(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 293 235
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 88304846.4

(51) Int. Cl.[4]: G 09 G 3/36

(22) Date of filing: 27.05.88

(30) Priority: 29.05.87 JP 133816/87

(43) Date of publication of application:
30.11.88 Bulletin 88/48

(84) Designated Contracting States: DE GB

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(54) **Display device and driving system thereof.**

(57) A display device, which takes a specified period to rewrite the picture elements in one horizontal scanning period, comprises M pcs. of scanning lines divided into a plurality of groups each containing K pcs. of scanning lines ($K > 1$, $M > 1$, K, M: positive integers) and elements for supplying scanning signals to the M pcs. of scanning lines to rewrite an image. The scanning signal-supplying elements output scanning signal to the first scanning line of each group in the first frame, to the second scanning line of each group in the second frame, and to the Kth scanning line of each group in the Kth frame so that the M pcs. of scanning lines are rewritten by K times of scanning.

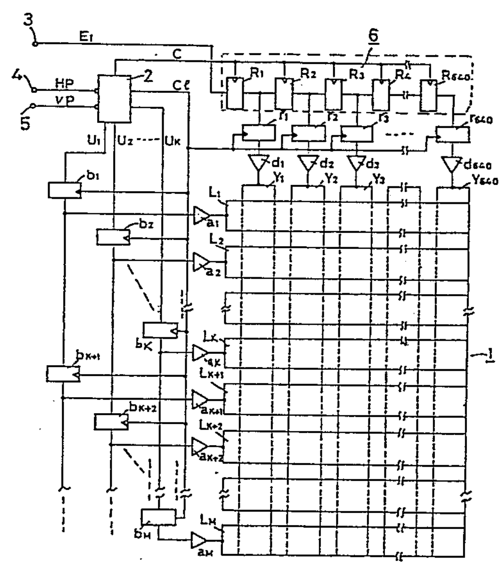

Fig. 1

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Description

DISPLAY DEVICE AND DRIVING SYSTEM THEREOF

Background of the Invention

The present invention relates to a display device or more particularly to a display device having such an incomplete memory characteristic as that of ferrodielectric liquid crystal and which takes a specified time to rewrite the picture elements, and to a driving system of the display device.

Ferrodielectric liquid crystal is a well-known element with incomplete memory characteristic. When a picture is to be displayed on a matrix type display panel that uses ferrodielectric liquid crystal, video signals are sent from, say a personal computer to the display panel. Since the video signals from the personal computer are non-interlace signals, however, it is not possible to use all frames of the signals in displaying the picture on the panel because of the time restriction for rewriting by the ferrodielectric liquid crystal. Conventionally, therefore, a picture is displayed by using, for instance, every other frame of video signals.

Assuming that the number of scanning lines M of a video signal sent from a personal computer is 200 and that the time required by the liquid crystal for rewriting the picture elements in one horizontal scanning period is 200 μs, the frame frequency fF on the screen is calculated as:

$$fF = \frac{1}{f \times M} = \frac{1}{200 \times 10^{-6} \times 200} = 25 \text{ Hz}$$

If the memory characteristic of the liquid crystal is incomplete, when a figure "1" is kept written, the luminance of the image changes little by little after the figure is rewritten, as shown in Figs. 7(1), 7(2), 7(3) and 7(4). For instance, the luminance of the picture elements on the lines L_1, L_2, L_3 and L_4 changes as shown in Figs. 7(1), 7(2), 7(3) and 7(4), respectively. The combined luminance of the 4 (vertical) x 4 (horizontal) picture elements changes at 25 Hz as shown in Fig. 7(5). Since human eyes can sense the luminance variation at a frequency not higher than 60 Hz, the above luminance change is sensed as a flicker so that the picture quality is deteriorated.

Summary of the Invention

An object of the present invention is to solve the above problem by providing a display device and its driving system which improves the display picture quality by controlling the operation of rewriting the picture elements.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

To achieve the above object, according to an embodiment of the present invention, a display device, which provides an incomplete memory characteristic and takes "r" seconds to rewrite the picture elements in one horizontal scanning period, comprises "M" scanning lines divided into a plurality of groups each containing "K" scanning lines ($K>1$, $M>l$, K, M = positive integers), and means for sending scanning signals to the "M" scanning lines so as to rewrite a picture. The scanning signal sending means sends scanning signals to the first scanning line in each scanning line group in the first frame, to the second scanning lines in each scanning line group in the second frame, and to the "K"th scanning line in each scanning line group in the "K"th frame so that the picture elements on the "M" scanning lines are rewritten by "K" times of scanning.

The present invention is effective for the condition of $60 > \frac{1}{r \times M}$ in which "r" is the time required for rewriting the picture elements in one horizontal scanning period.

The action of the present invention is described in the following, assuming $K = 2$, $M = 200$ and $r = 200$ μs for simplification.

In the first frame, the scanning lines of odd number 1, 3, 5, ..., 199 are scanned, and in the second frame the scanning lines of even number 2, 4, 6, ..., 200 are scanned, thus completing an entire picture in two frames. Specifically, picture signals input to the display device contain 200 effective scanning lines in one frame. However, all of these 200 effective lines are not used for each frame. For the first frame, the signals for scanning lines of odd number alone are used while those for scanning lines of even number are discarded. For the second frame, the signals for scanning lines of even number alone are used while those for scanning lines of odd number are discarded. As a result, picture elements are written at 50 Hz on the display panel, compared with 25 Hz by the conventional device. This results in less conspicuous flicker of a picture.

