrodes 36 in association with 2-bit color attribute data stored in the CCRAM 304. The PWM signal generated by the PWM signal generator 401 is sent to the segment driver 407.

25 The above will be discussed more specifically. The PWM signal generator 401 has four palettes A to D each for storing 4-bit data. The palettes A to D respectively correspond to the color attribute data 00 to 11 stored in

the CCRAM 304, and store palette data for setting the width of the pulse to be applied to the LCD panel 3 to an arbitrary value in sixteen levels (background color: 0000, red: 0110, blue: 1101 and green: 1111) as shown in Fig. 10, 5 at the time the color attribute data is specified. When palette data is set to 1101, for instance, a pulse whose width is 12/15 of one horizontal scan period, for example, is produced.

Writing of data in the palettes A to D is executed by 10 an instruction command "write palette data." More specifically, of displayable sixteen colors, four which can simultaneously be displayed are selected, are set in the palettes A-D and are selected to be displayed by the color attribute data.

15 In this embodiment, for example, the background color, red, blue and green are displayed with the color attribute data "00," "01," "10" and "11," respectively. It is further assumed that the LCD panel 3 is driven with a duty ratio of 1/33 and a bias of 1/5, the values of the 20 effective voltages to be applied to the segment electrodes 36 for setting those colors are set to 6.73 to 6.82 V for red, 6.86 to 6.94 V for blue, 7.00 to 7.55 V for green and 6.55 V for the background color, and data "0000," "0110," "1011" and "1111" have previously been written in the 25 palettes A to D for controlling the pulse width of the segment signal in order to acquire those effective voltage values.

In setting data (palette data) to the palettes A-D,

the display controller 10 supplies the "palette data writing command" and each palette data to the output interface circuit 100. The output interface circuit 100 sets this command in the command decoder 206 and supplies
5 the palette data to the palettes A-D via the status registers 205.

When receiving data from the picto RAM 302, the parallel/serial converter 402 reconstructs color attribute data of each segment, and converts the reconstructed color
10 attribute data to serial data which is in turn sent to the shift register 403.

When receiving a character pattern from the CGROM 303 and color attribute data corresponding to that character pattern from the CCRAM 304, the parallel/serial converter
15 402 outputs the supplied color attribute data for enabled dots specified by the character pattern, selects the color attribute data of the background color for disabled dots and sends the selected color attribute data to the shift register 403 after conversion to serial data.

20 The shift register 403 sequentially stores serial data (color attribute data specifying the display colors of the individual pixels) supplied from the parallel/serial converter 402 while shifting the serial data. When one dot line of serial data is stored, for example, the shift
25 register 403 transfers the data in parallel to the latch circuit 406.

The common signal generator 404 sequentially generates common drive signals to drive (scan) the common electrodes

38 of the LCD panel 3, based on the common timing signal coming from the timing synthesizer 203. The common drive signals generated by the common signal generator 404 are sequentially transferred to the common driver 405.

5 The common driver 405 sequentially drives the common electrodes 38 in response to the common drive signals.

 The latch circuit 406 latches segment driving data (color attribute data specifying the display colors of the individual pixels) supplied from the shift register 403 and
10 outputs the data to the segment driver 407.

 The segment driver 407 combines the data from the latch circuit 406, the display color setting PWM signal from the gradation PWM signal generator 401 and the segment driving supply voltage from the LCD voltage synthesizer 514
15 to produce a segment drive signal to sequentially drive the segment electrodes of the LCD panel 3.

 A description will now be given of the operation of the color LCD apparatus 1 to display characters in colors.

 When a character to be displayed on the associated
20 character display area 3b and the display color are set, the display controller 10 supplies a write command together with the character data (character code data), the display position data and the color attribute data of the target character to the output interface circuit 100.

25 When receiving those data from the display controller 10, the output interface circuit 100 supplies the character data and color attribute data to the DDRAM 301 and the CCRAM 304 respectively via the status registers 205.

Further, the output interface circuit 100 causes the address counter 204 to generate a 6-bit address corresponding to the display position. In accordance with this address, the memory areas in the DDRAM 301 and the
5 CCRAM 304 which correspond to each display position are addressed.

Moreover, the output interface circuit 100 gives a command "write DDRAM data and CCRAM data" to the command decoder 206.

10 The command decoder 206 decodes this command and supplies the write control signal to the DDRAM 301 and the CCRAM 304.

As a result, 8-bit character data is stored in the addressed memory area in the DDRAM 301, i.e., the memory
15 area corresponding to the display position, and 2-bit color attribute data is stored in the addressed memory area in the CCRAM 304, i.e., the memory area corresponding to the display position.

The above-described processing is repeated for each
20 display position.

In the case where "2" is displayed in "red" on the character display area 3b at the second line and the fourth digit as shown in Fig. 3, for example, the display controller 10 supplies the display position "the second
25 line and the fourth digit," the character data of "2," the color attribute data specifying "red" and the write command to the output interface circuit 100. The output interface circuit 100 respectively supplies the character data

indicating "2" and the color attribute data indicating "red" to the DDRAM 301 and the CCRAM 304 via the status registers 205. Further, the output interface circuit 100 causes the address counter 204 to generate the 6-bit
5 address (010100) corresponding to the display position. In accordance with this address, the memory areas in the DDRAM 301 and the CCRAM 304 which correspond to the position "the second line and the fourth digit" are addressed. Furthermore, the output interface circuit 100 gives the
10 command "write DDRAM data and CCRAM data" to the command decoder 206. The command decoder 206 decodes this command and supplies the write control signal to the DDRAM 301 and the CCRAM 304. As a result, 8-bit character data indicating "2" is stored in the addressed memory area in
15 the DDRAM 301, i.e., the memory area corresponding to the display position, and 2-bit color attribute data indicating "red" is stored in the associated memory area in the CCRAM 304.

By repeating the above processing is repeated as
20 needed, data to be displayed on the character display areas 3b can sequentially be set in the DDRAM 301 and the CCRAM 304.

When only the display color of character data already stored in the DDRAM 301 is to be altered, the display
25 controller 10 may supply the color attribute data and the "CCRAM data writing command" to the output interface circuit 100 to write the color attribute data into the CCRAM 304 without manipulating the DDRAM 301.

When only a display character is to be altered while leaving the display color already stored in the DDRAM 301 unchanged, the display controller 10 may supply the character data and the "DDRAM data writing command" to the
5 output interface circuit 100 to write the color attribute data into the DDRAM 301 without manipulating the CCRAM 304.

In setting the display color of each segment (pattern) of the picto display area 3c, the display controller 10 sets the display colors segment by segment, and supplies
10 the segment numbers, the color attribute data indicating their colors and the "picto RAM 302 writing command" to the output interface circuit 100.

Upon reception of those data, the output interface circuit 100 separates the color attribute data of the
15 individual segments to a lower-bit set and an upper-bit set and sequentially supplies those sets of data to the picto RAM 302.

The output interface circuit 100 causes the address counter 204 to sequentially generates 6-bit addresses of
20 the picto RAM 302.

The output interface circuit 100 supplies the "picto RAM writing command" to the command decoder 206. The command decoder 206 decodes this command and supplies a control signal, such as a write enable signal, to the picto
25 RAM 302.

Consequently, 2-bit color attribute data of the each segment is stored, separated at the relatively same address positions in two adjoining memory areas of an odd-numbered

address and an even-numbered address.

In the example shown in Fig. 3, there are three segments (patterns) of "frame", "Eng.", and "Jap.". In displaying those segments in the "background color," "red" and "blue" respectively, the display controller 10 supplies the numbers of the individual patterns, the color attribute data (00, 01, 10) indicating their display colors and the "picto RAM writing command" to the output interface circuit 100.

10 The output interface circuit 100 sends the "picto RAM writing command" to the command decoder 206. The command decoder 206 decodes this command and supplies the write control signal to the picto RAM 302. The output interface circuit 100 causes the address counter 204 to sequentially
15 generate the addresses "000000" and "001000." Further, the output interface circuit 100 separates the color attribute data to a lower-bit set (001) and an upper-bit set (010) and supplies those sets of data to the picto RAM 302 in synchronism with the addressing. Consequently, the color
20 attribute data "00" specifying the background color is stored in the bits D0 of the addresses "000000" and "001000" in the picto RAM 302, the color attribute data "01" specifying "red" is stored in the bits D1, and the color attribute data "10" specifying "blue" is stored in
25 the bits D2.

The address counter 204 may be permitted to sequentially generate addresses so that write data is supplied to the picto RAM 302 at the timing at which the

desired address is output.

The command decoder 206 decodes the command and supplies the write control signal to the palettes A-D. As a result, palette data is written in the respective
5 palettes A-D as shown in Fig. 11.

When the character data is written in the DDRAM 301, the color attribute data is written in the picto RAM 302 and the CCRAM 304 and the palette data is written in the palettes A-D in the above manner, preparation for data
10 display is completed.

In displaying an image on the LCD panel 3, the display controller 10 supplies a display command to the output interface circuit 100. In response to this command, the output interface circuit 100 first sets a read command for
15 the picto RAM 201 in the command decoder 206. The command decoder 206 decodes this command and supplies a read control signal to the picto RAM 302. Further, the output interface circuit 100 causes the address counter 204 to sequentially update the address values from "00Q000".

20 The picto RAM 302 sequentially reads data from the addresses specified by the address counter 204 and supplies the data to the parallel/serial converter 402. The parallel/serial converter 402 temporarily stores the data read from the picto RAM 302, reconstructs 2-bit color
25 attribute data when data read from adjoining two memory areas are acquired, converts the color attribute data to serial data and supplies the serial data to the shift register 403.

