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(71) **Applicant**: **NOKIA CORPORATION** [FI/FI]; Karakaari 7, FI-02610 Espoo (FI).

(72) **Inventor**: **LAITINEN, Mikko Ilmari**; Sentraalinkuja 7, FI-24800 Halikko (FI).

(74) **Agents**: **NOKIA CORPORATION** et al.; IPR Department, Jussi Jaatinen, Karakaari 7, FI-02610 Espoo (FI).

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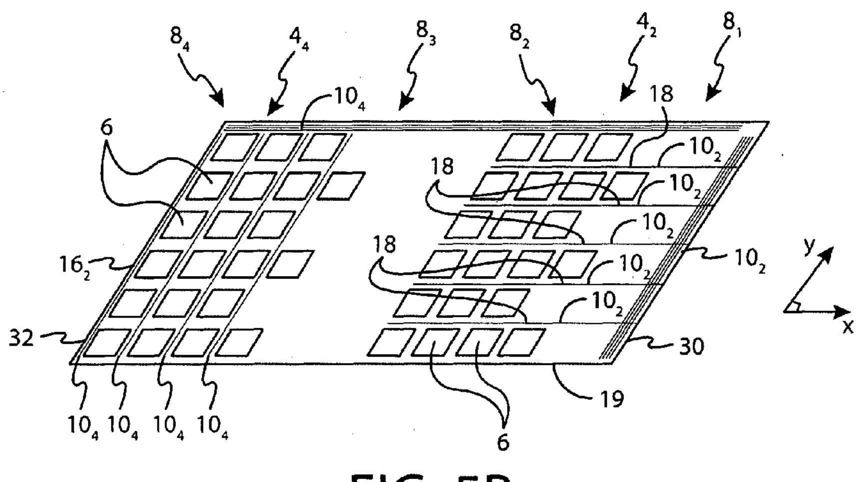

FIG. 5B

(57) **Abstract**: An apparatus comprising: a sensing arrangement comprising: a first array of capacitive sensor electrodes comprising a first plurality of distinct capacitive sensor electrodes distributed in a first layer over a first sensing area; first conductive traces operatively connected to the first plurality of distinct capacitive sensor electrodes; a second array of capacitive sensor electrodes comprising a second plurality of distinct capacitive sensor electrodes distributed in a second layer over a second sensing area, wherein the first layer and the second layer are different layers; and second conductive traces operatively connected to the second plurality of distinct capacitive sensor electrodes.

TITLE

TOUCH SENSOR ARRAY

TECHNOLOGICAL FIELD

Embodiments of the present invention relate to an apparatus. In particular, they relate to an apparatus comprising a plurality of capacitive sensor electrodes distributed over a sensing area.

BACKGROUND

Current touch sensitive displays may use a plurality of capacitive sensor electrodes distributed over a sensing area. The capacitive sensor electrodes sense a proximal grounded object such as a user's finger touching the sensing area.

BRIEF SUMMARY

According to various, but not necessarily all, embodiments of the invention there is provided an apparatus comprising: a sensing arrangement comprising: a first array of capacitive sensor electrodes comprising a first plurality of distinct capacitive sensor electrodes distributed in a first layer over a first sensing area ; first conductive traces operatively connected to the first plurality of distinct capacitive sensor electrodes; a second array of capacitive sensor electrodes comprising a second plurality of distinct capacitive sensor electrodes distributed in a second layer over a second sensing area, wherein the first layer and the second layer are different layers; and second conductive traces operatively connected to the second plurality of distinct capacitive sensor electrodes.

According to various, but not necessarily all, embodiments of the invention there is provided a method comprising: arranging capacitive sensor electrodes for touch sensing over a sensing area as a first sub-set of the capacitive sensor electrodes, distributed in a first layer over a first sub-set of the sensing area and as second sub-set of the capacitive sensor electrodes, distributed in second layer over a second sub-set of the sensing area; and
routing first conductive traces to the first sub-set of the capacitive sensor electrodes and second conductive traces to the second sub-set of the capacitive sensor electrodes.

According to various, but not necessarily all, embodiments of the invention there is provided apparatus and methods as defined in the appended claims.

BRIEF DESCRIPTION

For a better understanding of various examples of embodiments of the present invention reference will now be made by way of example only to the accompanying drawings in which:

Fig 1 illustrates an example of an apparatus comprising a sensing arrangement comprising a plurality of capacitive sensor electrodes distributed over a sensing area in at least two different layers;

Fig 2 illustrates an example of a sensing arrangement comprising

a plurality of capacitive sensor electrodes distributed over a sensing area in at least two different layers;

Fig 3 schematically illustrates an example of a cross-section through a sensing arrangement;

Figs 4A and 4B illustrate an example of layers of a sensing arrangement and the arrangement, according to a first embodiment, of capacitive sensor electrodes and conductive traces within the layers;

Fig 4C illustrates in more detail an example, according to the first embodiment, of a configuration of conductive traces operatively connected to capacitive sensor electrodes in a lower layer;

Figs 5A and 5B illustrate an example of layers of a sensing arrangement and the arrangement, according to a second embodiment, of capacitive sensor electrodes and conductive traces within the layers;

Fig 5C illustrates in more detail an example, according to the second embodiment, of a configuration of conductive traces operatively connected to capacitive sensor electrodes in a lower layer;

Figs 6A and 6B illustrate an example of layers of a sensing arrangement and the arrangement, according to a third embodiment, of capacitive sensor electrodes and conductive traces within the layers;

Fig 6C and 6D illustrates in more detail an example, according to the third embodiment, of the configurations of conductive traces operatively connected to capacitive sensor electrodes in a lower layer;

Fig 7 illustrates an example of a method;

Fig 8A illustrates an example of a touch panel module;

Fig 8B illustrates an example of a touch sensitive display module; and

Fig 8C illustrates an example of an electronic device.

DETAILED DESCRIPTION

The Figures illustrate an apparatus 2 comprising: a sensing arrangement 5 comprising: a first array 4_1 of capacitive sensor electrodes 6 comprising a first plurality N_1 of distinct capacitive sensor electrodes 6 distributed in a first layer 16_1 over a first sensing area 8_1; first conductive traces 10_1 operatively connected to the first plurality N_1 of distinct capacitive sensor electrodes 6;

a second array 4_2 of capacitive sensor electrodes 6 comprising a second plurality N_2 of distinct capacitive sensor electrodes 6 distributed in a second layer 16_2 over a second sensing area 8_2, wherein the first layer 16_1 and the second layer 16_2 are different layers; and second conductive traces 10_2 operatively connected to the second plurality N_2 of distinct capacitive sensor electrodes 6.

Fig 1 illustrates an apparatus 2 comprising: a sensing arrangement 5 comprising a plurality of capacitive sensor electrodes 6 distributed over a sensing area 8 and conductive traces 10 at least partially distributed over the sensing area 8.

In this example, the apparatus 2 overlies a display 40 and operates as a capacitive touch panel for the display 40. The display 40 and the apparatus 2 in combination form a touch sensitive display configured to detect a variation in capacitance arising from proximity of a user input device 42 to one or more of the plurality of capacitive sensor electrodes 6.

The sensing arrangement 5 is configured to sense a variation in capacitance arising from proximity of a user input device 42 at or over the sensing area 8 of a touch surface 7. In this example the user input device 42 is a user's finger.

The apparatus 2 is configured to sense the (x, y) position of the user's finger within the sensing area 8 when it touches the sensing area 8 of the touch surface 7. In some examples, the apparatus 2 may additionally provide a (z) position of the user's finger when it is close to but not touching the sensing area 8 of the touch surface 7 and/or provide an (x, y) position of the user's finger when it is close to but not yet touching the sensing area of the touch surface 7. The apparatus 2 may therefore provide for not only two-dimensional sensing but also three-dimensional sensing.

The apparatus 2 may optionally comprise a first shield electrode 12 overlying conductive traces 10 at least outside the sensing area 8; and a second shield electrode 20 underlying, in the sensing area 8, the conductive traces 10 and the capacitive sensor electrodes 6.

In this apparatus 2, the capacitive sensor electrodes 6 distributed over the sensing area 8 comprise multiple arrays 4_n of capacitive sensor electrodes 6, each array 4_n comprising a plurality N_n of distinct capacitive sensor electrodes 6. At least some of the multiple arrays 4_n of capacitive sensor electrodes 6 occupy different layers 16.