Brief Description of the Drawings

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein:

Fig. 1 is a circuit diagram showing the construction of the display device of a first embodiment of the present invention;

Fig. 2 is a chart of signal waveform in each part thereof;

Fig. 3 is a circuit diagram showing the construction of the display device of a second embodiment of the invention;

Fig. 4 and 5 are charts of signal waveform in each part thereof;

Fig. 6 is a chart for explaining the effect of the present invention; and

Fig. 7 is a chart for explaining the conventional device.

Detailed Description of the Embodiments

According to an embodiment of the present invention, a display device such as an X-Y matrix type liquid crystal display panel contains a pair of insulating substrates with a liquid crystal layer sandwiched therebetween. "M" pcs. of scanning electrodes are provided on the inner side of one of the substrates, and "N" pcs. of signal electrodes on the inner side of the other substrate, the scanning electrodes crossing the signal electrodes at a right angle. The display device of the present invention provides an incomplete memory characteristic and takes "r" seconds to rewrite the picture elements in one horizontal scanning period. An example of a substrate with an incomplete memory characteristic is ferrodielectric liquid crystal. The insulating substrate of the display device may be made of a conducting member with an insulating film formed thereon or made of a conducting member alone. The insulating substrates having scanning electrodes and signal electrodes respectively are covered with insulating films, respectively. An effective display region is realized by the "M" scanning electrodes and the "N" signal electrodes.

The present invention is characterized in the following features.

The "M" scanning electrodes are divided into "P" groups each containing "K" scanning electrodes ($K > 1$, $P > 1$, K, P = integers). By the first frame, all the first scanning electrodes in all groups are scanned sequentially. Then by the second frame, all the second scanning electrodes in all groups are scanned sequentially. This process is repeated until all the "K"th scanning electrodes in all groups have been scanned by the "K"th frame. Namely, "P" scanning electrodes are scanned sequentially by each frame, and this scanning process is repeated "K" times to scan "M" scanning electrodes, thus rewriting the picture elements for one picture.

If "M" cannot be divided by "K", at least one of the "P" groups may contain fewer than "K" electrodes. But preferably every group should contain the same number of electrodes.

With $K = 2$, for instance, every other scanning line is rewritten by each frame. With $K = 3$, every third scanning line is rewritten by each frame.

The present invention is effective particularly for the condition of $60 > \frac{1}{r \times M}$.

In the following description, the display device is assumed to be an X-Y matrix type liquid crystal display panel in which the number of scanning electrodes "M" = 200, and the number of signal electrodes "N" = 640. It is not intended that the present invention is limited to the above; the number of electrodes "M" and "N" may be changed as desired.

In the X-Y matrix liquid crystal display panel 1 of the present invention, signal electrodes $Y_1, Y_2, \ldots Y_{N=640}$ are provided on the first insulating substrate, and scanning electrodes $L_1, L_2, \ldots L_{M=200}$ on the second insulating substrate. The signal electrodes and the scanning electrodes are covered with insulating films for insulation between the electrodes. A ferrodielectric liquid crystal layer (such as CS-1014 by Chisso Corporation) is placed between the first and second insulating substrates.

Image data to be supplied to the signal electrodes $Y_1, Y_2, \ldots Y_{640}$ is sent in form of input signals Ei through a terminal 3 to a shift register 6 which comprises D flip flops $R_1, R_2, \ldots R_{640}$ corresponding to the signal electrodes respectively. The input signals Ei are applied to the data terminals of the D flip flops $R_1, R_2, \ldots R_{640}$. A basic clock pulse signal C is supplied from a converter circuit 2 to the clock terminals of the D flip flops $R_1, R_2, \ldots R_{640}$ so that data signals are output sequentially from the D flip flops $R_1, R_2, \ldots R_{640}$ in this order. The data signals thus output pass through D flip flops $r_1, r_2, \ldots r_{640}$ and drivers $d_1, d_2, \ldots d_{640}$ and are input to the signal electrodes $Y_1, Y_2, \ldots Y_{640}$. Horizontal clock pulse signals $c\ell$ are supplied as clock signals to the D flip flops $r_1, r_2, \ldots r_{640}$.

Here, the image data or video signals contains "M" pcs. of scanning electrodes or scanning lines in one frame. When a picture is to be rewritten by "K" frames, the same image signals are supplied "K" times.

Using horizontal synchronizing pulse HP and vertical synchronizing pulse VP that are input through terminals 4 and 5, a converter circuit 2 generates basic clock pulse signal C and horizontal clock $c\ell$. The converter circuit 2 also generates selection signals $U_1, U_2, \ldots U_K$ for selecting one of the 1st to the "K"th electrodes of each group. One of the selection signals U_1, U_2, ... U_K becomes high in each frame, the selection signal of high level changes in the order of U_1, U_2, ... U_K as a frame changes. Specifically, the selection signal U_1 becomes high in the first frame, and the selection signal U_2 becomes high in the second frame as shown in Fig. 2. And eventually, the selection signal U_K becomes high in the Kth frame (not shown).

Receiving the selection signal U_1 and the horizontal clock pulse signal $c\ell$, D flip flops b_1, b_{K+1}, ... supply rewrite signals through drivers a_1, a_{K+1}, ... to the scanning electrodes L_1, L_{K+1}, ... Similarly, receiving the selection signal U_2 and the horizontal clock pulse signal C1, D flip flops b_2, b_{K+2}, ... supply rewrite signals through drivers a_2, a_{K+2}, ... to the scanning electrodes L_2, L_{K+2}, ... With the selection signal U_K as well, rewrite signals are supplied to the specified scanning electrodes. Namely, on receiving the selection signal UK and the horizontal clock pulse signal C1, D flip flops b_K, b_{2K}, ... b_M supply rewrite signals through drivers a_K, a_{2K}, ... to the scanning electrodes L_K, L_{2K}, ... L_M.