The shift register 403 sequentially stores the serial data input from the parallel/serial converter 402 and transfers the stored data to the latch circuit 406 when, for example, one line (one common electrode) of color attribute data is stored. The end of one line can be determined from the read address in the picto RAM 302 or the like.

The latch circuit 406 sends the latched color attribute data to the segment driver 407.

10 The segment driver 407 combines the data from the latch circuit 406, the PWM signal from the PWM signal generator 401 and the segment driving supply voltage from the LCD voltage synthesizer 514 to produce a segment drive signal and applies this drive signal to the segment
15 electrodes 36.

As mentioned earlier, the PWM signal is set based on data set in the palettes A-D, and the segment drive signal has a pulse width corresponding to the data set in the palette specified by the color attribute data. . . .

20 When the color attribute data of the segment "Eng." of the picto display area 3c is set to "01" as shown in Fig. 7, for example, the segment driver 407 produces the segment signal whose pulse width corresponds to the palette data "0110" set in the palette B corresponding to the color
25 attribute data "01" as shown in Fig. 10, and applies this segment signal to the associated segment electrode 36.

Based on the common timing signal supplied from the timing synthesizer 203, the common signal generator 404

sequentially generates the common drive signals to drive the common electrodes 38 of the LCD panel 3. The common drive signals generated by the common signal generator 404 are sequentially transferred to the common driver 405.

- 5 Based on the common drive signals, the common driver 405 sequentially drives the common electrodes 38 of the LCD panel 3.

When data reading from the picto RAM 302 is completed, the output interface circuit 100 supplies the "DDRAM 301
10 reading command" to the command decoder 206. The command decoder 206 decodes this command and supplies the read control signal to the DDRAM 301, the CGROM 303 and the CCRAM 304.

The output interface circuit 100 further causes the
15 address counter 204 to generate the 6-bit address corresponding to the display position. According to this address, the memory areas in the DDRAM 301 and the CCRAM 304 which are associated with each display position are addressed.

20 Consequently, the character data stored in the DDRAM 301 is sequentially read out. The CCROM 303 is addressed with the read character data, so that one line of character pattern data corresponding to the character data is read in the units of six bits, for example, and is supplied to the
25 parallel/serial converter 402.

Likewise, the color attribute data stored in the CCRAM 304 is sequentially read and is supplied together with the associated character pattern data to the parallel/serial

converter 402.

In accordance with the supplied character pattern data, the parallel/serial converter 402 selects the 2-bit color attribute data supplied from the CCRAM 304 for
5 enabled dots, selects the color attribute data indicating the background color for disabled dots and sends the selected color attribute data to the shift register 403 after conversion to serial data.

The shift register 403 sequentially stores the color
10 attribute data supplied from the parallel/serial converter 402 and transfers the stored data to the latch circuit 406 when, for example, one line (one common electrode) of color attribute data is stored. The end of one line can be determined from the read address in the DDRAM 301 or the
15 like.

The latch circuit 406 sends the latched color attribute data to the segment driver 407.

The segment driver 407 combines the data from the latch circuit 406, the PWM signal from the PWM signal
20 generator 401 and the segment driving supply voltage from the LCD voltage synthesizer 514 to produce a segment drive signal and applies this drive signal to the segment electrodes 36. At this time, the segment driver 407 reads palette data from one of the palettes A-D using each color
25 attribute data as an address, produces the segment drive signal whose pulse width corresponds to the read data and applies this drive signal to the segment electrodes 36.

As the above-described operation is repeated, the

character pattern of arbitrary character data stored in the
DDRAM 301 is displayed in the color which is specified by
the color attribute data stored in the CCRAM 303. A fixed
pattern is displayed on the picto display area 3c in the
5 color specified by the color attribute data stored in the
picto RAM 302. What is more, the color specified by the
color attribute data can be finely adjusted by the palette
data.

In short, this embodiment can display an image on the
10 LCD panel having a plurality of display areas, e.g., the
picto display area and the character display area, by
specifying display colors in different ways.

This invention is not limited to the above-described
embodiment, but may be modified and adapted in various
15 other forms.

Although the foregoing description of this embodiment
has been given with reference to the case where character
data and color attribute data are supplied to the output
interface circuit 100 from the display controller 10, color
20 attribute data may have previously been set in the CCRAM
304 and only a character code may be supplied later.
Likewise, character data may have previously been set in
the DDRAM 301 and only color attribute data may be supplied
later.

25 The driver can take an arbitrary structure. In this
embodiment, when data is displayed on the picto display
area 3c, the picto RAM 302 is selectively enabled for data
reading, while when for instance, data is displayed on the

character display areas 3b, the DDRAM 301 and the CCRAM 304 are selectively enabled for data reading. Instead, different addresses may be assigned to the picto RAM 302, the DDRAM 301 and the CCRAM 304 so that display data is
5 changed according to the difference between the addresses.

For example, each memory area in the picto RAM 302 may be designated with the address "00" to "07" output from the address counter 204, so that color attribute data (one bit in this data) in that area is sequentially read in the
10 units of six bits and each memory area in the DDRAM 301 and the CCRAM 304 is specified with the address at "08" or following it. This structure significantly facilitates the control to enable and disable each memory.

The CGROM 303 may be constituted of a backed-up RAM or
15 the like, so that the area from the address "00" to the address "07" in the CGROM can be used as the picto RAM. In this case, however, character data should take a value equal to or greater than "08."

Although the palettes A-D are provided in the PWM
20 signal generator 304 and the PWM signal indicating the pulse width corresponding to the data set in the palettes A-D is generated in this embodiment, the palettes A-D may be provided in the segment driver 407. In this case, the PWM signal generator 401 generates the PWM signal which
25 specifies sixteen levels of pulse widths. The segment driver 407 selects one of the palettes A-D in accordance with the data (color attribute data) supplied from the latch circuit 406, and generates the segment signal whose

pulse width corresponds to the value set in the selected palette, based on the PWM signal.

Although the display patterns of the picto display area 3c are fixed in the above-described embodiment, the number, shapes and the like of the display patterns (segments) of the picto display area 3c may be set arbitrarily. For example, the density of the segments of the picto display area 3c may be set the same as the dot density of the character display area so that a pictograph can be displayed in a dot pattern. In this case, display colors can be designed dot by dot.

Fig. 11 exemplifies a character which is displayed as a pictograph in a dot pattern.

In this example, the elements "1," "/" and "4" in the character "1/4" are displayed in different colors. In this case, bit data of the color attribute data with the weight "1" is set at the address "00" in the picto RAM 302, bit data of the color attribute data with the weight "2" is set at the address "01" and those bits are used as a pair, as shown in Fig. 12.

By displaying a pictograph in such a dot pattern, it is possible to display the elements "1," "/" and "4" in the character "1/4" as gradations (colors) corresponding to the palette data in Fig. 10, namely the element "1" in red, the element "/" in green and the element "4" in blue as shown in Fig. 11.

In the case of displaying the pictographs together with "1/4," the color weight for the addresses "02," "04"

and "06" is set to "1," the color weight for the addresses "03," "05" and "07" is set to "2," and those bits are likewise used as a pair.

To increase the number of gradations, the number of
5 addresses to be a set should be increased. (For example, a set of three addresses can provide 8 gradations, and a set of four addresses can provide sixteen gradations.)

As apparent from the above, the display color of a pictograph can be adjusted dot by dot by using the bits at
10 relatively the same positions in adjoining memory areas in the picto RAM 302 as a pair and giving the gradation (color) weights to those bits.

Although the foregoing description of this embodiment has been given with reference to the case where the pulse
15 width modulation (PWM) system for gradation control is used as a method of displaying characters and pictographs in colors, the above-described gradation (color) display of characters and pictographs can also be accomplished by the gradation frame thinning method.

20 Although the foregoing description of this embodiment has been given with reference to the case where the memory areas with adjoining odd-numbered and even-numbered addresses in the picto RAM 302 are used as a pair, the weight of the color as a pictograph attribute is set by two
25 bits and a character or pictograph is displayed in different colors dot by dot, it is possible to use any other method of setting the weight of the color as a pictograph attribute.

With the memory area structure of the picto RAM 302 having addresses set in the units of 8 x 6 bits, for example, gradations may be set dot by dot by giving a color weight to adjoining bits (two bits) in each memory area and
5 using those two bits as a pair.

In this case, in the memory area from the addresses "02" to "07" in the picto RAM as shown in Fig. 14, color weights "1" and "2" are alternately set in the column direction as shown in the memory area at the address "04."
10 A gradation like "11 (green)," associated with the palette data shown in Fig. 10, can be set dot by dot by setting the color weight "1" to the right-hand input data "1" in the adjoining pair of bits and setting the color weight "2" to the left-hand input data "1" as shown in the memory area at
15 the address "02."

Therefore, a pictograph can be displayed in colors by giving color weights to the adjoining bits (two bits) in an arbitrary address in the picto RAM and using those bits as a pair. This scheme can allow the color LCD apparatus to
20 accomplish multifarious displays.

Although four gradations are controlled by the adjoining bits (two bits) in an arbitrary address (memory area) in the picto RAM 302, it is possible to display a pictograph in eight gradations using three bits in an
25 arbitrary address or in sixteen gradations using four bits. In this case, however, the number of palette data should be increased.

the gradation setting scheme used to display a

pictograph can also be used in registering an arbitrary character as an additional character.

