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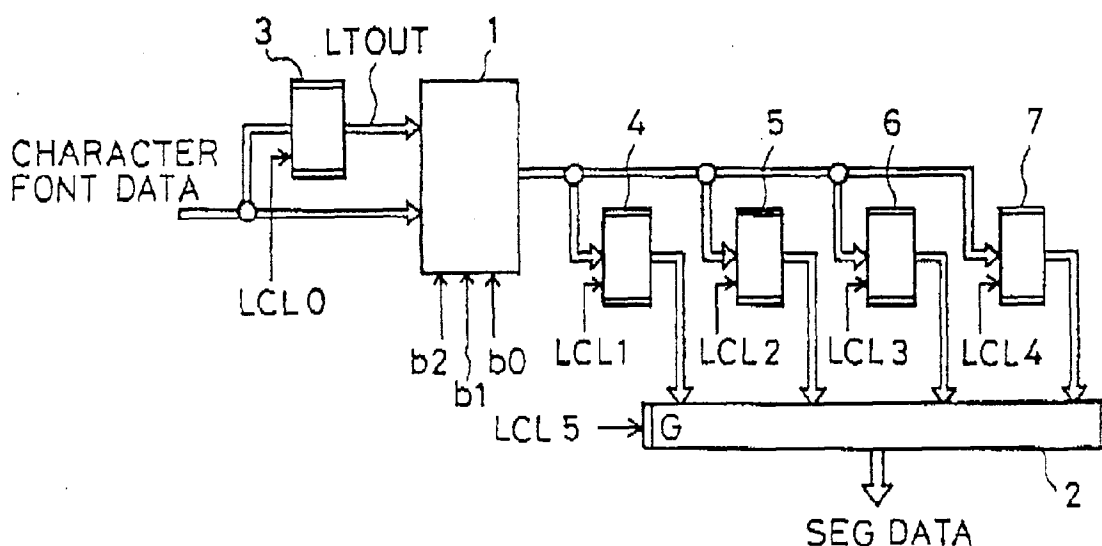
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(54) **Liquid crystal driving apparatus and personal instruments incorporating the same**

(57) In a liquid crystal driving apparatus, character font data of two characters which are continuously read out from a character font ROM are shifted by any number of dots by a shifter (1), and a shift result is

latched every character to be displayed. A data shift operation is carried out while removing blank data corresponding to boundaries between characters in display data of one line in a horizontal direction (data of one common line) in a 6-dot font display mode.

F I G. 1



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Description

The present invention relates to a liquid crystal driving apparatus for use in a display means such as a portable or personal information terminal or the like, and particularly to a liquid crystal driving apparatus for reading out font data from a character font ROM to display characters on a matrix-type display device, and a portable or personal instrument using the same.

A liquid crystal driving apparatus having a character font ROM generally displays any character at a specific position on a liquid crystal display by writing any character code into a specific address of a display RAM (Random Access Memory).

In this liquid crystal driving apparatus, a character code is read out from the display RAM in synchronism with a display timing to input the character code into a character font ROM (hereinafter referred to as "CGROM (Character Generator ROM)") and then transmit character font data to a display device. A series of these operations will be hereunder described with reference to Fig. 2.

In general, the display operation of the liquid crystal driving apparatus is under the control of a CPU. A CPU interface 9 serves as an input port for the CPU, and the CPU writes a display content into the display RAM 10 through the CPU interface 9, that is, the CPU writes the character code into the specific address corresponding to a specific position on a display panel. A character code is periodically read out from the display RAM 10 by a timing control circuit 8, and then input to the CGROM 11. The timing control circuit 8 generates a common timing and transmits common timing information to a common driver 13.

The timing control circuit 8 also transmits the common timing information to the CGROM 11, and the CGROM 11 determines data of character fonts to be output on the basis of both the signals of the character code from the display RAM 10 and the common timing information. The character font data from the CGROM 11 are transmitted to a shift latch circuit 12. The shift latch circuit 12 continues a data shift operation until display data of one line in a horizontal direction of the display panel are filled, and transmits the shift result as display data to a segment driver 14.

Fig. 3 shows an example of the shift latch circuit 12.

The character font data are output from the CGROM 11 every character.

Therefore, when four characters are required to be displayed as shown in Fig. 4, the CGROM 11 is accessed at four or more times at one common timing (for data of one line in the horizontal direction).

Through one access operation to the CGROM 11, the font data are loaded to a shift register group A of Fig. 3, and then the font data are shifted to a shift register group B with a shift clock signal which is output from a shift CLK generator 15.

In the case of Fig. 3, when the shift CLK is gener-

ated at six times, the shift register group A becomes empty. Therefore, a second access operation to the CGROM 11 is performed to load the character font data to the shift register group A again. This operation is repeated for each of the four characters.

According to the liquid crystal driving apparatus as described above a scroll operation of displayed characters on a dot basis in a horizontal direction, like an electric sign board, has been conventionally performed by changing the number of shift clock pulses generated in a CLK generator 15 shown in Fig. 3. In this case, a display character can be shifted to the left side dot by dot every time the clock number is incremented by "1" as shown in Fig. 4.

Further, it is a general manner in a character display mode that when display pixels are arranged in a matrix form, a blank dot line is disposed between characters to represent the boundary between the characters as shown in Fig. 4. For example, when plural characters each of which is represented with 5x7 dots are displayed in a horizontal direction, it is reasonable to represent the characters with character fonts each of which comprises 6x7 dots containing a line of blank dots. The mode in which each character is represented with a character font of 6x7 dots is referred to as "6-dot font display mode" in this specification.

