IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor	:	Daniel Skagmo
App. No.	:	Unknown
Filed	:	Herewith
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Unassigned
Art Unit	:	Unassigned

PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Preliminary to examination on the merits, please amend the above-identified U.S. application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 5 of this paper.

Amendments to the Drawings begin on page 8 of this paper. A "Replacement Sheet" for each sheet of drawings being amended can be found in the Appendix.

Remarks/Arguments begin on page 9 of this paper.

Replacement Drawing Sheets begin on page 11 of this paper.

Marked Substitute Specification begins on page 29 of this paper.

Clean Substitute Specification begins on page 62 of this paper.

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AMENDMENTS TO THE SPECIFICATION

Changes are shown below in highlighted form, where insertions appear as underlined text (e.g., insertions) while deletions appear as strikethrough text (e.g., ~~deletions~~) or double brackets (e.g., [[deletions]]). Both marked-up and clean versions of the substitute specification are included herewith.

Please amend paragraph 87 as follows:

[0087] Figures 15a, 15b, 15c, and 15d ~~to 15d are~~ show magnified cross-sectional views of the touch sensing apparatus according to different examples; and

Please amend paragraph 90 as follows:

[0090] Fig. 1a schematically illustrates a variant of an 'above surface optical touch system', as discussed in the Background Art section above, where the light from the emitters 301 travel above the touch surface 302 of the panel 305 via reflection on an edge reflector 303. Figure 1b illustrates a top plan view of figure 1a in an example of a touch-sensitive apparatus 100.

Please amend paragraph 97 as follows:

[0097] The substrate 106 may be fixed to a carrier 110 mounted around the perimeter 104 of the light transmissive panel 101, as schematically illustrated in Figs. 1a, 1b, and [[–]] 2. By directly joining the substrate 106 to the carrier 110 provided around the perimeter 104, the assembly of the touch sensing apparatus 100 may be further facilitated, as the amount of components can be kept at a minimum. For example, the substrate 106 can be accurately fixed in relation to the carrier 110, due to the small tolerances possible in the direction of the substrate 106 aligned in parallel with the normal axis 107 in Fig. [[1]]2, as discussed above. The carrier 110 may for example comprise a cavity 116, as discussed further below, being precisely dimensioned to accommodate the width of the substrate 106 along the direction 107', i.e. the short-side of the substrate 106. Then, accurate positioning of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 is possible as the carrier 110 is mounted around the perimeter 104 thereof. The carrier 110 may extend

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substantially in the direction 107' parallel with the normal axis 107, as with the substrate 107, to achieve a compact mounting around the perimeter 104. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

Please amend paragraph 99 as follows:

[0099] The carrier 110 may be arranged to at least partly enclose edges 111 of the light transmissive panel 101, as shown in the example of Fig. 2[[1]]. This provides for further increasing the robustness of the touch sensing apparatus 100, and improving the accuracy of the alignment of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 since the carrier 110, having the emitters and detectors 103, 103', fixed thereto, may also be directly supporting the light transmissive panel 101 around the perimeter 104. The carrier 110 may comprise a slot in which the light transmissive panel 101 is fitted around the perimeter 104.

Please amend paragraph 100 as follows:

[0100] The carrier 110 may comprise fixing elements 112 configured to attach the carrier 110 to a display unit 113, 121. The display unit may comprise a display support 121 and a display panel 113, which collectively is referred to as a display unit in the present disclosure. Having the carrier 110 attachable to the display unit 113, 121, by fixing elements 112, advantageously provides for further facilitating the assembly of the touch sensing apparatus 100 to a display unit, since the carrier 110 can be directly joined to the latter. Alignment is thus facilitated, due to the minimum amount of components needing such alignment to each other. The robustness of the touch sensing apparatus 100 is further improved, while mass production is made less complex due the minimized number of assembly steps. The fixing elements 112 may comprise any elements configured to provide for fixing of the position of the carrier 110 to the display unit 113, 121. In the example[[s]] shown in Fig.~~Figs.~~ [[1 -]] 2, the carrier 110 has openings 115, 115', 115", discussed further below, which may be aligned with corresponding openings 127 of a support of the display unit 121, through which mounting elements 114 may be positioned for the fixing. It is conceivable however that

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the carrier 110 has other types of recesses or protrusions which may interlock with a corresponding mating surface of the display unit 113, 121.

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AMENDMENTS TO THE CLAIMS

The following listing of claims replaces all prior versions thereof. Changes are shown below in highlighted form, where insertions appear as underlined text (e.g., insertions) while deletions appear as strikethrough text (e.g., ~~deletions~~) or double brackets (e.g., [[deletions]]).

1. – 5. (Canceled)

6. (NEW) A touch sensing apparatus, comprising:

a panel that defines a touch surface;

a plurality of light emitters and detectors arranged along a perimeter of the panel;

a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a receptacle; and

an optical element configured to be slidably fitted in the space between the panel and the first portion and seals the plurality of light emitters from contaminants from the touch surface, said optical element comprising a mating portion configured to engage with the receptacle of the first portion.

7. (NEW) The touch sensing apparatus according to claim 6, wherein the support structure further comprises a second portion configured to enable mounting of the plurality of emitters.

8. (NEW) The touch sensing apparatus according to claim 7, wherein the plurality of emitters are mounted on an electronics board that is supported by the second portion, said plurality of emitters configured to emit light above the touch surface.

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9. (NEW) The touch sensing apparatus according to claim 6, wherein the optical element is configured to slide in a direction parallel to a plane of the touch surface.

10. (NEW) The touch sensing apparatus according to claim 6, wherein the mating portion comprises a reference surface configured to engage with a reciprocal reference surface on the first portion.

11. (NEW) The touch sensing apparatus according to claim 10, wherein the reference surface comprises a first reference portion for aligning in a first direction and a second reference portion for aligning in a second direction.

12. (NEW) The touch sensing apparatus according to claim 10, wherein the reference surface is configured to align the optical element with respect to the first portion in a plane parallel with the touch surface.

13. (NEW) The touch sensing apparatus according to claim 6, wherein the optical element is configured to slide in a direction that is perpendicular to a plane of the touch surface.

14. (NEW) The touch sensing apparatus according to claim 6 wherein the mating portion comprises a resiliently deformable seal configured to engage with the receptacle.

15. (NEW) The touch sensing apparatus according to claim 14 wherein the resiliently deformable seal is extrudable along one or more surfaces of the optical element.

16. (NEW) The touch sensing apparatus according to claim 6 wherein the mounting portion substantially extends an entire length of the optical window.

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17. (NEW) The touch sensing apparatus according to claim 6, wherein the mating portion comprises a projection having a cross-sectional shape for positive engagement with a reciprocal hole of the receptacle.

18. (NEW) The touch sensing apparatus according to claim 6, wherein the mating portion comprises a resiliently deformable projection that is deformable on engagement with the receptacle and forms a snap-fit engagement therebetween.

19. (NEW) The touch sensing apparatus according to claim 6, wherein the optical element comprises a plurality of mating portions.

20. (NEW) The touch sensing apparatus according to claim 6, wherein the at mating portion comprises at least one discrete upstanding projection for engagement with a reciprocal hole in the receptacle.

21. (NEW) The touch sensing apparatus according to claim 20, wherein the at least one discrete upstanding projection is at least one or more of a peg, a hook, a latch, a clamp, or a fastener.

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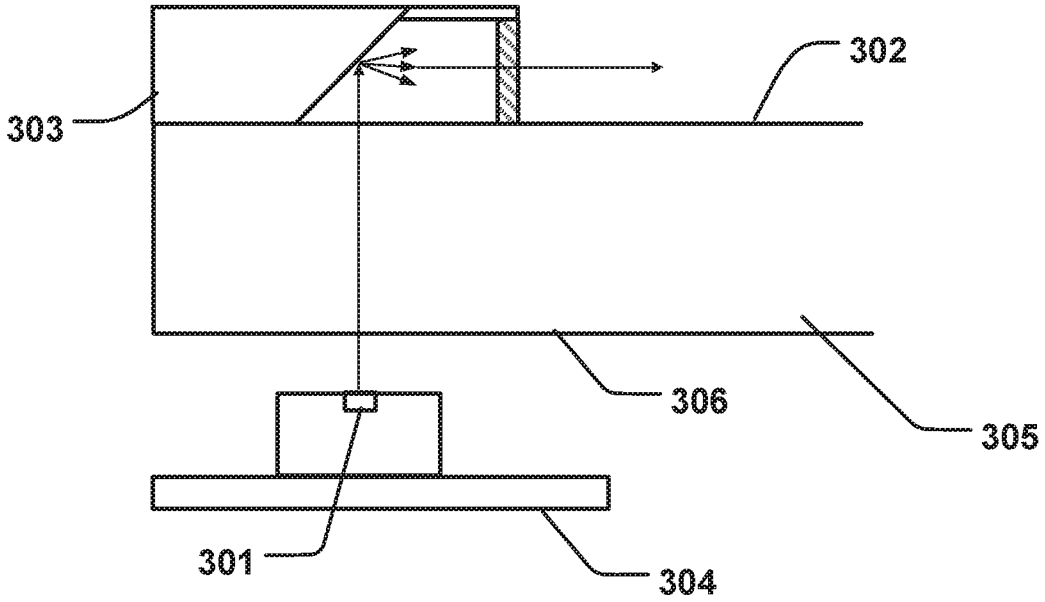


FIG. 1A

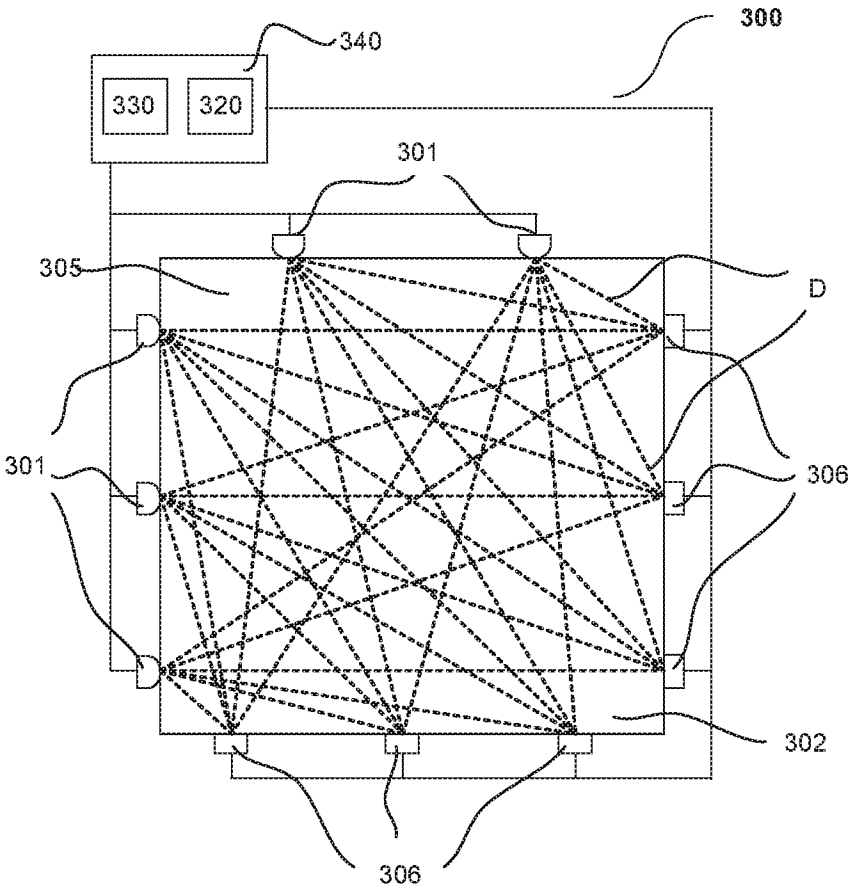


FIG. 1B

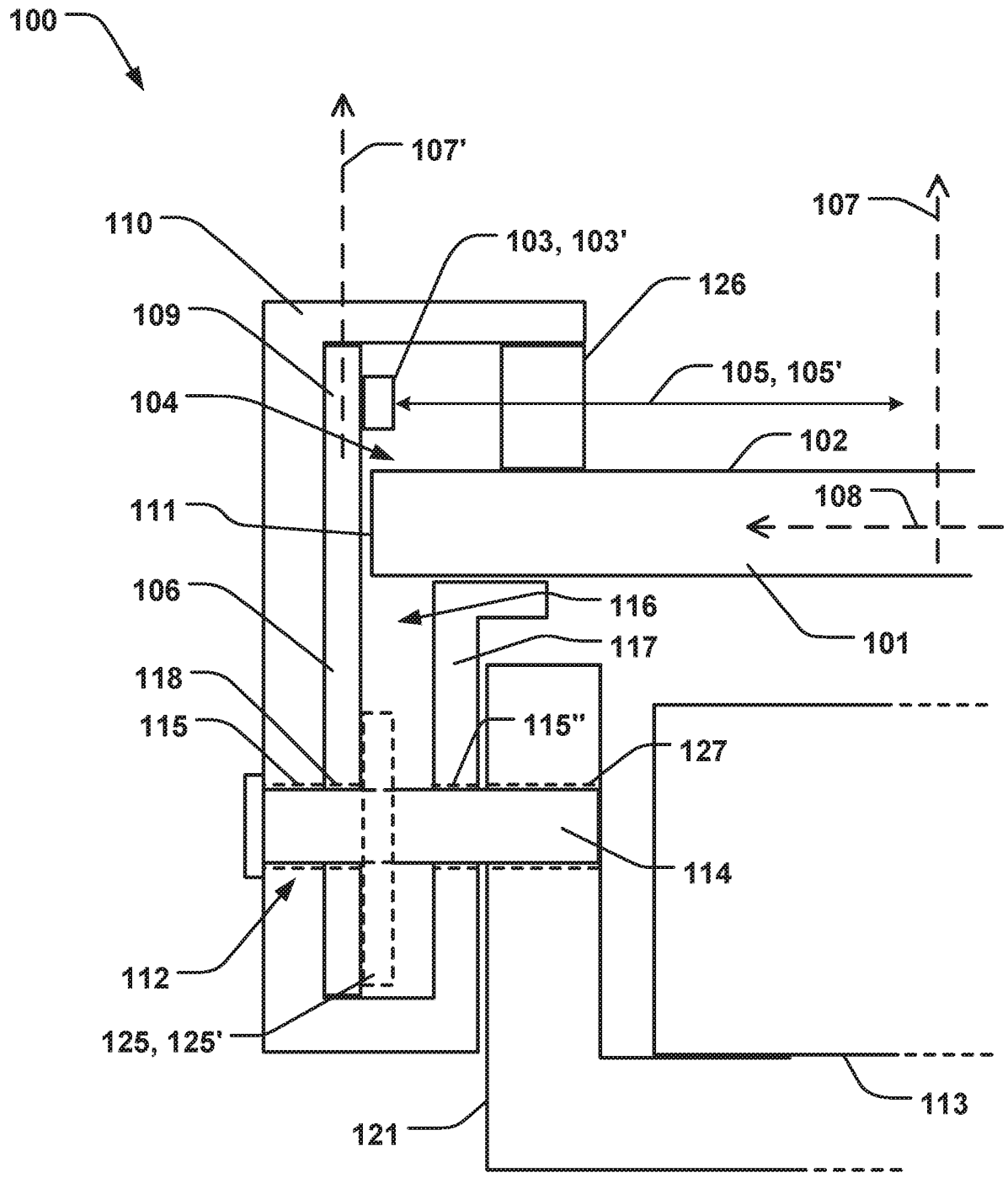

100
107'
107
110
103, 103'
126
109
105, 105'
104
102
108
111
106
116
117
101
118
115
115''
127
114
112
125, 125'
113
121