Additional characters may be registered by using the picto RAM as the character generator RAM (CGRAM), for
5 example.

Fig. 15 exemplifies the memory structure of the picto RAM which also serves as a CGRAM.

The structure of the picto RAM is substantially the same as that of the picto RAM shown in Fig. 7, with the
10 difference lying in that the addresses "00" and "01" are used exclusively for the CGRAM while the addresses "02" to "07" are used for both the CGRAM and the picto RAM.

In this case, "00h" to "07h" can be used as character codes to be input to the DDRAM 301. In other words, when a
15 character code within this range is to be displayed on the character display areas 3a, data stored in the picto RAM 302 at every adjoining addresses should be used as a pair and should be sent to the shift register 403 from the parallel/serial converter 402 as font data given gradation
20 line by line. The other operation is the same as that for ordinary character font data.

Additional characters may be stored by using any adjoining bits in the picto RAM 302 as a pair.

As discussed above, an additional character can be
25 displayed in different gradations dot by dot, by using the picto RAM as a CGRAM.

Although only one embodiment of the present invention has been described herein, it should be apparent to those

skilled in the art that this invention may be embodied in many other specific forms without departing from the spirit or scope of the invention.

This Sheet Has Been Replaced



CLAIMS

1. A liquid crystal display apparatus characterized by comprising:

5 a liquid crystal display panel (3) for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having at least two display areas (3b, 3c);

designation means (301 to 304) for respectively
10 setting display colors in said at least two display areas (3b, 3c); and

drive means (400) for generating drive signals respectively to said at least two display areas (3b, 3c) in accordance with display colors specified by said
15 designation means (301 to 304) and applying said drive signals to said liquid crystal display panel (3), thereby displaying colors, specified by said designation means (301 to 304), on said at least two display areas (3b, 3c).

2. The liquid crystal display apparatus according to
20 claim 1, characterized in that said at least two display areas (3b, 3c) of said liquid crystal display panel (3) include a first display area (3b) for displaying an image comprising a plurality of pixels and a second display area (3c) for displaying an image comprising at least one pixel;
25 and

said designation means includes means (301, 303, 304) for specifying a display image, a display color and a display position for said first display area and means





(302) for specifying a display color for said second display area (3c).

3. The liquid crystal display apparatus according to claim 2, characterized in that said first display area (3b) has a dot matrix display area, and said second display area (3c) has a pictograph display section.

4. The liquid crystal display apparatus according to claim 2, characterized in that said first display area (3b) has a character display areas for displaying a plurality of characters each comprising a plurality of pixels; and

said second display area (3c) has an image display area for displaying an image comprising at least one pixel.

5. The liquid crystal display apparatus according to claim 4, characterized in that said designation means has means (301, 303, 304) for specifying characters to be displayed, display colors and display positions to said drive means (400) with regard to said character display areas (3b), and specifying a display color of an image with regard to said image display area (3c).

6. The liquid crystal display apparatus according to claim 5, characterized in that said designation means (301 to 304) specifies, for each of said plurality of characters, said character, display color and display position and specifying said display color for each pixel constituting said image.

7. The liquid crystal display apparatus according to claim 4, characterized in that said designation means (301 to 304) comprises:





character code storage means (301) for storing character codes in association with positions at which said first display area (3b) of said liquid crystal display panel (3) displays said characters;

5 character color data storage means (304) for storing display color data of characters in association with said character codes stored in said character code storage means (301); and

image color data storage means (302) for storing image
10 color data to be displayed on said second display area (3c).

8. The liquid crystal display apparatus according to claim 7, characterized in that said image color data storage means (302) stores individual bits of said image
15 color data in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory area.

9. The liquid crystal display apparatus according to claim 7, characterized in that at least one of said
20 character color data storage means (304) and said image color data storage means (302) stores p-bit display color data for designating any of 2^p colors, where p is a positive integer; and

said drive means (400) includes means for converting
25 said p-bit display color data to q-bit display color data where q is a positive integer greater than p and means (400) for driving said liquid crystal display panel (3) to display said display data in a display color corresponding





to said q-bit display color data after conversion.

10. The liquid crystal display apparatus according to claim 1, characterized in that said liquid crystal display panel (3) is comprised of a reflection type of liquid crystal display device which changes display colors by changing retardation of a liquid crystal by controlling an applied voltage.

11. A method of driving a liquid crystal display apparatus for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having at least two display areas (3b, 3c), said method characterized by comprising the steps of;

respectively setting display colors in said at least two display areas (3b, 3c); and

generating drive signals respectively to said at least two display areas (3b, 3c) in accordance with the display color setting and applying said drive signals to said liquid crystal display panel (3), thereby displaying set colors on said at least two display areas (3b, 3c).

12. The method according to claim 11, characterized in that said at least two display areas (3b, 3c) of said liquid crystal display panel (3) include a first display area (3b) for displaying an image comprising a plurality of pixels and a second display area (3c) for displaying an image comprising at least one pixel; and

said setting step specifies a display image, a display color and a display position for said first display area (3b) and a display color for said second display area (3c).





13. The method according to claim 12, characterized in that said first display area (3b) has a dot matrix display area, and said second display area (3c) has a pictograph display section.

5 14. The method according to claim 12, characterized in that said first display area (3b) has character display areas for displaying a plurality of characters each comprising a plurality of pixels; and

said second display area (3c) has an image display
10 area for displaying an image comprising at least one pixel.

15 15. The method according to claim 14, characterized in that said setting step specifies, with regard to said character display areas (3b), characters to be displayed, display colors and display positions, and with regard to said image display area (3c), a display color of an image.

16. The method according to claim 15, characterized in that said setting step specifies, for each of said plurality of characters, said character, display color and display position and said display color for each pixel,
20 constituting said image.

17. The method according to claim 14, characterized in that said setting step includes steps of storing character codes in character code storage means (301) in association with positions at which said liquid crystal
25 display panel displays said characters, storing display color data of characters in character color data storage means (304) in association with said character codes stored in said character code storage means (301), and storing





image color data to be displayed on said second display area in image color data storage means (302), and

said driving step includes a step of driving said liquid crystal display panel (3) based on data stored in
5 said character code storage means (301), said character color data storage means (304) and said image color data storage means (302).

18. The method according to claim 17, characterized in that individual bits of said image color data are stored
10 in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory area.

19. The method according to claim 17, characterized in that said setting step stores in at least one of said character color data storage means and said image color
15 data storage means, p-bit display color data for designating any of 2^p colors; and

said driving step converts said p-bit display color data to q-bit display color data ($q > p$) and drives said liquid crystal display panel in such a way as to display
20 said display data in a display color corresponding to said q-bit display color data after conversion.

20. The method according to claim 11, characterized in that said liquid crystal display panel (3) is comprised of a reflection type of liquid crystal display device which
25 changes display colors by changing retardation of a liquid crystal by controlling an applied voltage.



1/15

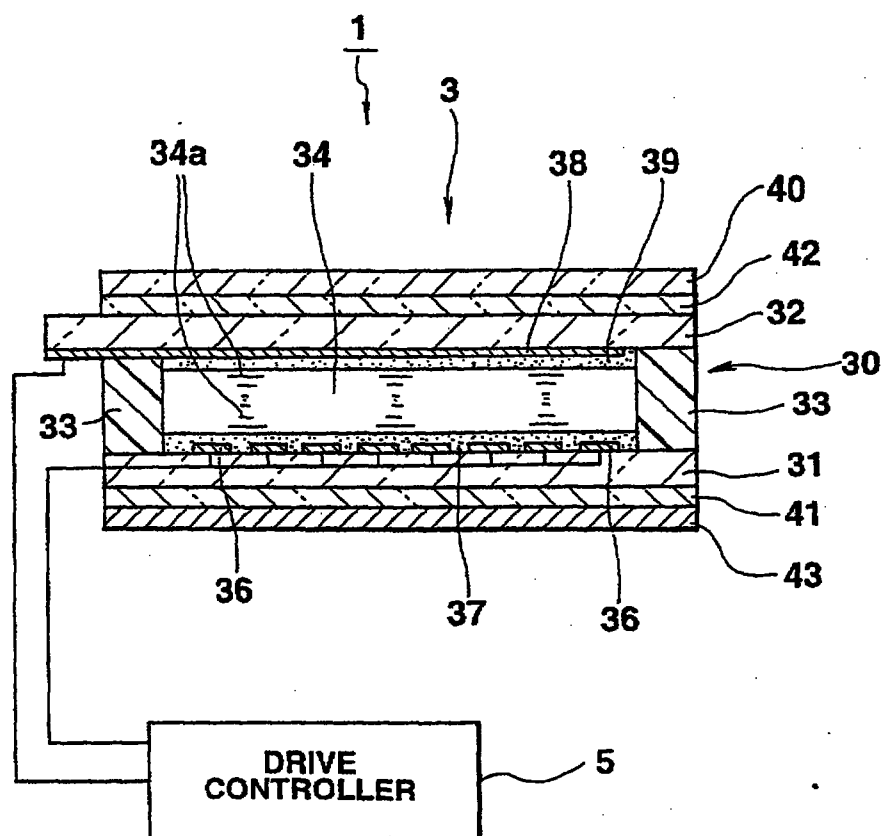
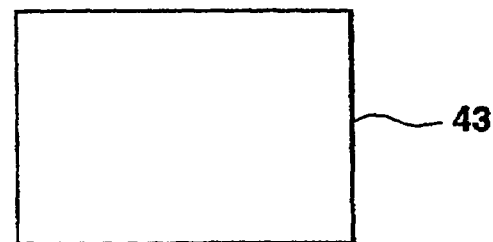
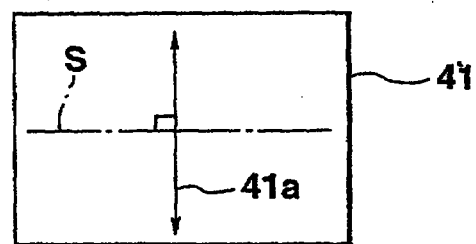
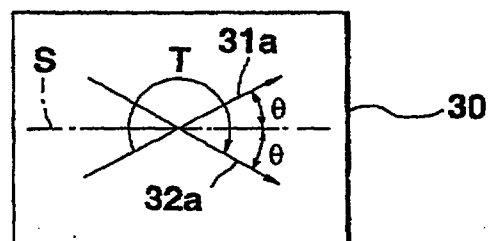
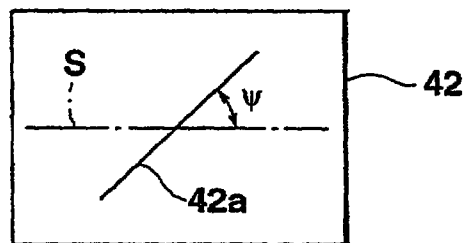
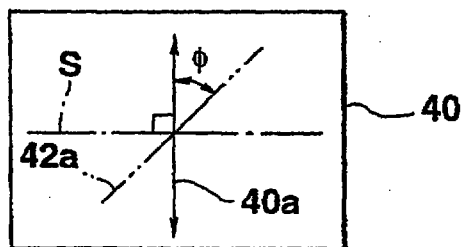