For example, as illustrated in Figs 4A, 4B, 5A, 5B, 6A, 6B, a first array 4_1 of capacitive sensor electrodes 6 comprising a first plurality N_1 of distinct capacitive sensor electrodes 6 is distributed in a first layer 16_1 over a first sensing area 8_1. A second array 4_2 of capacitive sensor electrodes 6 comprising a second plurality N_2 of distinct capacitive sensor electrodes 6 is distributed in a second layer 16_2 over a second sensing area 8_2. The first layer 16_1 and the second layer 16_2 are different layers.

First conductive traces 10_1 are operatively connected to the first plurality N_1 of distinct capacitive sensor electrodes 6 and second conductive traces 10_2 are operatively connected to the second plurality N_2 of distinct capacitive sensor electrodes 6.

The first array 4_1 of capacitive sensor electrodes 6 is configured to sense the (x, y) position of the user's finger within the first sensing area 8_1 when it touches the first sensing area 8_1 of the touch surface 7. In some examples, the apparatus 2 may additionally provide a (z) position of the user's finger when it is close to but not touching the first sensing area 8_1 of the touch surface 7 and/or provide an (x, y) position of the user's finger when it is close to but not yet touching the first sensing area 8_1 of the touch surface 7. The apparatus 2 may therefore provide for not only two-dimensional sensing but also three-dimensional sensing.

The second array 4_2 of capacitive sensor electrodes 6 is configured to sense the (x, y) position of the user's finger within the second sensing area 8_2 when it touches the second sensing area 8_2 of the touch surface 7. In some examples, the apparatus 2 may additionally provide a (z) position of the user's finger when it is close to but not touching the second sensing area 8_2 of the touch surface 7 and/or provide an (x, y) position of the user's finger when it is close to but not yet touching the second sensing area 8_2 of the touch surface 7. The apparatus 2 may therefore provide for not only two-dimensional sensing but also three-dimensional sensing.

Figs 4A and 4B illustrate a first array 4_1 of capacitive sensor electrodes 6 and a second array 4_2 of capacitive sensor electrodes 6, that occupy different layers 16 and are used in combination to detect touch input at or over the sensing area 8.

Fig 4A illustrates an example of a first array 4_1 of capacitive sensor electrodes 6 comprising a first plurality N_1 of distinct capacitive sensor electrodes 6 distributed in a first layer 16_1 over a first sensing area 8_1. First conductive traces 10_1 are operatively connected to the first plurality N_1 of distinct capacitive sensor electrodes 6.

Fig 4B illustrates an example of a second array 4_2 of capacitive sensor electrodes 6 comprising a second plurality N_2 of distinct capacitive sensor electrodes 6 distributed in a second layer 16_2 over a second sensing area 8_2. The first layer 16_1 and the second layer 16_2 are different layers. Second conductive traces 10_2 area operatively connected to the second plurality N_2 of distinct capacitive sensor electrodes 6.

The first sensing area 8_1 and the second sensing area 8_2 do not overlap.

Referring to Fig 4B, the second layer 16_2 underlies the first layer 16_1.

The first array 4_1 of capacitive sensor electrodes 6 is positioned proximal to a first edge 30 of the sensing arrangement 5 and the second array 4_2 of capacitive sensor electrodes 6 is positioned distal from the first edge 30 of the sensing arrangement 5.

The second conductive traces 10_2 are routed from the first edge 30 underneath the first array 4_1 of capacitive sensor electrodes 6 in the first layer 16_1 to the second array 4_2 of capacitive sensor electrodes 6 in the second layer 16_2. The second conductive traces 10_2 where they are routed underneath the first array 4_1 comprise conductive trace portions 18 that have a higher conductivity per unit length than the first conductive traces 10_1.

The higher conductivity conductive trace portions 18 may, for example, be wider than the first conductive traces 10_1 where they extend across an area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6.

Fig 4C illustrates in more detail an example, according to the first embodiment, of a configuration, in a lower layer 16_2, of second conductive traces 10_2 operatively connected to the second array 4_2 of capacitive sensor electrodes 6.

For clarity of illustration, only one row/column of the second array 4_2 of capacitive sensor electrodes 6 is explicitly illustrated and only some of the capacitive sensor electrodes 6 in that row/column are illustrated. Only the second conductive traces 10_2 operatively connected to the illustrated capacitive sensor electrodes 6 are explicitly illustrated.

In Fig 4C, the second conductive traces 10_2 where they are routed underneath the first array 4_1 of capacitive sensor electrodes 6 comprise wider portions 18 that have a higher conductivity per unit length than the first conductive traces 10_1. The higher conductivity conductive trace portions 18 are, in this example, wider than the first conductive traces 10_1 where they extend across the area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6. Bends in the second conductive traces 10_2 are used to route the higher conductivity portions 18 of the second conductive traces 10_2 underneath capacitive sensor electrodes 6 of the first array 4_1 of capacitive sensor electrodes 6

Figs 5A and 6A illustrate a first array 4_1 of capacitive sensor electrodes 6 and a third array 4_3 of capacitive sensor electrodes 6, that occupy the same layer 16_1 and are used in combination to detect touch input. Fig 5B and 6B illustrate a second array 4_2 of capacitive sensor electrodes 6 and a fourth array 4_4 of capacitive sensor electrodes 6, that occupy the same layer $16_{2.}$

The first array 4_1 of capacitive sensor electrodes 6, the third array 4_3 of capacitive sensor electrodes 6, the second array 4_2 of capacitive sensor electrodes 6 and the fourth array 4_4 of capacitive sensor electrodes 6 are used in combination to detect touch input in or over the sensing area 8.

The third array 4_3 of capacitive sensor electrodes 6 comprises a third plurality N_3 of distinct capacitive sensor electrodes 6 distributed in the first layer 16_1 over a third sensing area $8_{3..}$ Third conductive traces 10_3 are operatively connected to the third plurality N_3 of distinct capacitive sensor electrodes 6.

The fourth array 4_4 of capacitive sensor electrodes 6 comprises a fourth plurality N_4 of distinct capacitive sensor electrodes 6 distributed, in the second layer $16_{2,}$ over a fourth sensing area 8_4. Fourth conductive traces 10_4 are operatively connected to the fourth plurality N_4 of distinct capacitive sensor electrodes 6.

The first array 4_1 of capacitive sensor electrodes 6 is configured to sense at least two positional components (x, y) of a touch input that positions the touch input within the first sensing area 8_1. The second array 4_2 of capacitive sensor electrodes 6 configured to sense at least two positional components (x,y) of a touch input that positions the touch input within the second sensing area $8_{2.}$ The third array 4_3 of capacitive sensor electrodes 6 is configured to sense at least two positional components (x, y) of a touch input that positions the touch input within the third sensing area 8_3. The fourth array 4_4 of capacitive sensor electrodes 6 configured to sense at least two positional components (x,y) of a touch input that positions the touch input within the fourth sensing area 8_4.

The first sensing area 8_1, the second sensing area 8_2, the third sensing area 8_3 and the fourth sensing area 8_4 are non-overlapping or substantially non-overlapping.

Referring to Figs 5A and 5B, the first layer 16_1 and the second layer 16_2 may be integrated into a single apparatus 2. Referring to Figs 6A and 6B, the first layer 16_1 and the second layer 16_2 may be integrated into a single apparatus 2.

Referring to Figs 5A and 5B, the first array 4_1 is positioned adjacent a first edge 30 and the third array 4_3 is positioned distal from the first edge 30 and distal from a second edge 32 that opposes the first edge 30.

In this example, the first array 4_1 and the third array 4_3 have the same layout pattern of capacitive sensor electrodes 6, however the third array $4_3$is shifted in the first direction (x).

The first conductive traces 10_1 extend parallel to a first direction (x) from an edge 30 into the first sensing area 8_1. The first conductive traces 10_1 are separated in a second direction (y) (orthogonal to the x direction) so that the first conductive traces 10_1 are distributed over the first sensing area 8_1.

The third conductive traces 10_3 extend parallel to the first direction (x), from the first edge 30, along a side 34 orthogonal to the first edge 30 outside the sensing area 8. The third conductive traces 10_3 are grouped together along the side 34 and do not pass over but run beside the first sensing area 8_1.

The third conductive traces 10_3 then extend from the side 34 in the second direction (y) into the third sensing area 8_3.The third conductive traces 10_3 are separated in the first direction (x) so that the third conductive traces 10_3 are distributed over the third sensing area 8_3.