FIG. 2

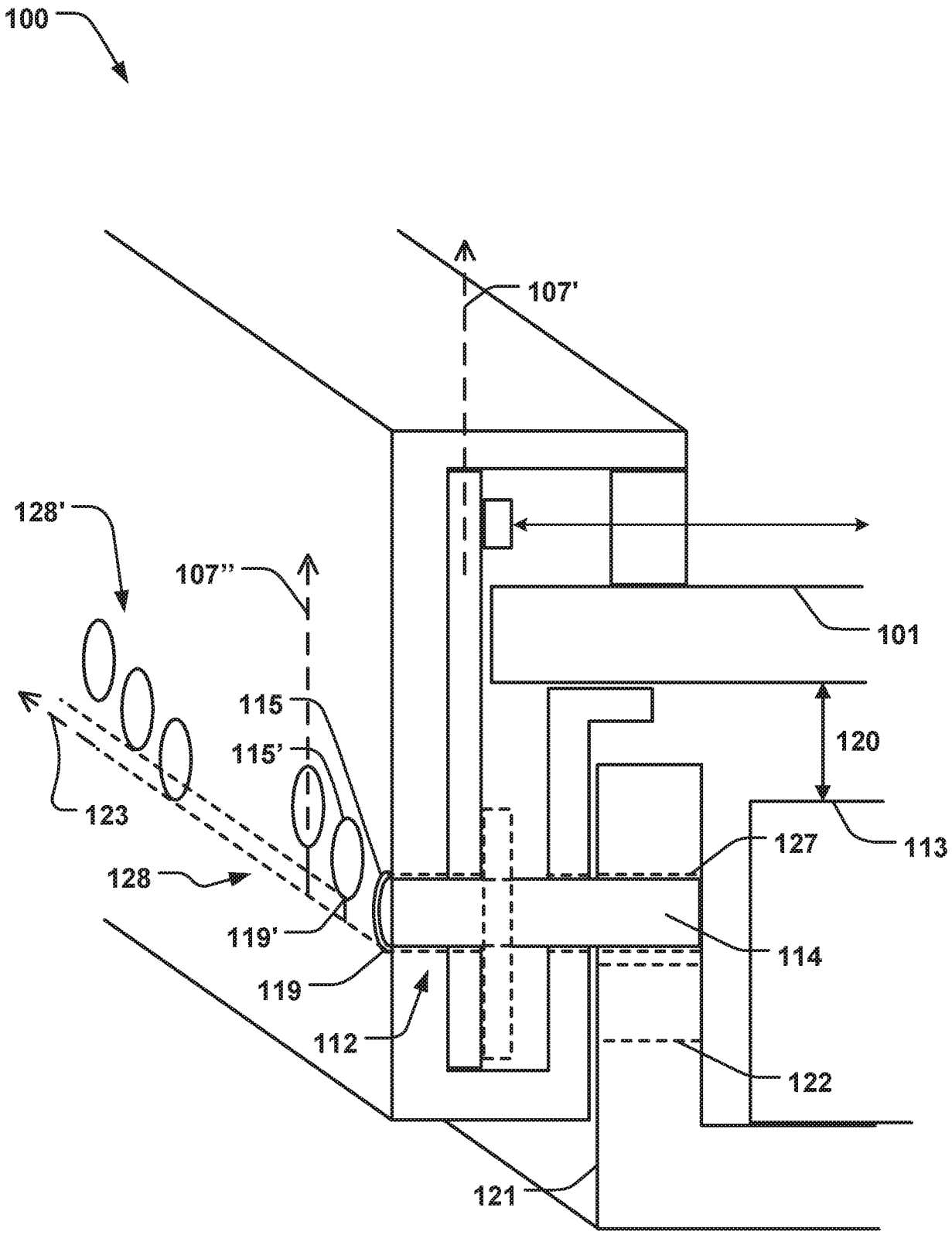

100
107'
128'
107''
101
115
115'
120
123
127
113
128
119'
114
119
112
122
121

FIG. 3

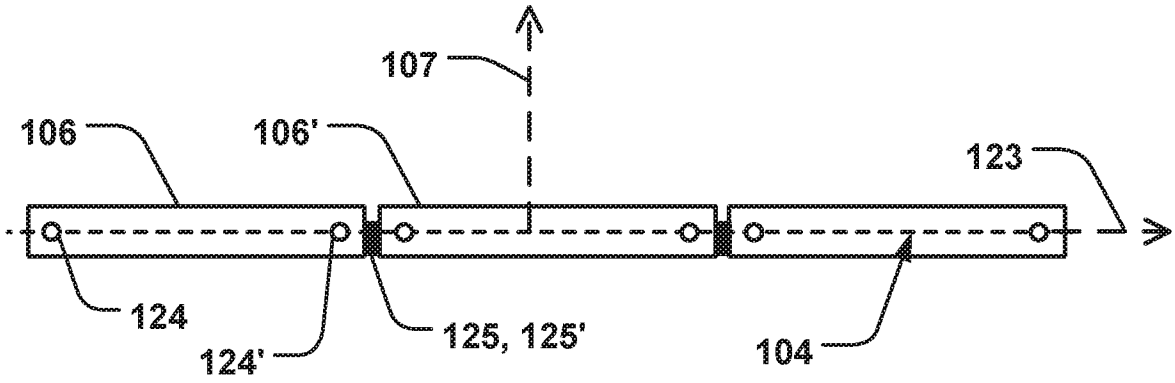


FIG. 4A

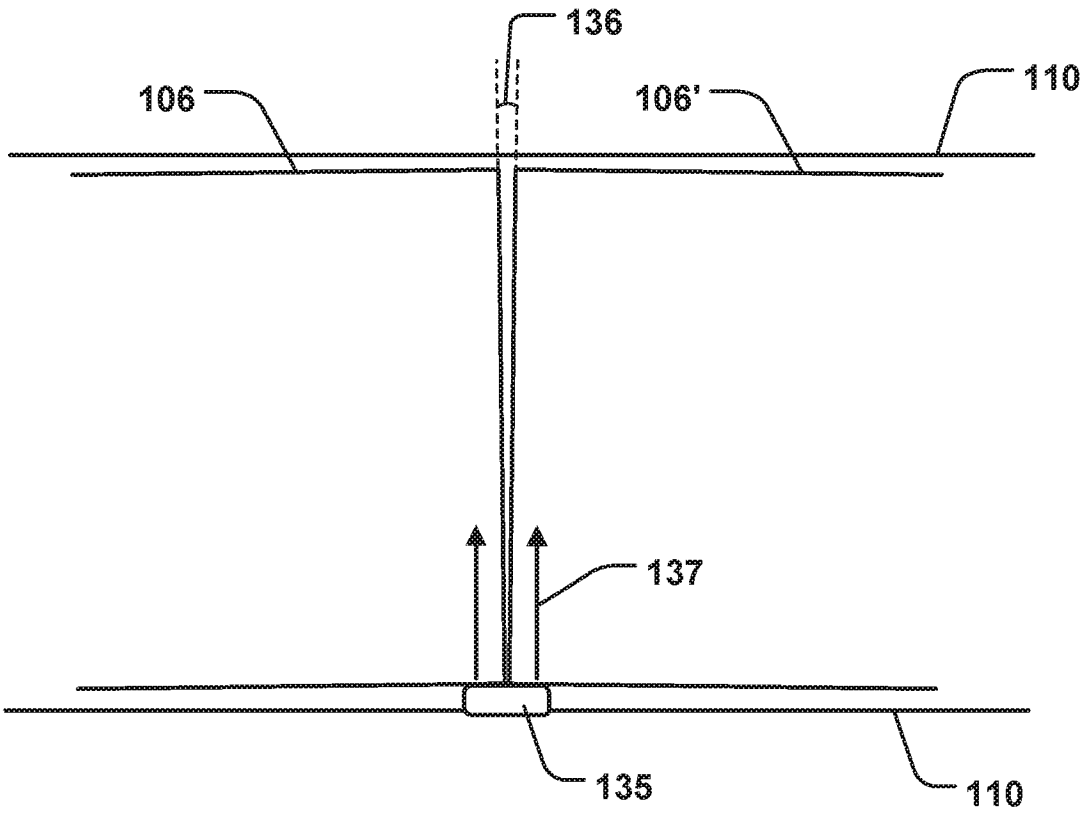


FIG. 4B

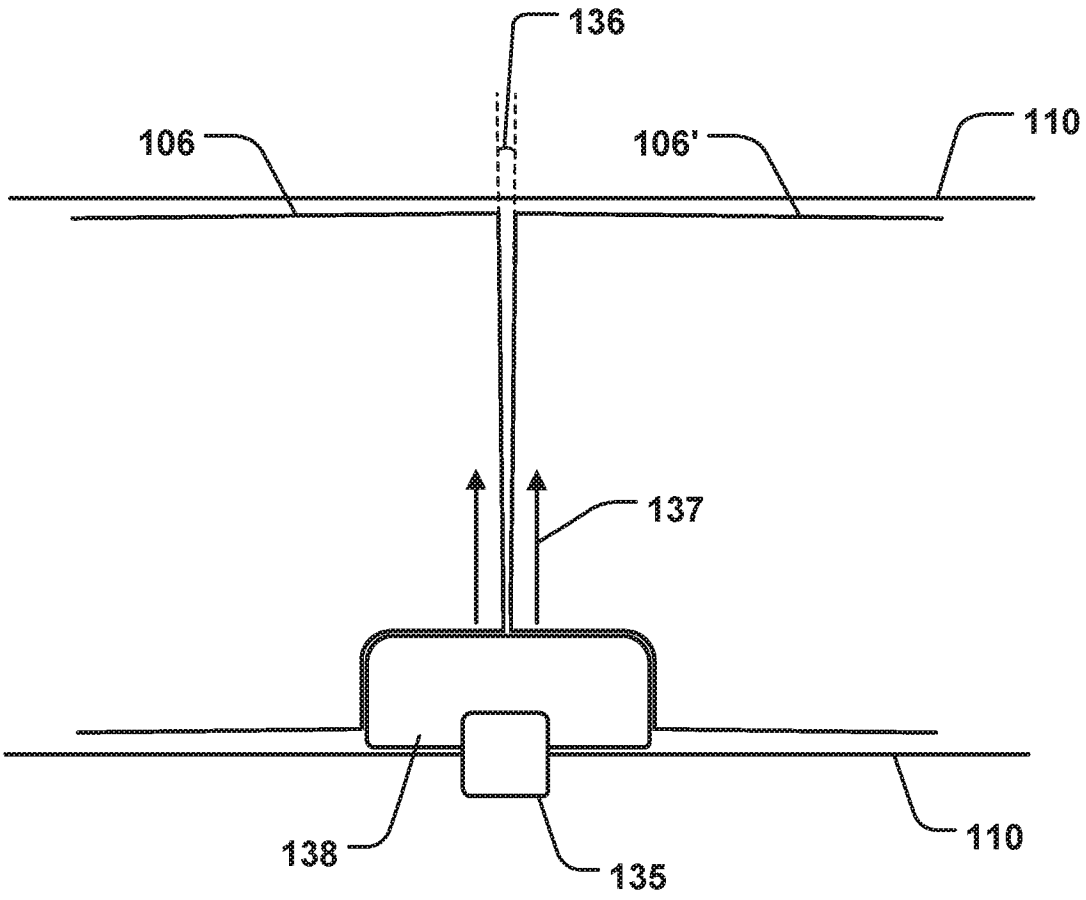


FIG. 4C

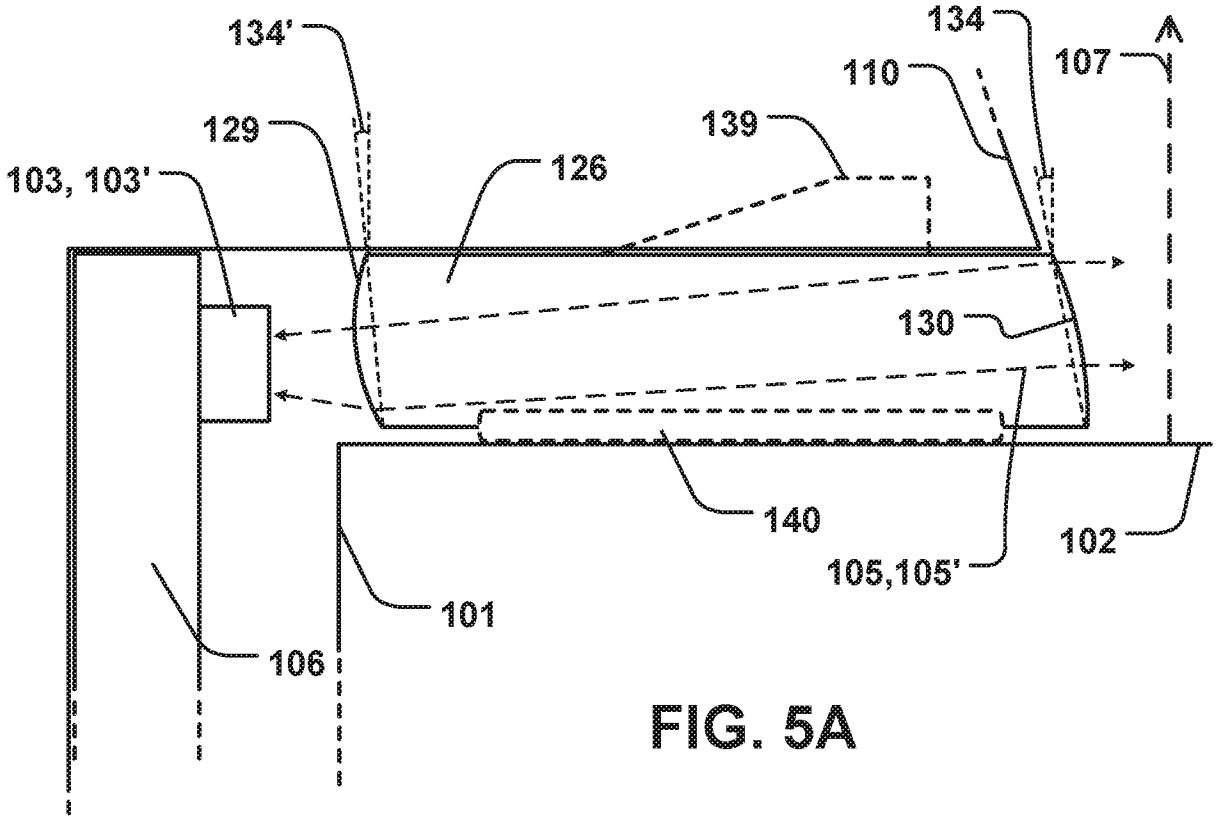

134'
134
107
110
129
139
126
103, 103'
130
140
102
105,105'
101
106

FIG. 5A

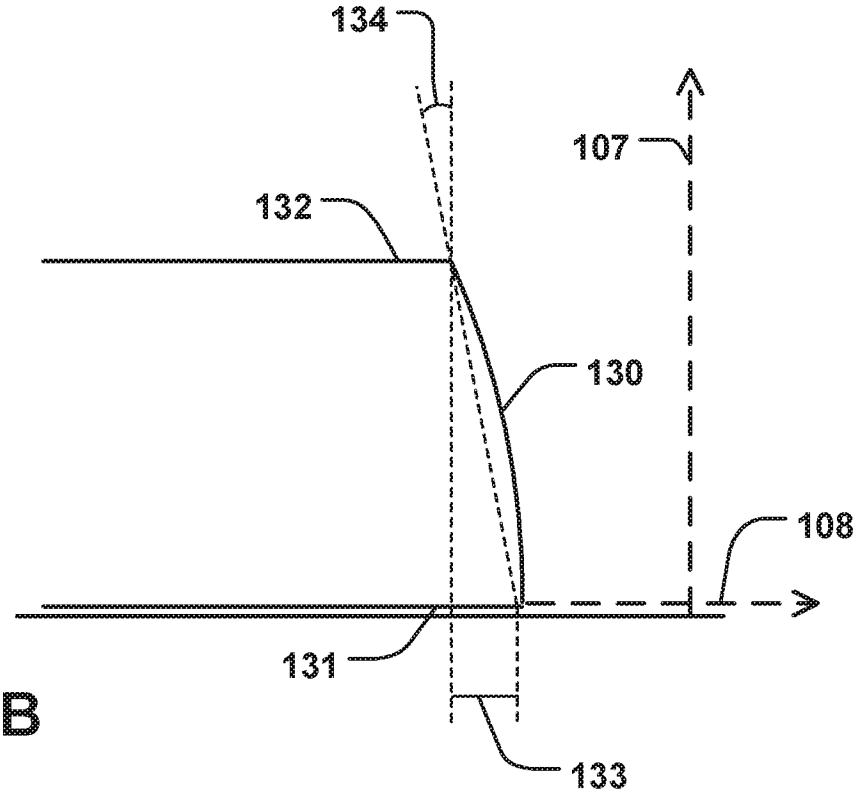

134
107
132
130
108
131
133

FIG. 5B

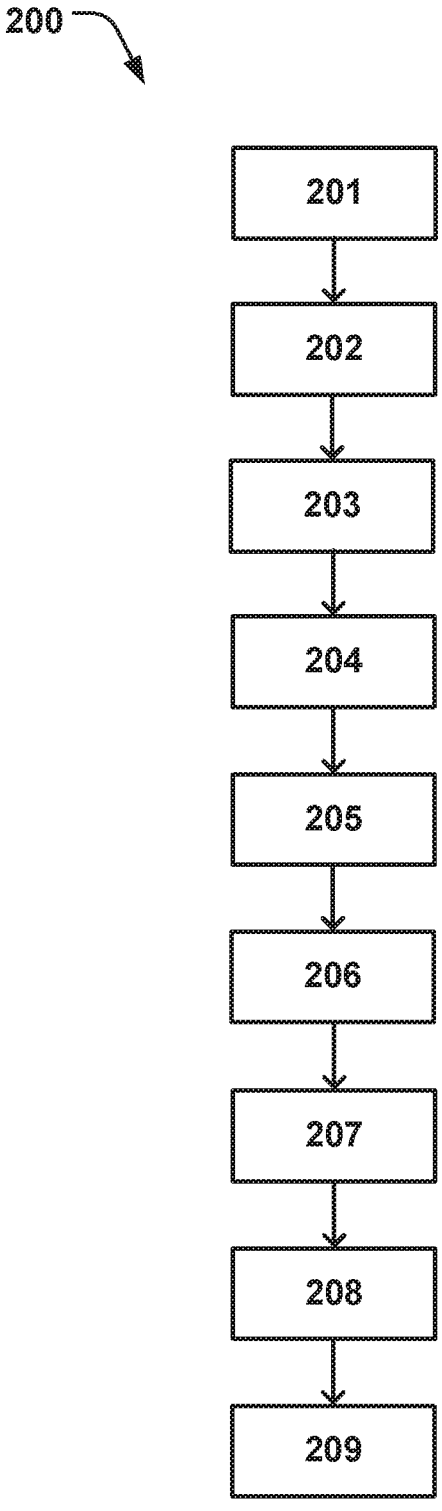


FIG. 6

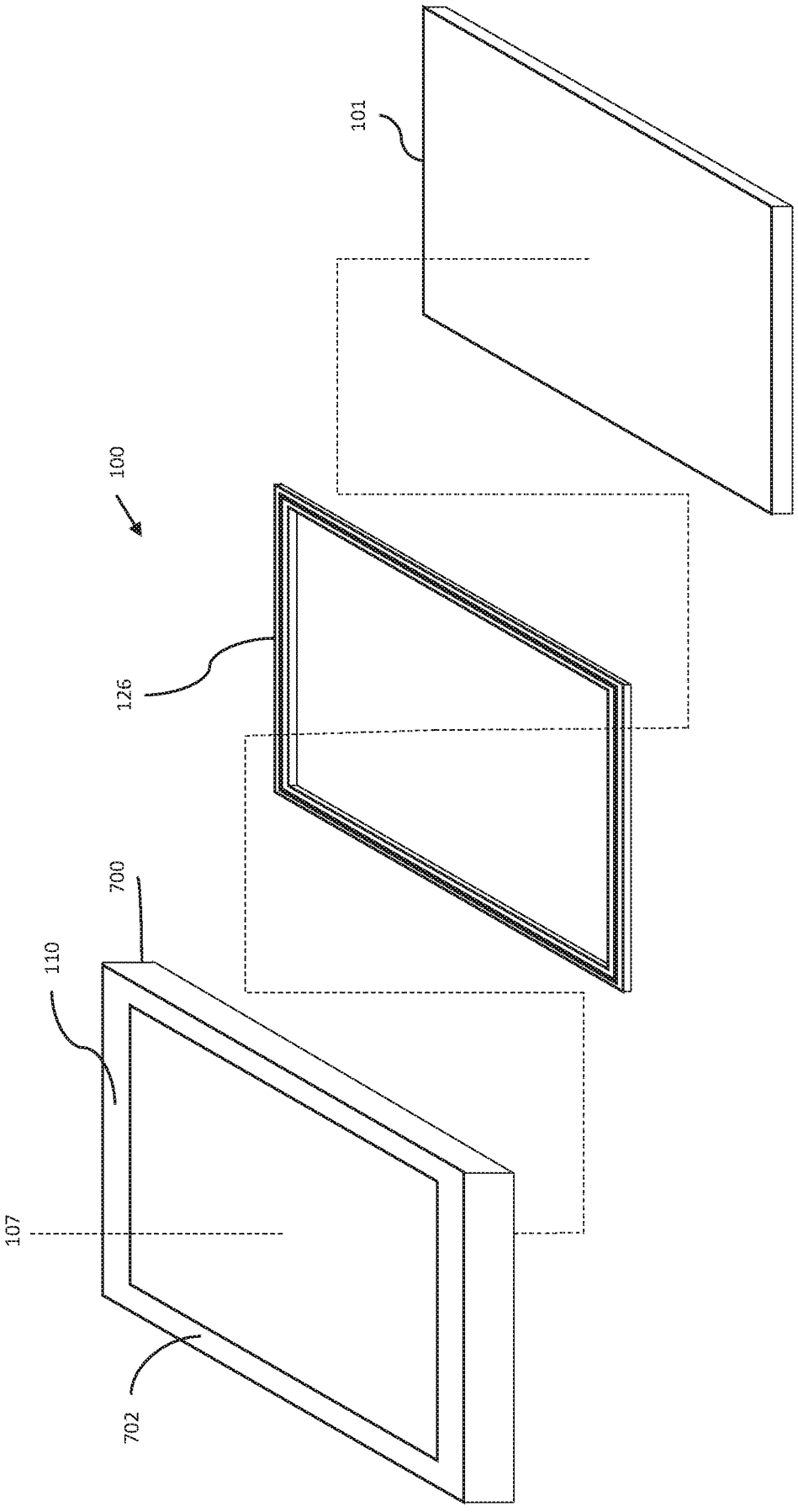


FIG. 7

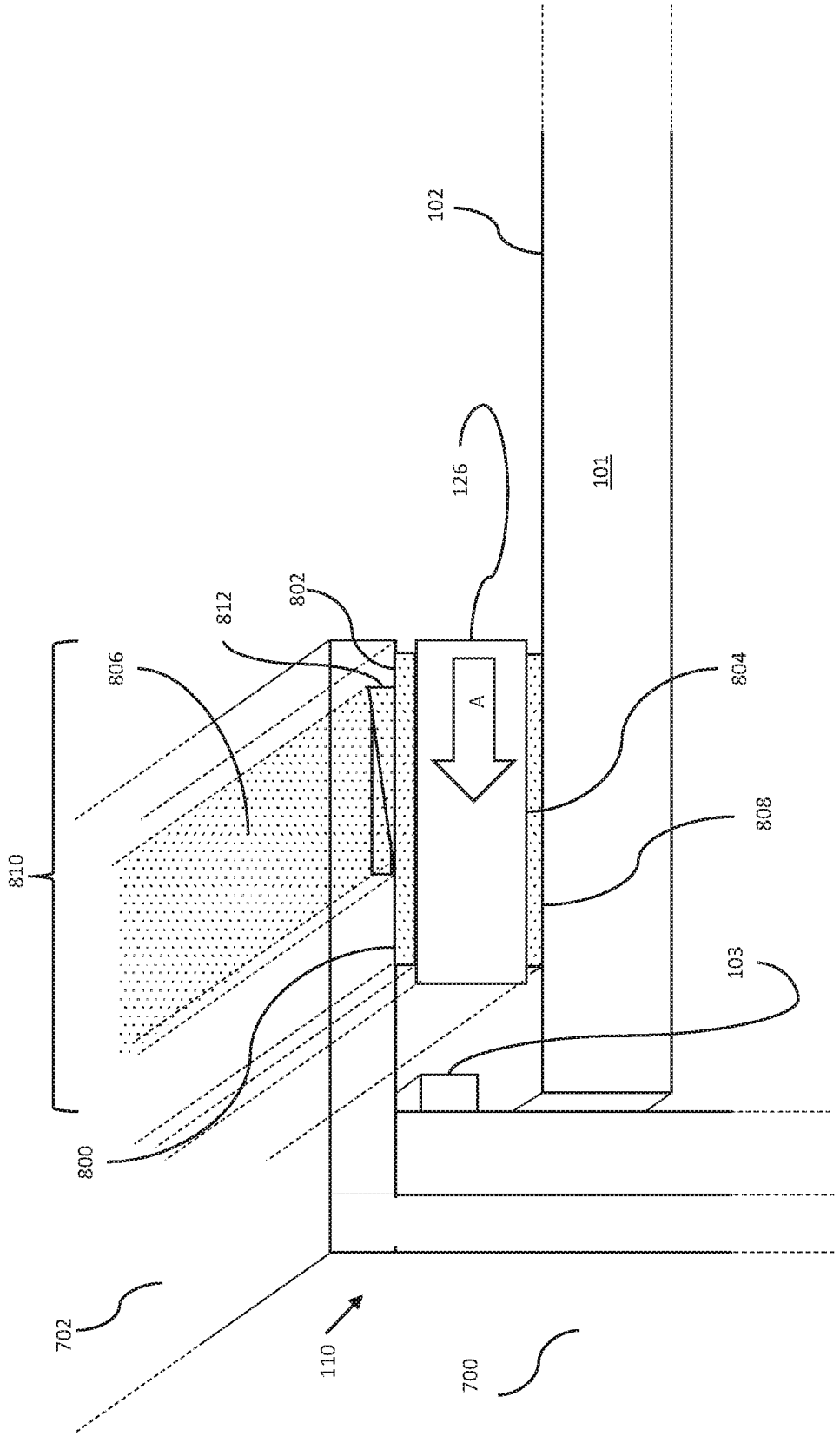


FIG. 8

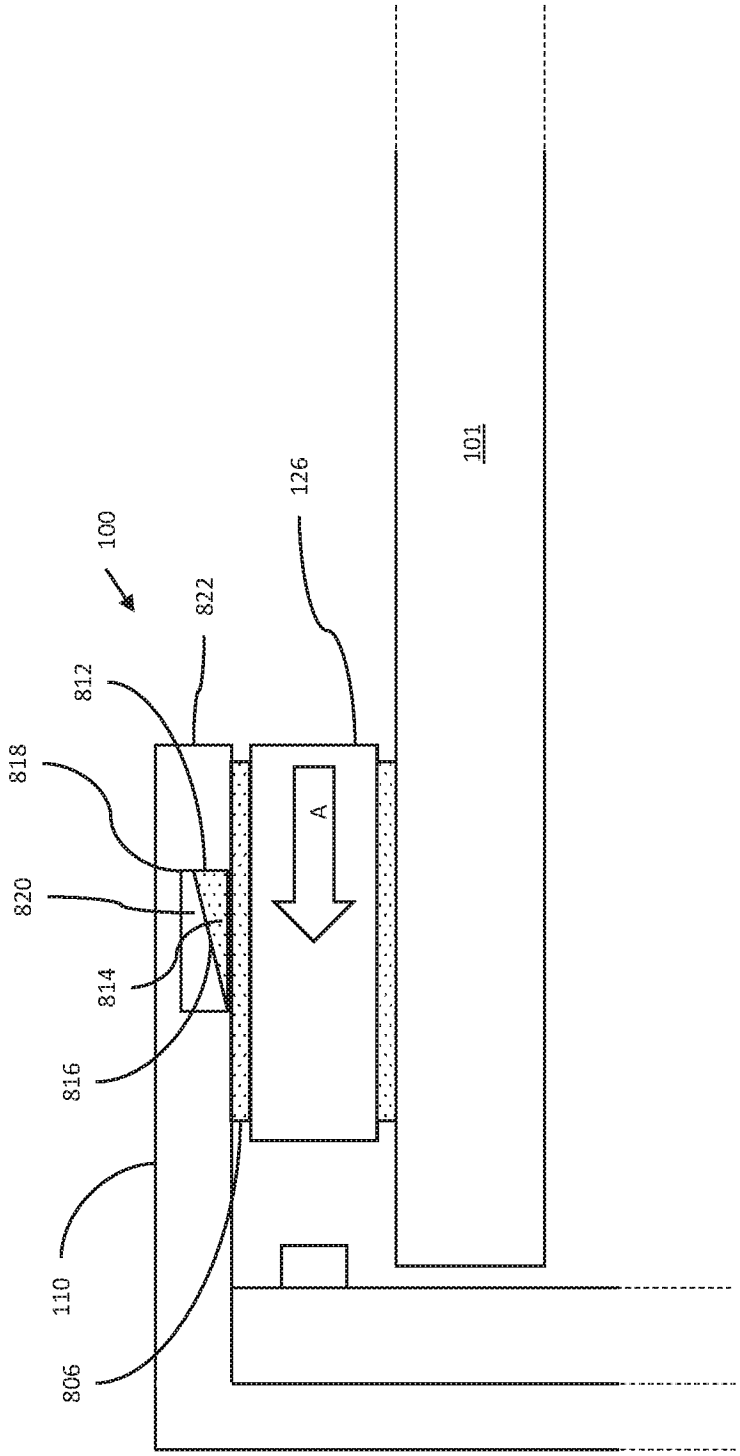


FIG. 9

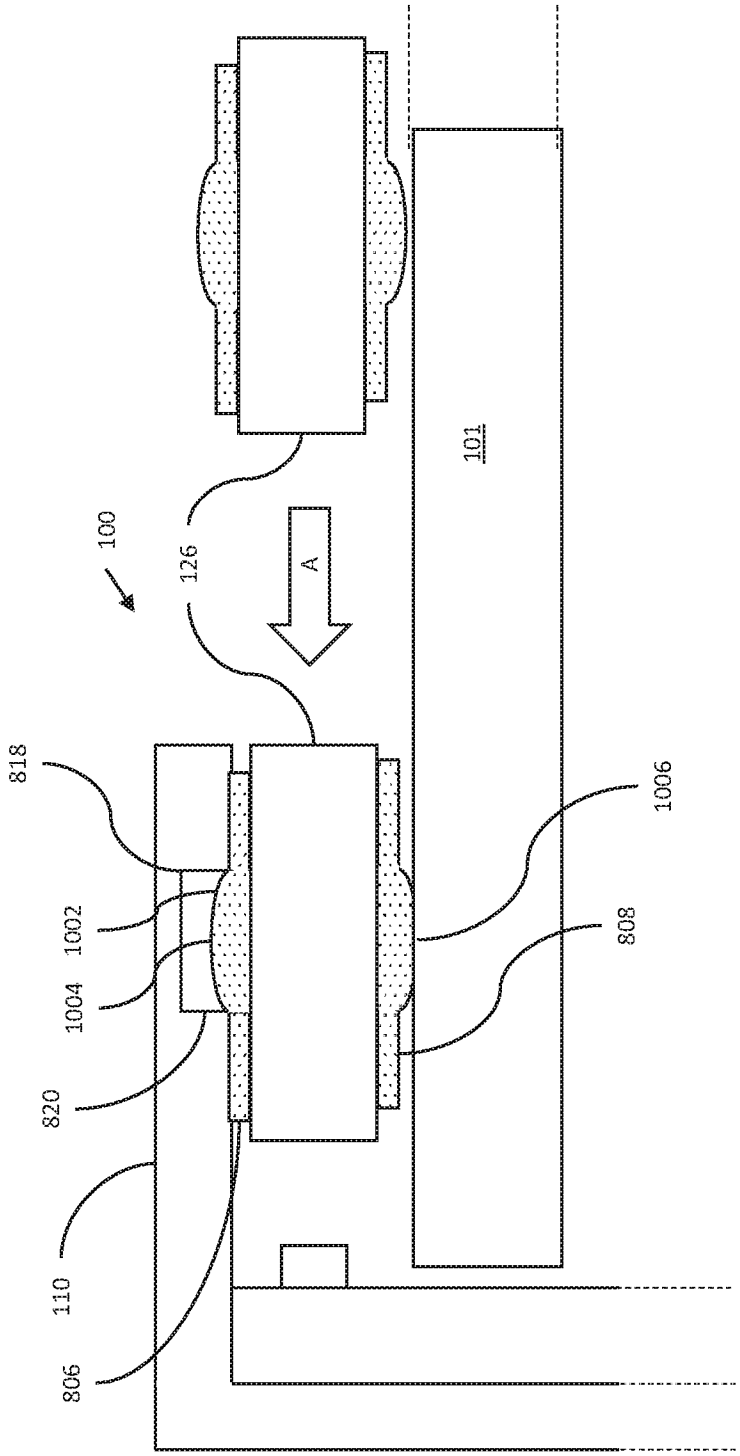


FIG. 10

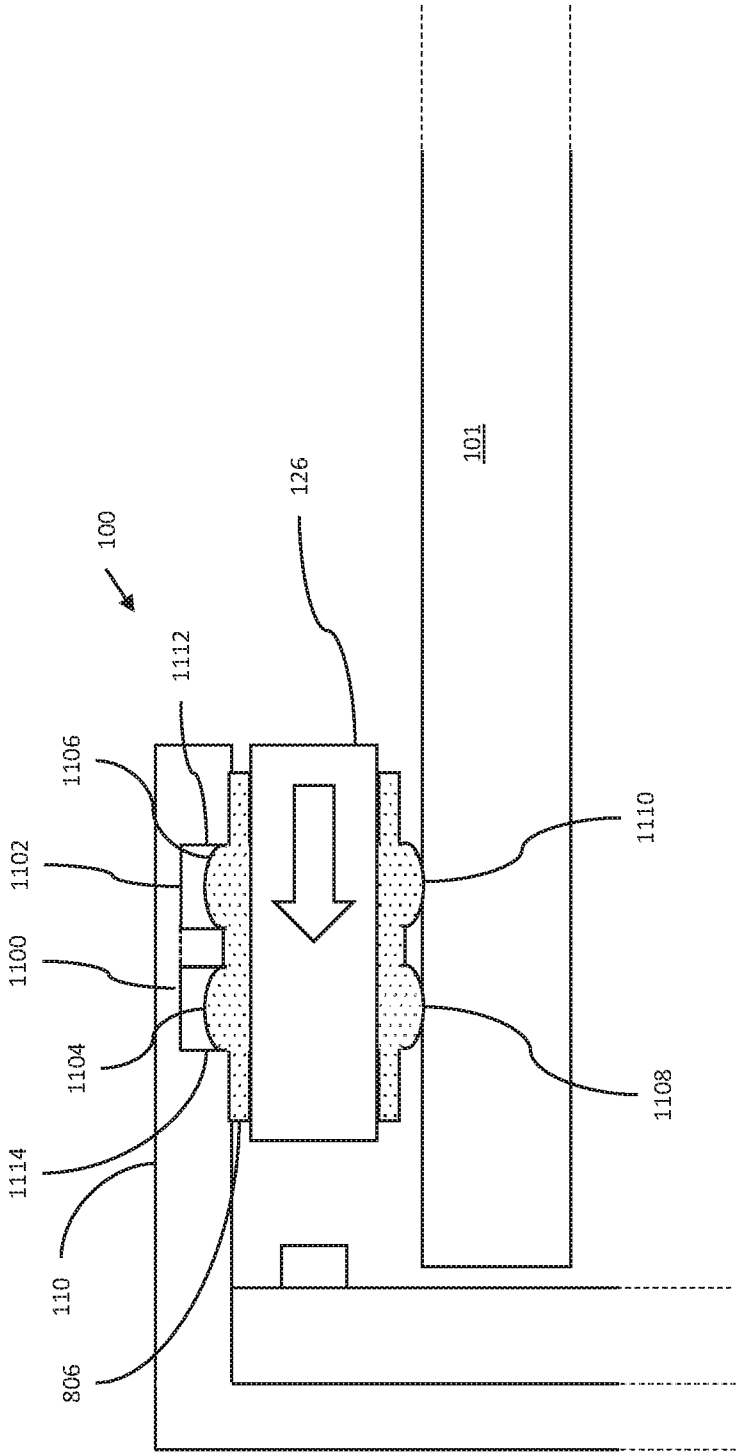


FIG. 11

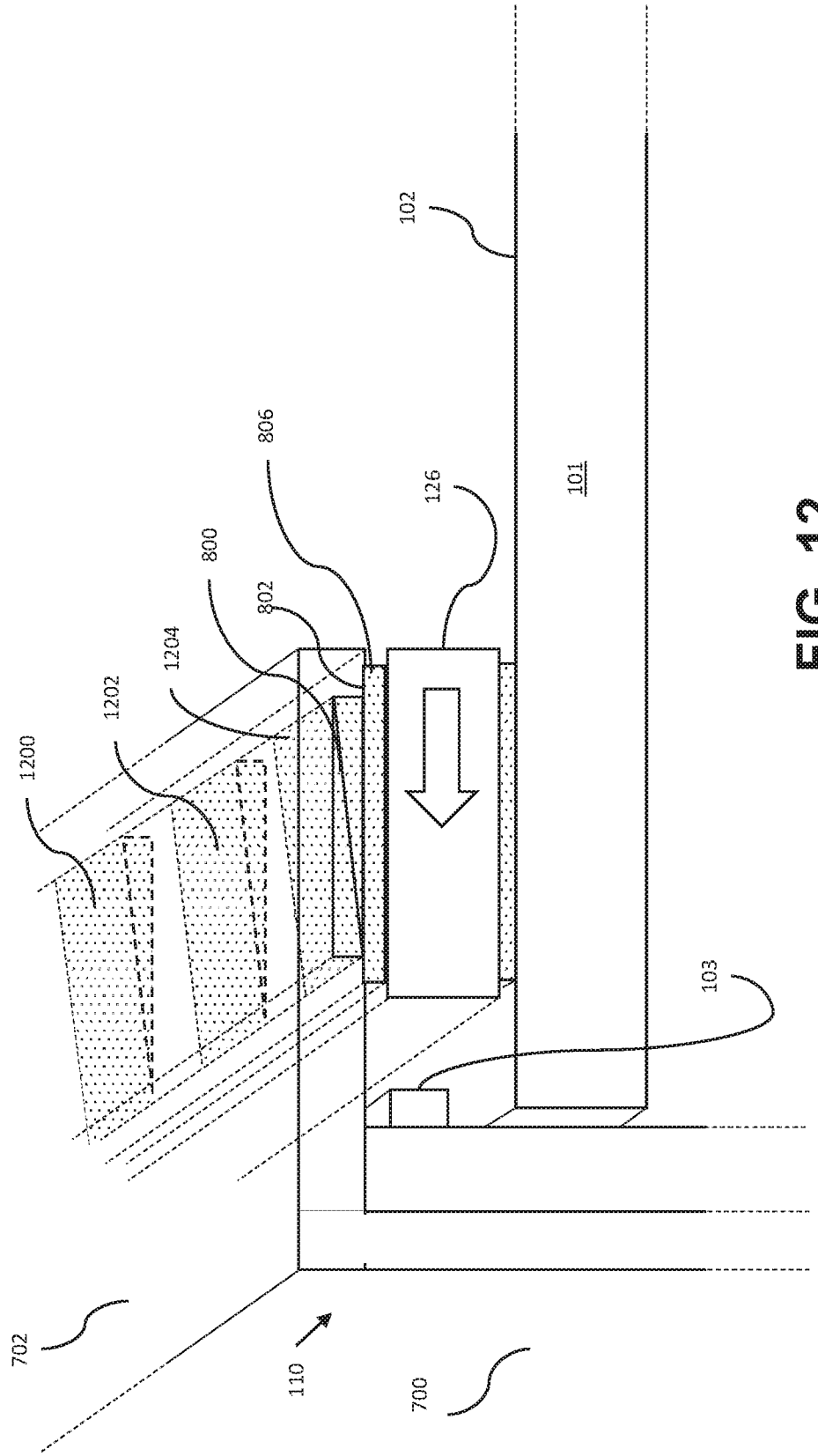


FIG. 12

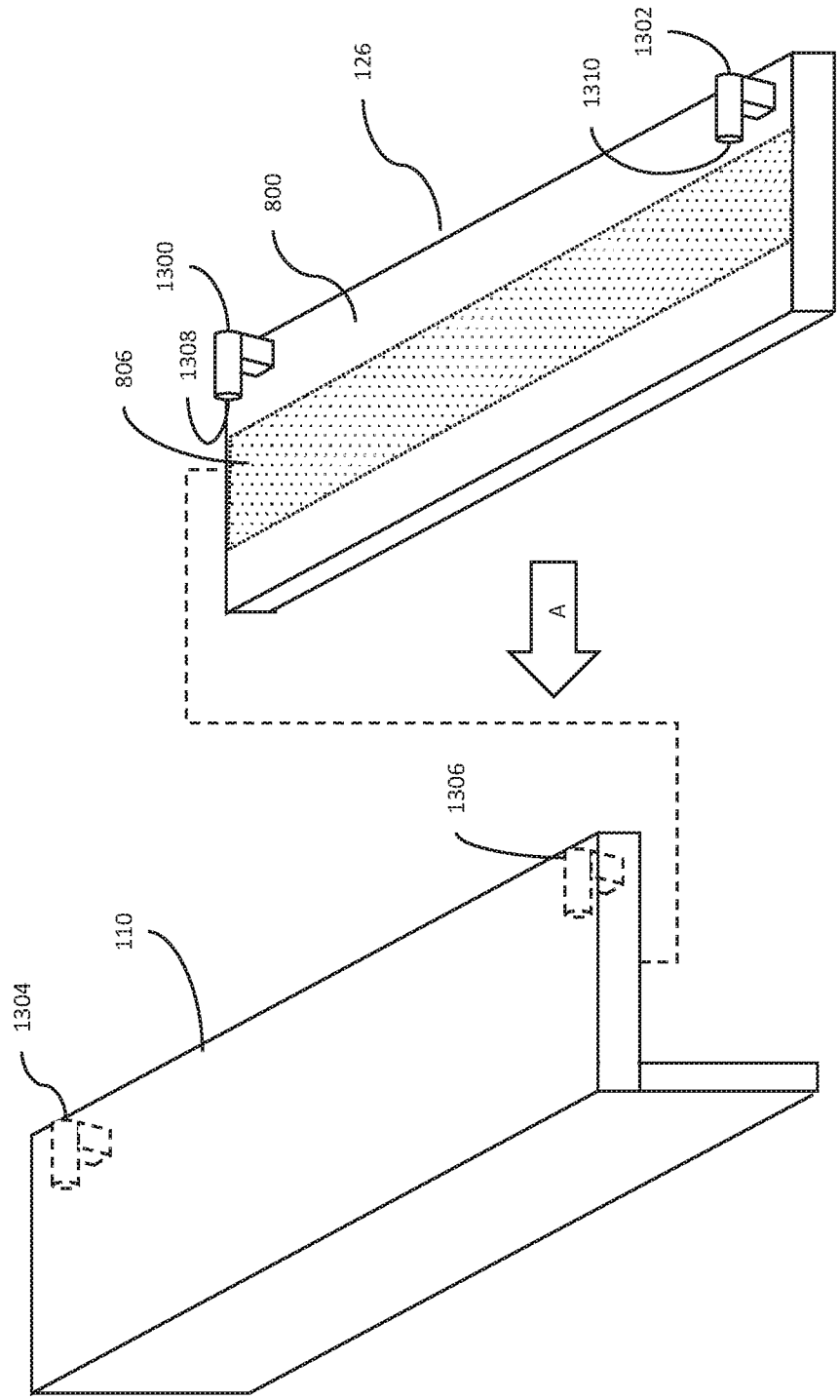


FIG. 13

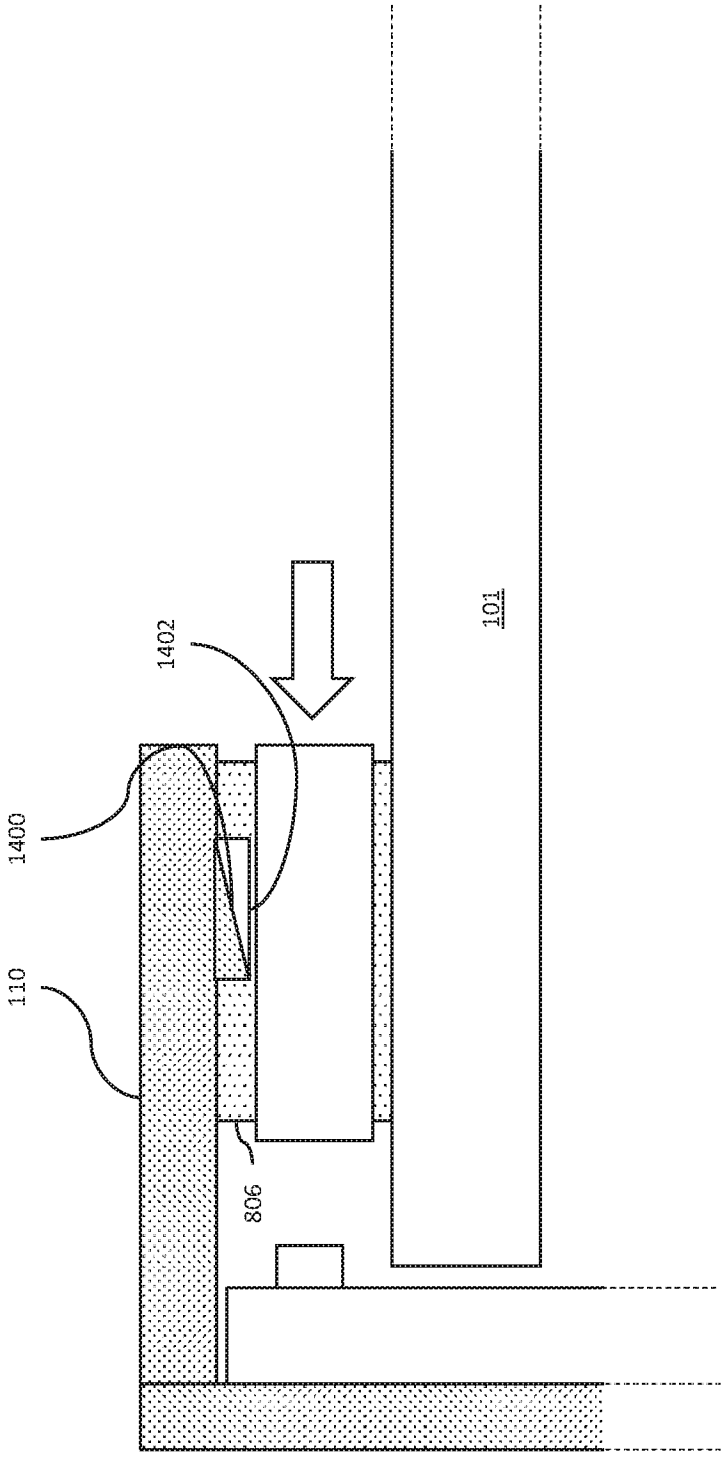


FIG. 14

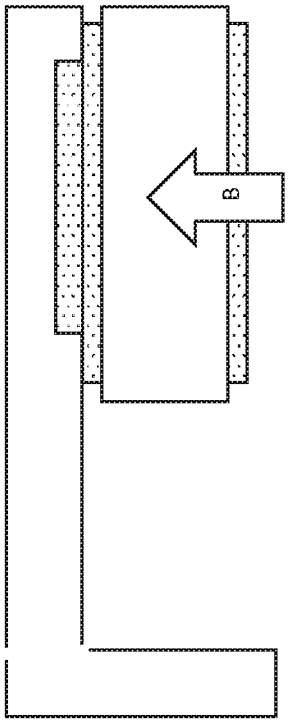


FIG. 15B

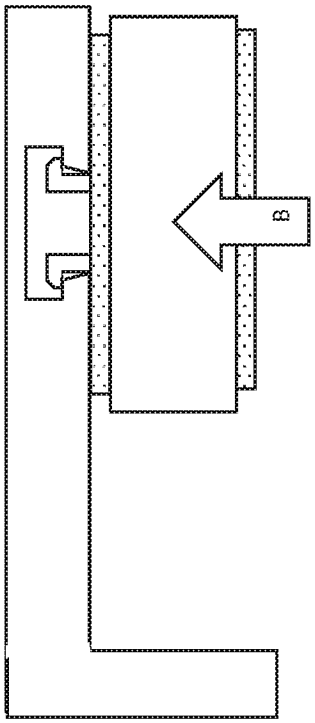


FIG. 15D

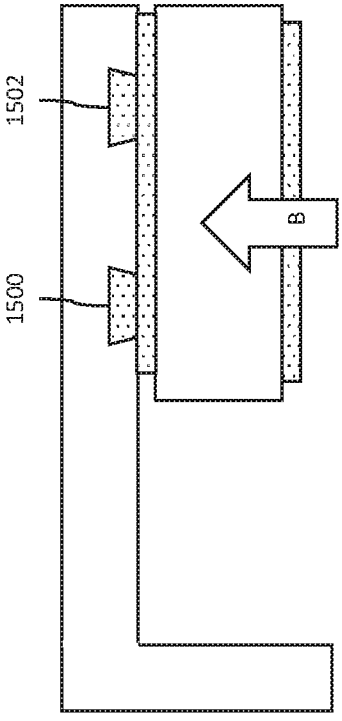


FIG. 15A

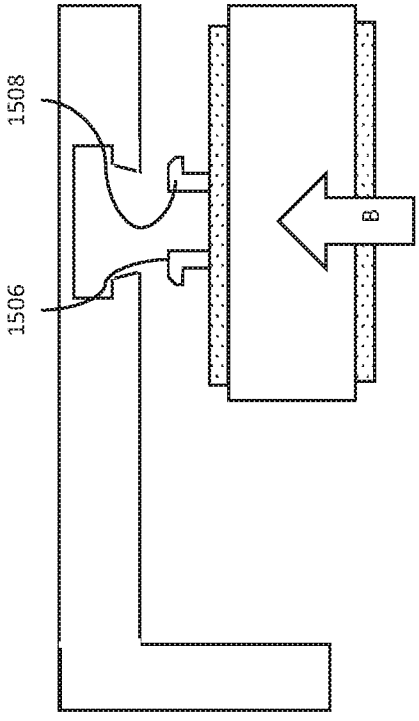


FIG. 15C

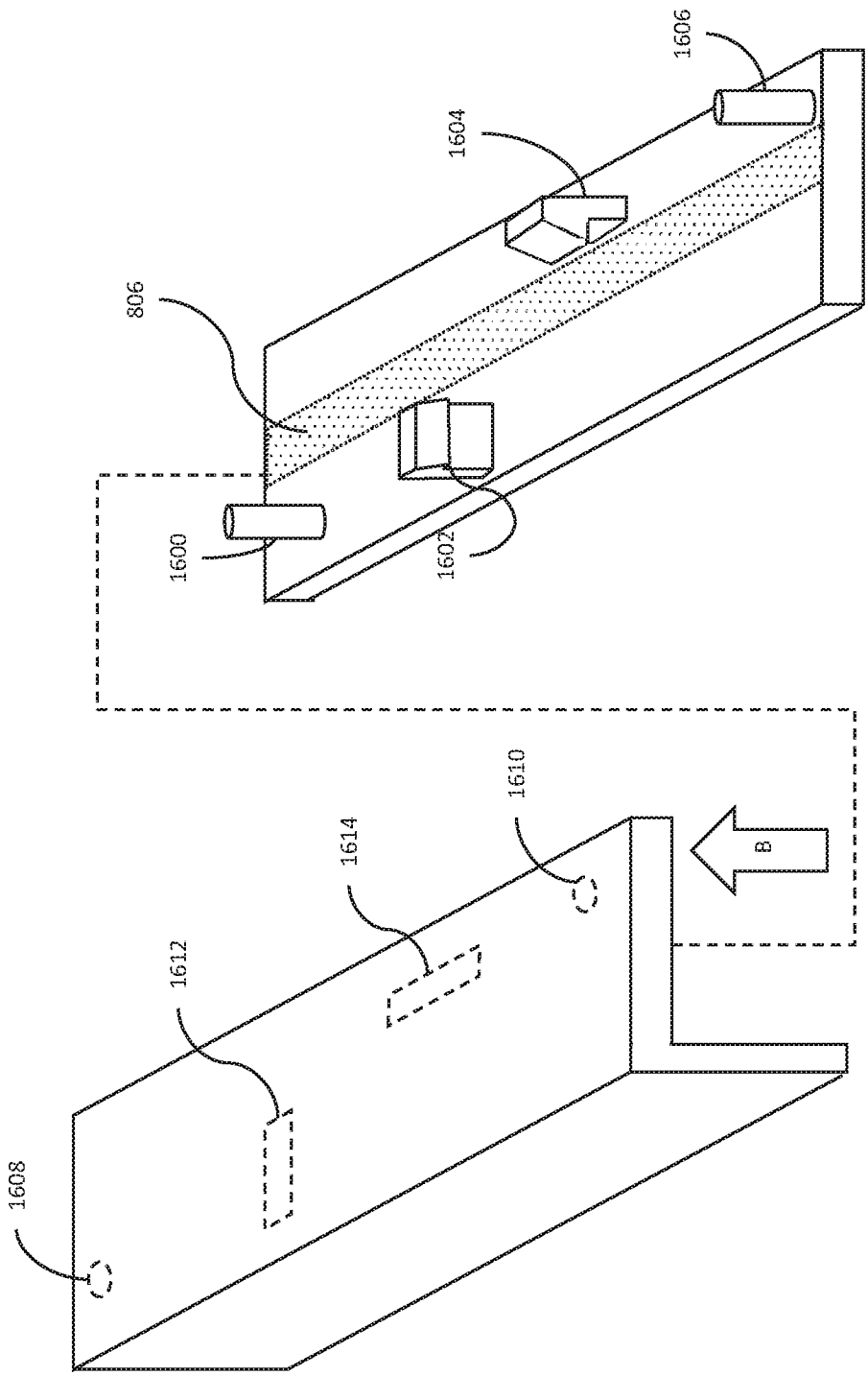


FIG. 16

TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND

Field of the Invention

[0002] The present invention relates to touch-sensing apparatus that operate by propagating light by diffusive light scattering above a panel, and in particular to optical and mechanical solutions for defining the light paths and control of curvature of the panel. The present invention relates furthermore to a method of assembling a touch sensing apparatus.

Background of the Invention

[0003] In one category of touch-sensitive panels known as 'above surface optical touch systems', a set of optical emitters are arranged around the periphery of a touch surface to emit light that is reflected to travel above the touch surface. A set of light detectors are also arranged around the periphery of the touch surface to receive light from the set of emitters from above the touch surface. An object that touches the touch surface will attenuate the light on one or more propagation paths of the light and cause a change in the light received by one or more of the detectors. The location (coordinates), shape or area of the object may be determined by analysing the received light at the detectors.