In the 6-dot font display mode, one dot in each horizontal line must be occupied by the "blank" information for each boundary between characters on a line, and thus the display efficiency in terms of the number of driving lines for segments is low. Accordingly, if a liquid crystal panel is beforehand designed to have a blank space of one dot (this portion has been subjected to no patterning treatment over a manufacturing process) which is formed at the boundary between characters as shown in Figs. 8B and 8C, a segment driving signal representing "blank" information is unnecessary, and thus the display efficiency is enhanced. As described above, when a display panel having no wiring for pixels at the boundary between characters is used, a character font of 5x7 dots can be treated as display information, and this mode is hereinafter referred to as "5-dot font display mode".

Both the 6-dot font display mode and the 5-dot font display mode can perform a scroll operation in the horizontal direction by using a conventional driving apparatus, like an electric sign board.

However, in these conventional methods, the following two problems occur when the scroll operation is performed on a dot basis.

A first problem is as follows. It is necessary to generate shift clock pulses whose number corresponds to the total number of display dots arranged in the horizontal direction, and thus the frequency of the shift clock pulses must be set to a very high frequency. For example, when a display frame of 10 characters x 4 lines of characters is displayed at 60Hz in the 6-dot font display mode, the total dot number in the horizontal direction is

equal to $10 \times 6 = 60$ dots, and the total dot number in the vertical direction is equal to $4 \times 8 = 32$ dots (32 common). Therefore, the frequency of the shift clock pulses must be set to $60\text{Hz} \times 32 \text{ common} \times 60 \text{ dots} = 115.2\text{kHz}$ at the lowest.

Since the frequency of the shift clock pulses is high as described above, a switching operation of the driving apparatus is carried out at high speed, and thus there is a disadvantage that a current demand at the operating time is increased. When this driving apparatus is designed in one chip of integrated circuit for use in a portable information terminal, the lifetime of a battery is shortened and the design of "portable structure" cannot sufficiently provide its merit.

The second problem is as follows. When the scroll operation is carried out, like the electric sign board, in the 5-dot font display mode by using a display panel having no wiring for pixels at the boundary between characters, the blank between the characters is lost through one-dot scroll as shown in Fig. 8B (i.e., the neighbouring characters are brought into contact with each other at the edge portions thereof), and further each character itself is laterally extended at portions of the panel where the wiring is omitted. Therefore, the character is deformed at these portions, and this causes erroneous character recognition.

In order to solve the first problem as described above, according to one aspect of the present invention, there is provided a liquid crystal driving apparatus comprising a storage device for storing character font data and outputting font data every character, a shift latch circuit for developing the output of the storage device into image data of one line in a horizontal direction on a display panel, and a segment driver for converting the output of the shift latch circuit to a liquid crystal driving waveform, characterised in that

said shift latch circuit comprises a first latch circuit for holding the output of said storage device at a first timing (LCLO), a first shifter circuit for receiving the output of said storage device and the output of said first latch circuit at the first timing and shifting the received outputs by a predetermined bit amount, second latch circuits whose number is equal to the number of characters in the horizontal direction and which are connected to one another in parallel so as to successively hold the output of said first shifter circuit at serial timings (LCL1-LCL4), and a third latch circuit for holding the output of the second latch circuit at a second timing (LCL5).

In order to solve the second problem, according to a second aspect of the present invention, there is provided a liquid crystal driving apparatus having a storage device for storing character font data and outputting font data every character, a shift latch circuit for developing the output of the storage device into image data of one line in a horizontal direction on a display panel, and a segment driver for converting the output of the shift latch circuit to a liquid crystal driving waveform, characterised by further comprising a second shifter circuit which is

provided to prevent bits corresponding to blank data between characters out of image data of one line in the horizontal direction on a display panel, which are developed by said shift latch circuit being supplied to the segment driver.

According to the first aspect of the present invention, in order to perform the lateral scroll operation on dot basis, font data (corresponding to a character) which are read out from the storage device such as the CGROM which serves to store character font data and output the font data every character, are first held at the first timing by the first latch circuit. Both the output (font data) of the first latch circuit and font data (corresponding to a character adjacent to the above character) which are sequentially read out from the CGROM are arranged, and then these font data of the neighbouring two characters are shifted in the first shifter circuit, and the output of the first shifter circuit is held into the second latch circuits at sequential timings. Therefore, the number of shift clock pulses is not necessary to be proportional to the total dot number, but may be proportional to the number of characters in the horizontal direction. Accordingly, the frequency of the shift clocks can be reduced, and thus the first problem can be solved.

In order to solve the second problem, according to the second aspect of the present invention, the circuit connection is made so that in the 5-dot font display mode, the blank data to be displayed at the wiring-omitted portions between characters are avoided by the second shifter circuit, so that a scroll operation can be performed without deforming the characters. Fig. 8C shows a display example of this case. When the characters are scrolled to the left side by one dot, the left edges of the characters are just hidden at the blank space portions as shown in Fig. 8C, and the hidden edge of each of the characters appears at its neighbouring character area again when the characters are scrolled by a further one dot, i.e. a total of two dots. Such a display is just like an outside scene which is viewed through a window of a travelling train. That is, a part of the scene which is hidden by the frames of the window cannot be seen, however, it can be seen as the train travels. Likewise, by continuously scrolling the displayed characters, the characters can be seen with no deformation as if they flow in the horizontal direction, whereby the erroneous character recognition can be suppressed.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying diagrammatic figures, in which:

Fig. 1 shows an embodiment of a shift and latch circuit according to the present invention;

Fig. 2 is a block diagram showing a liquid crystal driving apparatus according to the present invention;

Fig. 3 shows a conventional shift and latch circuit; Fig. 4 is a diagram showing a liquid crystal display according to the present invention:

Figs. 5A and 5B show timing charts to explain an effect of the present invention;

Fig. 6A shows a timing chart to show an operation of the present invention;

Figs. 6B and 6C are diagrams showing the operation of the present invention;

Fig 7 is a diagram showing a second shifter circuit of the present invention; and

Figs. 8A, 8B and 8C are diagrams to show an effect of the second shifter circuit.