FIG.1

FIG.2



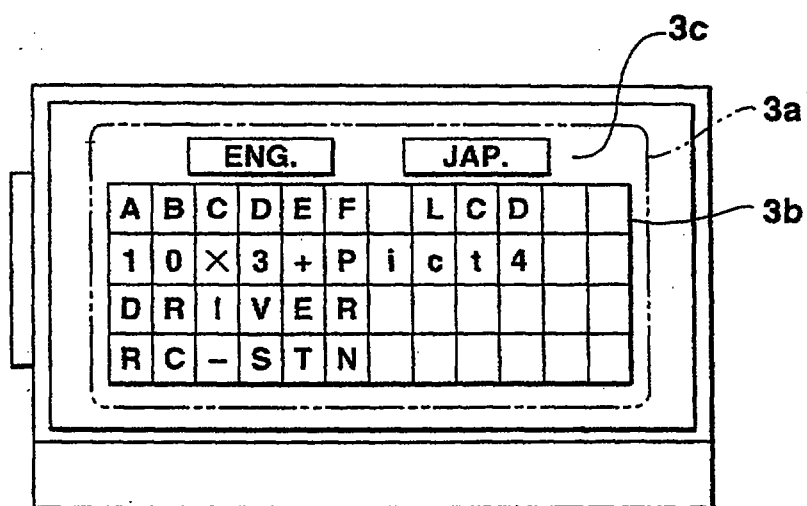


FIG.3

4/15

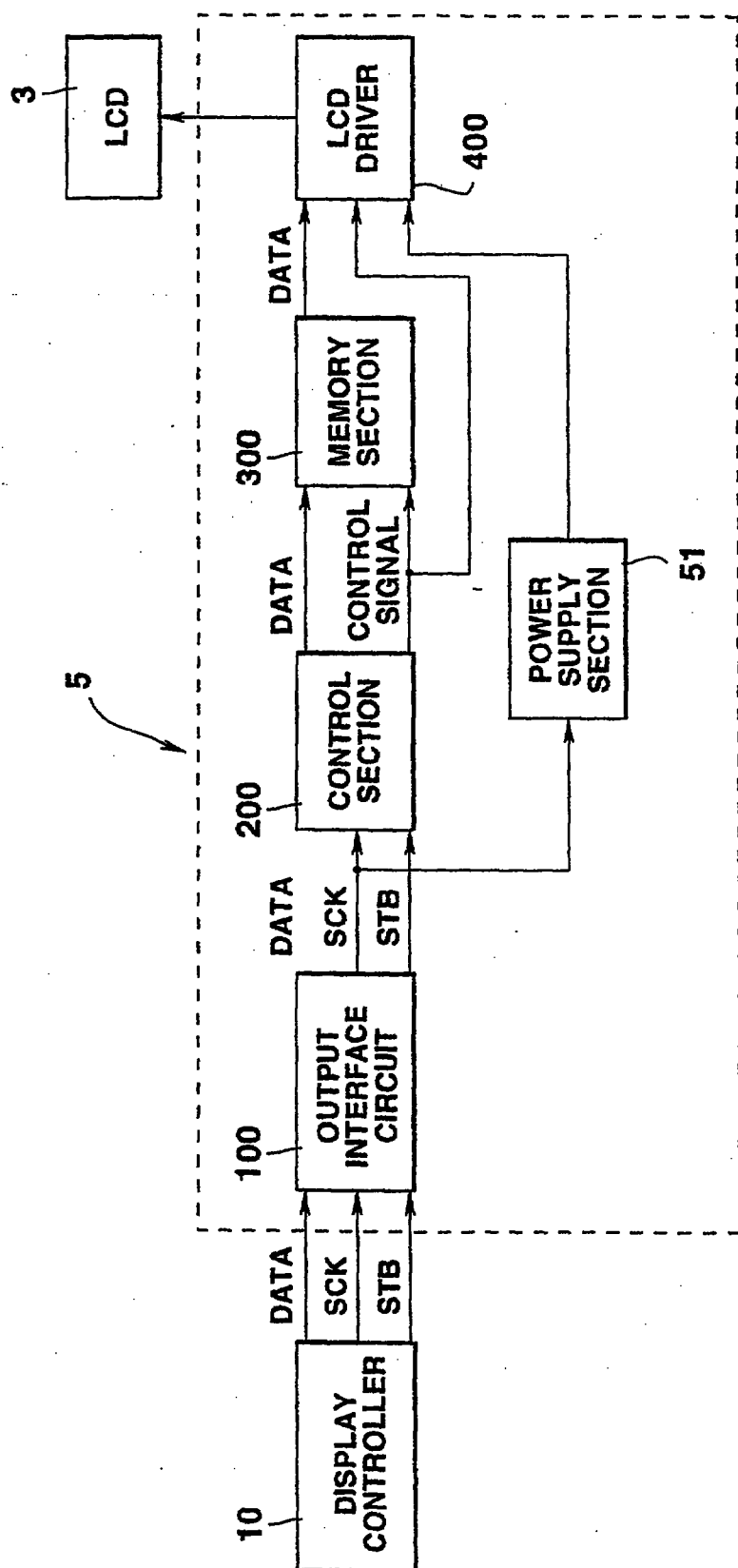


FIG.4

5/15

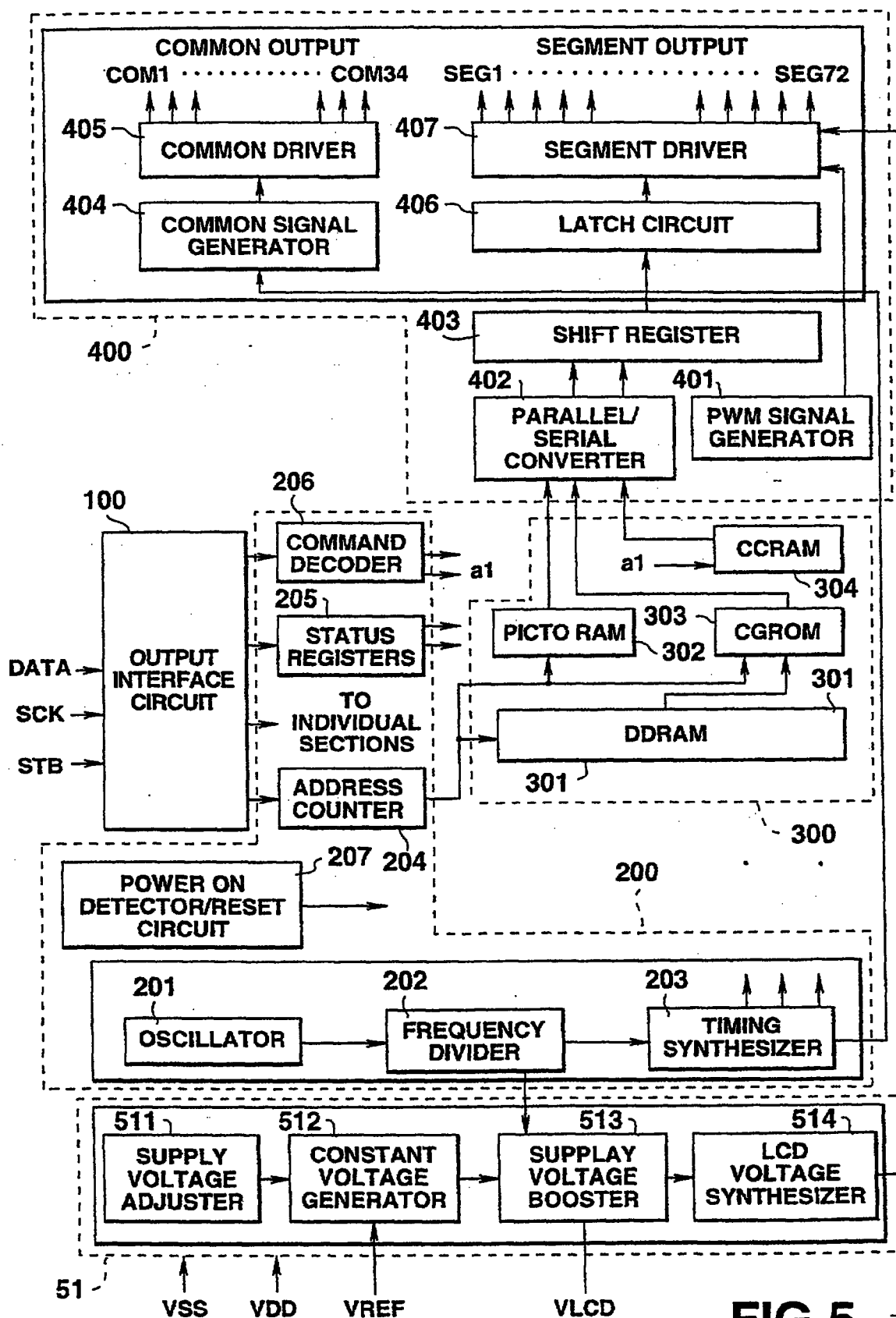
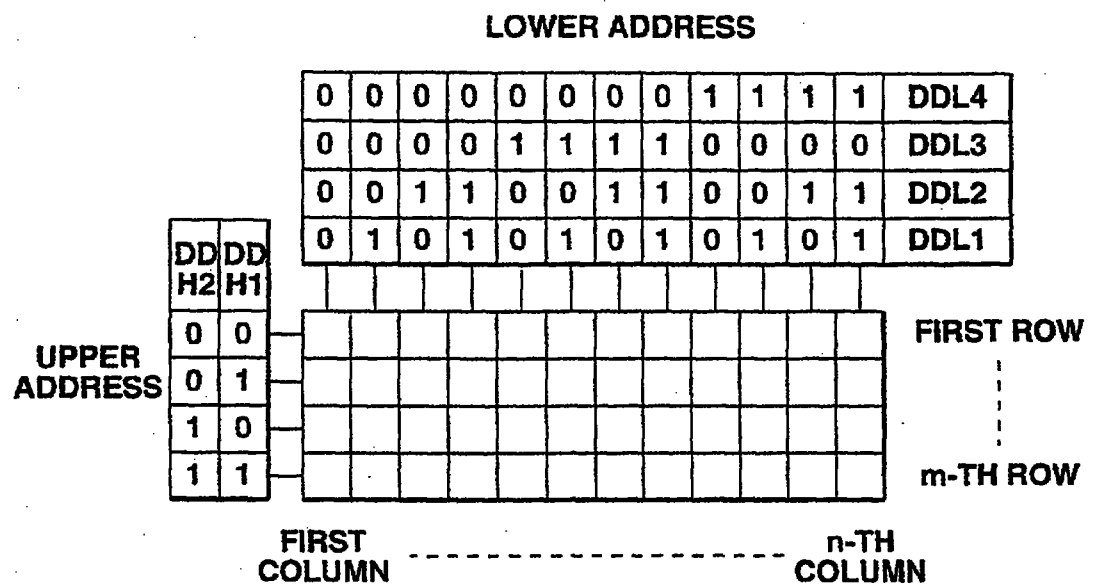


FIG. 5

DDRAM STRUCTURE
(m ROWS n COLUMNS DISPLAY MODE, m x n x o BITS)