On receiving a selection signal and a horizontal clock pulse signal, the D flip flop b_1 supplies an output equivalent to the selection signal to the following D flip flop b_{K+1} simultaneously as it supplies rewrite signal to the scanning electrode L_1. The D flip flop b_{K+1}, on receiving the signal output from the D flip flop b_1 and a horizontal clock pulse signal C1, outputs rewrite signal to the scanning electrode L_{K+1} and simultaneously supplies an output equivalent to the selection signal to the following D flip flop. Through the repetition of this operation, the scanning electrodes of the same order in all groups are rewritten sequentially in the same frame period.

As a result, the lines L_1, L_{K+1}, ... are rewritten in the first frame, the lines L_2, L_{K+2}, ... are rewritten in the second frame, and the lines L_K, L_{2K}, ... are rewritten in the Kth frame so that all the effective scanning lines are rewritten in K frames, as indicated partly by the signal driver output D in Fig. 2. With $K = 2$, all the effective scanning lines are rewritten in two frames, the scanning lines of odd number being rewritten in the first frame and the scanning lines of even number being rewritten in the second frame.

Fig. 3 shows an example in which the present invention is applied to a split X-Y matrix type liquid crystal display panel 1. In this second embodiment, the display panel is divided into a first block 1A and a second block 1B. The first and second display block 1A and 1B are driven under the same condition as described later. The number of scanning electrodes in the effective display region is M, with M′ pcs. in the first display block 1A and M′ pcs. in the second display block 1B. The M′ scanning electrodes in each of the first and second display blocks 1A and 1B are divided into P′ groups each containing K′ electrodes.

In the display device of this construction, the first scanning electrodes of the groups are scanned first, and the second scanning electrodes of the groups are scanned next. This process is repeated until the K′th electrode ot the groups are scanned. In other words, 2P′ scanning electrodes are scanned in each time, and the scanning operation is conducted K′ times to rewrite the picture on an entire display panel divided into the first and the second display blocks.

The action of the display device of the second embodiment shown in Fig. 3 is described assuming the number of scanning electrodes $M = 200$, the number of scanning electrodes in each of the first and second display blocks $M' = 100$, and the number of signal electrodes $N = 640$. In each of the first and second display blocks, the scanning electrodes are divided into groups each containing K′ electrodes. In this example, $K' = 2$. Therefore, the scanning lines of even number and the scanning lines of odd number are scanned separately.

A hundred scanning electrodes L_1, L_2, .. L_{100} are arranged in the first display block 1A, and a hundred scanning electrodes L_{102}, L_{102}, ... L_{200} are arranged in the second display block 1B. Both the first and the second display blocks 1A and 1B have 640 signal electrodes Y_1, Y_2, ... Y_{640}. Ferrodielectric liquid crystal is used as a liquid crystal layer for each of the display blocks 1A and 1B.

Signal electrode drivers d_1, d_2, ... d_{640} and D flip flops r_1, r_2, ... r_{640} and R_1, R_2, ... R_{640} for registers are basically the same as those for the first embodiment shown in Fig. 1. These elements are provided for the first and the second display blocks 1A and 1B independently. Image input signals Ei, horizontal synchronizing pulses HP and vertical synchronizing pulses VP as shown in Fig. 4 are input from a personal computer to terminals 3, 4 and 5, respectively. On the basis of these signal inputs, a first converter circuit 2 outputs image data signals Ei_1 and Ei_2, horizontal synchronizing pulses HP and basic selection pulses U shown in Fig. 5. The image data signals Ei_1 are supplied to the D flip flop R_1 for the first display block 1A, and the image data signals Ei_2 are supplied to the D flip flop R_1 for the second display block 1B.

On the basis of the horizontal synchronizing pulses HP and the basic selection pulses U, a second converter circuit 2′ generates basic clock pulse signals c, horizontal clock pulse signals $c\ell$ and selection signals U_1 and U_2. In the present embodiment, the first and second converter circuit 2 and 2′ are provided separately. They may be combined in one circuit. Outputs from the first and second converter circuits 2 and 2′ are shown in Fig. 5.

Referring to Fig. 3, the selection signals U_1 are supplied to D flip flops b_1 and b_{101}, and the selection signals U_2 to D flip flops b_2 and b_{102}. The output from the D flip flop b_1 is given to the first scanning electrode L_1 via a scanning electrode driver a_1. The output from the D flip flop b_{101} is given to the scanning electrode L_{101} in the second display block 1B via a scanning electrode driver a_{101}. D flip flops b_3, b_5, ... b_{99} are connected in series after the D flip flop b_1, but they are not shown in Fig. 3. The outputs from the D flip flops b_3, b_5, ... b_{99} are connected via scanning electrode drivers a_3, a_5, ... a_{99} to the scanning electrodes L_3, L_5, ... L_{99} in the first display block 1A. Similarly, D flip flops b_{103}, b_{105}, ... b_{199} are connected in series after the D flip flop b_{101}, although they are not shown. The outputs from the D flip flops b_{103}, b_{105}, ... b_{199} are connected via scanning electrode drivers a_{103}, a_{105}, ... a_{199} to the scanning electrodes L_{103}, L_{105}, ... L_{199} in the second display block 1B.

The second selection signals U_2 are provided to D flip flops b_2 and b_{102}. Similarly, D flip flops b_4, b_6, ... b_{100} are connected in series after the D flip flop b_2, and D flip flops b_{104}, b_{106}, ... b_{200} after the D flip flop b_{102}. The D flip flops b_2, b_{100}, b_{102} and b_{200} drive the scanning electrodes L_2, L_{100}, L_{102} and L_{200} through the scanning electrode drivers a_2, a_{100}, a_{102} and a_{200}, respectively, as shown in Fig. 3. The D flip flops b_4, b_6, ... b_{99} and b_{104}, b_{106}, ... b_{198} drive the corresponding scanning electrodes in the same manner as the above but the description thereof is omitted here. The clock pulse signal inputs to the scanning electrodes from the D flip flops b_1, ... b_{200} are horizontal clock pulse signals $c\ell$ generated by the second converter circuit 2′, and the clock pulse signal inputs to the signal electrodes from the D flip flops r_1, r_2, ... r_{640} are also the horizontal clock pulse signals $c\ell$.