[0004] In a variant of such 'above surface optical touch system', illustrated in Fig. 1a in cross-section, the emitters 301 are arranged on a substrate 304, and light from the emitters travel above the touch surface 302 of the panel 305 via reflection or scattering on an edge reflector or diffusor 303. As shown in top-down view figure 1b, the light will then continue until deflected by a corresponding edge reflector at an opposing edge of the light transmissive panel, where the light will be scattered back down through the transmissive panel and onto the detectors 306.

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[0005] Detectors 306 are distributed around the periphery of touch surface 302, to receive part of the propagating light. The light from each of emitters 301 will thereby propagate inside the transmissive panel 305 to a number of different detectors 306 on a plurality of light paths D. In the illustrated example, the apparatus 300 also includes a controller 320 which is connected to selectively control the activation of the emitters 301 and, possibly, the readout of data from the detectors 306. Depending on implementation, the emitters 301 and/or detectors 306 may be activated in sequence or concurrently. The signal processor 330 and the controller 320 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 330 and the controller 320 may be at least partially implemented by software executed by a processing unit 340.

[0006] A problem with such previous systems is the cumbersome alignment between the components thereof, which makes assembly more difficult and costly. Sub-optimal alignment results in signal loss, which moreover is an inherent problem in previous solutions due to the multiple components involved in the light scattering process. Another issue affecting the signal and scattering of the light in the touch sensing apparatus is uncontrolled glass warpage, i.e. distortions of the curvature of the light transmissive panel which will affect the light path and the detection process. While it is critical to accurately control such distortions, previous solutions incorporate complex solutions that may not allow to fully optimize glass warpage control in a mass production line without limiting the throughput of the production.