**FIG.6**

7/15

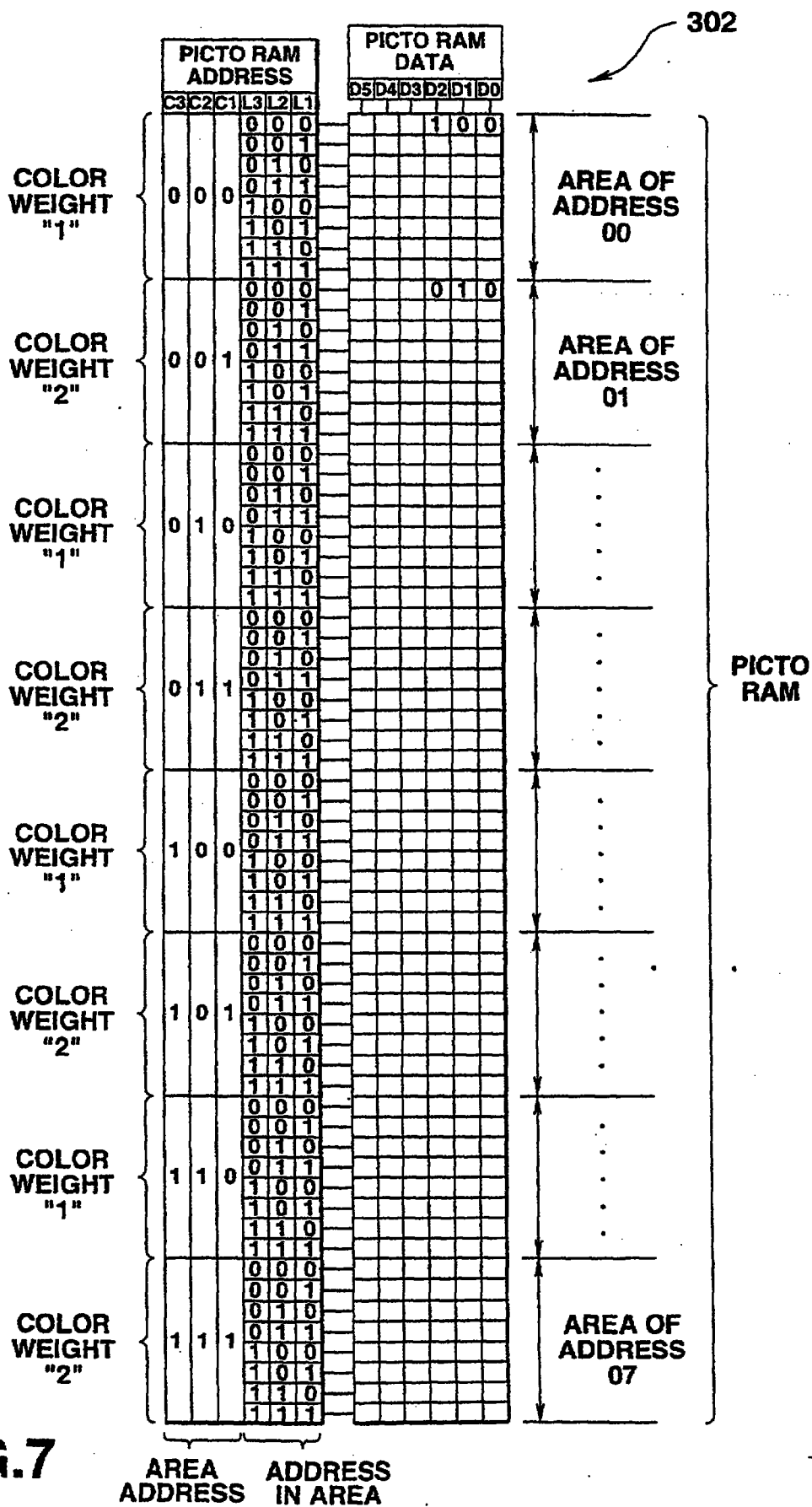


FIG.7

8/15

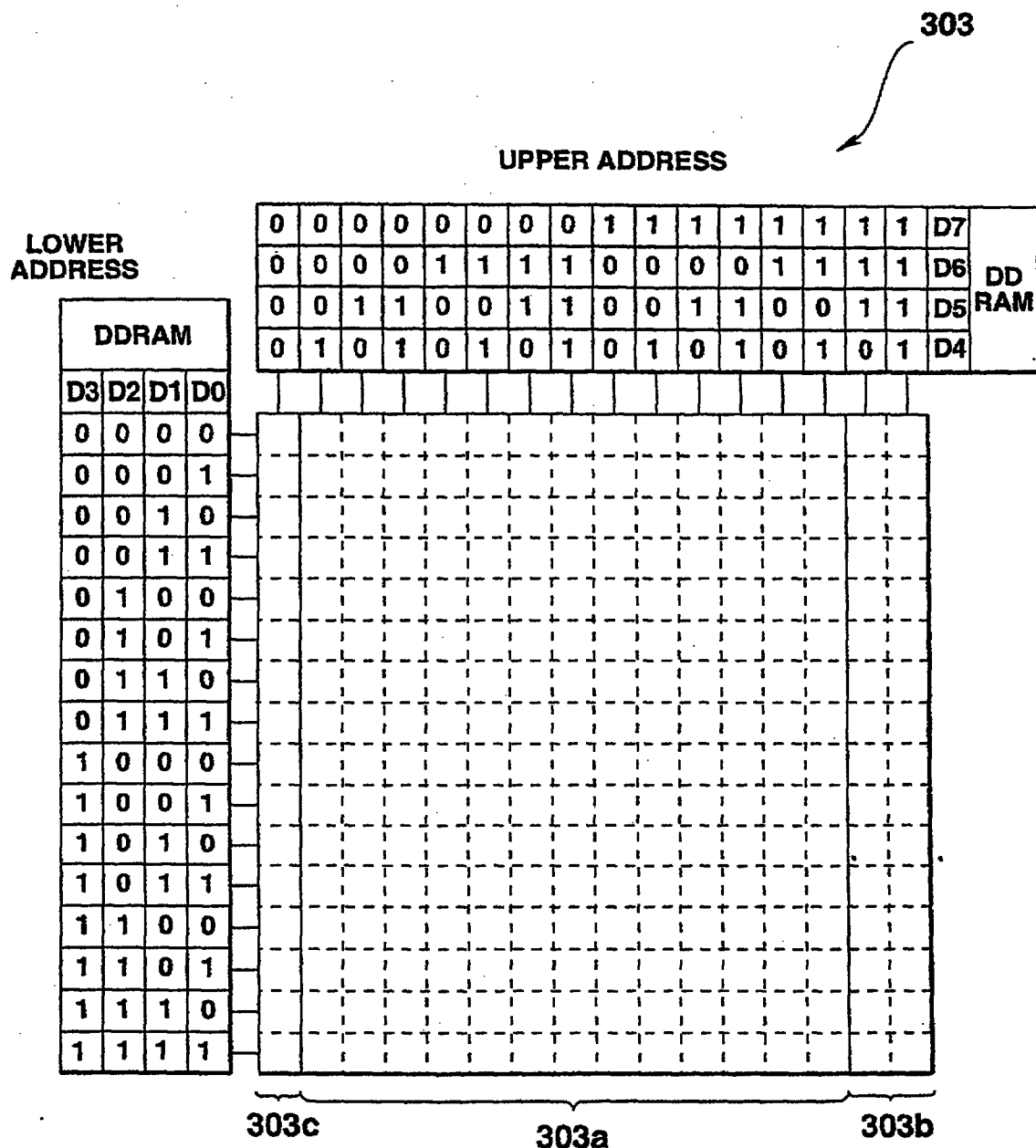
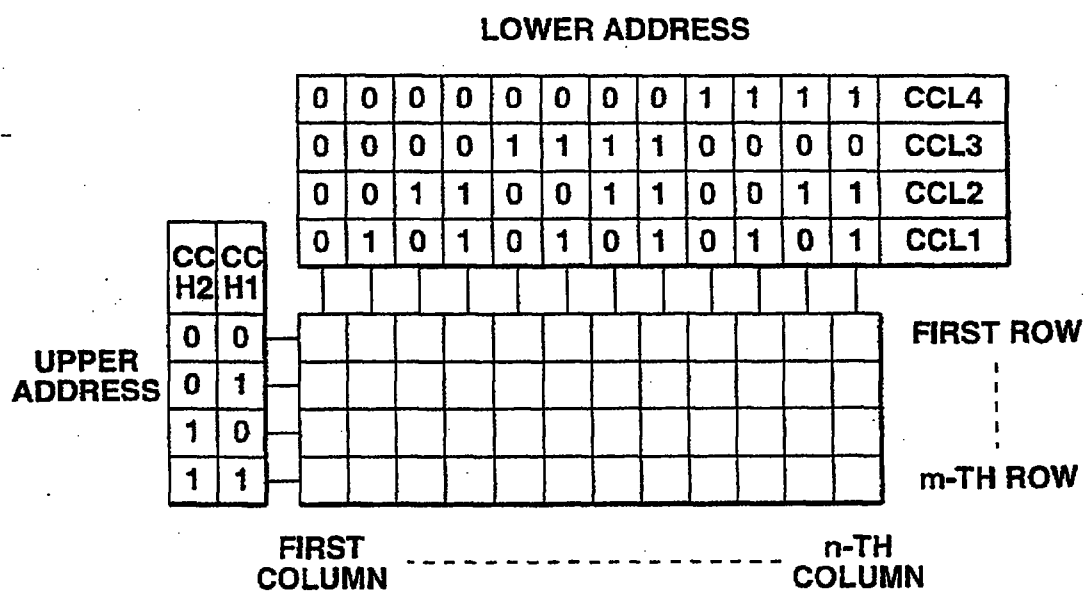


FIG.8

9/15

CCRAM STRUCTURE
 (m ROWS n COLUMNS DISPLAY MODE, m x n x o BITS)

**FIG.9**

10/15