In the first frame, selection signals U_1 are supplied to the data terminals of the D flip flops b_1 and b_{101}. On the basis of the selection signals and the horizontal clock pulse signals $c\ell$ supplied as clock pulse signal inputs, the D flip flops b_1 and b_{101} supply the scanning electrodes L_1 and L_{101} with the output P_1 shown in Fig. 5. The outputs P_1 are also input to the data terminals of the following D flip flops b_3 and b_{103} (not shown). On the basis of the signal input P_1 and the horizontal clock pulse signals $c\ell$ supplied as clock pulse signal inputs, the D flip flops b_3 and b_{103} output signals P_3 of Fig. 5 to the scanning electrodes L_3 and L_{103}. The similar pulses are output from the subsequent D flip flops to the corresponding scanning electrodes, and in the end of the first frame, the outputs from the D flip flops b_{97} and b_{197} are input to the data terminals and horizontal clock pulse signals to the clock terminals of the D flip flops b_{99} and b_{199}, which then supply the scanning electrodes L_{99} and L_{199} with signals P_{99} shown in Fig. 5. Thus, the first scanning electrodes of all groups are rewritten. In other words, rewrite signals are output sequentially to all the scanning electrodes of odd number in the first frame.

In the second frame, similar pulses are output from the D flip flops related to the second scanning electrodes of the groups, namely to the scanning electrodes of even number. The duration of the pulses P_1, P_3, ... P_{99} is set at "r" sec. (about 200 μs in this embodiment) which is needed by liquid crystal to rewrite picture elements. "r/2" shown for the image data signal Ei in Fig. 5 is 100 μs in this embodiment.

Referring to Fig. 5, in the duration of the pulse P_1, for example, the D flip flops r_1, r_2, ... r_{640} for the signal electrodes output signals to the first scanning line in the first display block 1A and to the 101st scanning line in the second display block 1B. Therefore, the scanning line L_1 and L_{101} are rewritten in the duration of the pulse P_1. Similarly, the scanning lines L_3 and L_{103} are rewritten in the duration of the pulse P_3. Thus, the scanning lines of odd number L_1, L_3, ... L_{99}, and L_{101}, L_{103}, ... L_{199} are written in the first frame, and the scanning lines of even number L_2, L_4, ... L_{100}, and L_{102}, L_{104}, ... L_{200} are rewritten in the second frame. In the third frame, the same scanning electrodes as in the first frame are rewritten.

In the second embodiment shown in Fig. 3, the number of scanning electrodes in each group K′ is assumed to be 2 so that a picture is completed in two frames. It should be understood that the second embodiment shown in Fig. 3 can be modified easily to set K′ to any desired value other than 2.

The effect of the present invention with K (or K′) = 2 as shown in Figs. 1 and 3 is explained with reference to Fig. 6. When a figure "1" is kept written on the display screen, the luminance of the figure on the scanning electrodes L_1, L_2, L_3 and L_4 is shown in Figs. 6(1), 6(2), 6(3) and 6(4). The combined luminance of the 4 (vertical) x 4 (horizontal) picture elements is shown in Fig. 6(5). It means that the apparent frequency for rewriting the entire image is 50 Hz although each scanning line is rewritten at 25 Hz. According to the present invention, therefore, flicker decreases and the picture quality improves compared with the picture by the conventional device in which an entire picture is rewritten at 25 Hz. With K = 2, every other scanning line is rewritten in each frame. With K = 3, every third line is rewritten in each frame.

According to the present invention, as mentioned above, the display device which provides an incomplete memory characteristic and takes a specified time to rewrite the picture elements in one horizontal scanning period decreases flicker by increasing the apparent speed of rewriting the picture elements. This results in improved picture quality.

In the above embodiments of the present invention, it is assumed that the number of effective scanning lines in the effective display region is M. The total number of scanning lines in the display device may be greater than M. For M = 200, for instance, the total number of scanning line may be, say, 262.

While only certain embodiments of the present invention have been described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the present invention as claimed.

There are described above novel features which the skilled man will appreciate give rise to advantages. These are each independent aspects of the invention to be covered by the present application, irrespective of whether or not they are included within the scope of the following claims.

Claims

1. A display device which takes a specified period to rewrite the picture elements in one horizontal

scanning period, comprising:

M pcs. of scanning lines divided into a plurality of groups each containing K pcs. of scanning lines ($K > 1$, $M > 1$, K, M: positive integers); and

means for supplying scanning signals to the M pcs. of scanning lines to rewrite an image; wherein