Preferred embodiments according to the present invention will be described hereunder with reference to the accompanying drawings.

Fig. 1 shows a shift and a latch circuit according to the present invention.

Character font data of one character (5 bits + 1 bit of blank data = 6 bits, in total) which are read out from a CGROM 11 are input to a first latch circuit 3 and a first shifter circuit 1, and the output (6 bits) of the first shifter circuit 1 is input to respective second latch circuits 4 to 7 in parallel. The output of the first shifter circuit 1 is latched and held at sequential timings (LCL1 to LCL4) every time the character font data are read out from the CGROM 11.

A timing control circuit 8 shown in Fig. 2 counts a display timing so as to meet the number of characters to be displayed in the horizontal direction (in this case, four characters). It is apparent from a timing chart of Fig. 6A that the display timing is counted from "0" to "4". In synchronism with this timing, character codes are transmitted from the display RAM 10 to the CGROM 11, and then the CGROM 11 outputs character font data ("A", "B", "C", "D", "E") as shown in Fig. 6A. The output of the CGROM 11 is taken into a first latch circuit 3 at a first timing (i.e., LCL0) which is output every time the count value of the display timing varies, and both the output (LTOU) of the first latch circuit 3 and the output of the CGROM 11 are input to a first shifter circuit 1.

In the first shifter circuit 1, as shown in Figs. 6B and 6C, the output (LTOU) of the first latch circuit 3 and the output of the CGROM 11 which correspond to neighbouring display characters are arranged in the horizontal direction, and shifted to the left side by a specified scroll amount. In this case, (b2, b1, b0) = (0, 2, 0), that is, two-dot shift is performed, and 4 dots at the right side of the character font "A" and 2 dots at the left side of the character font "B" are output from the first shifter circuit 1. The output of the first shifter circuit 1 is held in the second latch circuits 4, 5, 6 and 7 at the sequential timings LCL1, LCL2, LCL3 and LCL4 which are successively output every time the count of the display timing varies. At the time when image data of one line in the horizontal direction on the display panel are filled, the data are held in the third latch circuit 2 at a second timing of LCL5, and transmitted to a segment driver 14.

By altering the size of shift performed by the first shifter circuit 1, a lateral scroll operation can be per-

formed.

In the present invention containing the shift and latch circuit shown in Fig. 1, the filling of the image data of one line in the horizontal direction on the display panel is performed by using the sequential clocks (LCL1 to LCL4) which are generated every display timing as shown in Fig. 6. That is, it is sufficient to generate the latch clock on a character basis every time the character font data output from the CGROM 11 vary

Regarding the clock frequency required for the liquid crystal driving apparatus, Fig. 5A shows a timing chart of a conventional circuit, and shift clock pulses for 6 dots are required every time the character font data for a single character is loaded. Therefore, when five characters are displayed in the horizontal direction, shift clock pulses of $5 \times 6 = 30$ clock pulses are required between common cycles.

On the other hand, according to the present invention, latch clock pulses for only five characters are sufficient even when the character font data of five characters are loaded from the ROM. Actually, in order to read out the character font data of one character from the ROM, character codes must be beforehand read out from the display RAM 10. Therefore, the liquid crystal driving apparatus needs clocks operating at one-rank higher speed to access to the display RAM 10. However, if there are clocks whose speed is twice as high as the latch clocks for five characters, the continuous access to the RAM and the ROM can be performed. If the display case of 10 characters x 4 lines at 60Hz as described in the prior art is applied to this case, that is, when a display frame of 10 characters x 4 lines is displayed at 60Hz in this embodiment, the required clock frequency is equal to $60\text{Hz} \times 32 \text{ common} \times 10 \text{ characters} \times \text{twice} = 38.4\text{kHz}$, and thus the display can be performed at a sufficiently lower frequency (38.4kHz) than the frequency (115.2kHz) of the prior art.

Further, as shown in Fig. 7, the outputs of the second latch circuits 4 to 7, that is, pixel data (S1, S2, S3, ..., S34, S35, S36) to be displayed in the horizontal direction are input to the second shifter circuit 20, and the output of the second shifter circuit 20 is input to the third latch circuit 2. Note that in Fig. 7, a second shifter circuit 20 able to accept the output from six second latch circuits (i.e. display data for six characters) is shown. The pixel data in the horizontal direction contain blank data at the boundaries between characters in the 6-dot font display mode. The blank data are input to S1, S7, S13, S19, S25, S31, and these data are not required in the 5-dot font display mode. Accordingly, the second shifter circuit 20 is connected to remove these unnecessary data in the 5-dot font display mode. The pixels S2 to S6 are connected (input) to the inputs D1 to D5 of the third latch circuit 2, the pixels S8 to S12 are connected to D6 to D10, and the pixels S14 to S18 are connected to D1 to D5. That is, the second shifter circuit 20 is constructed so that the pixels S1, S7, S13, S19, S25, S31, corresponding to the blank data in the pixels S1 to S36 are

not input to the third latch circuit 2.

The multiplexer 19 shown in Fig. 7 can switch the 6-dot font display mode and the 5-dot font display mode to each other by selecting one of the data in two directions. In the 5-dot font display mode, the multiplexer 19 outputs an input from an upper right side to a lower side, as shown in Fig. 7. This data flow corresponds to a shift operation. Therefore, in Fig. 7, the blank data of S1, S7, S13, S19, S25, S31 are neglected, and the third latch circuit 2 holds the pixel data at the second timing and outputs SEG data to the lower side.

If it is desired to operate in a 6-dot font display mode, the multiplexer 19 outputs an input from an upper left side to a lower side, as shown in Fig. 7. This data flow corresponds to a non-shift operation.

