US005510813A

United States Patent [19]

Makinwa et al.

[11] **Patent Number: 5,510,813**

[45] **Date of Patent: Apr. 23, 1996**

[54] **DATA PROCESSING DEVICE COMPRISING A TOUCH SCREEN AND A FORCE SENSOR**

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[21] Appl. No.: **289,829**

[22] Filed: **Aug. 12, 1994**

[30] **Foreign Application Priority Data**

Aug. 26, 1993 [BE] Belgium 09300875

[51] **Int. Cl.**[6] **G09G 3/02**

[52] **U.S. Cl.** **345/173**; 345/104; 345/179; 341/33

[58] **Field of Search** 345/173, 174, 345/175, 156, 179, 104; 178/18, 19; 341/33, 34, 22

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,293,734	10/1981	Pepper, Jr.	178/18
4,475,235	10/1984	Graham	178/18
4,723,836	2/1988	Kone et al.	345/174
4,731,694	3/1988	Gräbner et al.	341/33
4,740,781	4/1988	Brown	345/174
4,853,498	8/1989	Meadows et al.	178/19
4,961,968	7/1989	Hilsum et al.	345/104
5,119,079	6/1992	Hube et al.	345/146
5,231,381	7/1993	Duwaer	345/174

FOREIGN PATENT DOCUMENTS

0340096	11/1989	European Pat. Off. .	
0419145	3/1991	European Pat. Off.	345/173

OTHER PUBLICATIONS

Research Disclosure, No. 302, Jun. 1989, Havant GB p. 456 RD30289–Touch Screen With Combined Force and Position Sensing.

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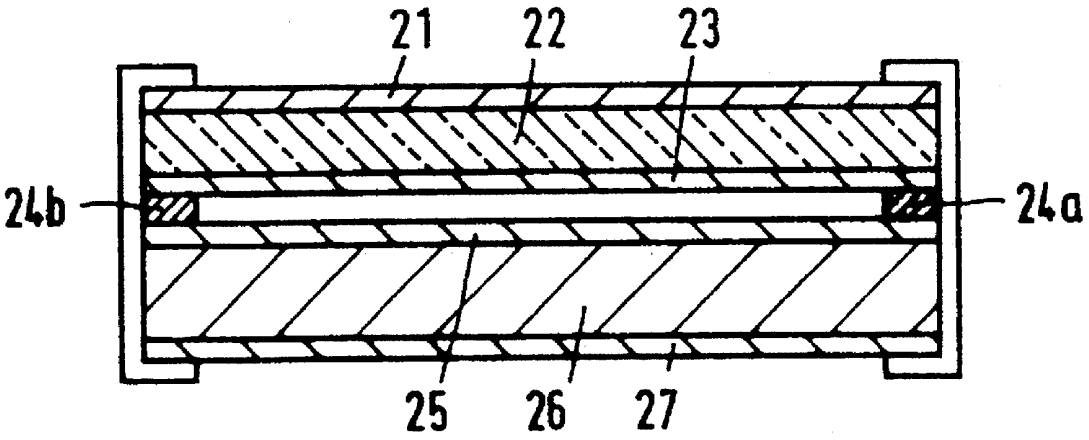
[57] **ABSTRACT**

A data processing device comprises a touch screen with a touch position sensor. The position sensor is suitable to detect a touch position on the screen from a change in a current pattern in a conductive panel. The device also comprises a touch force sensor provided with a second conductive panel which extends substantially parallel to the touch screen. The screen is at least partly movable relative to the second panel in a direction transversely of the second panel. The force sensor is suitable to determine a force from a capacitance value between the touch screen and the second panel. The device is suitable for the combined processing of the position and force detected in response to touching.