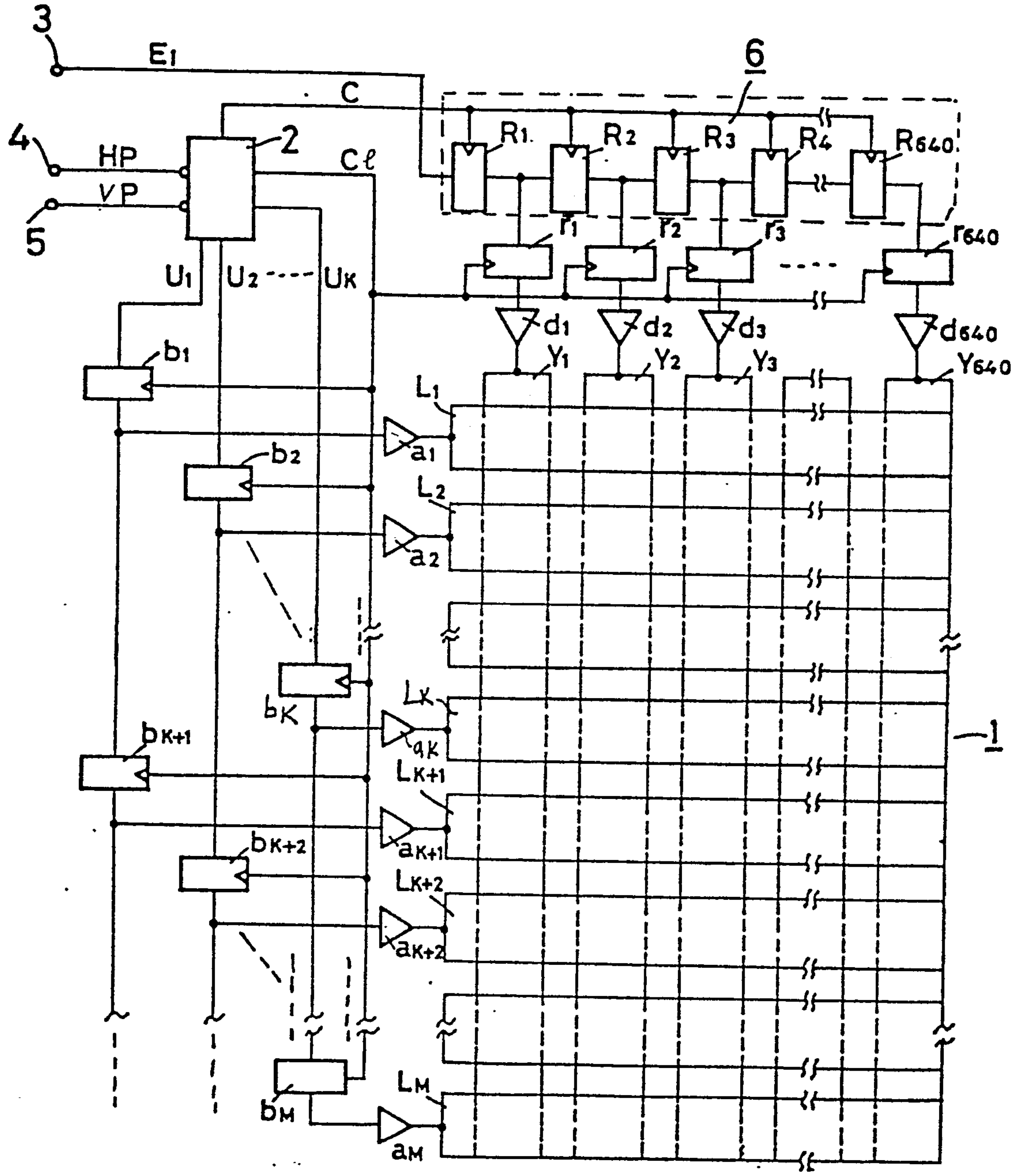
the means for supplying scanning signals outputs scanning signal to the first scanning line of each group in the first frame, to the second scanning line of each group in the second frame, and to the Kth scanning line of each group in the Kth frame so that the M pcs. of scanning lines are rewritten by K times of scanning.

2. The display device of claim 1, wherein assuming the specified period required for rewriting picture element is r, the display device satisfies the condition of $60 > \frac{1}{r \times M}$.

3. The display device of claim 1, wherein the display device is a liquid crystal display device.

4. A display device having a matrix array of display elements, scanning and data electrodes, and a display control circuit for applying scanning signals to said scanning electrodes and data signals to said data electrodes, said display control circuit being arranged to perform a succession of scanning operations in each of which a plurality (P) of said scanning electrodes are sequentially energised, wherein a complete scanning of the matrix array involves a plurality (K) of said scanning operations in each of which corresponding scanning electrodes from a plurality (P) of groups thereof are sequentially energised.

5. A display device according to claim 4 wherein the matrix is divided into a plurality of sections, each including a respective set of said scanning electrodes, each set comprising a said plurality of scanning electrode groups, the display control circuit being operable so that in each said scanning operation the sequential energization of the corresponding scanning electrodes from the groups of said respective sets takes place simultaneously.