The second conductive traces 10_2 extend, from the first edge 30, parallel to the first direction (x) underneath the first sensing area 8_1 into the second sensing area 8_2. The second conductive traces 10_2 are separated in a second direction (y) so that the second conductive traces 10_2 are distributed over the first sensing area 8_1 and the second sensing area 8_2.

The second conductive traces 10_2 comprise conductive trace portions 18 that have a higher conductivity per unit length than the first conductive traces 10_1.

The higher conductivity conductive trace portions 18 may, for example, be wider than the first conductive traces 10_1 where they extend across an area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6.

Fig 5C illustrates in more detail an example, according to the second embodiment, of a configuration, in a lower layer 16_2, of second conductive traces 10_2 operatively connected to the second array 4_2 of capacitive sensor electrodes 6.

For clarity of illustration, only one row/column of the second array 4_2 of capacitive sensor electrodes 6 is explicitly illustrated and only some of the capacitive sensor electrodes 6 in that row/column are illustrated. Only the second conductive traces 10_2 operatively connected to the illustrated capacitive sensor electrodes 6 are explicitly illustrated.

In Fig 5C, the second conductive traces 10_2 where they are routed underneath the first array 4_1 of capacitive sensor electrodes 6 comprise wider portions 18 that have a higher conductivity per unit length than the first conductive traces 10_1. The higher conductivity conductive trace portions 18 are, in this example, wider than the first conductive traces 10_1 where they extend across the area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6. Bends in the second conductive traces 10_2 are used to route the higher conductivity portions 18 of the second conductive traces 10_2 underneath capacitive sensor electrodes 6 of the first array 4_1 of capacitive sensor electrodes 6

The fourth conductive traces 10_4 extend parallel to the first direction (x), from the first edge 30, along the side 34 orthogonal to the first edge 30 outside the sensing area 8. The fourth conductive traces 10_4 are grouped together along the side 34 and do not pass over, but pass beside, the first sensing area 8_1 and the second sensing area $8_{2.}$

The fourth conductive traces 10_4 then extend from the side 34 in the second direction (y) into the fourth sensing area 8_4.The fourth conductive traces 10_4 are separated in the first direction (x) so that the fourth conductive traces 10_4 are distributed over the fourth sensing area $8_{4.}$

Referring to Figs 6A and 6B, the first array 4_1 is positioned adjacent a first edge 30 and the third array 4_3 is positioned adjacent the second edge 32 that opposes the first edge 30.

In this example, the first array 4_1 and the third array 4_3 have the same layout pattern of capacitive sensor electrodes 6, however the third array 4_3 is rotated 180 degrees relative to the first array $4_{1.}$

The first array 4_1 of capacitive sensor electrodes 6 is positioned proximal to a first edge 30 of the sensing arrangement 5 and the second array 4_2 of capacitive sensor electrodes 6 is positioned distal from the first edge 30 and from the second edge 32 of the sensing arrangement 5.

The third array 4_3 of capacitive sensor electrodes 6 is positioned proximal to a second edge 32 of the sensing arrangement 5 and the fourth array 4_4 of capacitive sensor electrodes 6 is positioned distal from the first edge 30 and from the second edge 32 of the sensing arrangement 5.

The first conductive traces 10_1 extend parallel to a first direction (x) from the edge 30 into the first sensing area 8_1. The first conductive traces 10_1 are separated in a second direction (y) (orthogonal to the x direction) so that the first conductive traces 10_1 are distributed over the first sensing area 8_1.

The third conductive traces 10_3 extend parallel to a first direction (x) from the second edge 32 into the third sensing area 8_3. The third conductive traces 10_3 are separated in a second direction (y) (orthogonal to the x direction) so that the third conductive traces 10_3 are distributed over the third sensing area 8_3.

The second conductive traces 10_2 extend, from the first edge 30, parallel to the first direction underneath the first sensing area 8_1 into the second sensing area 8_2. The second conductive traces 10_2 are separated in a second direction (y) so that the second conductive traces 10_2 are distributed over the first sensing area 8_1 and the second sensing area 8_2.

The second conductive traces 10_2 comprise conductive trace portions 18 that have a higher conductivity per unit length than the first conductive traces 10_1.

The higher conductivity conductive trace portions 18 may, for example, be wider than the first conductive traces 10_1 where they extend across an area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6.

The fourth conductive traces 10_4 extend, from the second edge 32, parallel to the first direction underneath the third sensing area 8_3 into the fourth sensing area 8_4. The fourth conductive traces 10_4 are separated in a second direction (y) so that the second conductive traces 10_2 are distributed over the third sensing area 8_3 and the fourth sensing area 8_4.

The fourth conductive traces 10_4 comprise conductive trace portions 18 that have a higher conductivity per unit length than the third conductive traces 10_3.

The higher conductivity conductive trace portions 18 may, for example, be wider than the third (or first) conductive traces 10_3 where they extend across an area 19' overlapping the third array 4_3 of capacitive sensor electrodes 6.

In this example, the second conductive traces 10_2 are routed 18 underneath the first array 4_1 of capacitive sensor electrodes 6 and thus extend across an area overlapping the first array 4_1 of capacitive sensor electrodes 6. The fourth conductive traces 10_4 are routed 18 underneath the third array 4_3 of capacitive sensor electrodes 6 and thus extend across an area 19' overlapping the third array 4_3 of capacitive sensor electrodes 6.

Fig 6C illustrates in more detail an example, according to the third embodiment, of a configuration, in a lower layer 16_2, of second conductive traces 10_2 operatively connected to the second array 4_2 of capacitive sensor electrodes 6.

For clarity of illustration, only one row/column of the second array 4_2 of capacitive sensor electrodes 6 is explicitly illustrated and only some of the capacitive sensor electrodes 6 in that row/column are illustrated. Only the second conductive traces 10_2 operatively connected to the illustrated capacitive sensor electrodes 6 are explicitly illustrated.

In Fig 6C, the second conductive traces 10_2 where they are routed underneath the first array 4_1 of capacitive sensor electrodes 6 comprise wider portions 18 that have a higher conductivity per unit length than the conductive traces in the first layer 16_1. The higher conductivity conductive trace portions 18 are, in this example, wider than the first conductive traces 10_1 where they extend across the area 19 overlapping the first array 4_1 of capacitive sensor electrodes 6. Bends in the second conductive traces 10_2 are used to route the higher conductivity portions 18 of the second conductive traces 10_2 underneath capacitive sensor electrodes 6 of the first array 4_1 of capacitive sensor electrodes 6

Fig 6D illustrates in more detail an example, according to the third embodiment, of a configuration, in a lower layer 16_2, of fourth conductive traces 10_4 operatively connected to the fourth array 4_4 of capacitive sensor electrodes 6.

For clarity of illustration, only one row/column of the fourth array 4_4 of capacitive sensor electrodes 6 is explicitly illustrated and only some of the capacitive sensor electrodes 6 in that row/column are illustrated. Only the fourth conductive traces 10_4 operatively connected to the illustrated capacitive sensor electrodes 6 are explicitly illustrated.

In Fig 6D, the fourth conductive traces 10_4 where they are routed underneath the third array 4_3 of capacitive sensor electrodes 6 comprise wider portions 18' that have a higher conductivity per unit length than the conductive traces in the first layer 16_1. The higher conductivity conductive trace portions 18' are, in this example, wider than the third conductive traces 10_3 where they extend across the area 19' overlapping the third array 4_3 of capacitive sensor electrodes 6. Bends in the fourth conductive traces 10_4 are used to route the higher conductivity portions 18' of the fourth conductive traces 10_4 underneath capacitive sensor electrodes 6 of the third array 4_3 of capacitive sensor electrodes 6.

Referring back to Figs 1 and 2, the apparatus 2 may comprises a second shield electrode 20 underlying, in the sensing area 8, the conductive traces 10 and the capacitive sensor electrodes 6.

The second shield electrode 20 may be a continuous uninterrupted single layer electrode that underlies the first and second layers 16_1 , 16_2.

Alternatively, the second shield electrode 20 may comprise electrodes that underlie the arrays of capacitive sensor electrodes 6 in the first layer 16_1 and may comprise electrodes, in a different layer, that underlie the arrays of capacitive sensor electrodes 6 in the second layer 16_2 That is the second shield electrode 20 may be a multi-layer electrode (occupying multiple layers) or a single layer electrode (occupying a single layer).

The first shield electrode 12 may be used to cover the conductive traces where they group, outside the sensing area 8, at the first and second edges 30, 32 and at the side 34. The first shield electrode 12 may be used to cover areas that lies outside the sensing area 8.