When the scroll display in the 5-dot font display mode is performed, for example when characters are shifted to the left side by one dot by the first shifter circuit 1, the font data at the left edges of the characters of the respective pixel data (S1, S2, S3 ..., S34, S35, S36) enter the positions S1, S7, S13, S19, S25, S31. However, through the shift operation of the second shifter circuit 20, the data at these positions are neglected, and thus these data are not displayed. When characters are shifted to the left side by two dots, the font data of the left edge of each character is displayed at the right edge in a display area of a character which is adjacent to the character at the left side. That is, the display shown in Fig. 8C is performed.

According to this embodiment, the characters are scrolled without being deformed in the 5-dot font display mode. Accordingly, the output of the second shifter circuit is input (connected) to the third latch circuit 2 in this embodiment, however, the same effect can be performed by using another connection (inputting) method. For example, the same effect can be obtained by the following method: all the pixel data (S1, S2, S3, ..., S34, S35, S36) to be displayed in the horizontal direction are held at the second timing in the third latch circuit 2, and the output of the third latch circuit 2 is input to the second shifter circuit 20 to delete the blank data at the positions S1, S7, S13, S19, S25, S31 and output the residual data to the segment driver 14. That is, the second shifter 20 may be disposed at any stage before the pixel data (S1, S2, S3, ..., S34, S35, S36) to be displayed in the horizontal direction are input to the segment driver 14.

with respect to the second problem of the prior art, as described above, the present invention has two methods, a first method of solving the first problem, and a second method of solving the second problem. These two methods show their effects individually and independently. That is, the frequency of the clocks required for the display can be reduced by using the first method for the first problem. Further, the scroll operation on dot basis can be performed with no deformation by using the second method for the second problem.

When the first and second methods are used, the lateral scroll operation can be performed with no char-

acter deformation by using the 5-dot font display mode having high display efficiency, and in addition, the frequency of the clocks for display can be lowered to reduce a current demand, thereby achieving a performance which is required for a portable or personal instruments having batteries.

When the liquid crystal driving apparatus of this invention is combined with a display panel on which display pixels are arranged in a matrix form, a liquid crystal display device having the above effects can be achieved. In addition, when the apparatus is combined with a CPU and a battery, a portable or personal instrument having excellent portability and the above effects can be achieved.

As described above, according to the present invention, even when displayed characters are laterally scrolled on dot basis like an electric sign board, the clocks required for the liquid crystal driving apparatus can be achieved at a sufficiently lower frequency than the conventional liquid crystal driving apparatus.

When the liquid crystal display device as described above is formed of a one-chip integrated circuit, the current demand of the integrated circuit can be reduced, and the improvement in lifetime of batteries, etc. which is required for future portable instruments can be achieved.

Further, according to the present invention, even in the 5-dot font display mode having high character display efficiency, the scroll operation on dot basis like an electric sign board can be performed with no character deformation as shown in Fig. 8C. This corresponds to such a natural phenomenon that when a person takes a view of an outside scene through a window of a travelling train, the person cannot see a part of the scene which is overlapped with window frames. However, the characters are scrolled in the horizontal direction without being deformed, a user can be prevented from erroneously recognising the characters.

This invention provides a liquid crystal driving apparatus having a storage device for storing character font data and outputting font data every character, a shift latch circuit for developing the output of the storage device into image data of one line in a horizontal direction on a display panel, and a segment driver for converting the output of the shift latch circuit to a liquid crystal driving waveform, characterised by further comprising a second shifter circuit which is provided to avoid bits corresponding to blank data between characters out of image data of one line in the horizontal direction on a display panel, which are developed by said shift latch circuit.

This invention provides a liquid crystal driving apparatus which contains a character font ROM therein and can perform a scroll display operation of displayed characters on dot basis in a horizontal direction, characterised in that character font data of two characters which are continuously read out from said character font ROM are shifted by a number of dots by a parallel shifter,

and a shift result is latched every character to be displayed.

The foregoing description has been given by way of example only and it will be appreciated by a person skilled in the art that modifications can be made without departing from the scope of the present invention.

Claims

1. A liquid crystal driving apparatus comprising a storage device (10) for storing character font data and outputting font data every character, a shift latch circuit (12) for developing the output of the storage device into image data of one line in a horizontal direction on a display panel, and a segment driver (14) for converting the output of the shift latch circuit to a liquid crystal driving waveform, characterised in that

said shift latch circuit comprises a first latch circuit (3) for holding the output of said storage device at a first timing (LCLO), a first shifter circuit (1) for receiving the output of said storage device and the output of said first latch circuit at the first timing and shifting the received outputs by a predetermined bit amount, second latch circuits (4, 5, 6, 7) whose number is equal to the number of characters in the horizontal direction and which are connected to one another in parallel so as to successively hold the output of said first shifter circuit at serial timings (LCL1-LCL4), and a third latch circuit (2) for holding the output of the second latch circuit (5) at a second timing (LCL5).

2. The liquid crystal driving apparatus as claimed in claim 1, further comprising a second shifter circuit (20) which is provided to prevent bits corresponding to blank data between characters out of image data of one line in the horizontal direction on a display panel, which are developed by said shift latch circuit being supplied to the segment driver.

3. A liquid crystal driving apparatus having a storage device (10) for storing character font data and outputting font data every character, a shift latch circuit (12) for developing the output of the storage device into image data of one line in a horizontal direction on a display panel, and a segment driver (14) for converting the output of the shift latch circuit to a liquid crystal driving waveform, characterised by further comprising a second shifter circuit (20) which is provided to prevent bits corresponding to blank data between characters out of image data of one line in the horizontal direction on a display panel, which are developed by said shift latch circuit being supplied to the segment driver.

4. A portable instrument having a battery, a CPU, a

liquid crystal display device and a liquid crystal driving apparatus, characterised in that said liquid crystal driving apparatus comprises the liquid crystal driving apparatus as claimed in claim 1.