3
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6
C
4
HP
2
Cℓ
R1
R2
R3
R4
R640
VP
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r640
U1
U2
Uk
d1
d2
d3
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Y2
Y3
Y640
L1
a1
b2
L2
a2
bK
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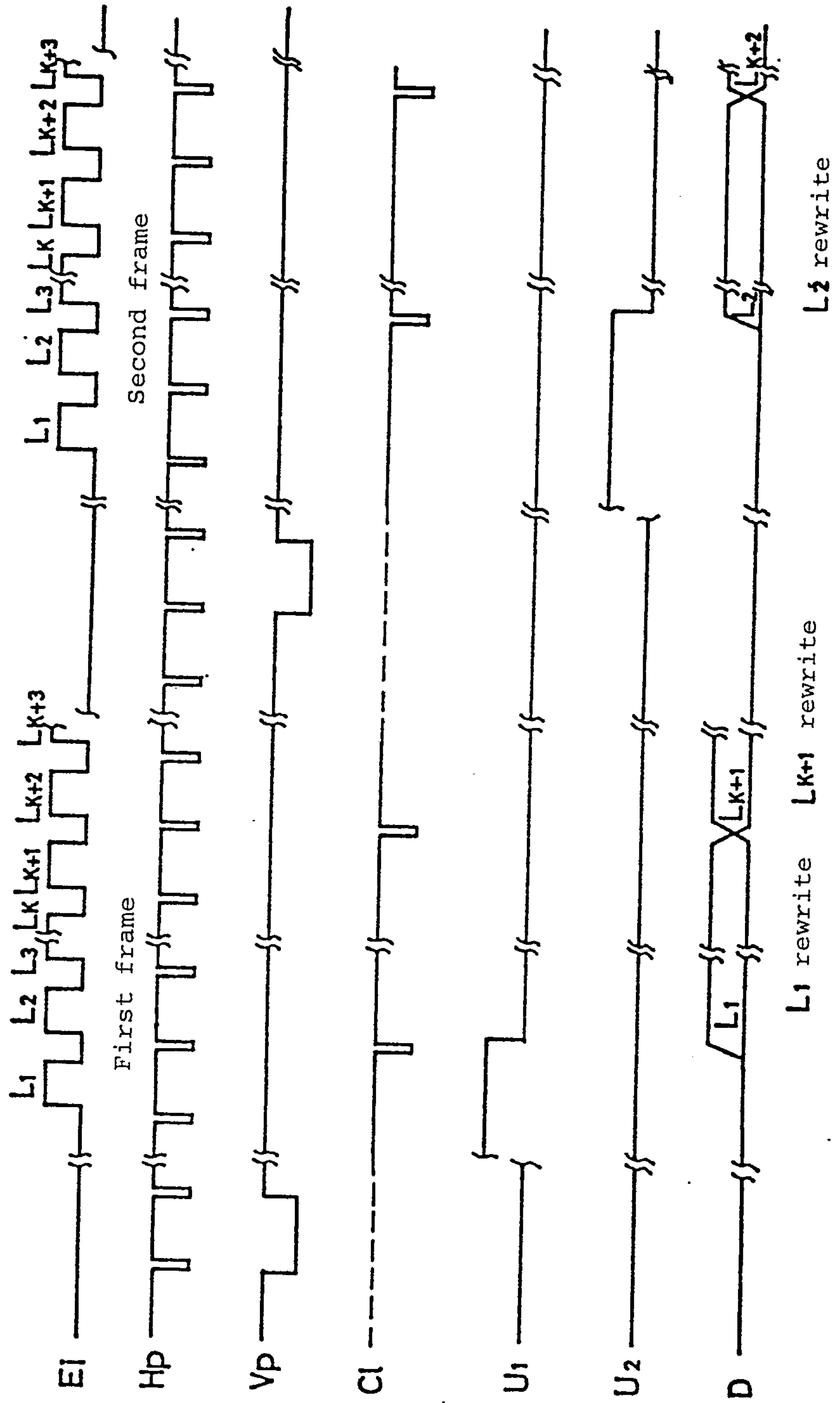
Fig. 1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Hp
Vp
Cl
U1
U2
D
L1
L2
L3
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LK+1
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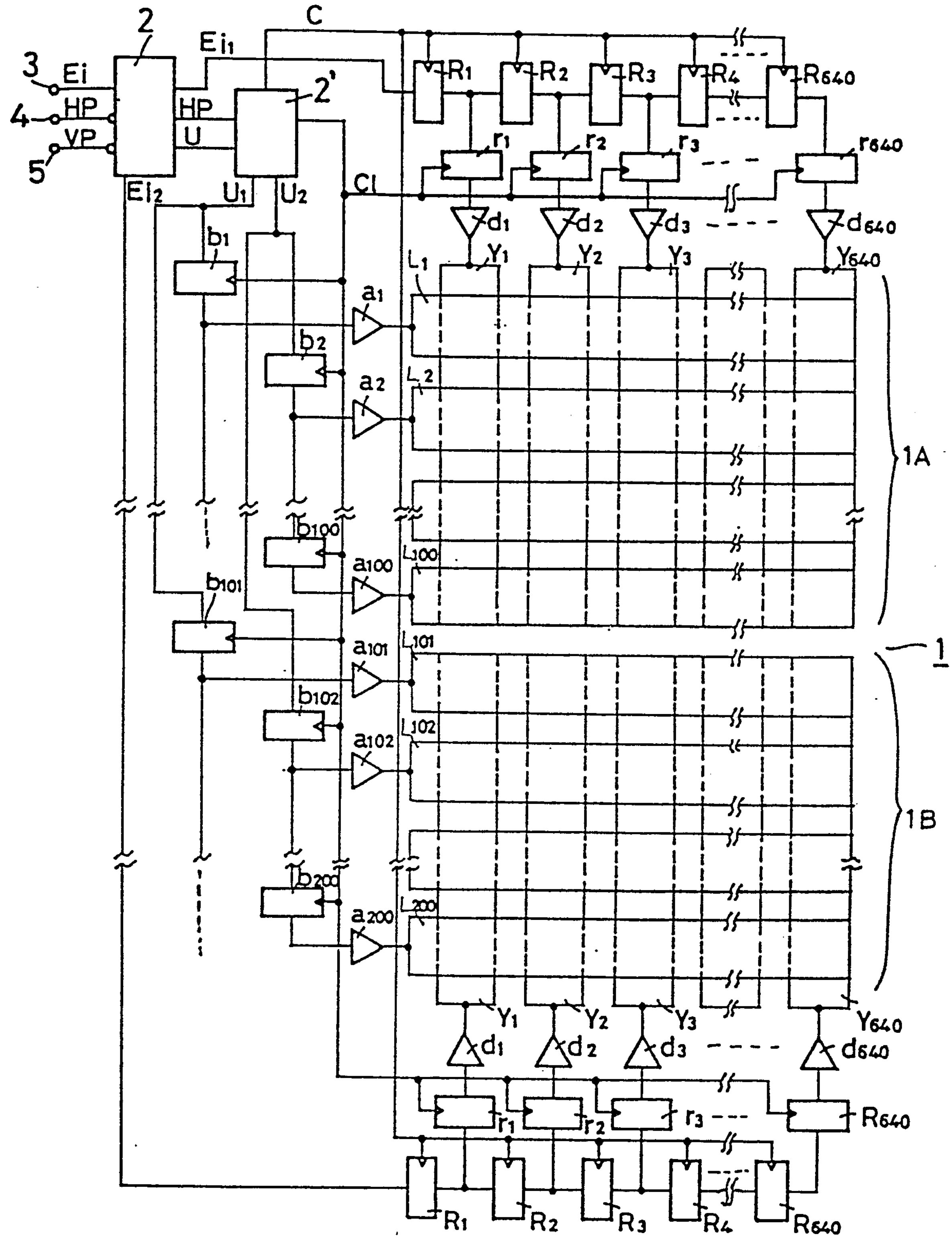
LK+3
First frame
Second frame
L1 rewrite
LK+1 rewrite
L2 rewrite

