

[54] **APPARATUS FOR DISPLAYING
CHARACTERS AND/OR LIMITED GRAPHS**

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abandoned.

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[51] Int. Cl..... G06f 3/14

[58] Field of Search.... 340/324 AD, 324 A, 168 SR

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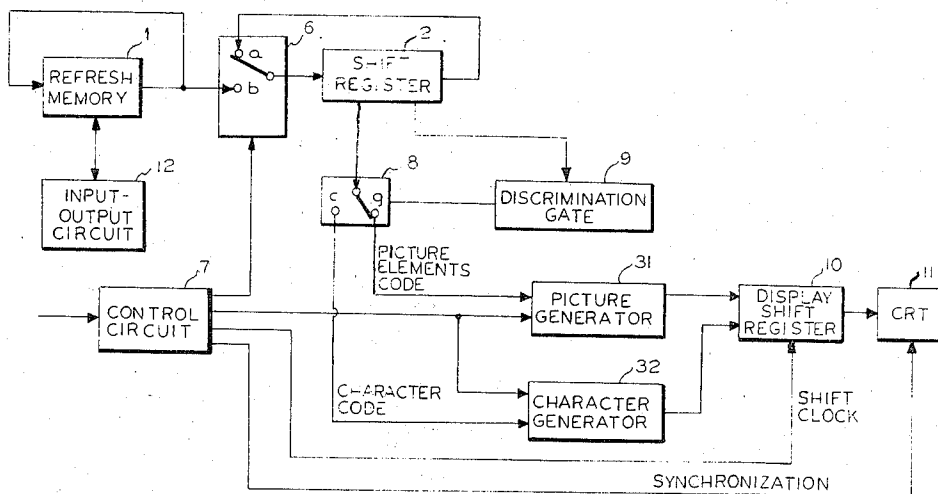
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[57] ABSTRACT

Character codes of plural lines from an input-output circuit are entered into a refresh memory circulating at a clock frequency. One of these lines of character codes is then transferred to a shift register during a time period necessary for scanning a space between two adjacent lines. The shift register circulates at a rate higher by an integer number times the clock frequency and is equal to a horizontal scanning time of a standard television system. The integer number corresponds to the number of scanning lines existing in the space. A pattern generator is driven by the output signals of the shift register to convert such signals into video signals which produce one line of a character pattern on the cathode ray tube of the standard television system.