5. A portable instrument having a battery, a CPU, a liquid crystal display device and a liquid crystal driving apparatus, characterised in that said liquid crystal driving apparatus comprises the liquid crystal driving apparatus as claimed in claim 2.

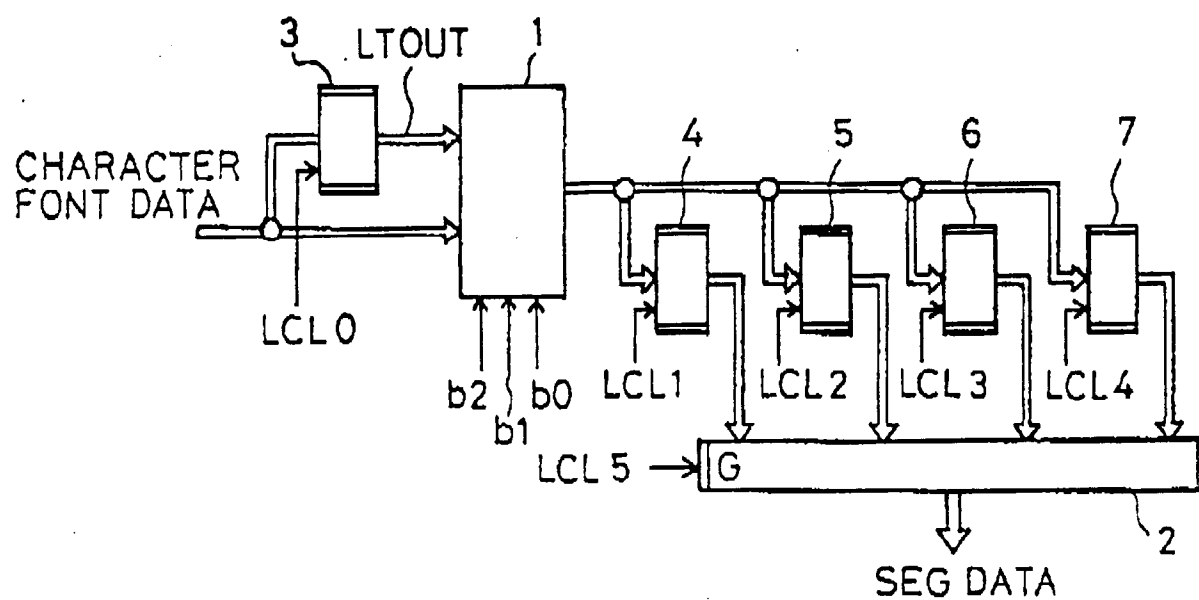
6. A portable instrument having a battery, a CPU, a liquid crystal display device and a liquid crystal driving apparatus, characterised in that said liquid crystal driving apparatus comprises the liquid crystal driving apparatus as claimed in claim 3.

7. A liquid crystal driving apparatus for driving a liquid crystal panel to display characters each comprising 5x7 dots, in which a blank space of one dot is provided between characters each having 5 dots in a horizontal direction, characterised in that a driving operation of said liquid crystal driving apparatus is performed so that font data of the left edge or right edge of a character font does not appear in a display space of an adjacent character when a scroll display operation is performed by one dot in the horizontal direction.

8. A liquid crystal driving apparatus which contains a character font ROM therein and can perform a scroll display operation of displayed characters on dot basis in a horizontal direction, characterised in that character font data of two characters which are consecutively read out from said character font ROM may be shifted by a preselected number of dots by a parallel shifter, and a shift result is latched every character to be displayed.

9. A liquid crystal driving apparatus as claimed in claim 2 or claim 3, wherein said second shifter circuit is incorporated into said shift latch circuit to prevent bits corresponding to blank data between characters out of image data of one line in the horizontal direction on a display panel being developed by said shift latch circuit.