COLOR	COLOR ATTRIBUTE DATA (CCRAM)	PALETTE	PALETTE DATA				
			D3	D2	D1	D0	DISPLAY COLOR CODE
BACKGROUND COLOR	0 0	A	0	0	0	0	0
RED	0 1	B	0	1	1	0	6
BLUE	1 0	C	1	0	1	1	11
GREEN	1 1	D	1	1	1	1	15

FIG.10

11/15

<DISPLAY EXAMPLE>

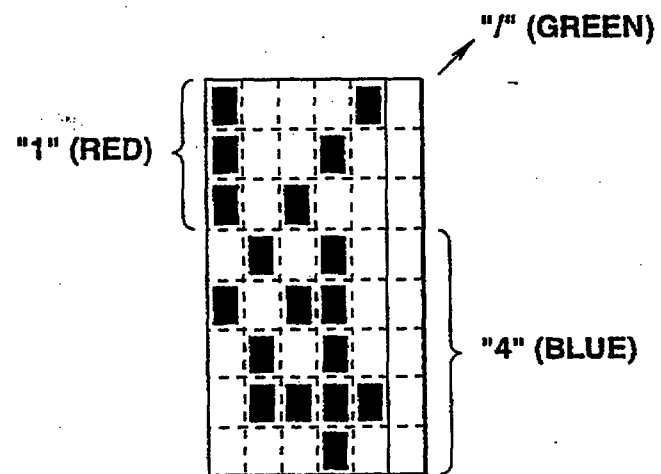
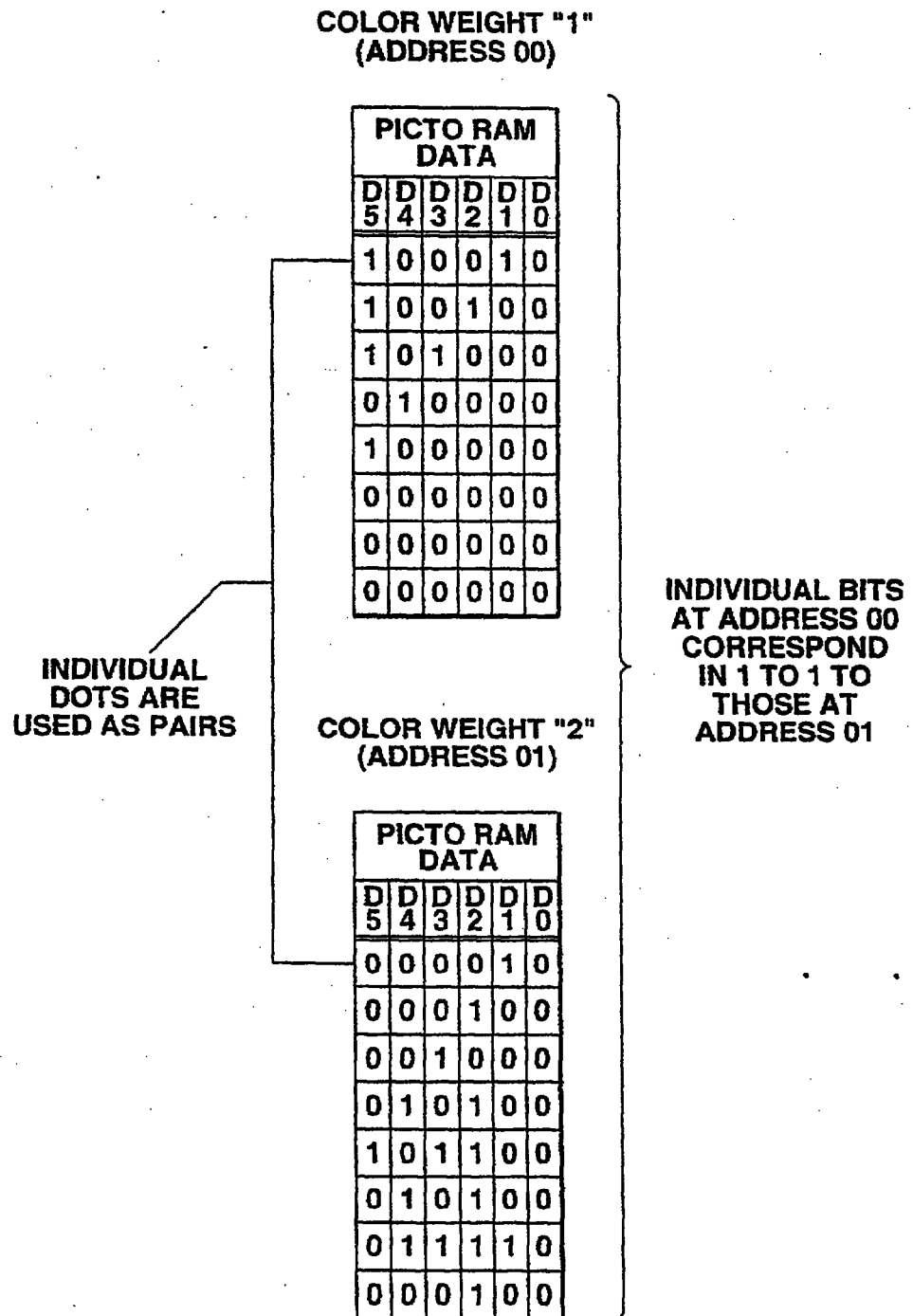