1 Claim, 11 Drawing Figures



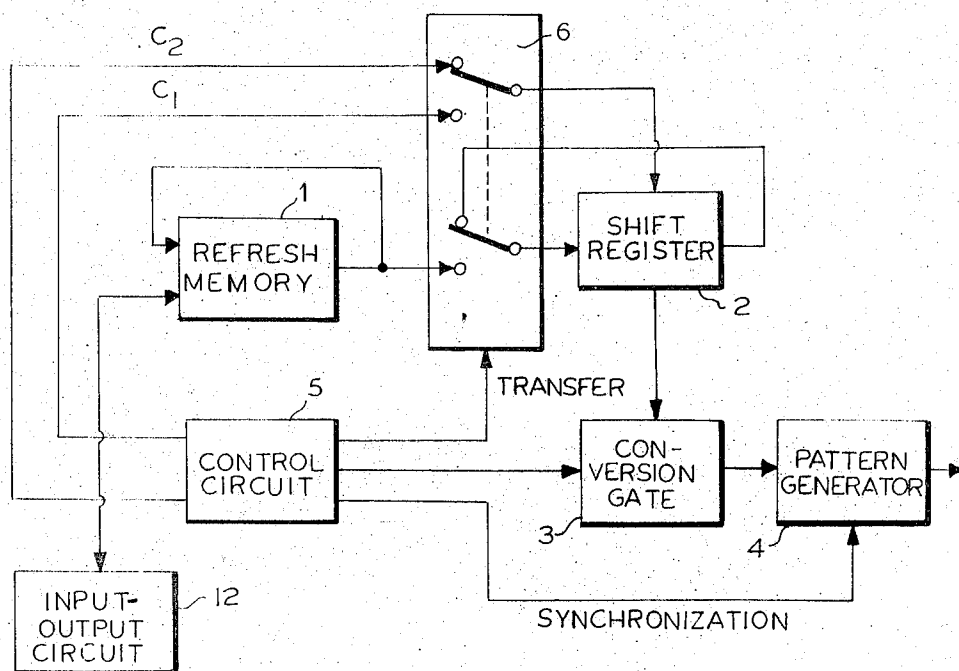


FIG. 1

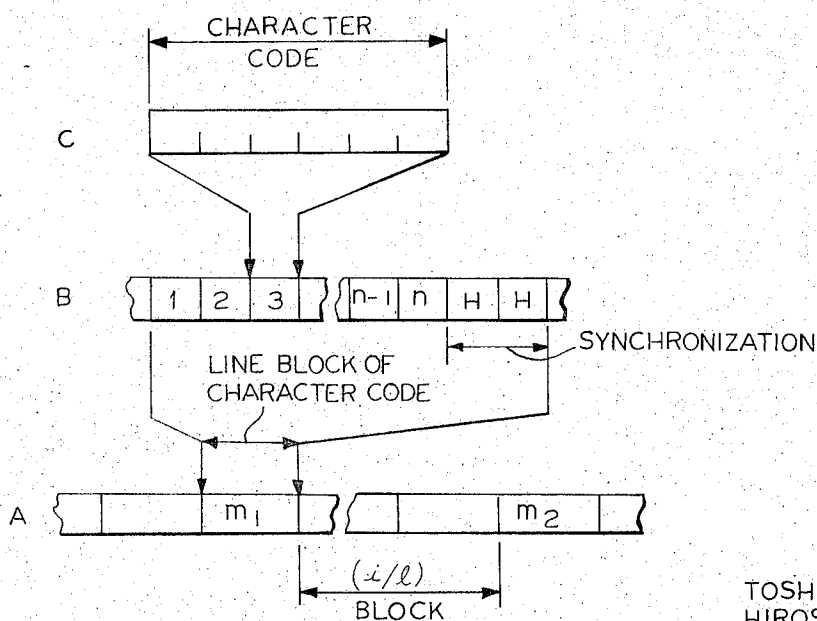


FIG. 2

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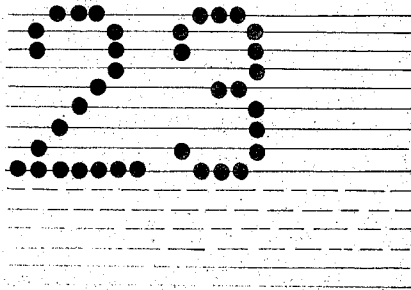