13 Claims, 2 Drawing Sheets



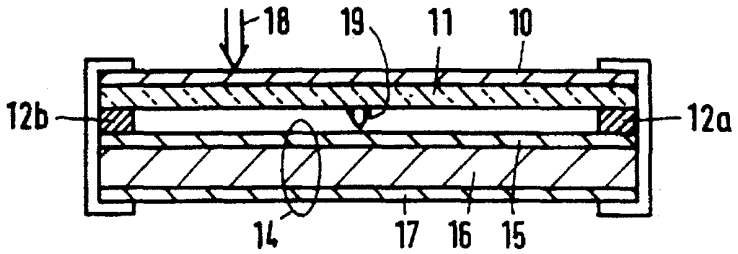


FIG.1

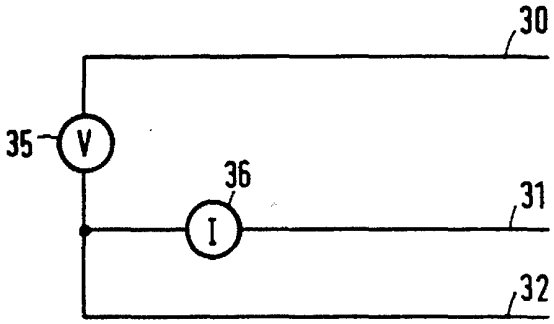


FIG.2

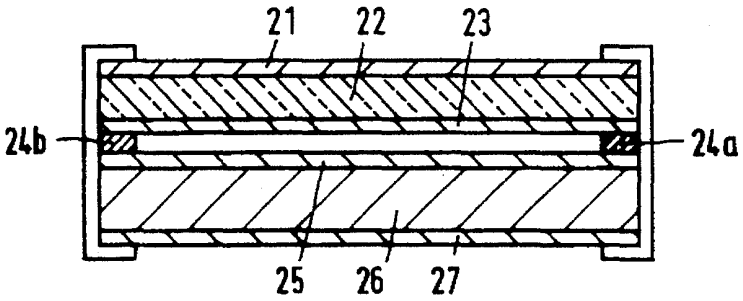


FIG.3

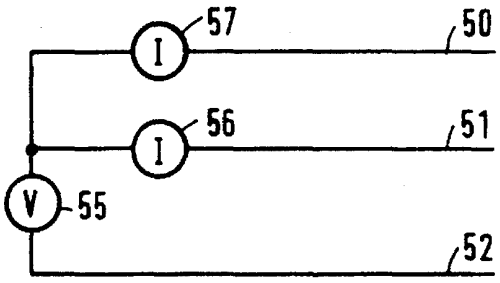


FIG.4

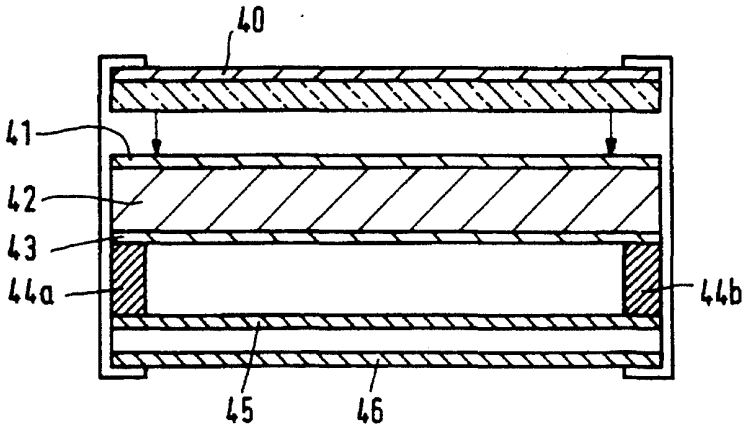


FIG.5

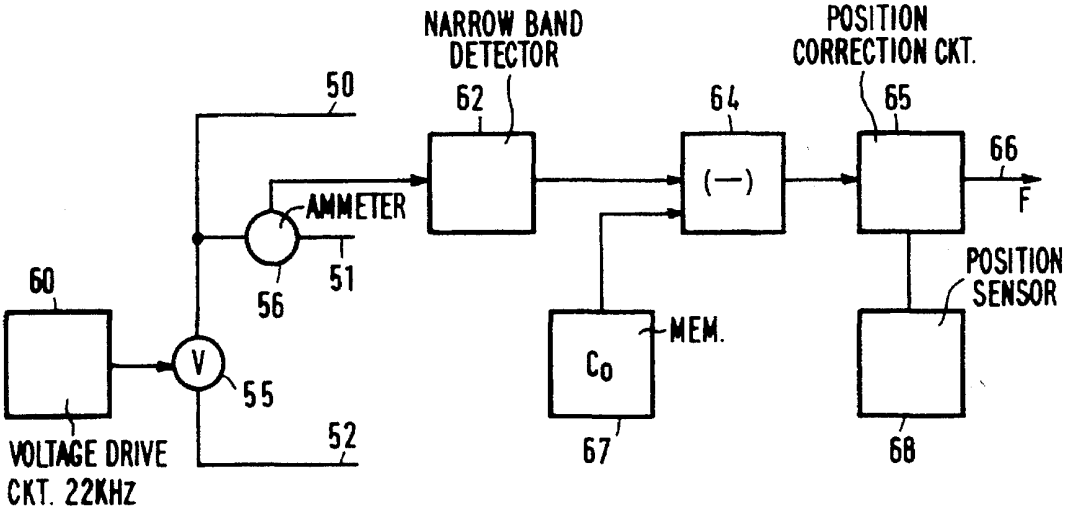


FIG.6

DATA PROCESSING DEVICE COMPRISING A TOUCH SCREEN AND A FORCE SENSOR

BACKGROUND OF THE INVENTION

The invention relates to a data processing device, comprising a touch screen with a touch position sensor which comprises a first conductive panel and is suitable to detect a touch position on the screen from a change in a current pattern in the first panel. A data processing device of this kind is known from U.S. Pat. No. 4,853,498.

During use the position sensor for example applies the same electric voltage, to a plurality of locations on the first panel. When the panel is touched or approached by a finger or any other at least slightly conductive object, a capacitive effect is produced so that current is drained from the panel. The position sensor can deduce the position where the touch surface has been touched or approached by measuring the amount of current drained from the various locations on the panel whereto the voltage is applied.

Preferably, the touch force is determined simultaneously with the position. In that case, for example

- the thickness of lines drawn by means of the position sensor can be adjusted in proportion to the force used,
- a distinction can be made between different types of use, such as control of cursor motions or icon selection, on the basis of different forces,
- a selection of a menu item can be confirmed by exerting additional force.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a data processing device which is suitable to measure the touch position as well as the touch force in response to touching.

To achieve this, the data processing device in accordance with the invention is characterized in that the device comprises a touch force sensor which is provided with a second conductive panel which is arranged substantially parallel to the touch screen which touch screen is at least partly movable relative to the second panel in a direction transversely of the second panel, the force sensor being arranged to determine a force from a capacitance value between the touch screen and the second panel, and the device being arranged for the combined processing of the position and force detected in response to touching. The touch screen and the second panel constitute respective plates of a capacitor. When a force is exerted on the touch screen, these plates move towards one another, so that the capacitance value of the capacitor changes. The capacitance value is, therefore, a fully electronically measurable measure of this force.

An embodiment of the data processing device in accordance with the invention is characterized in that the touch screen comprises a third conductive panel which is arranged between the first and the second panel, the force sensor being suitable to determine a variation of the capacitance value by means of a current flowing from the first and/or second panel to the third panel in order to charge or discharge the capacitance between the third panel on the one side and the first and/or second panel on the other side. The measurement of the capacitance value in response to a touch force could be disturbed by the capacitance of the finger or the other object touching or approaching the screen. Thus, the determination of the force is not unambiguous. These touch effects are eliminated by measuring exclusively the current to the third panel which constitutes an intermediate layer.