FIG.11

12/15

**FIG.12**

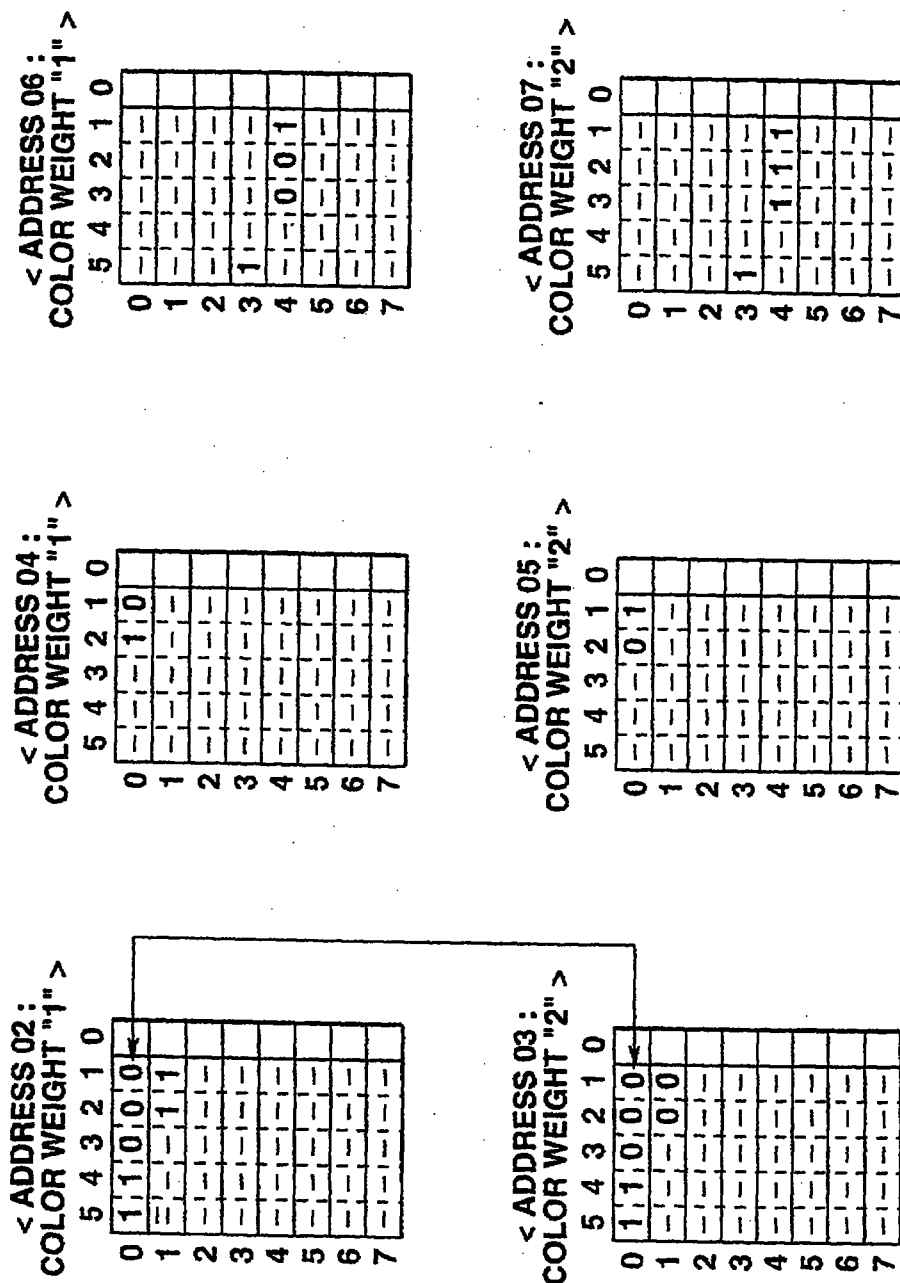
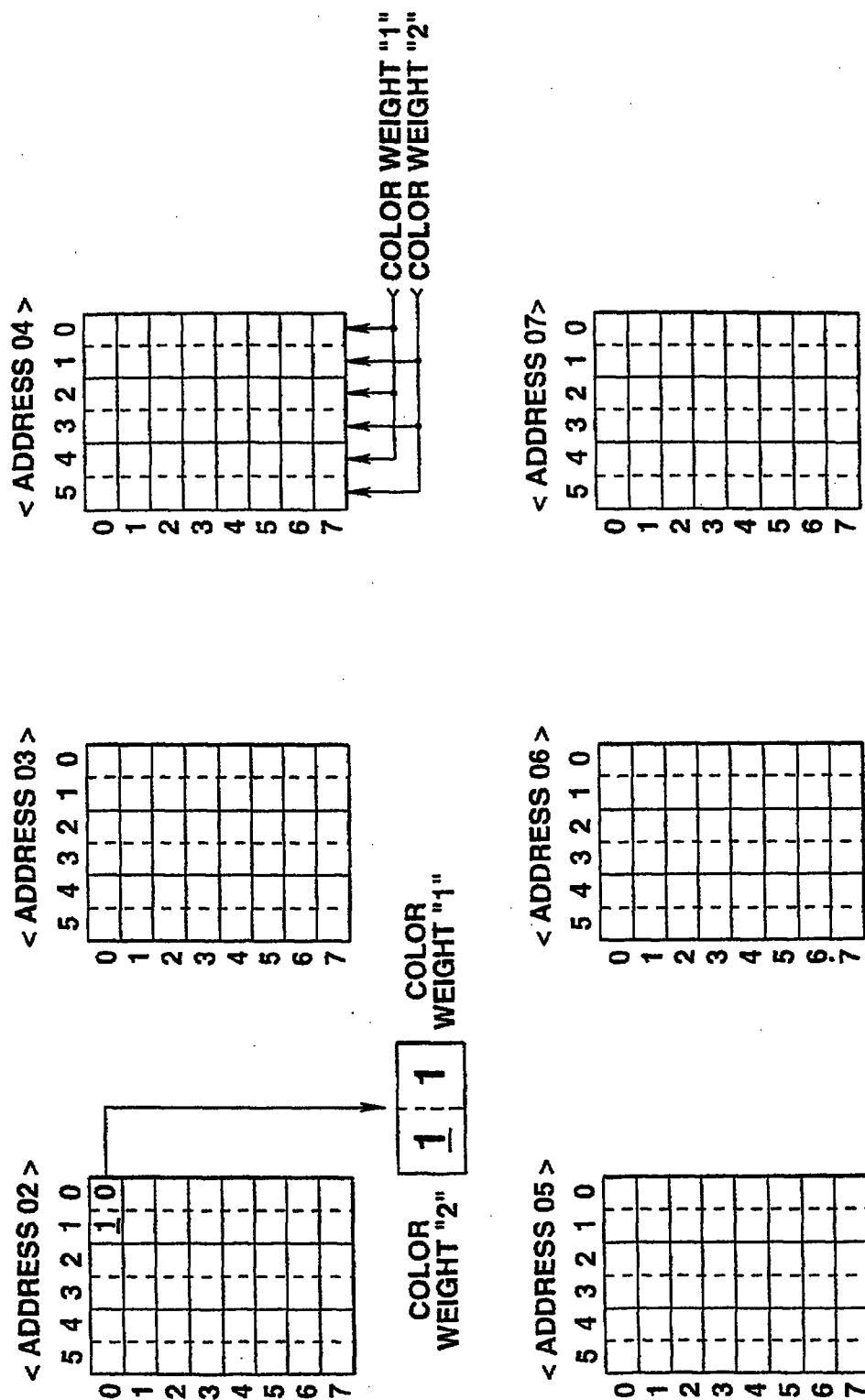