[0007] Some prior art systems rely on coupling and propagation of collimated light across the light transmissive panel. Such systems are however cumbersome to reliably implement due to the small tolerances with respect to the alignment of the components thereof. E.g. the light emitters- and detectors need to be precisely aligned in relation to various lenses and reflect the light via concave and/or convex reflection and/or refraction to get the desired collimation. Such precise alignment may be difficult to achieve in mass production. The use of collimated light, or light reflected by means of specular reflection, also adds to this complexity, which in turn results in a more expensive and less compact system. Furthermore, to reduce system cost, it may be desirable to minimize the number of electro-optical components.

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SUMMARY OF THE INVENTION

[0008] An objective is to at least partly overcome one or more of the above identified limitations of the prior art.

[0009] One objective is to provide a touch-sensitive apparatus based on "above-surface" light propagation which is robust and easy to assemble.

[0010] Another objective is to provide an "above-surface"-based touch-sensitive apparatus with efficient use of light.

[0011] One or more of these objectives, and other objectives that may appear from the description below, are at least partly achieved by means of touch-sensitive apparatuses according to the independent claims, embodiments thereof being defined by the dependent claims.

[0012] According to a first aspect, a touch sensing apparatus is provided comprising a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel. The light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the panel extends.

[0013] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0014] Preferably the substrate extends at least partly above the touch surface, whereby the plurality of light emitters and detectors are connected to a portion of the substrate extending above the touch surface.