An embodiment of the data processing device in accordance with the invention is characterized in that the first and the third panel are movable together relative to the second panel, the force sensor being suitable to apply to the first and the third panel the same electric measurement voltage signal relative to the second panel. Because the same measurement voltages are applied to the first and the third panel, it is ensured that variations in the current to the first panel are caused only by the touch capacitance, whereas variations in the current to the third panel are caused exclusively by the force exerted. The measurement voltage signal need concern only one component of the electric voltage present between the panels. The measurement voltage signal may be, for example one spectral component of the voltage present between the panels and the layer. The other components of the voltage need not be the same.

An embodiment of the data processing device in accordance with the invention is characterized in that the first and the third panel are provided on oppositely situated faces of a substrate. The substrate may be, for example a glass plate. This can be readily implemented and offers a suitable mechanical transfer of the touch force from the touch surface to the third panel.

An embodiment of the data processing device in accordance with the invention is characterized in that the second and the third panel are substantially rigidly arranged relative to one another, the force sensor being suitable to apply to the second and the third panel the same measurement voltage signal relative to the first panel. This reduces disturbances of the measurement of the touch force which are caused by currents to the second panel and which may occur notably when the second panel is situated substantially near an outer side of the device.

The edges of the touch screen can in principle be mechanically fixed relative to the second panel. The touch force then becomes manifest as a difference in bending of the touch screen and the conductive layer. A simple and rugged force sensor can thus be realised. However, it may be that in that case the sensitivity of the force sensor is too low when the screen is touched near the edge. The sensitivity may also be too low when use is made of a touch screen of low flexibility.

An embodiment of the data processing device in accordance with the invention is characterized in that the touch screen and the second panel are resiliently connected to one another. The touch screen can thus move as a whole relative to the second panel and the described sensitivity problems will not occur.

An embodiment of the data processing device in accordance with the invention is characterized in that the touch screen is flexible, the force sensor being suitable to determine the touch force from the measured capacitance value under correction from a detected touch position. The degree of bending of a layer is dependent on the force exerted as well as on the position where force is exerted. When the edges of the layer are fixed, bending will increase as the force is exerted further from the edges. Quantitative force measurement requires correction for this effect. Preferably, the touch position as measured with the touch surface is used for this purpose.

An embodiment of the data processing device in accordance with the invention which comprises an image display face on which there are provided control electrodes for controlling an image pattern is characterized in that the control electrodes form part of the second and/or third panel. The force sensor can thus be combined with, for example a

Liquid Crystal Display (LCD) screen, without a separate second panel being required. The control electrodes of an LCD consist of a number of line electrodes. When used for the force sensor, all control electrodes carry substantially the same electric voltage difference relative to the other panels, at least as far as the measurement voltage signal is concerned (which signal need only be one component of the electric voltage between the panels as has already been stated). Evidently, the further voltage components on the line electrodes may contain different control voltages for the LCD.

An embodiment of the data processing device in accordance with the invention is characterized in that the force sensor is suitable to measure the capacitance value by means of an alternating voltage of a frequency between harmonics of a line frequency for controlling the control electrodes. The capacitance value can be simply measured by means of an alternating voltage. The use of an alternating voltage enables disturbances of the force measurement due to other signals, such as the line frequency of the display, to be prevented by selective faltering (for example, by means of synchronous demodulation). For a line frequency of 15.625 Hz, for example a measurement frequency of 22 kHz can be used.

The sources liable to disturb the force measurement, for example the line drive of the display interface or the display illumination (usually driven at frequencies beyond 25 kHz) are known in advance. In that case a suitable measurement frequency can also be chosen in advance.

An embodiment of the data processing device in accordance with the invention is characterized in that it is suitable to perform interference measurements for several frequencies of the alternating voltage, in the absence of detection of touching of the touch surface, and for selecting a comparatively low interference frequency for use upon measurement of the capacitance value. In that case a suitable measurement frequency can also be chosen in the event of unknown interference sources, for example display illumination of a non-specified frequency. The detection of touching can be realised, for example by means of the touch position sensor.

