

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO DISPLAY DEVICES

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to display devices of the kind in which any one of a number of predetermined numerals or characters may be visibly displayed by applying a potential to different selected combinations of electrodes in an electrode system superimposed over and spaced from another electrode. Though not limited exclusively to its application thereto, the invention is most advantageously applicable to and primarily intended for time displaying liquid crystal display devices for electronic timepieces, notably wrist-watches.

According to this invention there is provided a display device including upper and lower superimposed electrode systems spaced apart and adapted to produce a visible display of any of a number of predetermined selectable numerals or characters by applying a potential difference between selected combinations of electrodes in the two systems wherein each of said two systems consists of a plurality of electrodes, those in each system being so shaped and disposed in relation to the shape and disposition of the electrodes in the other that one part of the shape of a selected displayed numeral or character can be displayed by simultaneously energising a selected combination of superimposed electrodes and another part of said numeral or character can be displayed by simultaneously energising a different selected combination of superimposed electrodes whereby the whole selected numeral or character may be visibly displayed by energising the different selected combinations in such rapid sequence that said numeral or character is seen as a whole by persistence of vision.

The invention is illustrated in and further

explained in connection with the accompanying drawings, in which:—

Figures 1 and 2, which are provided for purposes of explanation and comparison, illustrate a conventional known numeric display device of the liquid crystal type.

Figure 3 illustrates an embodiment of this invention in the same manner as Figure 1.

Figure 4 is an equivalent circuit representation of the liquid crystal display device of Figure 3 with wave forms for operating the same.

Figure 5 illustrates a multiple numeral or character display device in accordance with this invention.

Figure 6 is a block diagram of an electronic watch having a time displaying device in accordance with this invention, and

Figures 7 and 8 are explanatory of the manner of operation of the display.

Figure 1 shows, side by side for clarity of drawings and representation, the upper and lower electrode panels A and B of a conventional numeric display device of the liquid crystal type and Figure 2 is a simplified sectional view of these panels in their correct superimposed position with a layer of liquid crystal D. In a timepiece display arrangement for numerically displaying time in hours, minutes and seconds there would be six such devices, two for the hours, two for the minutes and two for the seconds. In each device the liquid crystal D is sandwiched between the upper panel A and the lower panel B and a sealing spacer C provides a gap between the electrode panels and holds the liquid in place. The electrodes themselves are in the form of metal deposits or thin metal film provided on the insides of the panels A and B. The liquid crystal is excited when a voltage is applied between two electrodes, one on each panel, and, as well known, by suitable selection of different electrodes for energisation, different numerals can be displayed by light due to irregular light reflection by the liquid crystal between energised electrodes.

Panel A in Figure 1 has seven electrodes

referenced α to g inclusive and panel B has one electrode referenced p . They are shaped as shown and, by suitably selecting different combinations of the electrodes on each of the six panels A for energisation simultaneously with the single electrode on the corresponding panel B, it is possible to display any time in hours, minutes and seconds in the form of numerals up to 24, 60 and 60. It will be seen however, that to enable this to be achieved it is necessary to provide forty-two lead-out connections from the electrodes on the panels A as well as from the electrodes on the panels B. This known arrangement is, therefore, very inconvenient and difficult to manufacture in practice in the case where the display device is to be the time display device of a small timepiece such as a wrist-watch. The present invention seeks to overcome the serious practical disadvantages and defects of a liquid crystal time display device requiring such a large number of external connections and to provide a device requiring much fewer external connections. The two parts of Figure 3 show, in the same manner as Figure 1, the upper and lower panels A and B of a preferred form of liquid crystal display device in accordance with this invention.

Referring to Figure 3 it will be seen that panel A has four electrodes, referenced by the greek letters α β γ and δ shaped as shown while the lower panel B has two electrodes shaped as shown, and referenced p and g . Each electrode has its own external connection.

Figure 4a is a connection diagram the external connections to the different electrodes being given the same references as are used for the respective electrodes in Figure 3. Figure 4b shows the wave forms which are applied to the external connections for causing the display of the numeral "3". This, of course, is chosen as one example only. The six wave forms are shown in correct time relationship in Figure 4b each wave form being referenced in accordance with the connection to which it is applied.

Referring to Figure 4b during the period t_n of the clock signal, voltage is applied via aa, cc and bb between electrode p on panel B and electrodes α β γ , on panel A. During the longer period $(t_n + 1)$ of the time signal voltage is applied via gg, and dd between electrode g on panel B and electrodes γ δ on panel A. The signal frequencies used should be high enough to enable the displayed numeral to appear practically continuously due to the persistence of vision of the human eye.

For the sake of simplicity of drawings and explanation, Figures 3 and 4 illustrate and serve to explain the operation of a display device of the single numeric or character type i.e. a device which will display only one numeral or character. A display device for a

watch and adapted to display any time in hours, minutes and seconds would, of course, have to be able to display six numerals. Figure 5, which needs little further explanation, shows such a display device, the two parts of Figure 5a showing the upper and lower electrode panels A and B and Figure 5b being an edge view. As will be seen panel A has six electrode arrangements (compare with the left hand part of Figure 3) and panel B has also six electrode arrangements (compare with the right hand part of Figure 3). The electrodes α , β , γ and δ of the six arrangements (one for each numeral) on panels A are (in each case) connected together and to a respective common terminal the resulting terminals being reference α , β , γ and δ in Figure 5(a). Each of the electrode arrangements on panel B has its own p and g terminals (as in Figure 3) the resulting terminals (six pairs i.e. twelve in all) being referenced $g_1, p_1, g_2, p_2, \dots, g_6, p_6$ in Figure 5a. In Figure 5b the two panels A and B appear in edge view, D being the liquid crystal and C the liquid retaining spacer. It will be observed that the left hand electrode arrangements in panels A and B of Figure 5 differ from the other electrode arrangements on these panels. This is because Figure 5 is drawn for the case in which the display device is assumed to be used to display time in an electronic watch and these left hand arrangements, being required to display hours, do not need to display the numerals 3 to 9 inclusive, display of the numerals 0, 1 and 2 being enough to display hours. Therefore electrodes not required for the numerals 0, 1 and 2 are omitted from these arrangements.