[0015] Preferably the substrate is fixed to a carrier mounted around the perimeter of the panel.

[0016] Preferably the carrier is arranged to at least partly enclose edges the panel.

[0017] Preferably the carrier comprises fixing elements configured to attach the carrier to a display unit.

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[0018] Preferably the fixing elements are configured to attach the position of the substrate in relation to the carrier and/or in relation to the display unit.

[0019] Preferably the fixing elements are configured to interlock with a mounting element for locking the position of the carrier and/or the substrate to the display unit.

[0020] Preferably the fixing elements comprise openings, wherein the carrier forms a cavity having walls at least partly enclosing the substrate, and wherein at least one of the walls comprises at least one of said openings.

[0021] Preferably the fixing elements comprise openings arranged in the carrier and in the substrate, wherein first openings of the carrier are aligned with second openings of the substrate, the first and second openings being configured to receive a mounting element configured to lock the position of the carrier and/or the substrate to the display unit.

[0022] Preferably the carrier is configured to be attachable to the display unit at an adjustable position along a direction parallel to the normal axis, whereby a distance between the panel and the display unit along the normal axis is variable upon attaching the carrier to the display unit at at least two different adjustable positions.

[0023] Preferably the fixing elements are configured to attach the carrier to the display unit at the adjustable positions along the direction parallel to the normal axis.

[0024] Preferably the openings are separated along a direction parallel to the normal axis, and/or wherein the carrier is attachable to a plurality of second openings in a display support of the display unit, the plurality of second openings being separated along the normal axis.

[0025] Preferably the carrier is formed from a single monolithic piece of material.