The measurement frequency can be selected for once and for all upon assembly or repeatedly during use. Moreover, in the absence of detection of touching, the capacitance value can be measured in the absence of an exerted force. This value then serves as a reference in calculating the force exerted from the capacitance value.

An embodiment of the data processing device in accordance with the invention is characterized in that the second or the third panel constitutes a system of conductor tracks for a magnetic stylus position sensor. The force sensor can thus be combined with the touch surface and a magnetic position sensor.

An embodiment of the data processing device in accordance with the invention, comprising an image display face and being suitable to generate, in response to touching, an image pattern in a location on the image display face which corresponds to the detected touch position, is characterized in that the device is suitable to enlarge the image pattern as the detected force is greater. For drawing lines the image pattern may be, for example a brush element such as a circle. This pattern remains when the touch position changes; the user can thus draw lines of variable thickness by moving the touch position across the screen while varying the force.

An embodiment of the data processing device in accordance with the invention is characterized in that the device is suitable to compare the detected force with several threshold values and to execute different operations in dependence on which threshold values are exceeded. The force can thus be used, for example for selecting icons or for implementing a "double click" function as the force is greater.

These and other aspects of the invention will be described in detail hereinafter with reference to Figures herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic side elevation of a liquid crystal display (LCD) provided with a touch screen.

FIG. **2** shows a configuration for voltage application and current measurement on a touch screen.

FIG. **3** is a diagrammatic cross-sectional view of a further assembly of a touch screen and an LCD.

FIG. **4** shows a further configuration for voltage application and current measurement on a touch screen.

FIG. **5** is a diagrammatic cross-sectional view of a further assembly of a touch screen and an LCD.

FIG. **6** shows an embodiment of a circuit for processing the measurement of the exerted force.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a diagrammatic side elevation of a liquid crystal display (LCD) provided with a touch screen. A number of components which are not essential to the invention have been omitted for the sake of clarity. The side elevation shows successively a transparent, conductive panel **10** (for example, of indium tin oxide, or ITO), a glass substrate **11**, and the LCD **14**. A first control electrode **15** and a second control electrode **17** of the LCD **14** are shown, a liquid crystal layer **16** being shown therebetween. The conductive panel **10** and the control electrodes **15**, **17** extend across substantially the entire surface of the LCD (perpendicularly to the plane of drawing). The glass substrate **11** and the LCD **14** are connected via resilient elements **12***a,b*, for example a rubber ring which extends along the entire circumference of the LCD **14** or along parts thereof.

During operation the panel **10** serves as a touch position sensor. Techniques for determining the touch position on a resistive, conductive layer are known per se. An example can be found in the cited U.S. Pat. No. 4,853,498 and also in the U.S. Pat. No. 4,293,734. In an embodiment a voltage is applied to the panel **10** by means of different electrodes (not shown) using these techniques. Under the influence of touching, this leads to a current flow through the panel **10**, for example via the capacitance between the panel **10** and a touching finger and subsequently via the body of the person touching to ground. This results in measurable currents through the electrodes on the panel **10**. The position of touching can be calculated from the ratio of these currents.

By touching the panel **10**, a force can be exerted on the panel **10** (symbolized by an arrow **18** in the Figure). In the case of a freed position of the LCD **14**, this force **18** will lead to compression of the resilient elements **12***a,b* and hence to displacement (symbolized by an arrow **19**) of the panel **10** and the glass substrate **11** in the direction of the LCD **14**. If necessary, mechanical guides can be provided so that displacement is possible exclusively in the direction of the panel. The displacement **19** is proportional to the force exerted.

The panel **10** and the first control electrode **15** of the LCD constitute the plates of a capacitor. The capacitance value of this capacitor is dependent on the distance between the

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