FIG. 1



F I G. 2

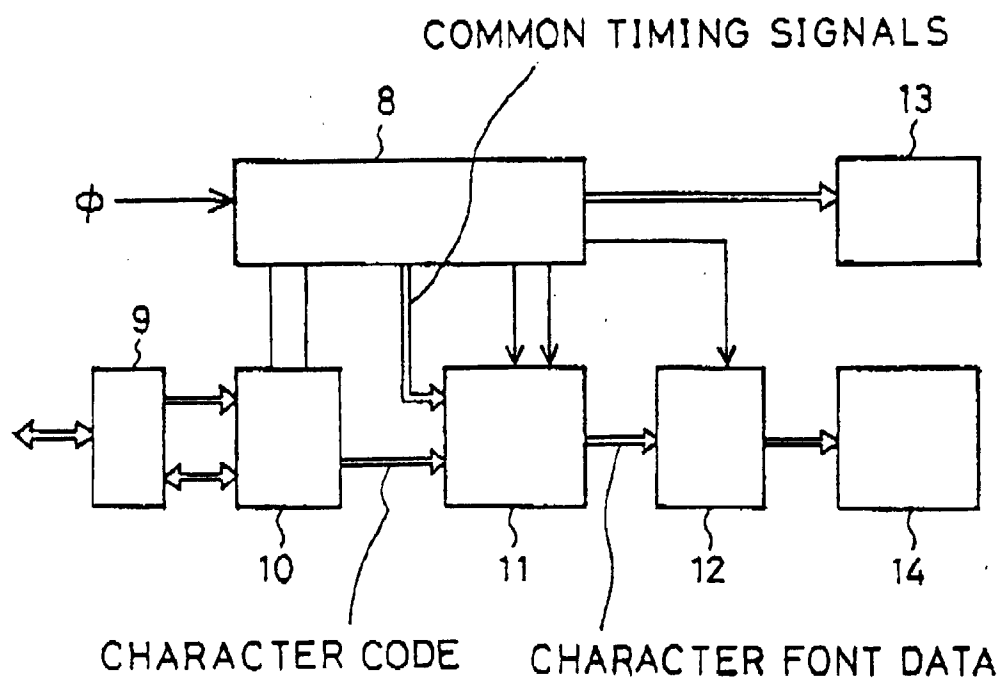


FIG. 3

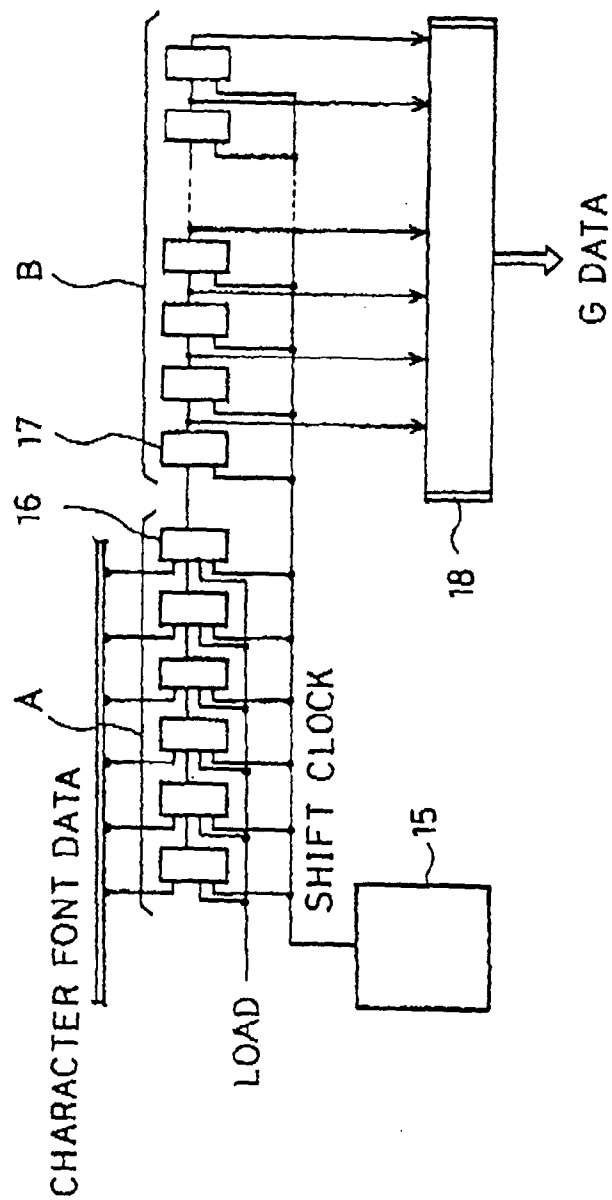
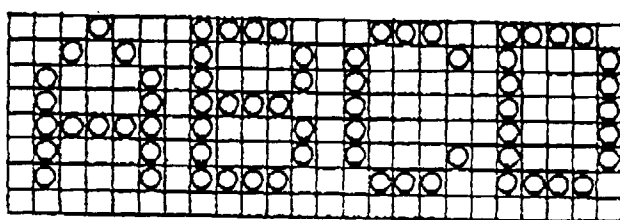
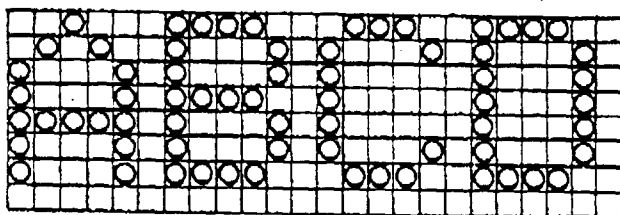