[0026] Preferably the substrate extends in a longitudinal direction along the perimeter of the panel, the substrate comprising secondary fixing units configured for variably attaching the position of the substrate on the carrier along the longitudinal direction and/or in the direction of the normal axis.

[0027] Preferably vertical alignment units are arranged between adjacent substrates extending in a longitudinal direction along the perimeter of the panel, wherein the vertical alignment units are configured to variably position the adjacent substrates in the direction of the normal axis so that an angle between the adjacent substrates is adjustable.

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[0028] Preferably a plurality of substrates extend in a longitudinal direction along the perimeter of the panel, wherein a first substrate of said plurality of substrates comprises a connection unit configured to directly interlock with a subsequent connection unit of a subsequent substrate when arranged adjacent said subsequent substrate.

[0029] Preferably a sealing window is arranged around the perimeter of the panel, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, and wherein at least one of the first and second surfaces comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0030] Preferably the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and wherein the second surface comprises a light collimating surface.

[0031] According to a second aspect, a touch sensing apparatus is provided comprising a panel extending in a plane having a normal axis, the panel defining a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel, wherein the light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The touch sensing apparatus comprises a sealing window arranged around the perimeter, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and

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wherein the second surface comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0032] Preferably the first surface and/or second surface form a curved edge convex to the sealing window.

[0033] According to a third aspect, a method of assembling a touch sensing apparatus is provided comprising; attaching a substrate having a plurality of light emitters and detectors to a carrier; attaching the carrier around a perimeter of a panel and arranging the substrate to extend in a direction parallel with a normal axis of a plane in which the panel extends.

[0034] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0035] Preferably the carrier if formed from a single monolithic piece of material, the carrier forming a cavity having walls at least partly enclosing the substrate, wherein at least one of the walls comprise openings, the method comprising fixing the carrier to a display unit by fixing mounting elements through said openings.

[0036] Preferably the method comprises adjusting a distance between the panel and a display unit along the normal axis by attaching the carrier to the display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0037] Preferably the method comprises adjusting a radius of curvature of the panel in the direction of the normal axis by attaching the carrier to a display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0038] According to a fourth aspect there is provided a touch sensing apparatus, comprising: a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel and the light emitters are arranged to emit a respective beam of emitted light above the touch surface, and the light emitters are arranged to receive detection light from the emitted light, a substrate on which the plurality of light emitters and detectors are mountable; and a sealing window sealable against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

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[0039] Preferably the sealing window is sealable between the touch surface and a surface of the substrate.

[0040] Preferably the surface of substrate is a surface of a carrier for protecting components of the touch sensing apparatus.

[0041] Preferably the carrier comprises an upper portion which overlaps a portion of the perimeter of the panel and the sealing window is sealable between the touch surface and the underside of the overlapping upper portion.

[0042] Preferably the at least one reference surface is arranged to engage with a reciprocal reference surface on the substrate.

[0043] Preferably the at least one reference surface comprises a first portion for aligning in a first direction and a second portion for aligning in a second direction.

[0044] Preferably the at least one reference surface aligns the sealing window with respect to the substrate in a plane parallel with the touch surface.

[0045] Preferably the at least one reference surface aligns the sealing window with respect to the substrate at a height above the touch surface.

[0046] Preferably the sealing window comprises at least one resiliently deformable seal engagable with the substrate.

[0047] Preferably the resiliently deformable seal comprises the at least one reference surface.

[0048] Preferably the seal is extrudable along one or more surfaces of the sealing window.

[0049] Preferably the at least one reference surface substantially extends the entire length of the sealing window.

[0050] Preferably the sealing window and / or the substrate comprise a projection having a cross-sectional shape for positive engagement with a reciprocal hole in the substrate and / or sealing window and the at least one reference surface is part of the projection.

[0051] Preferably the sealing window and / or the substrate comprise a resiliently deformable projection wherein the projection comprises the at least one reference surface comprises and the projection is deformable on engagement with the substrate and / or sealing window and forms a snap-fit engagement therebetween.

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[0052] Preferably the sealing window comprises a plurality of reference surfaces.

[0053] Preferably the at least one reference surface comprises at least one discrete upstanding projection for engagement with reciprocal hole in the substrate.

[0054] Preferably the at least one upstanding projection is one or more of, pegs, hooks, latches, clamps or fasteners.

[0055] According to a fifth aspect there is provided a method of manufacture of the touch sensing apparatus comprising: mounting a plurality of light emitters and detectors to a substrate, attaching the substrate around a perimeter of a panel; and mounting a sealing window against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

[0056] Further examples of the invention are defined in the dependent claims, wherein features for the second aspect of the disclosure are as for the first aspect mutatis mutandis.

[0057] Some examples of the disclosure provide for a touch sensing apparatus that is easier to manufacture and assemble.

[0058] Some examples of the disclosure provide for a touch sensing apparatus with fewer steps of assembly.

[0059] Some examples of the disclosure provide for a touch sensing apparatus that is less costly to manufacture.

[0060] Some examples of the disclosure provide for a facilitated alignment of emitters and detectors of touch sensing apparatus.

[0061] Some examples of the disclosure provide for facilitated control of the curvature of the touch surface of a touch sensing apparatus.

[0062] Some examples of the disclosure provide for a more robust touch sensing apparatus.

[0063] Some examples of the disclosure provide for a touch sensing apparatus that is more reliable to use.

[0064] Some examples of the disclosure provide for a touch sensing apparatus that has a better signal-to-noise ratio of the detected light.

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[0065] Some examples of the disclosure provide for a more compact touch sensing apparatus.

[0066] Still other objectives, features, aspects and advantages of the present disclosure will appear from the following detailed description, from the attached claims as well as from the drawings.

[0067] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] These and other aspects, features and advantages of which examples of the invention are capable of will be apparent and elucidated from the following description of examples of the present invention, reference being made to the accompanying drawings, in which;

[0069] Fig. 1a is a section view of a touch sensing apparatus according to the prior art;

[0070] Fig. 1b is a top-down view of a touch sensing apparatus according to the prior art;

[0071] Fig. 2 is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0072] Fig. 3 is a schematic illustration, in a perspective side view, of a touch sensing apparatus according to one example;

[0073] Fig. 4a is a schematic illustration, in a side view of Fig. 2, of a touch sensing apparatus according to one example;

[0074] Fig. 4b is a schematic illustration of a magnified section of Fig. 4a, according to one example;

[0075] Fig. 4c is a schematic illustration of a magnified section of Fig. 4a, according to one example;

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[0076] Fig. 5a is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0077] Fig. 5b is a schematic illustration of a magnified section of Fig. 5a, according to one example;

[0078] Fig. 6 is a flow chart of a method of assembling a touch sensing apparatus according to one example;

[0079] Figure 7 is a schematic exploded perspective view of different layers of the touch-sensing apparatus according to one example;

[0080] Figure 8 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0081] Figure 9 is a cross sectional view of the touch sensing apparatus according to one example;

[0082] Figure 10 is a cross sectional view of the touch sensing apparatus according to one example;

[0083] Figure 11 is a cross sectional view of the touch sensing apparatus according to one example;

[0084] Figure 12 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0085] Figure 13 is a schematic perspective view of the touch sensing apparatus according to one example;

[0086] Figure 14 is a cross sectional view of the touch sensing apparatus according to one example;

[0087] Figures 15a, 15b, 15c, and 15d ~~to 15d are~~ show magnified cross-sectional views of the touch sensing apparatus according to different examples; and

[0088] Figure 16 is a schematic perspective view of the touch sensing apparatus according to one example.

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DETAILED DESCRIPTION

[0089] In the following, embodiments of the present invention will be presented for a specific example of a touch-sensitive apparatus 100. Throughout the description, the same reference numerals are used to identify corresponding elements.

[0090] Fig. 1a schematically illustrates a variant of an 'above surface optical touch system', as discussed in the Background Art section above, where the light from the emitters 301 travel above the touch surface 302 of the panel 305 via reflection on an edge reflector 303. Figure 1b illustrates a top plan view of figure 1a in an example of a touch-sensitive apparatus 100.

[0091] Fig. 2 schematically illustrate a touch sensing apparatus 100 comprising a light transmissive panel 101 that defines a touch surface 102. In some embodiments the light transmissive panel 101 is located above a display 130 and permits light generated by the display 130 to propagate therethrough. However in other embodiments the light transmissive panel 101 can comprise light blocking material and does not permit the transmission of light therethrough. For example, the touch sensing apparatus 100, can be a trackpad or another touch interface which is remote from the display unit 130. Hereinafter the term "light transmissive panel" 101 will be used to describe either a light transmissive panel 101 or a solid, opaque panel 101.

[0092] A plurality of light emitters 103 and detectors 103' are arranged along a perimeter 104 of the light transmissive panel 101. The light emitters 103 are arranged to emit a respective beam of emitted light 105 above the touch surface 102. I.e. while the touch surface 102 extends along a plane 108, having a normal axis 107 directed towards a user performing touch operations on the touch surface 102, the emitted light 105 travels parallel with plane 108 and at a certain distance from the touch surface 102 in the direction of the normal axis 107, as schematically illustrated with respect to light beam 105, 105', in e.g. Fig. 2. Light 105, 105', can thus travel across the touch surface 102, between opposite sides thereof, without being reflected inside the light transmissive panel 101 itself.

[0093] In other embodiments, the plurality of light emitters 103 and detectors 103' are optionally arranged along a perimeter 104 of the light transmissive panel 101 at a different height. In some embodiments, the light emitters 103 and / or detectors 103' are

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arranged to emit a respective beam of emitted light 105 below the touch surface 102 and the light beams are guided around the light transmissve panel 101. The light beams can be guided around the light transmissive panel 101 with additional reflective components (not shown). For the purposes of brevity, the embodiments discussed hereinafter refer to the plurality of light emitters 103 and detectors 103' being arranged above the touch surface 102, but the embodiments also include the arrangement where the plurality of light emitters 103 and detectors 103' are mounted below the touch surface 102.

[0094] The light detectors 103' are arranged to receive detection light 105' from the emitted light 105. Fig. 2 illustrates a section of the touch sensing apparatus 100 adjacent the perimeter 104 of the light transmissive panel 101. In this section, the emitters and detectors 103, 103', are shown in the same view, as well as the emitted and detected light 105, 105', for clarity of presentation. The plurality of light emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel extends. By having the substrate 106 extending in parallel with the normal axis 107, the plurality of emitters and detectors 103, 103' are conveniently arranged, above the touch surface 102 to achieve a compact footprint in the direction of the plane 108 of the touch sensing apparatus 100 around the perimeter 104, while achieving a direct light path for the emitted or detected light 105, 105', above and across and touch surface 102. Thus, the emitted light 105 does not have to be reflected in order to diffusively spread above and across the touch surface 102, and a detector 103' may directly receive detection light 105' by being correspondingly positioned above the touch surface 102 at an opposite position anywhere around the perimeter 104. The amount of available light that can be utilized for the detection and characterization of an object touching the touch surface 102 can thus be maximized, and the signal to noise ratio can be improved. The touch sensing apparatus 100 may comprise a sealing window 126 as illustrated in Fig. 2, shielding the emitters and detectors 103, 103', from the outside. The emitted and detected light 105, 105', may thus only have to propagate through the sealing window 126 along the light path between the emitters and detectors 103, 103'. The sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the display.

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[0095] Having the substrate extending in the direction 107' being parallel with the normal axis 107 and the emitters and detectors 103, 103', arranged above the touch surface 102 provides for a less complex alignment to maximize the detection performance of the touch sensing apparatus 100. The position of the substrate 106 in the direction of the normal axis 107 can be accurately varied to achieve optical alignment with respect to the emitters and detectors 103, 103'. The ability to achieve an accurate positioning of the substrate 106, and consequently the emitters and detectors 103, 103', attached thereto, is also due to the increased accuracy by which the dimensions of the substrate 106 can be defined along the direction of the substrate 106 aligned with the normal axis 107 in Fig. 2. I.e. the substrate 106 is elongated and extends in a longitudinal direction 123 (Fig. 4a) around the perimeter 104 of the light transmissive panel 101, and it has a short-side extending in parallel with the normal axis 107. The short-side of the substrate 106, illustrated in the cross-sectional view of Fig. 2, may be manufactured to smaller tolerances, and by aligning this side with the normal axis 107, the tolerances for the alignment of the emitters and detectors 103, 103', along the normal axis 107 can be improved. The alignment can thus be both improved, and facilitated as discussed above. The latter advantage also provides for facilitated and less costly mass production of the touch sensing apparatus 100 and the various touch base display systems in which it may be implemented.

[0096] The substrate 106 may extend at least partly above the touch surface 102, whereby the plurality of light emitters and detectors 103, 103', are connected to a portion 109 of the substrate extending above the touch surface 102. This further provides for achieving a more robust alignment of the emitters and detectors 103, 103', relative to the light transmissive panel 101, by being directly joined to the substrate 106, and thereby simultaneously arranged above the touch surface 102. It may be conceivable however that the emitters and detectors 103, 103', are connected to the substrate 106 via connection elements (not shown) extending between the substrate 106 and to a position above the touch surface 102.

[0097] The substrate 106 may be fixed to a carrier 110 mounted around the perimeter 104 of the light transmissive panel 101, as schematically illustrated in 1a, 1b, and [[–]] 2. By directly joining the substrate 106 to the carrier 110 provided around the perimeter

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104, the assembly of the touch sensing apparatus 100 may be further facilitated, as the amount of components can be kept at a minimum. For example, the substrate 106 can be accurately fixed in relation to the carrier 110, due to the small tolerances possible in the direction of the substrate 106 aligned in parallel with the normal axis 107 in Fig. 2[[1]], as discussed above. The carrier 110 may for example comprise a cavity 116, as discussed further below, being precisely dimensioned to accommodate the width of the substrate 106 along the direction 107', i.e. the short-side of the substrate 106. Then, accurate positioning of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 is possible as the carrier 110 is mounted around the perimeter 104 thereof. The carrier 110 may extend substantially in the direction 107' parallel with the normal axis 107, as with the substrate 107, to achieve a compact mounting around the perimeter 104. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0098] Having the substrate 106 fixed to the carrier 110 allows also for having the carrier 110 wired as an electrical ground reference layer of the substrate 106.

[0099] The carrier 110 may be arranged to at least partly enclose edges 111 of the light transmissive panel 101, as shown in the example of Fig. 2[[1]]. This provides for further increasing the robustness of the touch sensing apparatus 100, and improving the accuracy of the alignment of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 since the carrier 110, having the emitters and detectors 103, 103', fixed thereto, may also be directly supporting the light transmissive panel 101 around the perimeter 104. The carrier 110 may comprise a slot in which the light transmissive panel 101 is fitted around the perimeter 104.

[0100] The carrier 110 may comprise fixing elements 112 configured to attach the carrier 110 to a display unit 113, 121. The display unit may comprise a display support 121 and a display panel 113, which collectively is referred to as a display unit in the present disclosure. Having the carrier 110 attachable to the display unit 113, 121, by fixing elements 112, advantageously provides for further facilitating the assembly of the touch sensing apparatus 100 to a display unit, since the carrier 110 can be directly joined to the latter. Alignment is thus facilitated, due to the minimum amount of components needing such

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alignment to each other. The robustness of the touch sensing apparatus 100 is further improved, while mass production is made less complex due the minimized number of assembly steps. The fixing elements 112 may comprise any elements configured to provide for fixing of the position of the carrier 110 to the display unit 113, 121. In the example[[s]] shown in Fig.~~Figs.~~ [[1 -]] 2, the carrier 110 has openings 115, 115', 115'', discussed further below, which may be aligned with corresponding openings 127 of a support of the display unit 121, through which mounting elements 114 may be positioned for the fixing. It is conceivable however that the carrier 110 has other types of recesses or protrusions which may interlock with a corresponding mating surface of the display unit 113, 121.