Fig. 2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4
HP
5
VP
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HP
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U1
U2
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d3
d640
Y1
Y2
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1A
1B
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Fig. 3

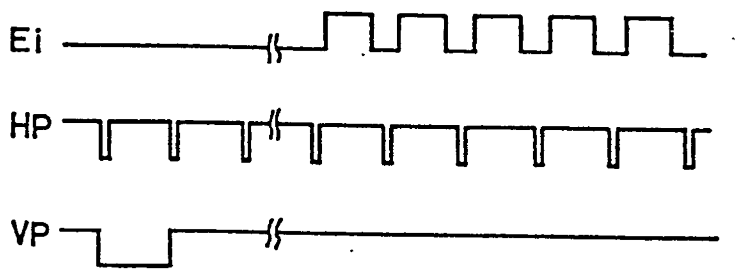
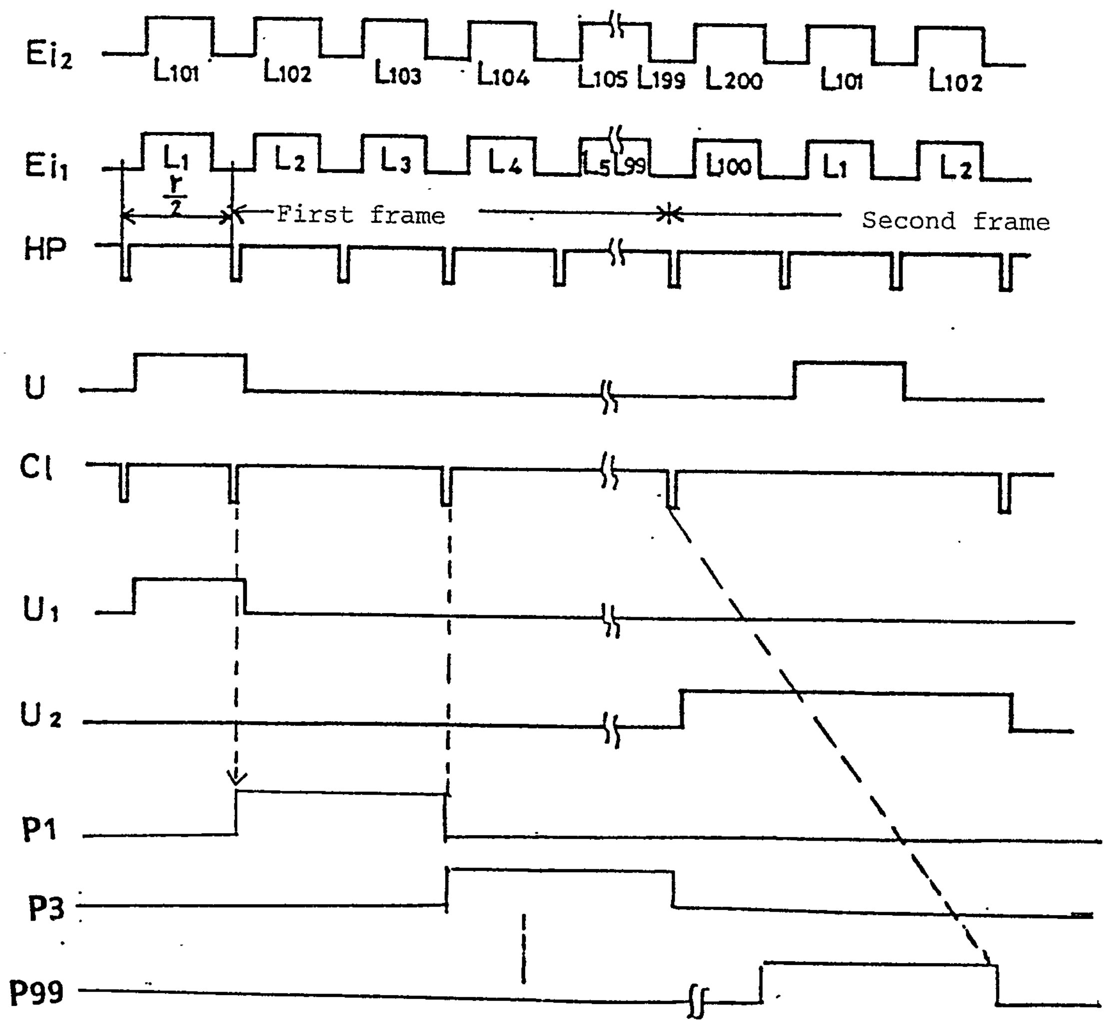

Ei
HP
VP

Fig. 4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L102
L103
L104
L105
L199
L200
L101
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Ei1
L1
L2
L3
L4
L5
L99
L100
L1
L2
First frame
Second frame
HP
U
Cl
U1
U2
P1
P3
P99