The conductive traces 10, the capacitive sensor electrodes 6 and the second shield electrode 20 overlie, in this example, a display 40. As they overlie a display 40 they are preferably transparent.

The first shield electrode 12, the conductive traces 10, the capacitive sensor electrodes 6 and the second shield electrode 20 may therefore be formed from conductive and transparent material. They may be formed from the same or similar material or mixtures of material. Examples of suitable conductive and transparent materials include, for example, Indium-Tin-Oxide (ITO) , metal mesh, silver nanowires and carbon nanotube composite.

In the above examples, the arrays 4 of capacitive sensor electrodes 6 are each arranged as a regular array and in combination form an array of capacitive sensor electrodes 6 that is an N row by M column regular array, with common fixed spacing between columns and common fixed spacing between rows. However, it should be appreciated that the arrays 4 of capacitive sensor electrodes 6 need not be regular arrays and may be any suitable distribution of capacitive sensor electrodes 6.

In the illustrated examples, each capacitive sensor electrode 6 has an associated conductive trace 10_n for conveying a signal generated by that capacitive sensor electrode 6 away from the sensor area 8. In the illustrated example, each capacitive sensor electrode 6 and its associated conductive trace 10_n is physically connected. The capacitive sensor electrodes 6 and the associated conductive traces 10_n may be arranged within a common plane 16_m. They may, for example, be formed by patterning a planar layer of transparent conductive material.

Fig 3 schematically illustrates a cross-section through the sensing arrangement 5 along a line corresponding to a capacitive sensor electrode 6.

The first shield electrode 12 is operatively connected to a node 22. Operatively connected means that there is a signal path but they may or may not be directly physically connected. When the apparatus 2 is operational the node 22 is held at a constant potential such as, for example, ground potential. Circuitry 24 is configured to provide a reference voltage signal to the first shield electrode 12. The circuitry 24 could be a simple galvanic connection to ground provided by, for example, a housing, a ground plane or a chassis.

In this example, a second shield electrode 20 is present. It is also operatively connected to the node 22.

Detection circuitry 26 is operatively connected between the first shield electrode 12 and the array 4 of capacitive sensor electrodes 6.

A multiplexer 28 is operatively connected between the detection circuitry 26 and the array 4 of capacitive sensor electrodes 6. The multiplexer 28 is configured to isolate, for detection, each of the plurality of capacitive sensor electrodes 6 of the array 4.

Drive circuitry 29 is configured to provide an alternating voltage to the first shield electrode 12 and, if present, the second shield electrode 20.

The drive circuitry 29 is configured to provide a time varying electric field at each of the capacitive sensor electrodes 6.

The detection circuitry 26 is configured to detect a variation in capacitance arising from proximity of a user input device 42 to one or more of the plurality of capacitive sensor electrodes 6. The detection circuitry 26 may comprise a low-impedance charge amplifier.

When the user's hand, or some other grounded user input device 42, is brought to the vicinity of the sensing area 8 of the apparatus 2, a capacitive current flows from the first shield electrode 12 through the detection circuitry 26 to one or more capacitive sensor electrodes 6. The charge amplifier in the detection circuitry 26 registers a charge displacement due to the current. The output of the charge amplifier is synchronously rectified and integrated, after which it is passed to an analog-to-digital converter and then provided as digital output 27 for processing in the digital domain.

The drive voltage and the drive frequency typically range from 1 V to 10 V and from 10 to 200 kHz, respectively.

Due to reasons of cost and size, a single charge amplifier and a single analog-to-digital converter may be used in the detection circuitry 26 for multiple capacitive sensor electrodes 6 and a multiplexer 28 may be used to isolate for sensing each capacitive sensor electrode 6 separately.

Fig 7 illustrates an example of a method 100.

At block 102, the method 100 comprises arranging capacitive sensor electrodes 6 for touch sensing over a sensing area 8 as 102A a first sub-set 4_1 of the capacitive sensor electrodes 6, distributed in a first layer

16_1 over a first sub-set 8_1 of the sensing area 8 and as 102B a second sub-set 4_2 of the capacitive sensor electrodes 6, distributed in a second layer 16_2 over a second sub-set 8_2 of the sensing area 8.

Referring back to the previous examples described, the first sub-set 4_1 of the capacitive sensor electrodes 6 correspond to the first array 4_1 of the capacitive sensor electrodes 6. The second sub-set 4_2 of the capacitive sensor electrodes 6 corresponds to the second array 4_2 of the capacitive sensor electrodes 6. The first sub-set 8_1 of the sensing area 8 corresponds to the first sensing area $8_{1.}$ The second sub-set 8_2 of the sensing area 8 corresponds to the second sensing area $8_{2.}$

At block 104 the method 100 comprises routing first conductive traces 10_1 to the first sub-set 4_1 of the capacitive sensor electrodes 6 and second conductive traces 10_2 to the second sub-set 4_2 of the capacitive sensor electrodes 6.

As described above, the second conductive traces 10_2 may be routed under the first sub-set 8_1 of the sensing area 8 to reach the second sub-set 8_2 of the sensing area 8.

More highly conductive (e.g. wider) traces 18 may be used for the second conductive traces 10_2 under the first sub-set 8_1 of the sensing area 8 than for the first conductive traces 10_1 (see Figs 4C, 5C, 6C, 6D for examples). This keeps the electrical resistance of the second conductive traces 10_2 small to reduce resistance-capacitance (RC) delays and improve measurement speed.

Additional sub-sets 4_n of the capacitive sensor electrodes 6, may be distributed in a layer 16_m over a nth sub-set 8_n of the sensing area 8. Conductive traces 10_n may be routed to the sub-set 4_n of the capacitive sensor electrodes 6. The conductive traces 10_n may be routed underneath other sub-sets $4_{n'}$ of the capacitive sensor electrodes 6 in an overlying layer $16_{m'}$. Referring back to the previous examples described, the nth sub-set 4_1 of the capacitive sensor electrodes 6 correspond to the third array 4_3 of the capacitive sensor electrodes 6 distributed in the first layer 16_1 (n=3, m=1) and the fourth array 4_3 of the capacitive sensor electrodes 6 distributed in the second layer 16_2 (n=4, m=2). The conductive traces 10_4 are routed underneath the sub-sets 4_1 of the capacitive sensor electrodes 6 in the overlying layer 16_1 (n'=1, m'=1).

Dividing the capacitive sensor electrodes 6 into arrays 4 may allow different routing configurations of the conductive traces 10 to their respective capacitive sensor electrodes 6 (there is a one-to-one mapping between conductive traces 10 and capacitive sensor electrodes 6). In the illustrated examples, the capacitive sensor electrodes 10 in an array are distributed in two-dimensions and occupy a single layer, each Is associated with a particular (x, y) co-ordinate. There is therefore a significant number of conductive traces 10 required (one for each co-ordinate). Different arrays may receive their conductive traces from different edges.

Dividing the arrays 4 of capacitive sensor electrodes 6 into different layers allows different routing configurations of the conductive traces 10 to their respective capacitive sensor electrodes 6, as the routing in one layer is not necessarily constrained by the configuration of conductive traces 10 and capacitive sensor elements 6 in any other layer.
In the example of Figs 4A, 4B, 4C, 5A, 5B, 5C and 6A, 6B, 6C, 6D, the first layer 16_1 may be an upper layer or a lower layer compared to the second layer 16_2 .

Fig 8A illustrates the apparatus 2 embodied as a touch panel module 134 that comprises the sensing arrangement 5. The apparatus 2 is operable as a functional sensing arrangement 5 and, with additional components, as a functional display. The touch panel module 134 may be used in combination with a display 40 to form a touch screen display.

Fig 8B illustrates the apparatus 2 embodied as a touch panel module 136 that comprises the sensing arrangement 5 and a display 40. The apparatus 2 is operable as a functional sensing arrangement 5 and as a functional display.

Fig 8C illustrates the apparatus 2 embodied as an electronic device 140 that at least comprises the sensing arrangement 5 and a display 40. The apparatus 2 is operable as a functional display 40 and a functional sensing arrangement 5. The electronic device 38 may, for example, additionally comprise a processor 138 that processes the output 27 of the detection circuitry 26.

As used here 'module' refers to a unit or apparatus that excludes certain parts/components that would be added by an end manufacturer or a user.