FIG. 4

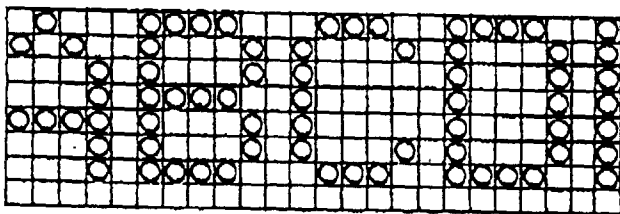
SHIFT CLOCK
COUNT



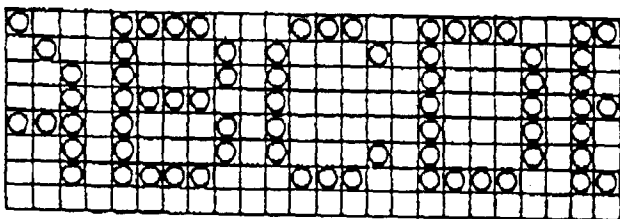
6×4



$6 \times 4 + 1$



$6 \times 4 + 2$



$6 \times 4 + 3$

FIG. 5 A

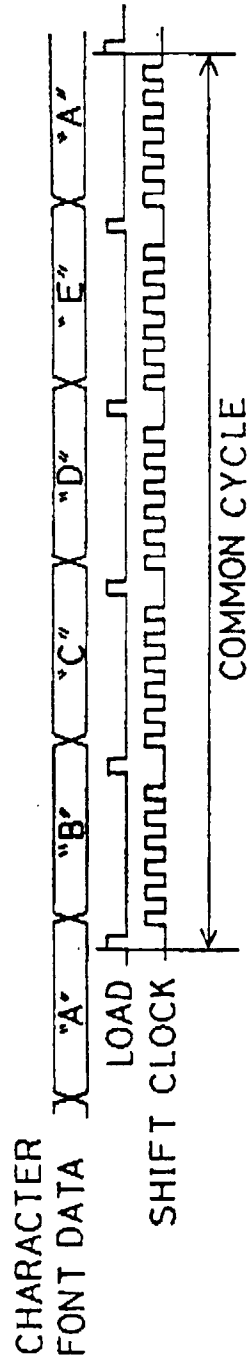


FIG. 5 B

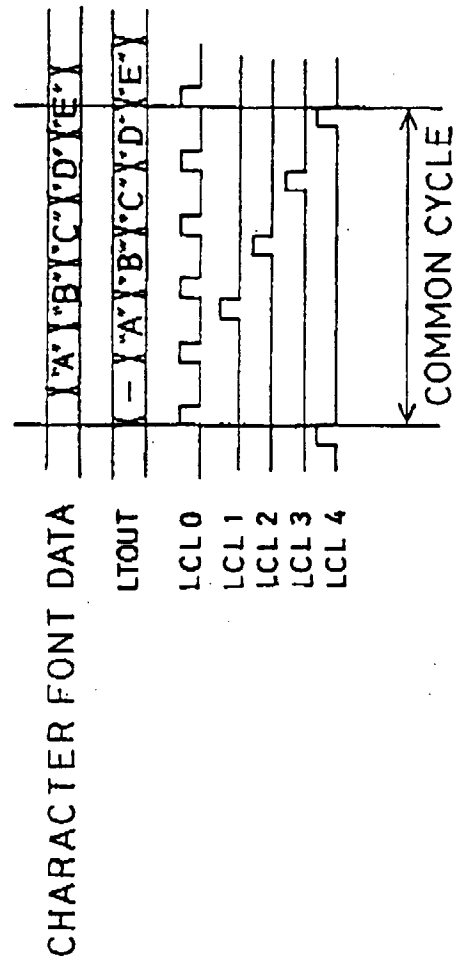


FIG. 6A

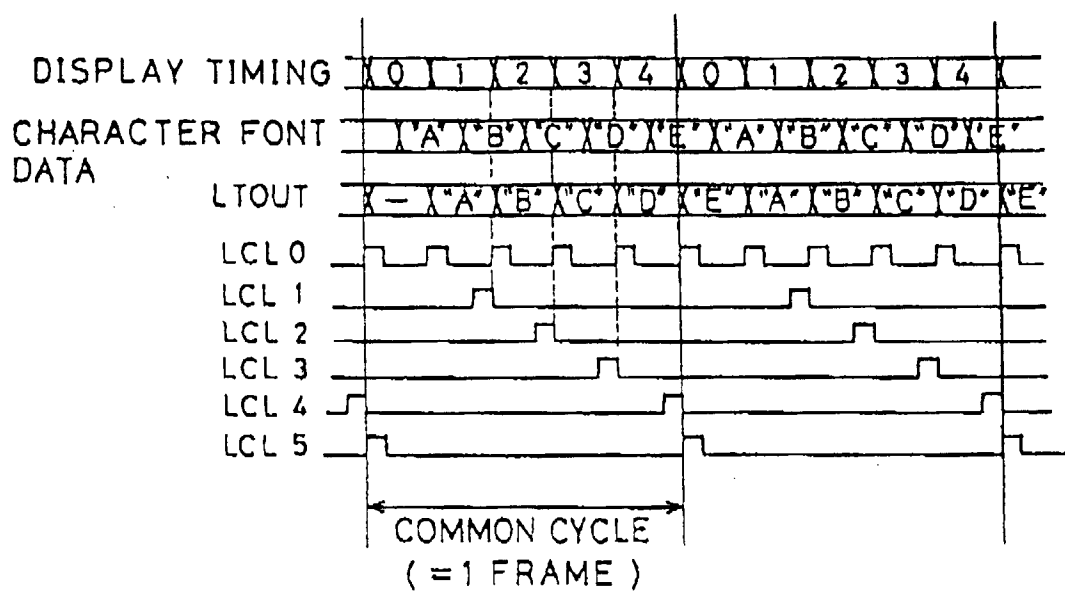
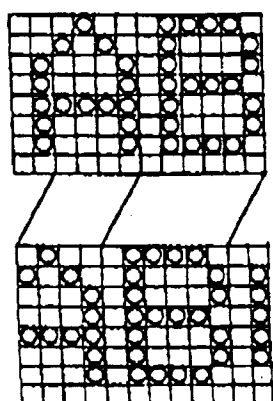
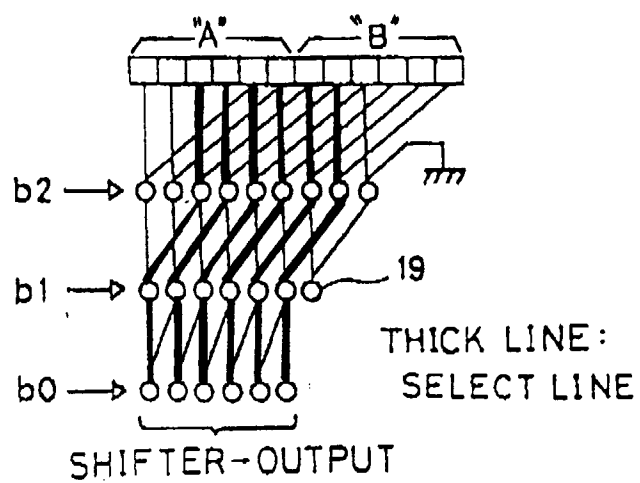