Fig. 5

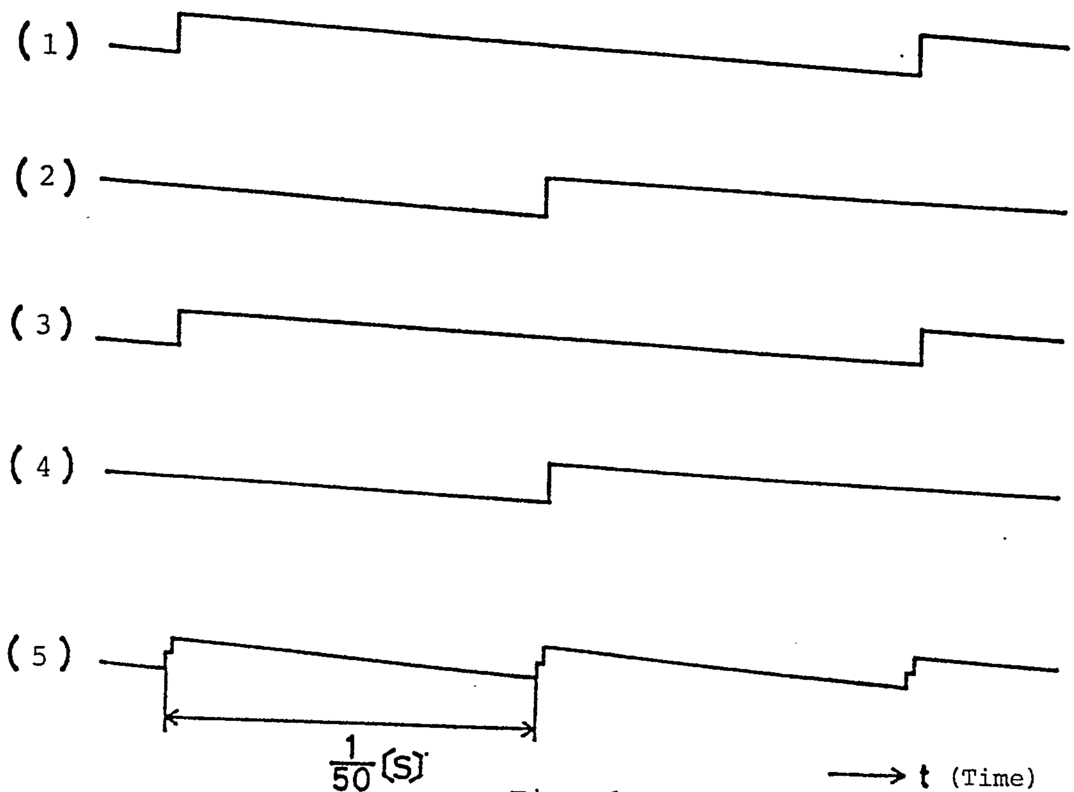

Fig. 6

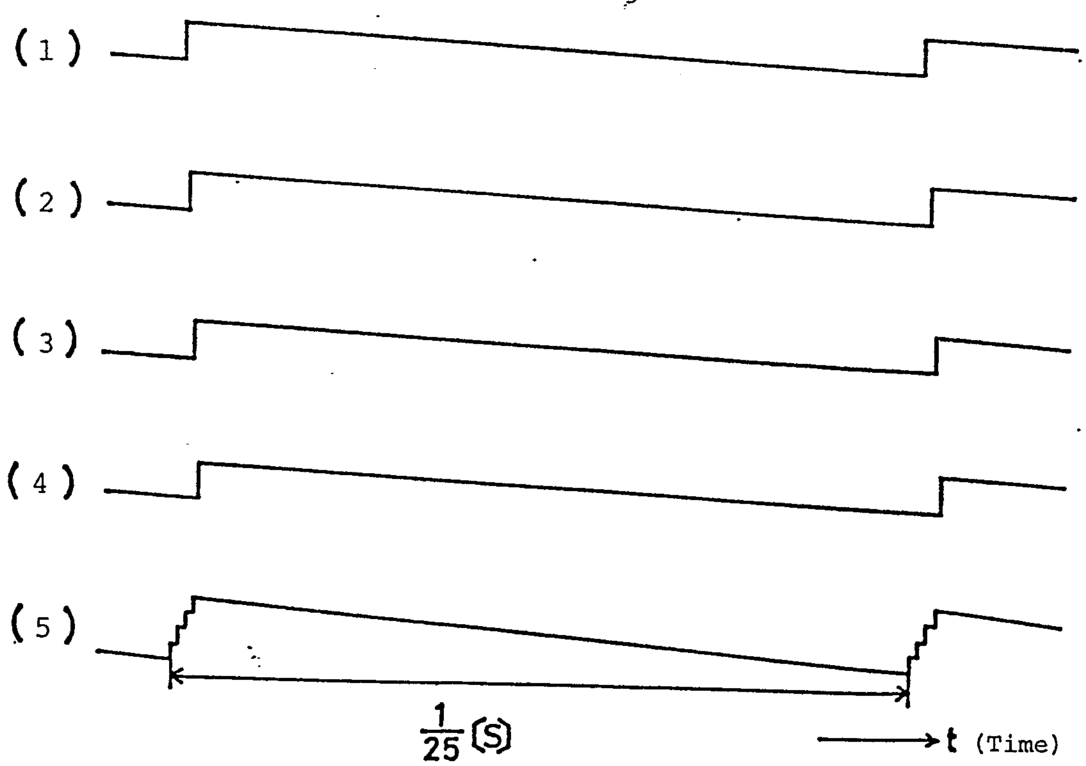

Fig. 7