In this document reference to an area refers to a two-dimensional space defined by a plane of the x and y components of a touch input position. Reference to an area overlapping another area refers to an intersection of volumes produced by projecting the areas normal to that plane. If areas are overlapping the projected volumes intersect and if the areas do not overlap the projected volumes do not intersect. Reference to an area overlapping another area does not necessarily imply an ordering to layers or components, which may be described explicitly.

Operatively connected means connected in a manner that enables the required functionality (operation). Any number or combination of intervening elements can exist (including no intervening elements) between two items that are operatively connected..

Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

Features described in the preceding description may be used in combinations other than the combinations explicitly described.

Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

I/we claim:

CLAIMS

1. An apparatus comprising:

a sensing arrangement comprising:

a first array of capacitive sensor electrodes comprising a first plurality of distinct capacitive sensor electrodes distributed in a first layer over a first sensing area ;

first conductive traces operatively connected to the first plurality of distinct capacitive sensor electrodes;

a second array of capacitive sensor electrodes comprising a second plurality of distinct capacitive sensor electrodes distributed in a second layer over a second sensing area, wherein the first layer and the second layer are different layers; and

second conductive traces operatively connected to the second plurality of distinct capacitive sensor electrodes.

2. An apparatus as claimed in claim 1, wherein the second conductive traces comprise conductive traces that have a higher conductivity per unit length than the first conductive traces.

3. An apparatus as claimed in claim 1 or 2, wherein the second conductive traces comprise conductive traces that are wider than the first conductive traces.

4. An apparatus as claimed in any preceding claim, wherein at least some of the second conductive traces extend across an area overlapping the first array of capacitive sensors.

5. An apparatus as claimed in any preceding claim, wherein the second layer underlies the first layer.

6. An apparatus as claimed in any preceding claim, wherein the first array of capacitive sensor electrodes is positioned proximal to a first edge of the sensing arrangement and the second array of capacitive sensor electrodes is positioned distal from the first edge of the sensing arrangement.

7. An apparatus as claimed in any preceding claim, wherein the second conductive traces are routed underneath the first array of capacitive sensor electrodes.

8. An apparatus as claimed in claim 7, wherein the second conductive traces where they are routed underneath the first array of capacitive sensor electrodes are wider than the first conductive traces.

9. An apparatus as claimed in any preceding claim, wherein the first sensing area and the second sensing area comprise non-overlapping portions,

10. An apparatus as claimed in any preceding claim, wherein the first sensing area and the second sensing area are non-overlapping.

11. An apparatus as claimed in any preceding claim, wherein the first array of capacitive sensor electrodes is configured to sense at least two positional components of a touch input that positions the touch input within the first sensing area and wherein the second array of capacitive sensor electrodes configured to sense at least two positional components of a touch input that positions the touch input within the second sensing area.

12. An apparatus as claimed in any preceding claim, comprising a third array of capacitive sensor electrodes comprising a third plurality of distinct capacitive sensor electrodes distributed over a third sensing area; and
third conductive traces operatively connected to the third plurality of distinct capacitive sensor electrodes.

13. An apparatus as claimed in claim 12, wherein the third array of capacitive sensor electrodes comprising a third plurality of distinct capacitive sensor electrodes is distributed in the first layer over a the third sensing area.

14. An apparatus as claimed in claim 12 or 13, comprising: a fourth array of capacitive sensor electrodes comprising a fourth plurality of distinct capacitive sensor electrodes distributed, in the second layer over a fourth sensing area and fourth conductive traces operatively connected to the fourth plurality of distinct capacitive sensor electrodes.

15. An apparatus as claimed in any of claims 12 or 13, wherein the first array and the third array are positioned adjacent opposing first and second edges.

16. An apparatus as claimed in claim 15, wherein the first conductive traces extend parallel to a first direction from the first edge into the first sensing area and wherein the third conductive traces extend parallel to the first direction from the second edge into the third sensing area.

17. An apparatus as claimed in claim 15 or 16, wherein the second conductive traces extend, from the first edge, parallel to the first direction underneath the first sensing area into the second sensing area and wherein the fourth conductive traces extend, from the second edge, parallel to the first direction underneath the third sensing area into the second sensing area.

18. An apparatus as claimed in any of claims 12 or 13, wherein the first array is positioned adjacent a first edge and the third array is positioned distal from the first edge and from an opposing third edge.

19. An apparatus as claimed in claim 18, wherein the first conductive traces extend parallel to a first direction from an edge into the first sensing area and wherein the third conductive traces extend parallel to the first direction, from the first edge, along a side orthogonal to the first edge and from the side in a second direction, orthogonal to the first direction, into the third sensing area.

20. An apparatus as claimed in claim 18 or 19, wherein the second conductive traces extend, from the first edge, parallel to the first direction underneath the first sensing area into the second sensing area and wherein the fourth conductive traces extend, from the first edge, parallel to the first direction along a side orthogonal to the first edge and from the side parallel to the second direction, orthogonal to the first direction, into the fourth sensing area.

21. An apparatus as claimed in any preceding claim, comprising:
a first shield electrode overlying, in the sensing area, at least the conductive traces; and
a second shield electrode underlying, in the sensing area, the conductive traces and the capacitive sensor electrodes.

22. An apparatus as claimed in claim 21, comprising a common connection between first and second shield electrode.

23. An apparatus as claimed in any of claims 21 or 22, wherein the second shield electrode is a continuous uninterrupted electrode.

24. An apparatus as claimed in any of claims 21, 22 or 23, wherein the capacitive sensor electrodes, the conductive traces and the second shield electrode are transparent.

25. An apparatus as claimed in any of claims 21 to 24 comprising detection circuitry connected between the first shield electrode and the capacitive sensor electrodes.

26. An apparatus as claimed in claim 25 comprising a multiplexer connected between the detection circuitry and the capacitive sensor electrodes, wherein the multiplexer is configured to isolate, for detection, each of the plurality of capacitive sensor electrodes of the array.

27. An apparatus as claimed in claim 25 or 26, wherein the detection circuitry comprises a low-impedance charge amplifier.

28. An apparatus as claimed in any of claims 21 to 27, comprising circuitry configured to provide a reference voltage signal to the first shield electrode.

29. An apparatus as claimed in claim 28, wherein the circuitry is configured to provide an alternating voltage to the first shield electrode.

30. An apparatus as claimed in any of claims 21 to 29, comprising drive circuitry configured to provide a time varying electric field at each of the capacitive sensor electrodes and detection circuitry configured to

detect a variation in capacitance arising from proximity of a user input device to one or more of the plurality of capacitive sensor electrodes.

31. An apparatus as claimed in claim 30, wherein the detection circuitry is configured to detect a variation in capacitance arising from proximity of a user input device at or over a touch surface.

32. An apparatus as claimed in claim 30 or 31 wherein the user input device is a user finger.

33. An apparatus as claimed in any preceding claim embodied as a touch panel module.

34. An apparatus as claimed in any preceding claim embodied as a touch sensitive display module.

35. An apparatus as claimed in any preceding claim embodied as an electronic device.

36. A method comprising:
arranging capacitive sensor electrodes for touch sensing over a sensing area as a first sub-set of the capacitive sensor electrodes, distributed in a first layer over a first sub-set of the sensing area and as second sub-set of the capacitive sensor electrodes, distributed in second layer over a second sub-set of the sensing area; and
routing first conductive traces to the first sub-set of the capacitive sensor electrodes and second conductive traces to the second sub-set of the capacitive sensor electrodes.

37. A method as claimed in claim 36 comprising routing the second conductive traces under the first sub-set of the sensing area to reach the second sub-set of the sensing area.

38. A method as claimed in claim 36 or 37, comprising using wider traces for the second conductive traces under the first sub-set of the sensing area than for the first conductive traces.