FIG. 3A

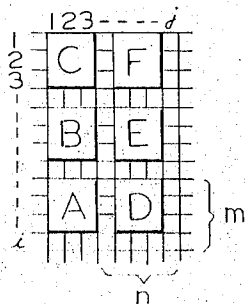


FIG. 3C

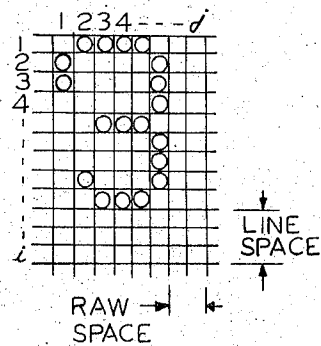


FIG. 3B

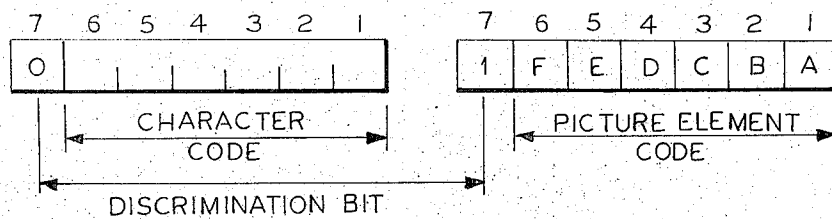


FIG. 3D

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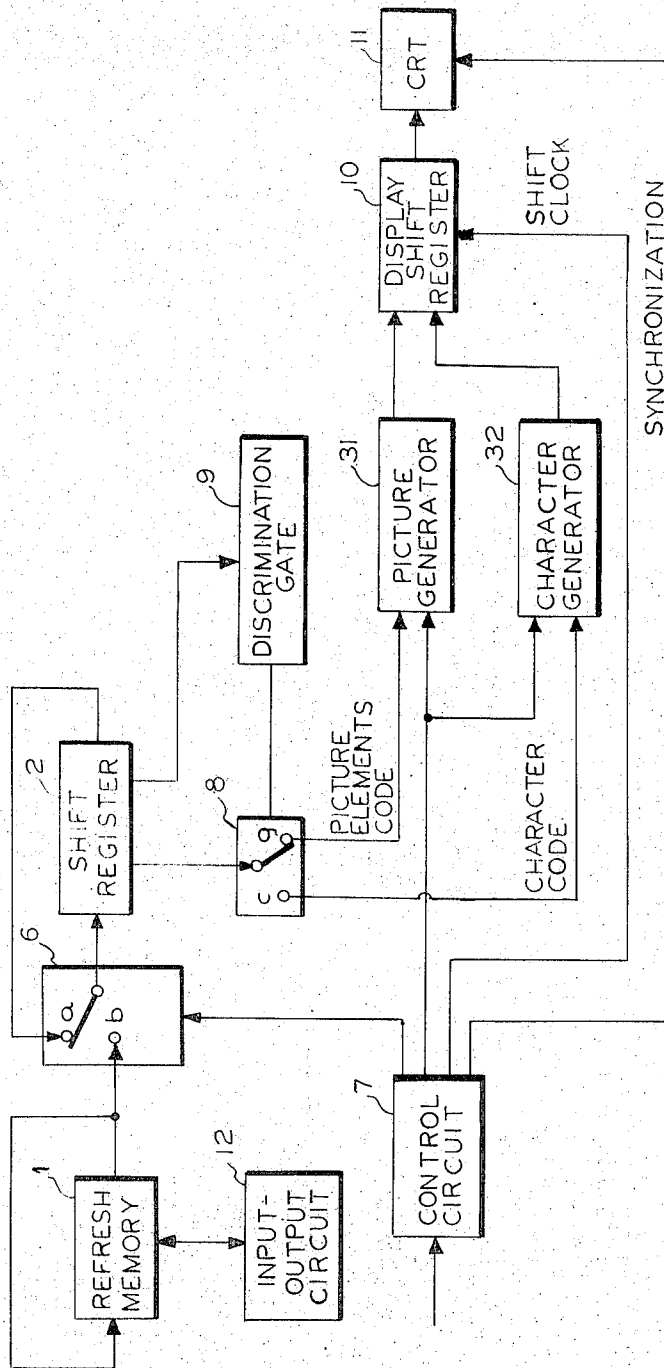


FIG. 4

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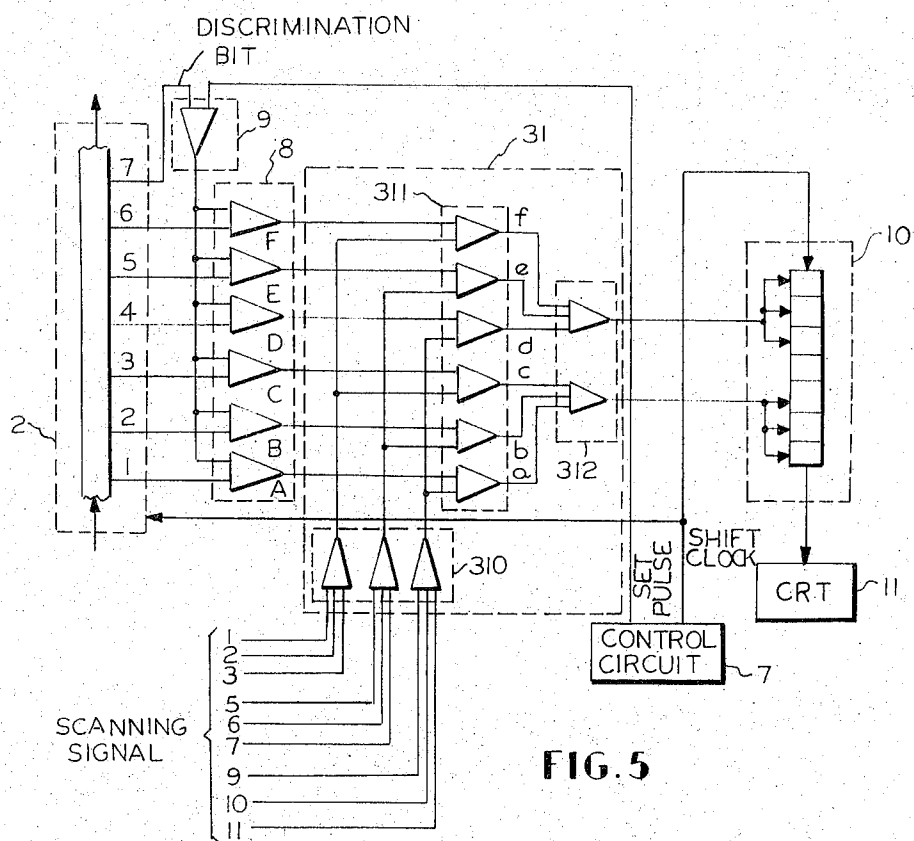