FIG13

14/15



15/15

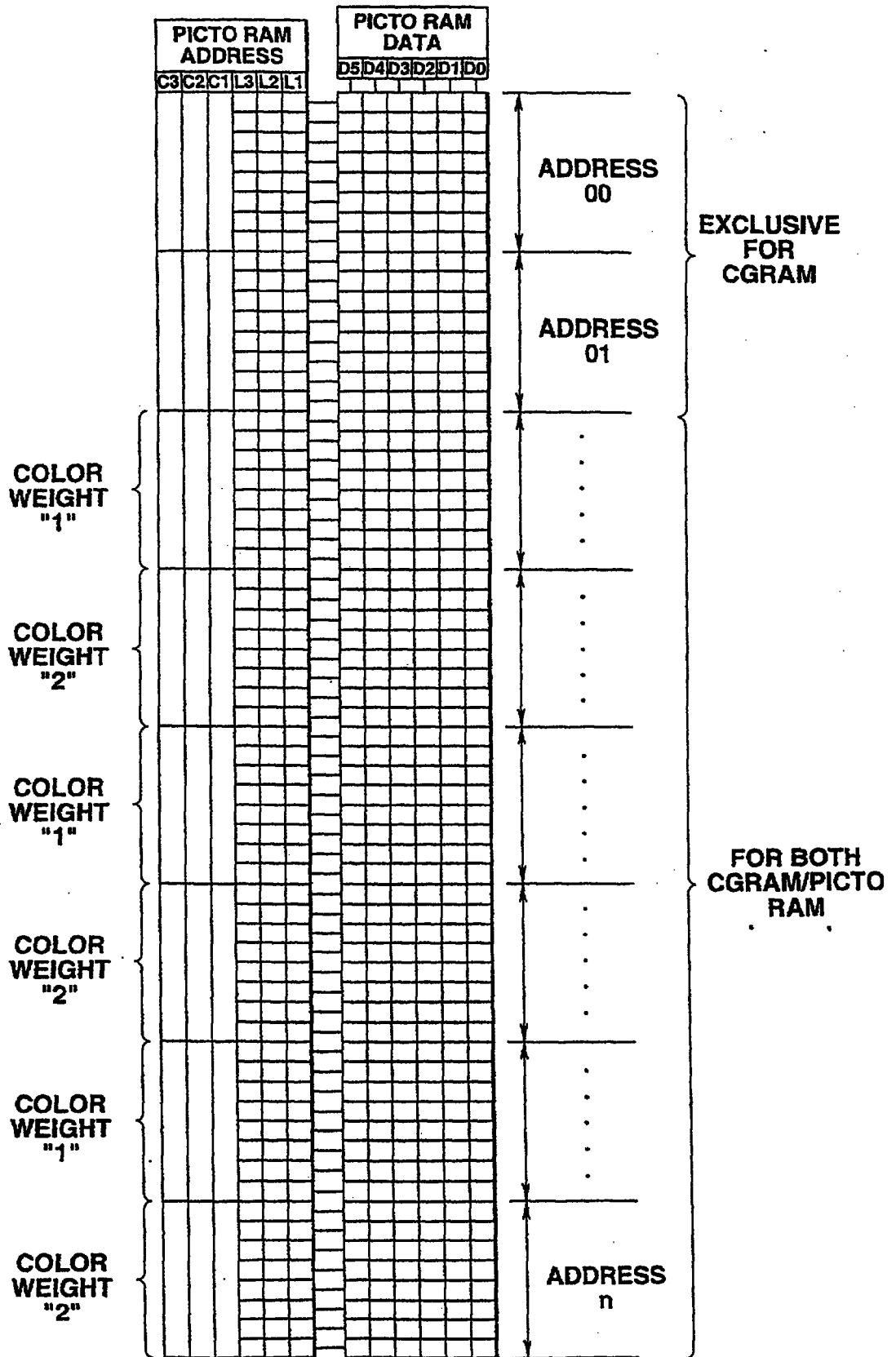


FIG.15

REPLACEMENT SHEETS		SG
☐ Description :	paged ... to paged ...	
☐ Claim(s) :	paged ... to paged ...	
☐ Drawing(s) :	paged ... to paged ...	
☐ Abstract :	paged ... to paged ...	
DATE OF RECEIPT ..7/9/99.....		

9705343-3

IPOS

41 Substitute sheet - 6 September 1999

- 7 SEP 1999

CLAIMS

1. A liquid crystal display apparatus characterized by comprising:

a liquid crystal display panel (3) for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having a character display area (3b) for displaying a plurality of characters each comprising a plurality of pixels and an image display area (3c) for displaying an image comprising at least one pixel;

designation means (301 to 304) for respectively setting display colors in said character and image display areas (3b, 3c), said designation means having means display color and a display position for each of the display characters, with respect to said character display area and means (302) for specifying a display color for the at least one pixel constituting said image display area (3c); and

drive means (400) for generating drive signals to display, on said character display area, the specified display characters with the specified colors at the specified positions with respect to said character and image display areas (3b, 3c) in accordance with specifications specified by said designation means (301 to 304) and drive signals to display the image on said image display area in accordance with the specification specified by said designation means, and applying said drive signals to said liquid crystal display panel (3), thereby displaying characters with colors at positions on said character display area and the image with a color specified by said designation means (301 to 304) on said image display area (3b, 3c).



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9705343-3

2. The liquid crystal display apparatus according to claim 1, characterized in that said first display area (3b) has a dot matrix display area, and said second display area (3c) has a pictograph display section.

3. A liquid crystal display apparatus characterized by comprising:

a liquid crystal display panel (3) for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having a first display area (3b) for displaying an image comprised of a plurality of pixels and a second display area (3c) for displaying an image comprised of at least one pixel

designation means (301 to 304), having means (301, 303, 304) for specifying display characters, display colors and display positions with respect to said first display area and means (302) for specifying a display color with respect to said second display area (3c); and

drive means (400) for generating a drive signal with respect to said first display area (3b) in accordance with the display characters, display colors and display positions specified by said designation means (301 to 304) and generating a drive signal with respect to said second display area (3c) in accordance with the color specified by said designation means (301 to 304) and applying the drive signals to said liquid crystal display panel (3), thereby displaying characters with colors at positions specified by said designation means (301 to 304), on said first display area (3b) and displaying the image with colors specified by said designation means;

wherein said designation means (301 to 304) comprises:



character code storage means (301) for storing character codes in association with positions at which said first display area (3b) of said liquid crystal display panel (3) displays said characters;

character color data storage means (304) for storing display color data of characters in association with said character codes stored in said character code storage means (301); and

image color data storage means (302) for storing image color data to be displayed on said second display area (3c).

4. The liquid crystal display apparatus according to claim 3, characterized in that said image color data storage means (302) stores individual bits of said image color data in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory area.

5. The liquid crystal display apparatus according to claim 3, characterized in that at least one of said character color data storage means (304) and said image color data storage means (302) stores P-bit display color data for designating any of 2^P colors, where P is a positive integer; and

said drive means (400) includes means for converting said P-bit display color data to q-bit display color data where q is a positive integer greater than P and means (400) for driving said liquid crystal display panel (3) to display said display data in a display color corresponding said q-bit display color data after conversion.

6. The liquid crystal display apparatus according to claim 1, characterized in that said liquid crystal



display panel (3) is comprised of a reflection type of liquid crystal display device which changes display colors by changing retardation of a liquid crystal by controlling an applied voltage.

7. A method of driving a liquid crystal display apparatus for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having a character display area (3b) for displaying a plurality of characters each comprising a plurality of pixels and an image display area (3c) for displaying an image comprising at least one pixel, said method characterized by comprising the steps of;

setting display characters to be displayed, and display colors and display positions of each of the display characters, with respect to said character display area and setting a display color for the at least one pixel constituting said image display area; and

generating drive signals to display, on said character display area, the set display characters with the set colors at the set positions with respect to said character display area (3b) in accordance with the setting step and drive signals to display the image on said image display area in accordance with the setting in the setting step, and applying said drive signals to said liquid crystal display panel (3), thereby displaying characters with colors at positions set in the setting step on said character display area and the image with a color set in the setting step on said image display area (3b. 3c).

8. The method according to claim 7, characterized in that said first display area (3b) has a dot matrix



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display area, and said second display area (3c) has a pictograph display section.

9. A method of driving a liquid crystal display apparatus for displaying different colors in accordance with an applied voltage, said liquid crystal display panel (3) having a character display area (3b) for displaying a plurality of characters each comprising a plurality of pixels and a image display area (3c) for displaying an image comprising at least one pixel, said method characterized by comprising the steps of;

setting display characters, display colors and display positions for said character display area (3b) and a display color for said image display area (3c);

generating drive signals respectively to said character and image display areas (3b, 3c) in accordance with the setting in the setting step and applying said drive signals to said liquid crystal display panel (3), thereby displaying set characters with set colors at set positions on said character display area and displaying the images with set color on said image display areas (3b, 3c);

wherein said setting step includes steps of storing character codes in character code storage means (301) in association with positions at which said liquid crystal display panel displays said characters, storing display color data of characters in character color data storage means (304) in association with said character codes stored in said character code storage means (301), and storing image color data to be displayed on said second display area in image color data storage means (302), and



7 SEP 1999

46 Substitute sheet - 6 September 1999

said driving step includes a step of driving said liquid crystal display panel (3) based on data stored in

said character code storage means (301), said character color data storage means (304) and said image color data storage means (302).

10. The method according to claim 9, characterized in that individuals bits of said image color data are stored in bits at relatively same positions in adjoining memory areas or in adjoining bits in a memory area.

11. The method according to claim 9, characterized in that said setting step stores in at least one of said character color data storage means and said image color data storage means, p-bit display color data for designating any of 2^p colors; and

said driving step converts said p-bit display color data to P-bit display color data ($q > p$) and drives said liquid crystal display panel in such a way as to display said display data in a display color corresponding to said q-bit display color data after conversion.

12. The method according to claim 7, characterized in that said liquid crystal display panel (3) is comprised of a reflection type of liquid crystal display device which changes display colors by changing retardation of a liquid crystal by controlling an applied voltage.



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☐ Drawing(s) : paged to paged
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(54) Title: ELECTRICALLY CONTROLLED BIRIFRINGENCE LIQUID CRYSTAL DISPLAY HAVING MORE DISPLAY AREAS AND METHOD OF DRIVING THE SAME

(57) Abstract

An electrically controlled birefringence type liquid crystal display panel has a pictograph (picto) display area and character display areas. Character codes are stored in a DDRAM (301) and color attribute data indicating the display colors of characters are stored in a CCRAM (302), both in one-to-one association with the character display areas. Character patterns for character codes stored in the DDRAM (301) are read from a character generator (303), and, simultaneously color attribute data in the CCRAM (304) is read out. A segment driver (407) controls voltages to be applied to the liquid crystal display panel based on the character pattern and the color attribute data, for displaying the characters in arbitrary colors. Color attribute data which specifies the display color of each of pixels constituting a pictograph is set in a picto RAM (302). The color attribute data of the individual segments are read from the picto RAM (302) at the timing for displaying a pictograph, and the segment driver (407) controls voltages to be applied to the liquid crystal display panel in accordance with this color attribute data, for displaying pictograph on the pictograph display area.