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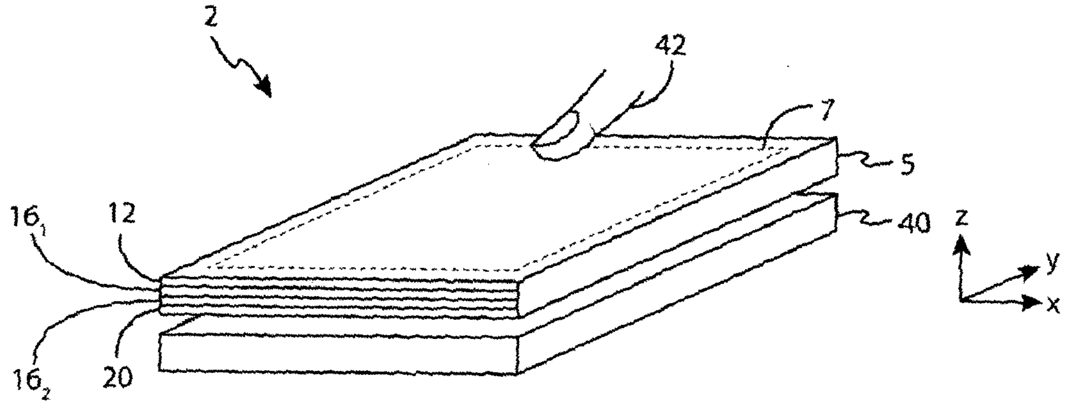

FIG. 1

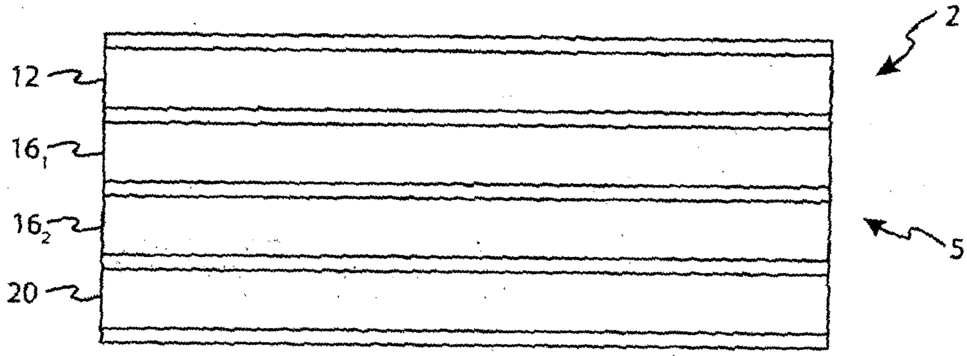

FIG. 2

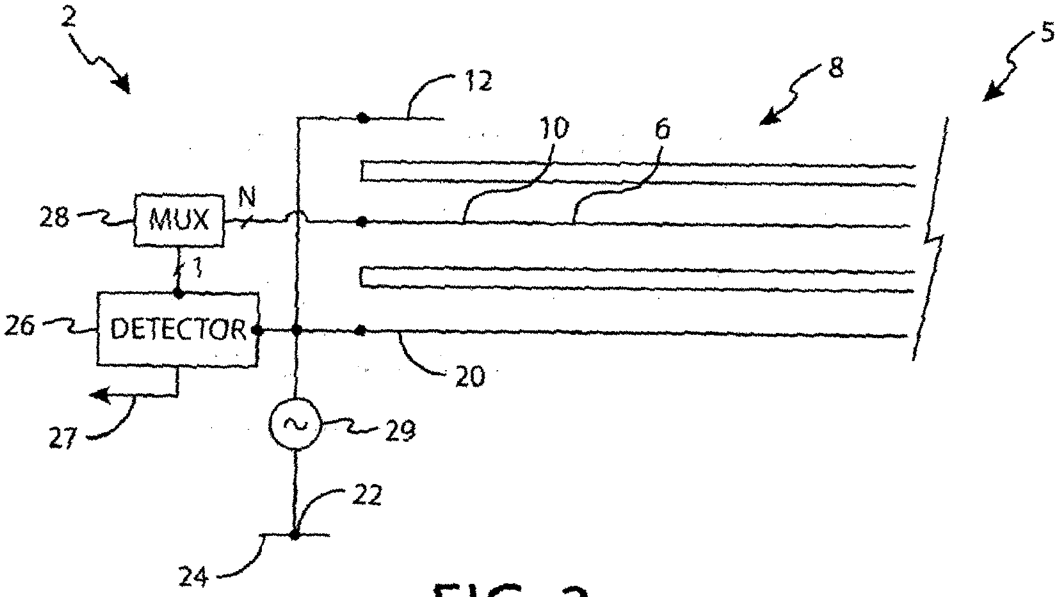

FIG. 3

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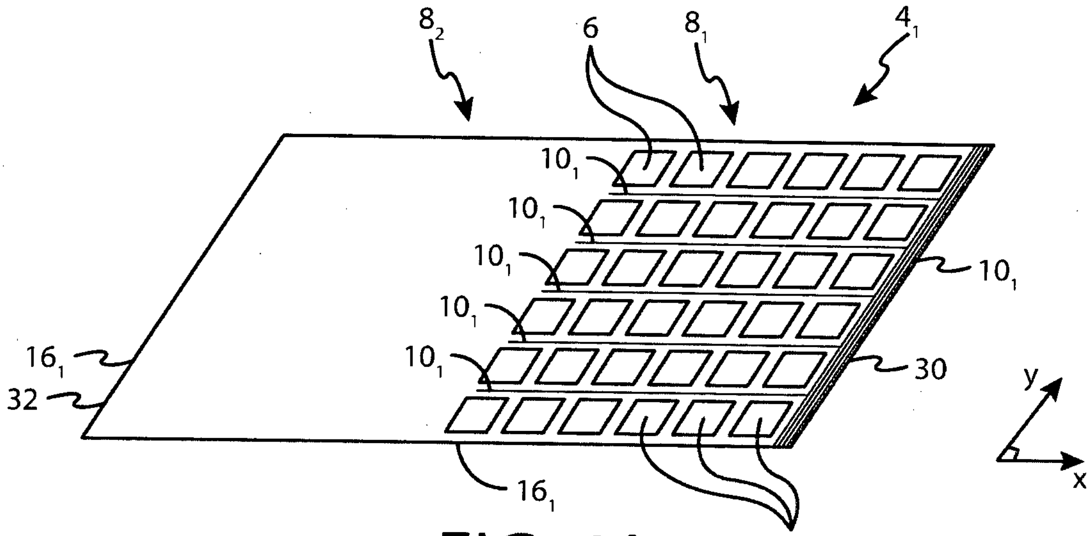