[0101] The fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the carrier 110. Thus, besides from fixing the position of the carrier 110 relative to the display unit 113, 121, the fixing elements 112 may also fix or at least support the position of the substrate 106 in relation to the carrier 110. It is conceivable that the substrate 106 may first be arranged in relation to the carrier 110, and the fixing elements 112 may be arranged to support and strengthen the fixing therebetween, while simultaneously fixing the carrier 110 to the display unit 113, 121. This may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100. From a similar aspect, the fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the display unit 113, 121. This may be seen as a consequence from the above, i.e. the fixing elements 112 contributing to the fixing of the substrate 106 to the carrier 110, which in turn is fixed to the display unit 113, 121. It is however conceivable that the fixing elements 112 may fix the substrate 106 directly to the display unit 113, 121, in which case the carrier 110 may act as a further support for the substrate 106.

[0102] In one example, as discussed further below, the substrate 106 may comprise second openings 118 which provides for such fixing or support. As mentioned, this may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100.

[0103] The fixing elements 112 may be configured to interlock with a mounting element 114 for locking the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. Figs. 2 – 3 show examples of having an elongated mounting element 114

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joining the carrier 110 and/or the substrate 106 to the display unit 113, 121. The mounting element 112 may however comprise any fastening element configured to exert a force between the carrier 110 and/or the substrate 106 to the display unit 113, 121, such as pins, bolts, screws, clips, clamps, locks, bars, rods, anchors, latches, clasps.

[0104] The fixing elements 112 may comprise openings 115, 115', 115'', as illustrated in Figs. 2 – 3. The carrier 110 may form a cavity 116 having walls 117 at least partly enclosing the substrate 106, illustrated in the example of Fig. 2. This may provide for increased stability of the fixing of the position of the substrate 106 in relation to the carrier 110. At least one of the walls 117 may comprise at least one of the openings 115, 115', 115'', as further illustrated in Fig. 2. Being able to directly fix the walls 117 of the carrier 110 enclosing the substrate 106 to the display unit 121, 113, provides for further simplifying manufacturing, and at the same time further increase the accuracy of the alignment of e.g. the emitters and detectors 103, 103', in relation to the light transmissive panel 101, since the minimized number of intermediate mounting components improves tolerance control. I.e. build-up of mounting errors in each assembly step is reduced and controlled. It is conceivable that the walls 117 may be fixed to the display unit 113, 121, by other fixing elements 112, such as recesses or protrusions interlocking with correspondingly mating surfaces of the display unit 113, 121, and/or fastening elements as exemplified above.

[0105] The fixing elements 112 may comprise openings 115, 115', 115'', 118, arranged in the carrier 110 and in the substrate 106. First openings 115, 115', 115'' of the carrier 110 may be aligned with second openings 118 of the substrate 106, as illustrated in the example of Fig. 2. The first and second openings 115, 115', 115'', 118 may be configured to receive a mounting element 114 configured to lock the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. This provides for further facilitated and improved alignment and assembly, and increased robustness. In the example of Fig. 2, the carrier 110 encloses the substrate 106 such that two opposite openings 115, 115'', of the carrier are arranged on either side of the substrate 106, but it is conceivable that the carrier 110 may be arranged on one side only of the substrate 106.

[0106] The carrier 110 may be configured to be attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis. A

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distance 120 between the light transmissive panel 101 and the display unit 113 along the normal axis 107 may thus be variable upon attaching the carrier to the display unit 113, 121 at at least two different adjustable positions 119, 119'. For example, turning to Fig. 3, the carrier 110 is attached at a first position 119 to the support of the display unit 121, via fixing unit 112. The first position 119 provides for the given distance 120 between the panel of the display unit 113. The distance 120 may then be decreased by instead attaching the carrier 110 at a second position 119' which is off-set with respect to the first position 119 in the positive direction of the normal axis 107, or the direction 107'' as illustrated in Fig. 3. If the fixing point to the support of the display unit 121 remains constant, e.g. at the opening 127 of a support 121 as illustrated, the carrier 110 will be moved in the opposite direction to the normal axis 107 and the distance 120 will be decreased. Having the carrier 110 being attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis 107, thus provides for simple and efficient adjustment of the position of the light transmissive panel 101.

[0107] Besides from overall controlling the distance 120, as discussed, such adjustment provides for efficiently controlling and varying the curvature of the light transmissive panel 101. I.e. varying the distance 120 as discussed at a second intermediate location 128', between opposite ends of the carrier 110, along the longitudinal direction 123, while maintaining the distance 120 at the opposite ends, such as at a first location 128, will affect the curvature of the carrier 110, and thereby the curvature of the light transmissive panel 101. E.g. decreasing the distance 120 at the second location 128' can produce a more concave shape, i.e. a decreased radius of curvature, of the carrier 110 and the light transmissive panel 101, in the direction of the normal axis 107. Increasing the distance 120 between the mentioned opposite ends can instead increase the radius of curvature in the direction of the normal axis 107. The curvature or warping of the light transmissive panel 101 can thus be controlled efficiently an in a facilitated manner, which is advantageous for increasing throughput in mass-production of displays incorporating the touch sensing apparatus 100 while keeping the warp of the light transmissive panel 101 under control. An optimized curvature of the light transmissive panel 101 increases the reliability and accuracy of the touch sensing apparatus 100.

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[0108] The fixing elements 112 may be configured to attach the carrier 110 to the display unit 121 at the adjustable positions 119, 119', along the direction 117'' parallel to the normal axis 107. Thus, the fixing units 112 be arranged at the different adjustable positions 119, 119', to adjust the distance 120 and the curvature of the a light transmissive panel 101 while providing for securely attaching the carrier to the display unit 113, 121. The fixing elements 112 may thus be arranged at least at the first and second locations 128, 128', along the longitudinal direction 123 as discussed above, where each of the locations in the longitudinal direction 123 may have at least two adjustable positions 119, 119', as illustrated in the example of Fig. 3.

[0109] The openings 115, 115', of the carrier 110 may be separated along a direction 117'' parallel to the normal axis 107, as illustrated in Fig. 3. Alternatively, or in addition, the carrier 110 may be attachable to a plurality of second openings 122 in a display support 121 of the display unit, where the plurality of second openings 122 are separated along the normal axis 107. Thus, the position 119, 119', may be remained fixed while the carrier 110 is attached to the support 121 at the various second openings 122, to adjust the curvature of the light transmissive panel 101 and/or the distance 120 as discussed above. Although the examples in Figs. 2 – 3, show openings 115, 115', 115'', 127, it is conceivable that the attachment between the carrier 110 and the display unit 121, 113, is provided by other fixing elements 112 as exemplified above.

[0110] The carrier 110 may be formed from a single monolithic piece of material. The structural integrity and the stability of the carrier 110 can thereby be increased, which further optimizes the parameters discussed above with respect to alignment, robustness, ease of assembly etc. One example of a possible process by which the carrier can be formed as a single piece of material is an extrusion process, but it is conceivable that the carrier 110 may be formed from other hot or cold metal or polymer working processes such as drawing, rolling, or molding processes.

[0111] The substrate 106 may extend in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. Fig. 4a illustrates a view of a plurality of substrates 106, 106', extending along the longitudinal direction 123. The light transmissive panel 101 and the carrier 110 holding the substrates have been excluded in the view for

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clarity of presentation. The substrates 106, 106', may comprise secondary fixing units 124, 124', configured for variably attaching the position of each of the substrates 106, 106', on the carrier 110 along the longitudinal direction 123 and/or in the direction of the normal axis 107. This provides for more accurately adjusting the position of the substrates 106, 106', in relation to the light transmissive panel 101. While each of the substrates 106, 106', may be within tolerances, the accumulated error obtained when several substrates 106, 106' are connected along the longitudinal direction 123 may exceed the total tolerance of the full length of the light transmissive panel 101. Such accumulation of errors may be effectively prevented by having secondary fixing units 124, 124', as elucidated above. The secondary fixing units 124, 124', may be provided on various locations on the substrates 106, 106', to allow for adjusting the position, such as on opposite ends thereof.

[0112] The touch sensing apparatus 100 may comprise vertical alignment units 135 arranged between adjacent substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. The vertical alignment units 135 are configured to variably position the adjacent substrates 106, 106', in the direction of the normal axis 107 so that an angle 136 between the adjacent substrates 106, 106', can be adjusted. Fig. 4b schematically illustrates a vertical alignment unit 135 positioned between adjacent substrates 106, 106', to vary the position thereof in the direction of the normal axis 107, i.e. along arrows 137, so that the angle 136 may be set to a desired value. The vertical alignment unit 135 thus provides for facilitating the alignment of the plurality of substrates 106, 106', to e.g. the curvature of the light transmissive panel 101. For example, if the light transmissive panel 101 is concave in the direction of the normal axis 107, initially parallel substrates 106, 106', may be angled to closely follow the concave shape of the light transmissive panel 101 by increasing the angle 136 between the substrates 106, 106', as schematically illustrated in Fig. 4b. The position of the emitters and detectors 103, 103', on the substrates 106, 106', may thus remain at an optimized vertical position relative the light transmissive panel 101 for various curvatures thereof. The vertical alignment unit 135 may comprise various units configured to change the position of the adjacent substrates 106, 106', in the direction of the normal axis 107, such as bolts, screws, pins, or any other elements that can provide an offset at the ends of the substrates 106, 106'.

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[0113] The touch sensing apparatus 100 may comprise force distributing units 138 positioned between adjacent substrates 106, 106', configured to provide a fixing force therebetween, as schematically illustrated in Fig. 4c. The force distributing units 138 may provide for improving and facilitating the fixing of the substrates 106, 106', to the carrier, without the need for dedicated fixing elements such as screws, bolts, etc to each end of respective substrates 106, 106', thereby reducing the amount of such fixing elements, which facilitates the assembly of the touch sensing apparatus 100.

[0114] The touch sensing apparatus may thus comprise a plurality of substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. A first substrate 106 of the plurality of substrates may comprises a connection unit 125 configured to directly interlock with a subsequent connection unit 125' of a subsequent substrate 106' when arranged adjacent said subsequent substrate, as schematically illustrated in Fig. 4a. It is thereby possible to directly connect subsequent substrates 106, 106', and eliminate the need for intermediate connectors, which further provides for facilitating the assembly of the touch sensing apparatus 100.

[0115] The touch sensing apparatus 100 may comprise a sealing window 126 as schematically illustrated in Figs. 5a-b. The sealing window 126 may be arranged around the perimeter 104 of the light transmissive panel 101. The sealing window 126 may comprise a first surface 129 facing the light emitters 103 or the light detectors 103', and an opposite second surface 130 arranged adjacent the touch surface 102. Emitted or detected light thus propagates between the first and second surface 129, 130. At least one of the first and second surfaces 129, 130, may comprises a light collimating surface 129, 130, configured to collimate light propagating above the touch surface 102. I.e. emitted light 105 will be collimated by the sealing window 126, so that the light propagating above the touch surface 102 will be collimated. Detectors 103' will receive the collimated light which will be focused through a corresponding sealing window 126. As the emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction parallel with a normal axis 107, it is possible to provide for a very precise and improved alignment thereof in relation to the sealing window 126, which allows for achieving collimated light in a highly optimized manner, and an associated increase in signal

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strength since more of the emitted light can be collected by the detectors 103'. The emitted light is collimated in a direction parallel with the plane 108 in which the light transmissive panel 101 extends. Collimating the light with sealing window 126 also allows for reducing the aperture of the sealing window 126, i.e. the thickness of the sealing window 126 in the direction of the normal axis 107, while still detecting a sufficient amount of light. This provides for reducing the amount of ambient light reaching the detectors 103', thus improving the signal to noise ratio.

[0116] Turning to Fig. 5b, the second surface 130 may extend in the direction of the normal axis 107 between a base surface 131 of the sealing window 126, facing the light transmissive panel 101, and an opposite top surface 132 of the sealing window 126. The base surface 131 may be offset from the top surface 132 along the direction of the plane 108 with an offset distance 133 so that the second surface 130 forms an angle 134 relative the normal axis 107. As further illustrated in Fig. 5b, the second surface may comprises the light collimating surface 130. Thus, in addition to having a convex shape as illustrated in Fig. 5b, the second surface 130 is arranged to assume a tilted configuration as provided by the offset distance 133. Having such angled configuration provides for reducing the impact of Fresnel reflexes. The Fresnel reflexes otherwise generate additional unwanted light paths that will reduce the apparent attenuation on some detection lines, especially when they run parallel to and near a sealing window 126. These Fresnel reflexes may also result in artifacts and false touch information. By having an angled and/or curved second surface 130 of the sealing window 126, the light may instead bounce off the second surface 130 with such an angle so that it leaves the plane 108, and thereby not interfere with the detection of the remaining light.

[0117] A sealing window 126 as described above can provide for the advantageous effects as described for touch sensing apparatuses having a plurality of light emitters and detectors arranged in a multitude of configurations, not limited to the configurations described in relation to Figs. 2 and 3 exemplified above. A touch sensing apparatus 100 is thus provided comprising a light transmissive panel 101 extending in a plane 108 having a normal axis 107, wherein the light transmissive panel defines a touch surface 102. The touch sensing apparatus 100 comprises a plurality of light emitters 103 and

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detectors 103' arranged along a perimeter 104 of the light transmissive panel, wherein the light emitters are arranged to emit a respective beam of emitted light 105 above the touch surface, wherein the light detectors are arranged to receive detection light 105' from the emitted light. The touch sensing apparatus 100 comprises a sealing window 126 arranged around the perimeter, wherein the sealing window comprises a first surface 129 facing the light emitters or the light detectors and an opposite second surface 130 arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface 131 of the sealing window, facing the light transmissive panel, and an opposite top surface 132 of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance 133 so that the second surface forms an angle 134 relative the normal axis, and wherein the second surface comprises a light collimating surface 130 configured to collimate light propagating above the touch surface.

[0118] The first surface 129, facing the emitters or detectors 103, 103', may also be angled, with an angle 134', as schematically illustrated in Fig. 5a, to provide for the desired light path from or towards the emitters or detectors 103, 103', respectively. The first surface 129 may also comprise a light collimating surface and have a convex shape towards the emitters or detectors 103, 103', as illustrated in Fig. 5a, in addition to being arranged at an angle 134'. The angles 134, 134', may be in the range of 2-10 degrees relative to the normal axis 107 to provide for a particularly advantageous reduction of Fresnel reflexes. An angle greater than 2 degrees avoids Fresnel reflexes and an angle of less that 10 degrees reduces the light field height.