Figure 6 is a block diagram of the driving arrangement for a display device as shown in Figure 5. The general operating method is as already described for one numeral, in connection with Figure 4, but, in order that it may be clearly understood, will be described in detail with reference to Figures 7 and 8. Known circuitry in block 1 derives from clock pulses fed in at (i) figure representative signals B, C and D which are supplied to a decoder 2 which converts them into signals which select the electrodes in the time display device 3 for energisation. A scanning circuit arrangement 4 scans the decoded signals B, C, D with a synchronising signal also supplied from the circuitry at 1 and fed in over lead S₁. The electrodes in the liquid crystal display device are selected and energised in accordance with the signals B, C and D after decoding by the decoder 2 and at times determined by the synchronising signals fed over lead S₁ so that time displays appear on the display device 3. In Figure 6 the display shown, by way of example, is the time 20h 56m 37s. The necessary circuitry for deriving the B, C, D signals, decoding them deriving the synchronising signals, and

scanning the decoded B, C, D signals so that an apparently continuous and continuously up-dated display of time is obtained may be as known and, because this circuitry forms per se no part of this invention, it is not illustrated or further described herein. Some of this circuitry is assumed to be within the block referenced 3 in Figure 6.

Figure 7 is a wave form diagram from which the method of operation will be clearly seen in detail. The wave forms are all drawn to a common time scale indicated by the arrow marked t and a time t_0 (which is not more than the time of persistence of vision) divided into four equal times t_1, t_2, t_3 and t_4 are also shown. The wave forms marked α, β, γ and δ are those applied to the connections so marked and, similarly, the wave forms applied at p and g are indicated by these references. Beneath the four wave forms referenced α, β, γ and δ are 10 pairs of wave forms, those of each pair consisting of a "p" wave form and a "g" wave form. The uppermost of these pairs shows the two wave forms used to display the numeral "0" as indicated by the reference 0 to the left of the appropriate bracket. The wave forms for displaying the numerals "1" to "9" are similarly shown as indicated by the brackets and the references 1 to 9. When any wave form is at its maximum positive potential electrode energisation occurs; when it is at its lowest value electrode energisation does not occur.

Figure 8 shows, by shading, the successive partial displays, produced in the successive times t_1, t_2, t_3 and t_4 , by the wave forms shown in Figure 7 for the numeral "3". The successive partial displays are produced at such a rate that, by virtue of persistence of vision, they all appear together as seen by the eye and, as will be apparent, they thus combine to produce the numeral "3".

The invention is not limited to the particular arrangements described and various modifications as regards the electrode arrangements are possible. Thus, in the illustrated embodiments a numeral displayed can be made up of up to seven segments or portions. Other electrode arrangements may be used to provide numerals such that a numeral displayed can be made up of up to eight or nine segments or portions.

WHAT WE CLAIM IS:—

1. A display device including upper and lower superimposed electrode systems spaced apart and adapted to produce a visible display of any of a number of predetermined selectable numerals or characters in light by applying a potential difference between selected combinations of electrodes in the two systems wherein each of said two systems consists of a plurality of electrodes, those in each system being so shaped and disposed in relation to the shape and disposition of the electrodes in the other that one part of the shape of a selected displayed numeral or character can be displayed by simultaneously energising a selected combination of superimposed electrodes and another part of said numeral or character can be displayed by simultaneously energising a different selected combination of superimposed electrodes whereby the whole selected numeral or character may be visibly displayed by energising the different selected combinations in such rapid sequence that said numeral or character is seen as a whole by persistence of vision.

2. A device as claimed in claim 1 wherein the two electrode systems are superimposed and spaced apart with a layer of liquid crystal between them, the device constituting a display device of the liquid crystal type.

3. A device as claimed in claim 1 or 2 wherein one electrode system consists of four electrodes and the other of two.

4. A display device comprising, in combination, a plurality of devices each as claimed in any of the preceding claims and each having upper and lower electrode systems, the upper systems being carried on a common panel and the lower systems being carried on another common panel.

5. Display devices substantially as herein described with reference to Figures 3 to 7 inclusive of the accompanying drawings.

6. A timepiece having a display device as claimed in any of claims 1 to 5 and adapted to display time by numeric display of at least hours and minutes.

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scanning the decoded B, C, D signals so that an apparently continuous and continuously up-dated display of time is obtained may be as known and, because this circuitry forms

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20 Beneath the four wave forms referenced α , β , γ and δ are 10 pairs of wave forms, those of each pair consisting of a "p" wave form and a "g" wave form. The uppermost of these pairs shows the two wave forms used to display the numeral "0" as indicated by the

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40 vision, they all appear together as seen by the eye and, as will be apparent, they thus combine to produce the numeral "3".

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