FIG. 5

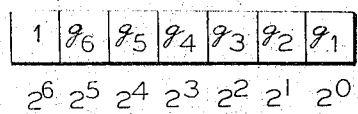


FIG. 6A

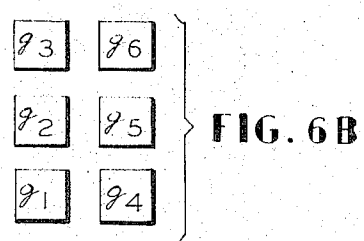


FIG. 6B

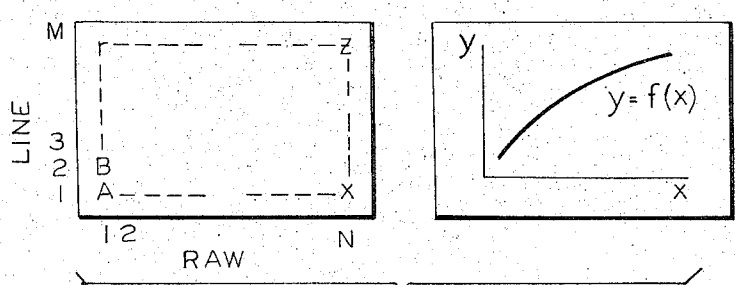


FIG. 6C

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APPARATUS FOR DISPLAYING CHARACTERS AND/OR LIMITED GRAPHS

This application is a Division of parent application Ser. No. 112,201 filed Jan. 22, 1971, now abandoned.

This invention relates to an apparatus for displaying characters and/or limited graphs on a cathode ray tube (CRT) by using standard television raster scanning and more particularly, the apparatus is characterized by a simultaneous display of characters and graphs.

The CRT display device is used very effectively in general for peripheral equipment and on-line remote terminals, as the medium of man-machine communication on a digital computer. The CRT display device is superior to the ordinary teletypewriter due to its high display speed, noiseless operation because it has no printing mechanism, and capability of editing and formatting functions of an off-line operation.

Although the CRT display device is well recognized and is much requested for use in man-machine communication, its wide use is not at present possible due to its high cost.

The conventional CRT display device using refresh memory (buffered CRT display) comprises two main parts, a controller and a console. The controller includes an interface circuit, an input-output circuit, a temporary memory (refresh memory), a character generation circuit and a control circuit. The console comprises a CRT, a CRT peripheral circuit and a keyboard.

An interface circuit is used to connect the display device with a digital computer and communication line. The control circuit controls operation of the interface circuit, the I/O circuit, the temporary memory, and the character generation circuit. A temporary memory stores character codes for displaying which are transmitted from the computer and keyboard. The character generation circuit produces a character pattern on the CRT face plate by using the codes stored in the temporary memory. The CRT peripheral circuit comprises a deflection circuit for deflecting an electron beam, a high voltage source and an intensity modulation circuit. The keyboard is used for providing input data, controlling transmission of the data and editing of the display contents.

As for the method for generating a pattern, there are four known methods: that is the character method, the monoscope method, the dots method and the strokes method.

When the CRT display device uses a normal television receiver, the dots method is widely used adopting raster scanning. According to the dots method, a character pattern is displayed in an $i \times j$ dots matrix. Because a character space is necessary in order to discern the characters from those on the next line, the scanning skip method is used. However, there are defects in this method, in that the usual television scanning system cannot be used and that dotted sequence curves are displayed.

In order to display characters and the limited graph with the $i \times j$ dots matrix pattern by using a delay line, for example by using a low cost magnetostrictive delay line, two registers are required, that is a refresh memory (temporary memory) and a shift register. A refresh memory can store any character codes corresponding to information to be displayed on the face plate, that is

M lines of N characters. After being stored in the refresh memory, the characters of one line (N characters) are transferred to the shift register therefrom. By circulating the shift register J times, one line is displayed on the CRT.

The number N of the characters to be displayed per line according to the conventional method is determined in accordance with the following equation;

$$N = T_D \cdot C / K$$

where

N = characters per line for screen format.

T_D = effective scanning time per line.