FIG. 6B



F I G. 6 C



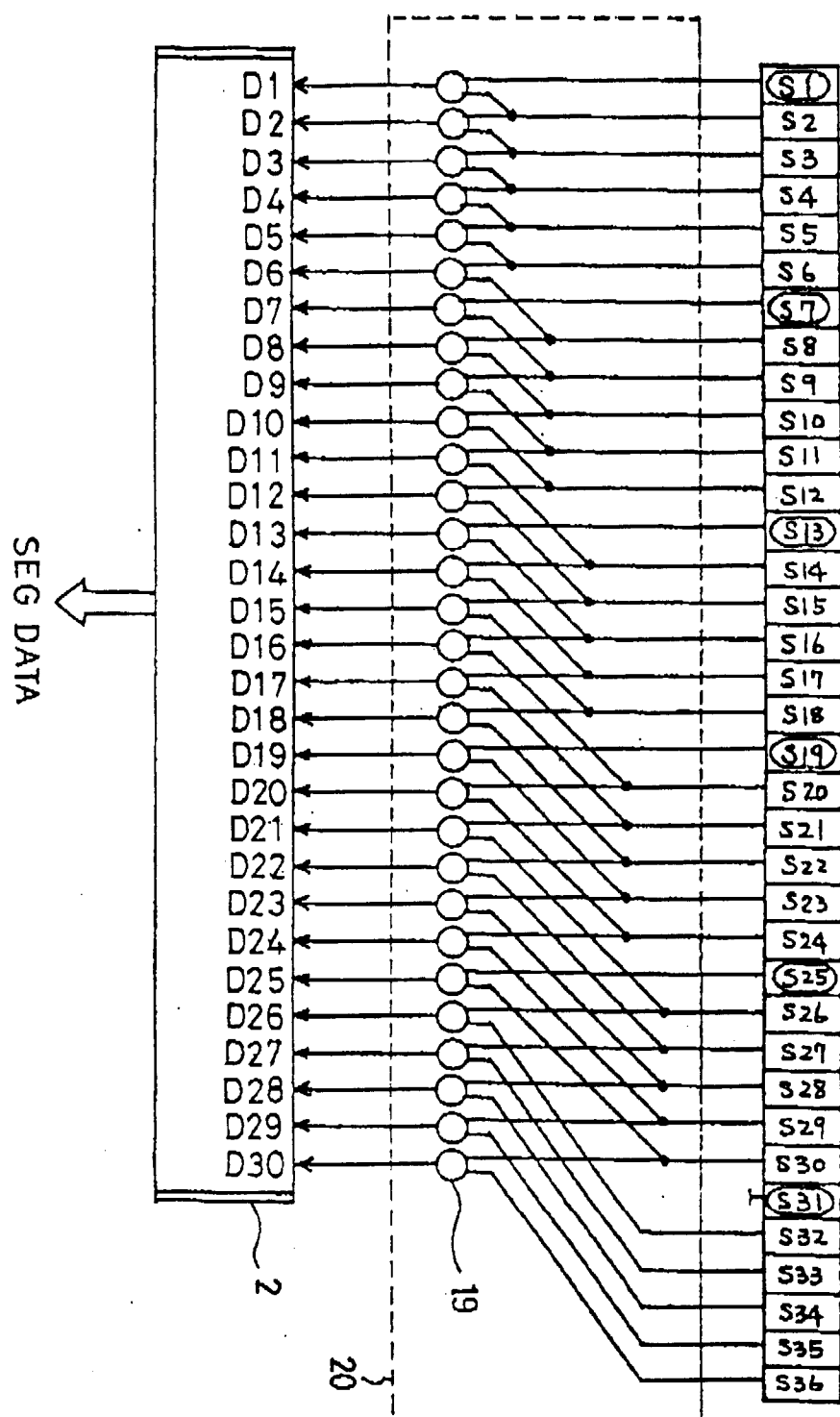


FIG. 7

FIG. 8 A

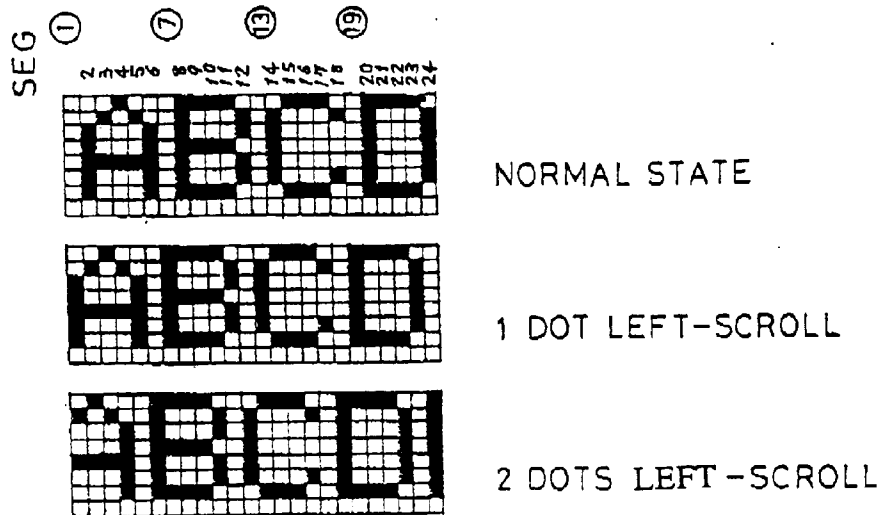


FIG. 8 B

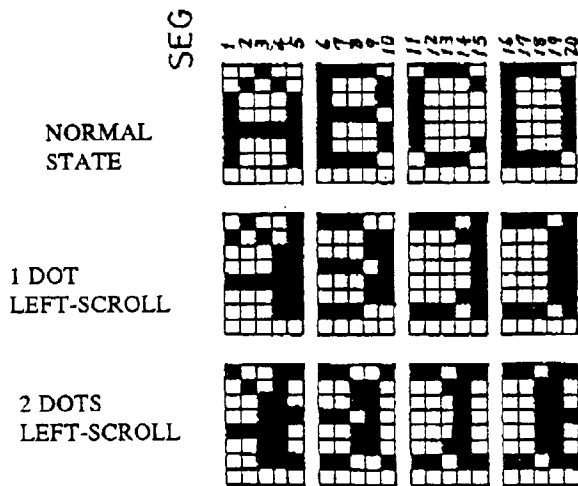


FIG. 8 C

