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(54) LIQUID CRYSTAL DISPLAY ARRANGEMENT

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese body corporate, 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 liquid crystal display arrangements.

Liquid crystal display devices have attracted particular attention in recent years because they have the following advantages over other types of display devices, for example, those employing display tubes:—

(1) Liquid crystal display devices may be made having a thickness of only several millimetres.

(2) The power consumption of liquid crystal display devices is only several $\mu\text{W}/\text{cm}^2$ area of display and they require a driving voltage of only several volts.

(3) Liquid crystal display devices provide a passive display which can be seen clearly in relatively good ambient light conditions.

(4) Liquid crystal display devices may be constructed to give a multi-coloured display.

In view of these advantages, there is a desire to use liquid crystal display devices in compact or portable instruments. Liquid crystal display devices also can be used to advantage with electronic circuitry of integrated circuit construction and can be driven directly to such circuitry.

According to the present invention there is provided a liquid crystal display arrangement comprising a liquid crystal display device having a plurality of terminals, and a plurality of elastic electrically conductive connecting members in frictional electrical connection with respective terminals.

Each connecting member may be made of electrically conductive bodies mixed in an elastic polymer. Said elastic polymer may be a rubber.

Preferably the terminals are in electrical contact with an electrode of the liquid cry-

stal display device, the electrode being made of tin oxide or indium oxide.

The liquid crystal display device, in the preferred embodiment, is of the field effect type.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 is a sectional view of a liquid crystal display device and is given to explain the operation thereof;

Figure 2(a) illustrates the construction of an electrode of a liquid crystal display device for displaying numerals, and Figure 2(b) is a side view thereof; and

Figure 3(a) is a sectional view of a known connecting lead for a liquid crystal display device and Figure 3(b) is a sectional view of a connecting lead for a liquid crystal display arrangement according to the present invention.

In the drawings like parts have been designated by the same reference numerals.

An explanation of the operation of a liquid crystal display device will be given with reference to Figure 1 which is a cross-section of one embodiment of a liquid crystal display device of the field effect type. The liquid crystal display device comprises two spaced-apart polarizers 1, 1¹ between which is sandwiched a liquid crystal cell. The liquid crystal cell consists of a pair of spaced-apart glass plates 2, 2¹ with liquid crystal material 5 therebetween. The plates 2, 2¹ are maintained spaced-apart and sealed against leakage of the liquid crystal material 5 therefrom by a spacer 4. The plates 2, 2¹ are provided on their opposed surfaces, i.e. on the surfaces in contact with the liquid crystal material, with electrodes 3, 3¹. As is well known the optical characteristics of the liquid crystal material change when an electric field is applied across it via the electrodes 3, 3¹. If the planes of polarization of the two polarizers are at right angles and if no electric field is applied across the liquid crystal material, the latter is optically active so that it rotates the plane of polarization of polarized light passing therethrough, through

90°. Thus the liquid crystal display device will appear light in colour since light will be transmitted therethrough. When an electric field is applied across the liquid crystal material *via* the electrodes 3, 3', the optical activity of the liquid crystal material is lost so that the liquid crystal display device appears dark in colour since light will not be transmitted therethrough. Thus depending upon the shape of the electrodes various patterns may be displayed by the liquid crystal display device.

Figure 2 (a) and Figure 2 (b) shows the electrode 3 consisting of a plurality (seven shown) of segments 6a to 6g which, when suitably energised, enables any of the numerals 0 to 9 to be displayed. Each segment has a terminal 7a to 7g respectively which extends outwardly of the liquid crystal cell so that appropriate driving signals from electronic circuitry (not shown) can be applied to the segments. It is not possible to solder connecting leads to the terminals 7a to 7g because, like the segments, they are composed of a film of, for example, tin oxide (SnO₂) or indium oxide (In₂O₃). In the past, therefore, connecting leads have either been adhered to the segments using a conductive binding agent or bent connecting leads have been used, as shown by the connecting lead 8 in Figure 3 (a) to engage frictionally the terminals.

However, when a conductive binding agent is used, it is found that it is apt to deteriorate in time due to the effects of temperature, dampness, etc. and is even unsatisfactory under ideal conditions. Whilst the use of bent connecting leads shown in Figure 3 (a) suffered less from the effects of temperature, dampness, etc. they are apt to harm the terminals when the liquid crystal display device is brought into electrical contact therewith because for good electrical contact the natural resiliency of the connecting leads is relied upon. Furthermore, the contact area between the bent connecting leads and the respective terminals is relatively small and indeed the degree of contact from one terminal to another varies. As a result, the use of bent connecting leads is unreliable. Water, etc. is apt to accumulate in the area of the terminals and their respective bent connecting leads due to capillary action: this is especially pronounced when the contact area is relatively small.

As shown in Figure 3 (b) the present invention provides a liquid crystal display arrangement which seeks to avoid these defects by providing an elastic connecting member 9 on each connecting lead 8 in frictional electrical contact with the respective terminal. The connecting members may be made of electrically conductive bodies mixed in an elastic polymer such as a rubber. The liquid crystal display arrangement according

to the present invention and described above has the advantages that:—

(1) The contact area between each connecting lead and its respective terminal is relatively large.

(2) The terminals are unharmed by contact with the connecting leads.

(3) A relatively good and reliable electrical connection is achieved between the terminals and the respective connecting leads.

(4) Shocks or vibrations, etc. are at least partially absorbed by the resiliency of the connecting members.

(5) Even if there are a relatively large number of terminals, the degree of connection between the terminals and the connecting leads seldom varies from one terminal to the next.

The present invention is particularly applicable when the terminals are part of thin-film electrodes and where shock resistance is required. A further advantage is that the liquid crystal display device can be exchanged relatively easily because there is only a frictional engagement between the connecting members and the terminals.

Liquid crystal display devices according to the present invention can be used in any type of portable instrument, such as timepieces, calculators, e.g. desk top calculators, etc.

WHAT WE CLAIM IS:—

1. A liquid crystal display arrangement comprising a liquid crystal display device having a plurality of terminals, and a plurality of elastic, electrically conductive connecting members in frictional electrical connection with respective terminals.

2. An arrangement as claimed in claim 1 in which each connecting member consists of electrically conductive bodies mixed in an elastic polymer.

3. An arrangement as claimed in claim 2 in which said elastic polymer is rubber.

4. An arrangement as claimed in any preceding claim in which the terminals are in electrical contact with an electrode of the liquid crystal display device, the electrode being made of tin oxide or indium oxide.

5. An arrangement as claimed in any preceding claim in which the liquid crystal display device is of the field effect type.

6. A liquid crystal display arrangement substantially as herein described with reference to and as shown in Figure 3 (b) of the accompanying drawings.

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However, when a conductive binding agent is used, it is found that it is apt to deteriorate in time due to the effects of temperature, dampness, etc. and is even unsatisfactory under ideal conditions. Whilst the use of bent connecting leads shown in Figure 3 (a) suffered less from the effects of temperature, dampness, etc. they are apt to harm the terminals when the liquid crystal display device is brought into electrical contact therewith because for good electrical contact the natural resiliency of the connecting leads is relied upon. Furthermore, the contact area between the bent connecting leads and the respective terminals is relatively small and indeed the degree of contact from one terminal to another varies. As a result, the use of bent connecting leads is unreliable. Water, etc. is apt to accumulate in the area of the terminals and their respective bent connecting leads due to capillary action: this is especially pronounced when the contact area is relatively small.

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