C = clock frequency (Hz) of the refresh memory.

K = bit length of the binary character code.

For example, when T_D is 50 μ sec, C is 1 MHz and K is 6 bits, the number N of the characters is nearly 8 characters per line.

In order to increase the number of the characters to be displayed per line for a screen format, it is necessary to make the clock frequency of the refresh memory higher or to make the effective scanning time longer. Further, a higher clock frequency of the refresh memory requires that the refresh memory have a short access time. This makes the memory system expensive. On the other hand, making a longer effective scanning time makes it impossible to use a standard television system and requires a special television system. This also increases the cost of the display device.

Also, it is very difficult to display a limited graph on the CRT face plate of the ordinary character CRT display. In order to display limited graphs on the character CRT display it is necessary to divide the picture plate of CRT into picture elements so that a graph is formed by appointing one character area to picture element positions. However, the quantity of information for addressing to display a graph is increased. Therefore, the display control circuit becomes complex and further software used for displaying also becomes very complex. Accordingly, the display device of this method becomes substantially more expensive.

The object of the present invention is to provide a low-cost novel CRT display device capable of using a character mode and a graphic mode together and of providing terminals of an on-line control system. Therefore, the device according to the invention can be used suitably for the terminals of a mini-computer and on-line remote terminals. The cost of the device can be decreased due to the simplified control circuit. Further the commercial television receiver is readily used for the CRT monitor in accordance with the invention.

These and other objects of the invention will become apparent upon consideration of the following description taken together with accompanying drawings in which:

FIG. 1 is a block diagram for illustrating the method of the invention;

FIG. 2 shows a character code to be located in the refresh memory;

FIGS. 3A-3D show a raster scanning pattern, a character pattern, picture element patterns and character and picture codes, respectively;

FIG. 4 is a block diagram for illustrating the method for displaying a limited graph and a character together;

FIG. 5 is a logic circuit diagram for producing the limited graph shown in FIG. 4; and

FIGS. 6A-6C show the codes, the picture element pattern and the limited graphic curve displayed in accordance with the system shown in FIG. 4.

Referring to FIG. 1, an input-output circuit 12 treats plural lines of character codes from a terminal of computer (not shown). A refresh memory 1 (a magnetostrictive delay line) is connected to said input-output circuit 12 and receives said character codes, and circulates at a clock frequency. A shift register 2 to receive one line of said character codes circulates at a circulating rate which is higher by an integer number times than said clock frequency of said refresh memory 1 and which is equal to a horizontal scanning time of a standard television system (not shown). Said integer number corresponds to a number of scanning lines at a line space between two adjacent lines of said character codes. A control circuit 5 is connected to a transfer exchange gate 6 to control the operation of said shift register 2. A serial to parallel conversion gate 3 is connected to said shift register 2 and to said control circuit 5. A character pattern generator 4 is connected to said control circuit 5 and to said serial to parallel conversion gate 3. Output signals produced at said serial to parallel conversion gate 3 are converted into video signals which are to be reproduced as one line of a character pattern on a cathode ray tube of said standard television system.

When the character codes are transmitted from the refresh memory 1 to said shift register 2 during a time period necessary for scanning a line space between two adjacent lines, the refresh memory 1 produces a clock pulse C1 to operate said shift register 2. Upon transmission of said character codes from said refresh memory 1 to said shift register 2, said pattern generation circuit 4 starts to display character codes (l scanning lines). As a result, the shift clock of said shift register 2 is changed to C2.

C1 and C2 are related by the following equation:

$$C2 = l \cdot C1$$

After the change of the clock from C1 to C2, the shift register 2 circulates at a rate higher by l times than said clock frequency at C1. During the circulation, output serial pulses of the shift register 2 are converted into parallel pulses in a character code by the serial to parallel conversion gate 3. The parallel character codes enter the character pattern generator 4. A video signal from said pattern generator 4 is displayed as a one line dotted pattern on the CRT.

A repeat of this operation l times causes a one line character pattern to be displayed on the CRT. In the space interval between the one line character pattern and the next line (l scanning lines), character codes of the next line are transferred from the refresh memory 1 to the shift register 2. When these operations are repeated M times a picture is displayed fully on the CRT. The refresh memory 1 when synchronized with a standard television system circulates to reveal 60 frames per second. When a character display of one line is finished, the refresh memory 1 transfers the next line character codes to the shift register 2. In order to cause the character code to address to the refresh memory 1, the character codes in the refresh memory 1 are arranged as shown in FIG. 2.