FIG. 4A

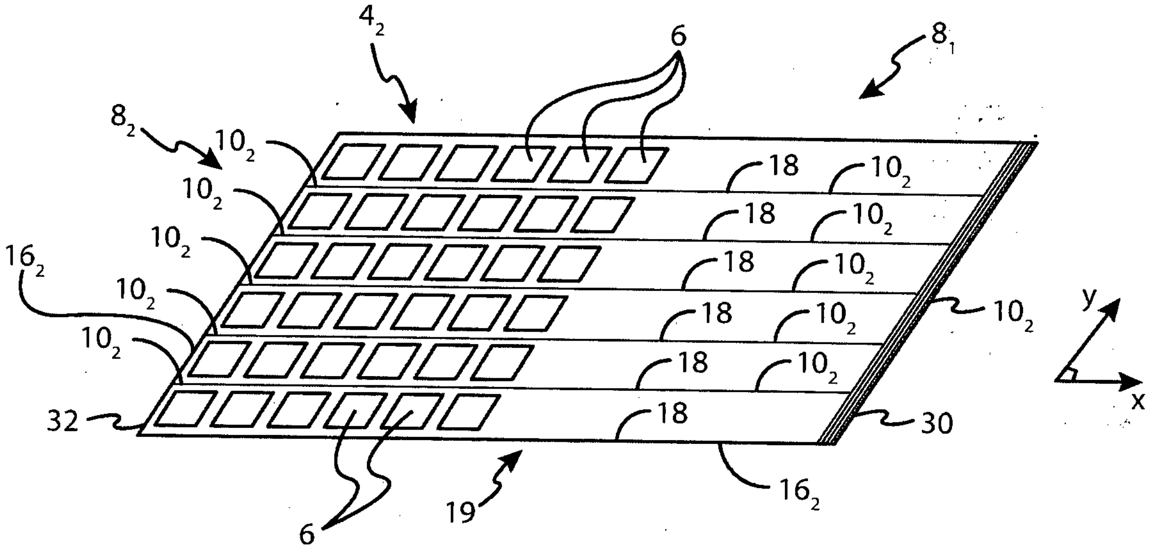

FIG. 4B

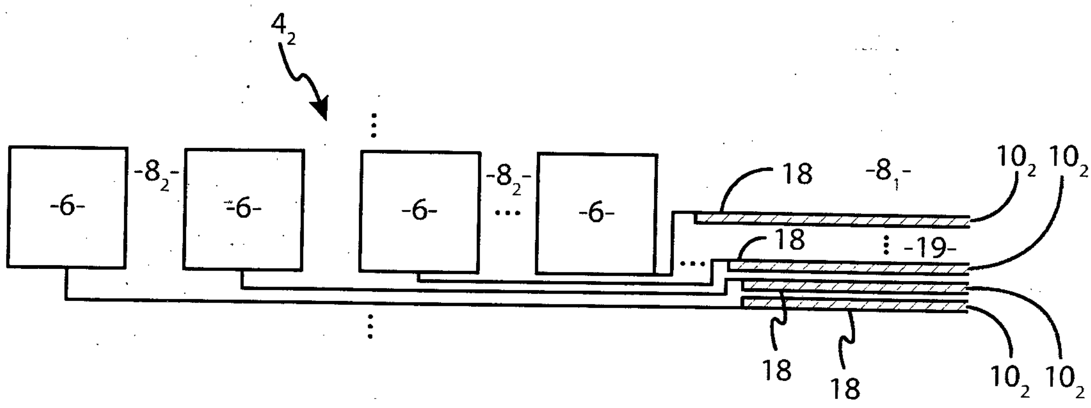

FIG. 4C

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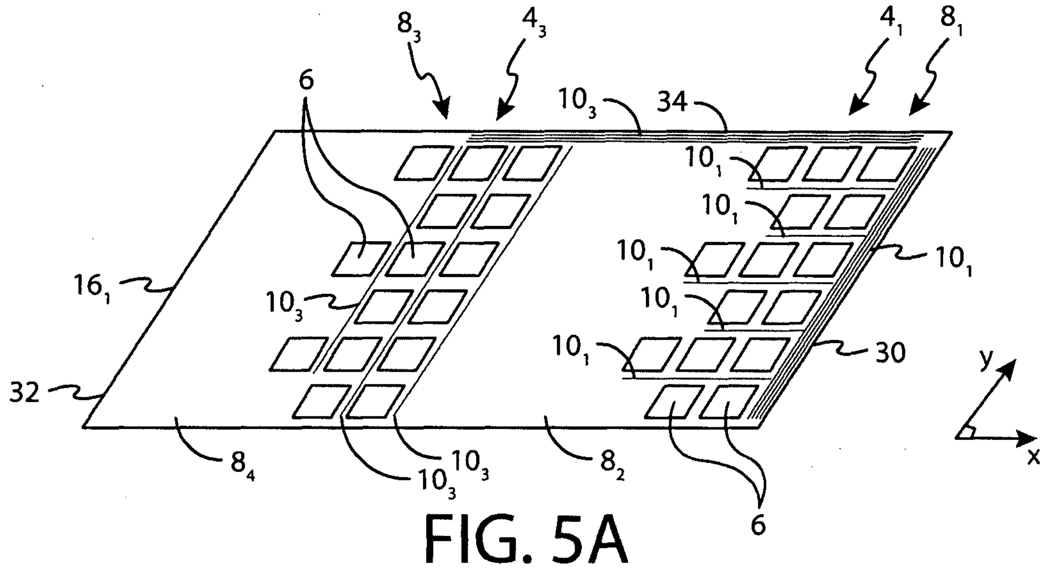

FIG. 5A

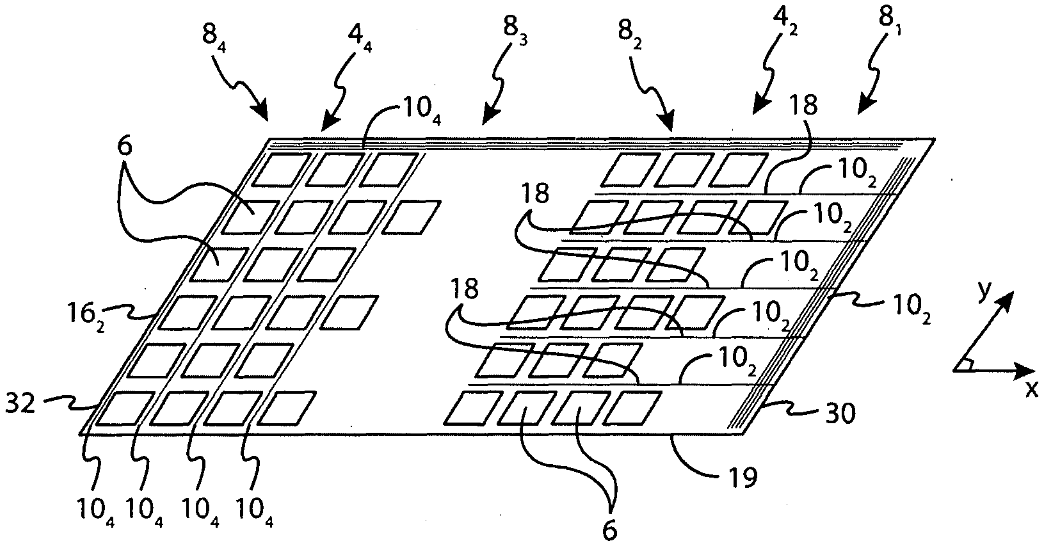

FIG. 5B

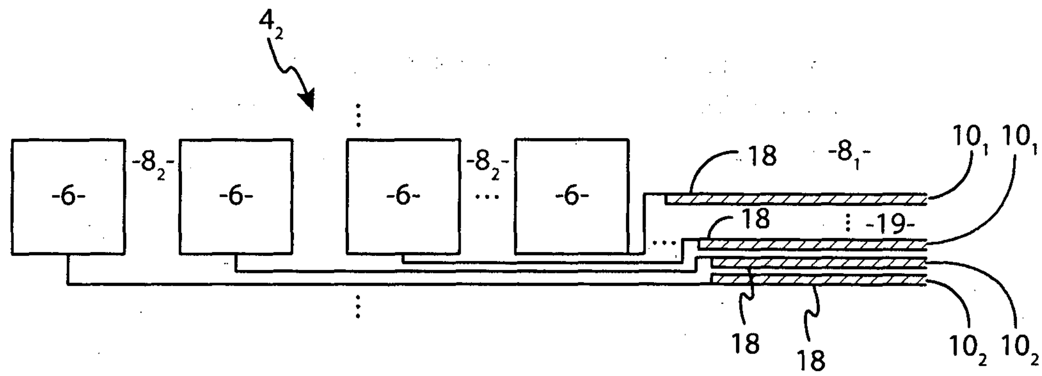

FIG. 5C

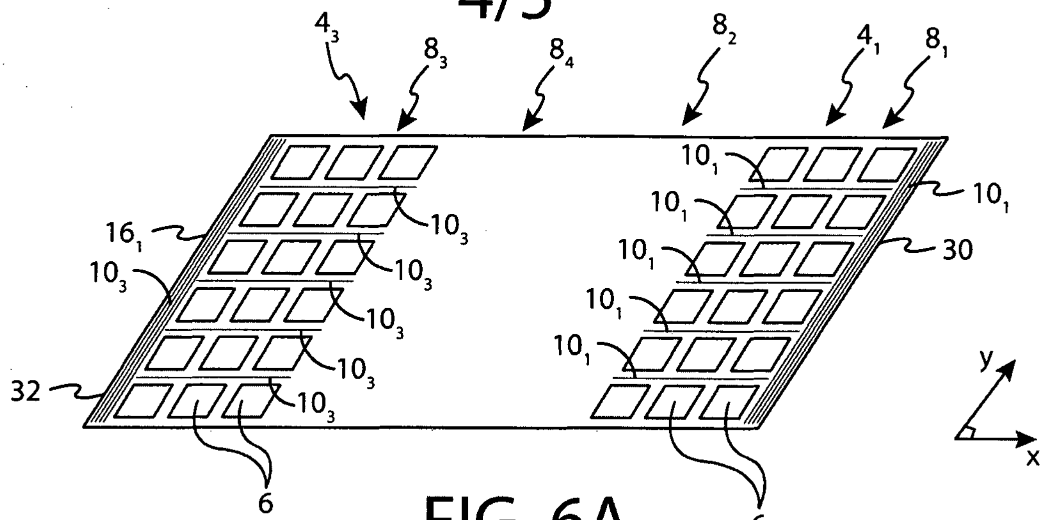

FIG. 6A

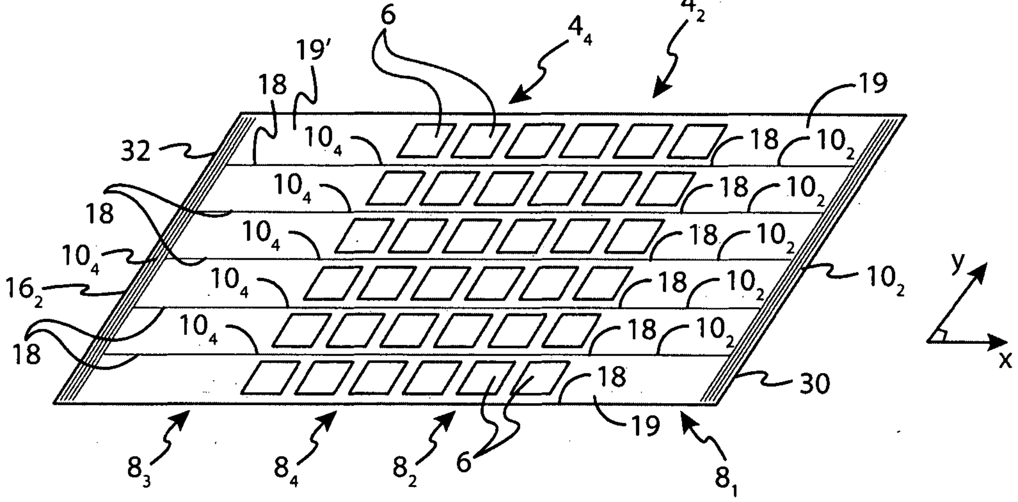

FIG. 6B

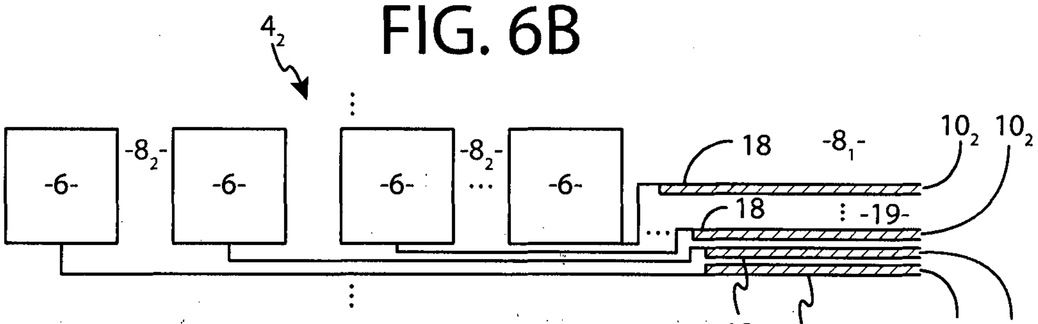

FIG. 6C

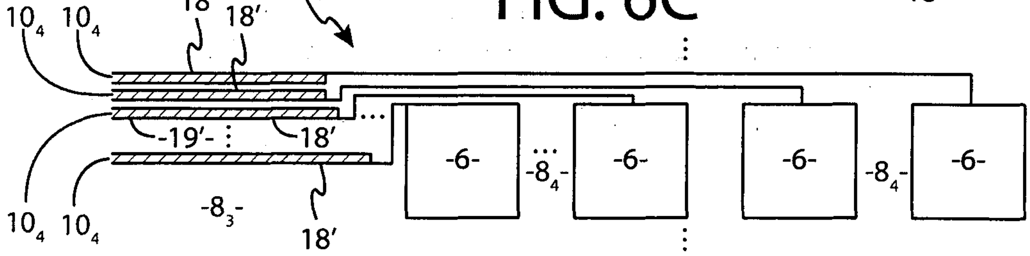

FIG. 6D

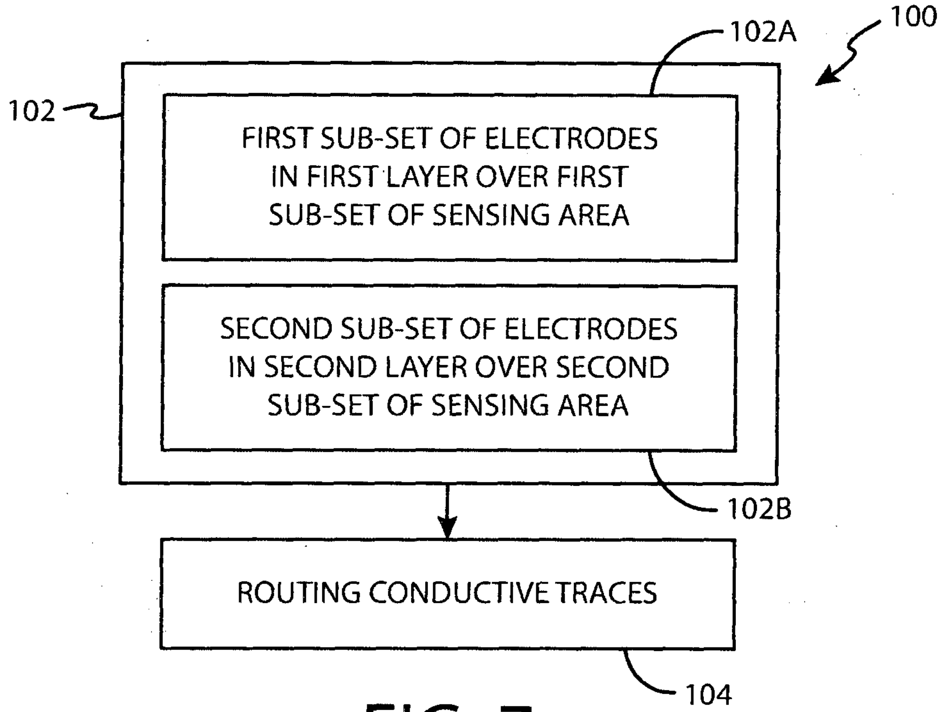

FIG. 7

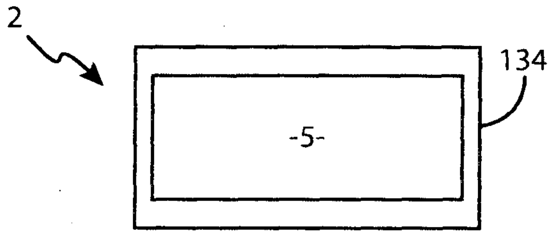

FIG. 8A

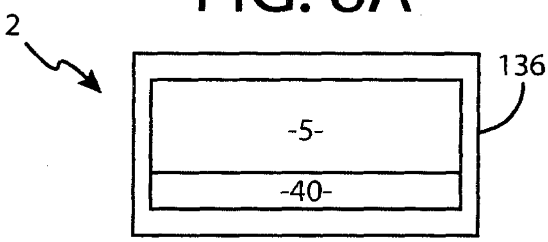

FIG. 8B

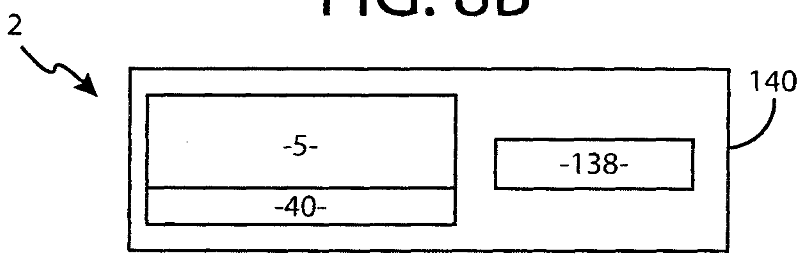

FIG. 8C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050512

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G06F, H03K, H01L, G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, COMPDX, INSPEC, TDB, NPL, Internet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009085891 A1 (YANG TUN-CHUN [TW] et al.) 02 April 2009 (02.04.2009) abstract; paragraphs [0034], [0037]-[0038], [0040]-[0042], [0051]; figures 3-11	1-38
X	US 2010123681 A1 (WU YUAN-CHUN [TW] et al.) 20 May 2010 (20.05.2010) abstract; paragraphs [0011], [0062], [0065]-[0066], [0070], [0074]; figures 3-4, 6, 8	1, 36
X	US 2009273570 A1 (DEGNER BRETT WILLIAM [US] et al.) 05 November 2009 (05.11.2009) abstract; paragraphs [0040], [0042], [0046]-[0047], [0050], [0052], [0063], [0072]; figures 3-8	1, 36

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 May 2014 (05.05.2014)	06 May 2014 (06.05.2014)

Name and mailing address of the ISA/FI
Finnish Patent and Registration Office
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Janne Viljas
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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