Referring to FIG. 2 reference character A designates character codes in the refresh memory 1, and m_1 and

m_2 are code sequences of one display line. The enlargement of m_1 is shown by B which is further enlarged to C. The character codes of one line (1, 2, ..., n) are stored in order in the refresh memory 1 and synchronous codes H succeed the character codes as shown in B. These codes form the line block m_1 . The line block m_2 of the characters to be displayed at the following line is arranged after the i/l blocks as shown at A in FIG. 2. Each block of the character codes to be displayed in order is arranged with an i/l block interval from each other. Such arrangement is controlled by the control circuit 5 when the input of these character codes is supplied to the refresh memory from the circuit 12.

In this method, the number N1 of characters which can be displayed in one line is calculated by the following equations

$$N1 = D \cdot C2 / K \quad (2)$$

$$= D \cdot C1 / K \quad (3)$$

$$= lN \quad (4)$$

Therefore, it is necessary to make the capacity of the refresh memory 1 and the shift register 2 larger l times than that of an ordinary refresh memory. An ordinary display system has more than two scanning lines at the interval space between the line of the characters and the succeeding line. A combination of the novel display system according to the present invention and the ordinary display system makes it possible to display characters in a number more by two times than that displayed only by the ordinary display system.

The above description is directed to horizontal raster scanning, but vertical raster scanning is achieved in a manner exactly similar to that of horizontal raster scanning. In case of the latter, the codes are transferred from the refresh memory 1 to the shift register 2 during a time period corresponding to the interval space between the rows of the character.

Accordingly, the display method of the present invention provides a CRT display system in which characters can be displayed by means of raster scanning adaptable for standard television system. The method of the invention has the advantages of being able to employ a commercial television receiver and a low speed magnetostrictive delay line and to be able to increase the number of characters to be displayed at one line.

Now, the following description will explain a method for displaying a limited graph by using a CRT character display system at a low cost in accordance with the present invention.

Referring to FIG. 3, a character pattern shown in FIG. 3A is displayed by dot points for horizontal raster scanning. Any character pattern can be displayed on this display system by using an ixj matrix such as shown in FIG. 3B. In addition, a limited graphic pattern also can be displayed as shown in FIG. 3C in which each picture element forms one block to be divided by an $n \times m$ dots matrix in one character area. The block of each picture element in the character area corresponds to each character code bit, and each of the picture element blocks is displayed independently. Now when the number of blocks is d , the graphs in number of 2^d combinations can be displayed in one character display area. The character pattern and graphic pattern are discriminated from each other by noting a given bit 7 of one character code, as shown in FIG. 3D. The remaining bits of the code are used as a pattern code.

The following will describe in more detail the operation of displaying limited graphs. Referring to FIG. 4, wherein similar reference characters designate networks similar to those of FIG. 1, an input-output circuit 12 treats plural lines of character codes from the terminal of a computer (not shown). A refresh memory 1 (a magnetostrictive delay line) is connected to said input-output circuit 12 and receives said character codes, and circulates at a clock frequency. A shift register 2 to receive one line of said character codes circulates at a circulating rate which is higher by an integer number times than said clock frequency of said refresh memory 1 and which is equal to a horizontal scanning time of a standard television system. Said integer number corresponds to the number of scanning lines at a line space between two adjacent lines of said character codes. A transfer control circuit 7 is connected to a transfer exchange gate 6 to control the operation of said shift register.

A display gate 8 is connected to said shift register 2. A discrimination gate 9 is connected to said shift register 2 and receives an output code from said refresh memory 1 so as to control said display gate 8. Said display gate 8 is switched to G or C depending upon the output signals of a picture code or a character code from said discrimination gate 9. Display gate 8 is connected to G and C to a picture elements generator 31 and a character generator 32, respectively. A display shift register 10 is connected to said picture elements generator 31 and to said character generator 32 and has an output signal controlled by said transfer control circuit 7 to form a video signal for the CRT 11.

At first, the transfer control exchange gate 6 is synchronized with a first scanning line of the displaying lines so as to couple with a *b* side thereof and then the character codes are transferred from the refresh memory 1 to the shift register 2. Just after the codes are transferred to the shift register 2, the transfer exchange gate 6 is reset to the *a* side. Then, the shift register 2 operates as a circulating register. The character codes are circulated in the shift register corresponding to the horizontal scanning lines.

The transfer of the character codes is controlled by the transfer control circuit 7. At first, the transfer control circuit 7 picks up a character code, 6, a bit 0 or 1, which defines the codes as character codes or graphic codes. The use of the bit 0 or 1 causes the display gate 8 to be switched to C or G by the control circuit 9. When the gate 8 is set at C, the character codes from the shift register 2 are supplied to the character generator 32. Then, the character generator 32 produces character patterns and the characters are displayed on the CRT face plate. The character generator 32 comprises a well known diode matrix or a pulse trans type magnetic core matrix, or the like, and generates the dot patterns in sequence by scanning lines as shown in FIG. 3D. The output signals from the character generator 32 are parallel *j* dots signals and are converted into serial *j* bits through the display shift register 10 so as to be sent to the CRT 11.

In case of graphic codes, the transfer control circuit 7 controls the display gate 8 to be set to G and the graphic codes from the shift register 2 are supplied to the picture elements generator 31, which generates a picture elements pattern corresponding to each code bit of the graphic codes. The output signals of the picture elements pattern generator 31 are supplied to the

display shift register 10, and displayed in a manner similar to that of the character display.

The picture elements generator 31 is shown in more detail in FIG. 5, in which similar numerical characters 2, 7, 8, 9, 10, 11 and 31 designate networks similar to those of FIG. 4.

As an example of an embodiment of the invention, it is considered that one character code in FIG. 3D consists of seven bits and the picture elements pattern in FIG. 3C is expressed by $i = 12$, $j = 8$ and $m = n = 3$. In this case, one character code has a maximum of six (2×3) picture elements and one picture element is defined by 3×3 dots which correspond to three horizontal scanning lines and three vertical dots. A picture element is spaced from an adjoining picture element by one horizontal scanning line and one vertical dot. The picture element bits A, B, C, D, E and F in FIG. 3D are positioned in one character area as shown in FIG. 3C.

Referring to FIG. 5, a shift register 2 is in operation for one character code and has a parallel code output supplied to a display gate 8 and to a discrimination gate 9. Input signals to said discrimination gate 9 through a refresh memory are in the form of the special fixed bit of FIG. 3D. Input signals to said display gate 8 through said refresh memory are composed of the picture elements code of FIG. 3D and the output signals of said discrimination gate 9. Output signals A, B, C, D, E and F of display gate 8 correspond to codes A, B, C, D, E and F of FIG. 3C, respectively. These output signals of said display gate 8 enter a picture generation gate 311 and produce a pattern of picture elements. A scanning signal also enters a scanning signal gate 310 which has output signals supplied to said picture generation gate 311 to produce picture elements pattern corresponding to every scanning line. Output signals (*a*, *b*, *c*, *d*, *e* and *f*) of said picture generation gate 311 enter, for generation of a picture element block, a picture element block gate 312 which has an output signal thereof supplied to a display shift register 10. Output signals of said display shift register 10 are controlled by a transfer control circuit 7 and are supplied to a CRT 11 for display of the pattern.

The picture element generator 31 of FIG. 4 is composed of scanning signal gate 310, picture element generator gate 311 and picture element block gate 312.

The operation of the pattern generation of picture elements is described in the following. When the discrimination bit of the code "7" in FIG. 3D is 1 (namely the code is a graphic code), all bits (A, B, C, D, E and F) of the graphic code are switched on by the discrimination gate 9 upon transfer of one character code to the shift register 2. In order to first display the picture elements C and F shown in the FIG. 3C by the picture elements generation gate 310 of the picture elements generator 31, the picture elements generation gate 310 in FIG. 5 is switched on by a first scanning signal and the code output signal C of the display gate 8. Similarly, the gate output *f* of the picture element generation gate 311 is gated out by the first scanning signal and the output signal F of the display gate 8. As the shift register 2 is in synchronization with the shift clock, the transfer control circuit 7 generates a set pulse only when a character code is fully supplied to the shift register 2. This means that the set pulse is synchronized with the end bit of the character code. By this set pulse, a set gate of the display gate 8 is opened and the signals of the picture element generator 31 are supplied to the dis-

play shift register 10. Then, the output signal of the display shift register 10 is displayed on the display CRT scanning spots of intensity modulation signal. As the discrimination gate 9 discriminates whether the code is character or graphic, the graphic character patterns can be displayed on the CRT face plate simultaneously.

This operation is repeated for every character code, and one dot pattern of the scanning line is fully displayed. One circulation of the shift registers 2 and 10 terminates the display of the first scanning line. This operation is repeated in scanning order and the picture elements C and F are displayed. Similarly by scanning the 5th, 6th and 7th scanning lines or 9th, 10th and 11th scanning lines, the picture elements B and E or A and D are displayed in order. A circulation of the shift register 2 for twelve times complete the display of one line pattern. Upon the completion, the transfer exchange gate 6 of FIG. 4 is set to the *b* side, and then each code of the next line is transferred from the refresh memory 1 to the shift register 20 so as to be displayed as a character or graphic pattern on the CRT. A repeat of this operation completes one display on the whole CRT. During this operation, the transfer control circuit 7 controls line synchronization, line exchange and the shift clock.

The character patterns are generated by the character generator 32, while a graphic pattern is formed by each of picture element patterns corresponding to each bit of the code. When one character is, for example, of six bits, $2^6 (=64)$ kinds of graphic elements can be formed by the code including the six bits. Such graphic elements make it easier to display any kind of limited graph. For instance when the number of the characters to be displayed on the whole CRT is MN (M lines of N characters) and one character area is constructed by six picture elements as in FIG. 3C, the resolution of the display face on the CRT is $2 \times N$ horizontal and $3 \times N$ vertical picture elements.

The display of $y = f(x)$ is explained with reference to FIG. 6. The code and picture elements are defined as shown in FIGS. 6A and 6B, and lines and rows are defined as in FIG. 6C. In connection with a code of DK/ corresponding to the display pattern the *l*th row of *k*th line, the matrix position of Pxy is defined by the following equations:

$$l = (x/2) + 1 \quad (5)$$

$$k = (Y/3) + \quad (6)$$

where

$$x = 0, 1, 2, \dots, (l-1)$$

(*x*) is integer part of *x*,
and a code of position Pxy is defined by the following equations:

$$\begin{aligned} \alpha &= x - 2(l-1) \\ &= 0 \\ &1 \end{aligned} \quad (7)$$

$$\begin{aligned} \beta &= y - 3(k-1) \\ &= 0 \\ &1 \\ &2 \end{aligned}$$

Accordingly, a code D to display a point Pxy is defined as follows:

$$D = 2^{3\alpha + \beta} \quad (9)$$

Then the display character position of this code is the *l*th character of the *k*th line. By the above equations, a code of any point Pxy is obtained easily. In addition, such display system can be used as graphical input equipment because a drawing of a graph on the CRT face plate results in the formation of codes in the refresh memory, and the formed codes can be converted into matrix positions by the above equations.

As described hereinbefore, according to a method of this invention, both the character pattern and limited graphs can be displayed simultaneously. The refresh memory can store both character codes of graphs and character codes of characters similar to each other. The display system of the invention has great advantages compared with the ordinary CRT character display system, so that it can be widely used as a graphical input machine and a simple input-output terminal machine.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An apparatus for displaying characters and limited graphs on a cathode ray tube of a standard television system, each character being displayed at a character area on said cathode ray tube, which character area is divided into (S-1) blocks for picture element display, the apparatus comprising:

- an input-output circuit;
- a refresh memory circulating at a clock frequency;
- a character generator;
- a picture element generator;
- means coupled to said input-output circuit and said refresh memory for entering character codes of plural lines from said input-output circuit into said refresh memory, each character code being formed by S bits, one of which is a discrimination bit for discriminating whether to drive said character generator or to drive said picture element generator and the others of which correspond to said (S-1) blocks of each character area;
- a shift register operatively coupled to said character generator and said picture element generator; and

means coupled to said shift register and said refresh memory for transferring said character codes to said shift register from said refresh memory, said character generator being driven in accordance with the value of said discrimination bit of the output signals produced by said shift register for converting said output signals into video signals which produce character patterns on said cathode ray

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tube, said picture element generator being driven in accordance with the value of said discrimination bit of the output signals produced at said shift register for converting said output signals produced at said shift register into video signals which produce picture element patterns on said cathode ray tube, whereby when it is determined in accordance with the discrimination bit in each of some predetermined character codes to drive said picture element generator, said picture element generator is

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driven by the output signals produced at said shift register and generates picture elements in some blocks of predetermined character areas in accordance with the value of each of said (S-1) bits of said some predetermined character codes so as to enable a display of a limited graph on said cathode ray tube, so that characters and limited graphs in a predetermined pattern can be displayed on said cathode ray tube.

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