[0119] The sealing window 126 may comprise a fixing element 139 configured to interlock to carrier 110. In the example in Fig. 5a, the fixing element comprises a protrusion 139 arranged to interlock with a corresponding recess in the carrier 110. Mounting and fixing of the sealing window 126 may thus be facilitated and improved since the fixing element 139 may snap into the carrier 110, without needing to have separate fixing units or adhesives joining the sealing window 126 to the carrier 110. In some circumstances, it is preferable not to use an adhesive because the adhesive may not be resilient in high temperatures. Use of an adhesive for fixing the sealing window 126 can be problematic because the uncured adhesive

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allows for relative movement between the components and precise alignment may be difficult. It is conceivable that the fixing element 139 may comprise any other shape, such as a recess, for interlocking with a corresponding mating surface of the carrier 110.

[0120] Alternative embodiments of the sealing window 126 will now be described in reference to Figure 7 to 16.

[0121] Figure 7 shows an exploded perspective schematic view of the touch sensing apparatus 100. The dotted line shows the normal axis 107 of the touch surface 102 at the center of the light transmissive panel 101. For the purposes of clarity, the exploded perspective view in Figure 7 shows the separate components side by side, but the dotted line of the normal axis 107 represents the order of how the components stack together. As mentioned previously the carrier 110 may extend substantially in the direction parallel with the normal axis 107. In this way the carrier 110 comprises a downwardly projecting skirt 700 from the upper surface 702.

[0122] The sealing window 126 is mountable on the carrier 110 and this will be discussed in further detail below. The sealing window 126 comprises a similar shape to the arrangement of the plurality of light emitters 103 and detectors 103' (not shown in Figure 7 for the purposes of clarity). The sealing window 126 is mounted such that the plurality of light emitters 103 and detectors 103' are between the sealing window 126 and the skirt 700. As shown in Figure 7, the sealing window 126 is a rectangular loop structure.

[0123] In some embodiments, the sealing window 126 may be formed from a single monolithic piece of material, thus providing for a robust sealing window 126 and a stable attachment to the carrier 110 and the light transmissive panel 101. The sealing window 126 may be formed by an extrusion process. In one embodiment, the sealing window is formed from two separate materials. A first material, such as a dyed PMMA or similar NIR transparent material, is used for a transparent section and a second material, such as a compressible light blocking material, is used for sealing off the E/D compartment. This may be achieved by e.g. using a co-extrusion process.

[0124] In other embodiments, the sealing window 126 is formed from a plurality of longitudinal pieces (not shown) and joined together to form a rectangular arrangement. Each longitudinal piece may be a single monolithic piece of material. Considering the sealing

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window 126 in Figure 7, the arrangement as shown in Figure 7 is formed from four pieces of extruded sealing window material 126. The four pieces are then joined together to construct the rectangular loop as shown in Figure 7. The four pieces of the extruded sealing window 126 can be adhered together with glue, or fastened together with screws, clips, clamps or any other suitable fastener. The glue can be applied and cured before the sealing window 126 is slid into the carrier 110 or the glue can be left to cure once the sealing window 126 is positioned in the carrier 110. Alternatively the four pieces are not fastened or glued together and are held in position with a friction fit.

[0125] The sealing window 126, once assembled, is sandwiched between the upper surface 702 of the carrier 110 and the light transmissive panel 101. In some embodiments, the sealing window 126 is slid into position between the carrier 110 and the light transmissive panel 101. Figure 8 shows the direction A in which the sealing window 126 is moved with respect to the carrier 110 and the light transmissive panel 101. In this embodiment the sealing window 126 is slid in a direction parallel with the plane of the light transmissive panel 101. In other embodiments, discussed in more detail below, the sealing window 126 can be inserted into the carrier 110 in a different direction such as parallel to the normal axis 107 and perpendicular to the touch surface 102.

[0126] In some embodiments the light transmissive panel 101 is not required to be light transmissive. For example the touch surface 102 can be on a medium through which light does not propagate. In some embodiments the touch surface 102 can be part of a surface which does not require light from a display unit 113, 121 to be visible there through. That is, the touch sensing apparatus 100 is remote from the display unit 113, 121 and the display unit 113, 121 is not stacked together with the other components as shown in Figure 7. In this way the light transmissive panel 101 can be considered to be a panel 101. For the purposes of clarity, the panel 101 has been referred to as a light transmissive panel 101, but all the embodiments are also applicable to a panel comprising an opaque or light blocking material.

[0127] Turning to Figure 8, the construction of the carrier 110, the sealing window 126 and the light transmissive panel will now be discussed in more detail. Figure 8 shows a partial perspective cross-sectional view of the touch sensing apparatus 100. In

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particular Figure 8 is magnified to show the arrangement between the carrier 110, the sealing window 126 and the light transmissive panel 101.

[0128] The sealing window 126 comprises a dual purpose. Firstly, the sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the edge of the light transmissive panel 101. This means that the sealing window 126 prevents ingress of dirt, water and other contaminants into the interior of the touch sensing apparatus 100. This helps protect the internal components such as the plurality of emitters and detectors 103, 103'. Secondly, the sealing window 126 allows light from the emitters and detectors 103, 103' to propagate therethrough. In some embodiments, as discussed in reference to Figure 5a, the sealing window can optionally comprise optical elements for refracting, deflecting, diverting or focusing the light beams therethrough. However in other embodiments, the sealing window is optically passive and does not comprise any optical elements for refracting, deflecting, diverting or focusing the light beams therethrough.

[0129] As can be seen from Figure 8, an upper sealing surface 800 of the sealing window 126 engages with an interior underside surface 802 of the carrier 110. The upper surface 702 of the carrier 110 is arranged to project over the light transmissive panel 101. In this way the carrier 110 overlaps a portion of the light transmissive panel 101 around the perimeter of the light transmissive panel 101. The portion 810 of the upper surface 702 that overlaps with the light transmissive panel 101 is indicated by a bracket in Figure 8. The overlapping portion 810 of the carrier 110 provides protection for the perimeter light transmissive panel 101 from shock and other physical forces. The overlapping portion 810 also provides an overhang on which the sealing window 126 can be mounted. The interior underside surface 802 of the carrier is an opposite face to the upper surface 702. A lower sealing surface 804 of the sealing window 126 engages with the touch surface 102.

[0130] In order to aid the sealing, the sealing window 126 optionally comprises one or more deformable seals or integral gaskets 806, 808 mounted on the upper sealing surface 800 and the lower sealing surface 804 respectively. The deformable seals 806, 808 are arranged to deform when the light transmissive panel 101 is urged towards the carrier 110. The deformable seals 806, 808 are extruded along the longitudinal length of the sealing

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window 126. In some embodiments the deformable seals 806, 808 are integral with the sealing window 126. As mentioned previously, in some embodiments the deformable seals 806, 808 can be manufactured at the same time as the sealing window 126 in a co-extrusion process. Alternatively the deformable seals 806, 808 are mounted and adhered to the sealing window 126 after the sealing window 126 has been extruded. In some embodiments the deformable seals 806, 808 are made from a thermoplastic elastomer (TPE). The deformable seals 806, 808 can be colored black to block transmission of light from the sealing window 126. The deformable seals 806, 808 can be any suitable color or material for absorbing light and minimizing light in-coupling.

[0131] In some embodiments the sealing window 126 is configured to be mounted between two surfaces for sealing and protecting the emitters and detectors 103, 103' from the outside environment. In some embodiments the sealing window 126 is arranged to seal against the touch surface 102 and the interior underside surface 802 of the carrier 110. In other embodiments the sealing window 126 can be mounted between any other surface to provide a sealed cavity 116 around the emitters and detectors 103, 103'. In some embodiments the sealing window 126 seals between the interior underside surface 802 and other surface. The other surface does not need to be the touch surface 102. Instead the other surface is another interior surface of the carrier 110 such as a surface on which the substrate 106 is mounted on. In some other embodiments the sealing window 126 is mounted and sealed against another components and neither of the touch surface 102 and the interior underside surface 802. In some embodiments the sealing window 126 is sealable against at least one surface of the touch sensing apparatus 100 for sealing a cavity 116 around the plurality of light emitters and detectors 103, 103'. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0132] In some embodiments the sealing window 126 comprises at least one reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The reference surface 812 will be discussed in further detail with respect to Figure 9 for the purposes of clarity.

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[0133] Figure 9 is a schematic cross-sectional view of the touch sensing apparatus 100. The sealing window 126 is inserted between the light transmissive panel 101 and the carrier 110. The upper deformable seal 806 comprises a reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The upper deformable seal 806 comprises a projection 814 which projects upwardly from the upper deformable seal 806 and the sealing window 126. In this way, the reference surface 812 is upright with respect to the sealing window 126. The projection 814 also optionally comprises a chamfer 816 in addition to the reference surface 812.

[0134] The chamfer 816 means that the deformable upper seal 806 does not snag on the carrier 110 when the sealing window 126 is inserted between the carrier 110 and the light transmissive panel 101. Accordingly as the sealing window 126 is pushed into place, the chamfer 816 urges against the interior underside surface 802 of the carrier 110. Initially, the deformable upper seal 806 is squashed between the carrier 110 and the light transmissive panel 101 when the sealing window 126 is being forced between the carrier 110 and the light transmissive panel 101.

[0135] The sealing window 126 is pushed towards a notch 820 located in the interior underside surface 802 of the carrier 110. In some embodiments, the notch 820 is a groove that extends around the periphery of the carrier 110. The notch 820 comprises a reciprocal reference surface 818 for aligning with the reference surface 812 of the projection 814. In particular, the notch 820 is a reference point for indicating that the sealing window 126 is inserted underneath the overlapping portion 810 sufficiently to form a seal and protect the internal components of the touch sensing apparatus 100. The notch 820 is positioned a predetermined distance from the edge 822 of the carrier 110. In some embodiments the predetermined distance is at least half the width of the sealing window 126.

[0136] When the sealing window 126 pushed sufficiently between the carrier 110 and the light transmissive panel 101, the deformed projection 814 is located within the notch 820. At this point when the sealing window 126 is located in the correct position with respect to the carrier 110, the reference surface 812 abuts against a reciprocal reference surface 818 in the notch 820 in the carrier 110.

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[0137] The compressed projection 814 resiles and expands once located in the notch 820. In this way, the project 814 snaps into position and positively engages with the notch 820. When the sealing window 126 is located and the projection 814 snaps into place, the sealing window 126 makes an audible "click". Additionally or alternatively the snapping of the projection 814 into position provides a tactile feedback during assembly that the sealing window 126 is seated correctly.

[0138] The size of the notch 820 is slightly larger than the dimensions of the projection 814. Accordingly the projection 814 fits snugly within the notch 820. This means that the frictional forces between the carrier 110, the light transmissive panel 101 and the sealing window 126 are sufficient to hold the sealing window 126 in place. Adhesive is not required to fix the sealing window 126 in place. However in some embodiments adhesive is optionally used in addition to the snap-fit positive engagement.

[0139] In some embodiments the reference surface 812 abuts against the reciprocal reference surface 818. This means that the sealing window 126 opposes the direction A by virtue of the engaged reference surfaces 812, 818. Removal of the sealing window 126 may only be achieved with a special tool which compresses the projection 814.

[0140] Once the sealing window 126 has been seated correctly in the carrier 110, the reference surfaces 812, 818 maintain the alignment between the carrier 110 and the sealing window 126. The deformable seals 806, 808 maintain the relative position of the sealing window 126 with respect to the carrier and prevents lateral movement in a plane parallel to the light transmissive panel 101. Furthermore, the reference surfaces 812, 818 ensure that the sealing window 126 is maintained at a certain height above the touch surface 102.

[0141] The shape and size of the deformable seal 806, 808 can be varied. Another embodiment with such a variation is shown in Figure 10. Figure 10 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement is the same as shown in reference to Figures 8 and 9, except the cross sectional shape of the deformable seal 806, 808 is different. In this embodiment the projection 1002 comprises a curved upwardly projecting bulge 1002 on the upper deformable seal 806. The bulge 1002 comprises a curved reference surface 1004 which engages with one or more reciprocal reference surfaces 818 of the notch

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820. The curved reference surface 1004 functions in a similar way to the chamfer 814 as described in reference to the previous embodiment when inserting the sealing window 126 between the light transmissive panel 101 and the carrier 110. The bulge 1002 has dimensions which are substantially the same width as the width of the notch 820 so that the sealing window 126 does not experience lateral movement in a direction parallel with the plane of the light transmissive panel 101. The lower seal 808 optionally comprises a similar bulge 1006 for engaging and sealing against the touch surface 102. By making the upper seal 806 and the lower seal 808 have the same cross section, manufacture can be simplified because the same die (not shown) can be used during extrusion of the deformable seals 806, 808.

[0142] Advantageously the shape of the projection 1002 means that the sealing window 126 can be removed with a similar magnitude of force to the force needed for insertion during assembly. Accordingly removal of the sealing window 126 may not require a tool. This can make maintenance which requires removal of the sealing window 126 easier.

[0143] Another embodiment is shown in Figure 11. Figure 11 shows a cross sectional side view of the touch sensing apparatus 100. Figure 11 is the same as shown in Figure 10 except that there is an additional projection and notch. The first notch 1100 and first bulge 1104 are substantially the same as the notch 820 and the bulge 1002 as discussed in reference to Figure 10. In addition, there is a second notch 1102 and a second bulge 1106. Likewise the lower seal 808 comprises similar first and second bulges 1108, 1110. Having two projecting bulges 1104, 1106 means that there are two points of sealing engagement between the sealing window 126 and the light transmissive panel 101 and the carrier 110 respectively. This means that there will be less rotation of the sealing window 126 about the deformable seal 806, 808. Accordingly, the tolerances needed to accommodate rotational movement of the sealing window about the longitudinal axis of the sealing window can be lower. There is also an increased surface area of the deformable seals 806, 808 and therefore the deformable seals will cool quicker during manufacture.

[0144] In another embodiment, the first and second bulges 1104, 1106 engage with a single notch 820 as shown in Figure 10. The dotted line between the first and second notches 1100, 1102 represents a single notch, similar to the notch 820 in Figure 10. In this case the first bulge 1104 engages a first reciprocal reference surface 1114 and the second

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bulge 116 engages with a second reciprocal reference surface 1112. The first and second reciprocal reference surfaces 1114, 1112 are walls of the notch 820.

[0145] Another embodiment will now be discussed in reference to Figure 12. Figure 12 shows a schematic perspective and cross-sectional view of the touch sensing apparatus 100. The arrangement as shown in Figure 12 is the same as shown in Figures 8 and 9 except that the deformable seal 806 comprises a plurality of discrete projections 1200, 1202, 1204. Each of the projections is deformable and is inserted between the light transmissive panel 101 and the carrier 110 in the same way as described with respect to the previous embodiments. The carrier 110 comprises a serious of reciprocal recesses (not shown for clarity) to receive a respective projection 1200, 1202, 1204. In this way less deformable material is required to perform the alignment function. The projections may be adhered to the deformable seal material 806 or the projections can be extruded. Each of the projections 1200, 1202, 1204 comprise a reference surface for aligning the projection and the sealing window 126 with the reciprocal recess in the carrier 110. In some embodiments the projections 1200, 1202, 1204 can comprise any suitable cross sectional shape. For example, the projections can comprise an oval curved cross section, similar to the bulges shown in the embodiments discussed in reference to Figures 10 and 11.

[0146] Figure 13 shows yet another embodiment. Figure 13 shows a schematic exploded perspective view of the touch sensing apparatus 100. For the purposes of clarity the light transmissive panel 101 is not shown. The sealing window 126 is the same as described in reference to the previous embodiments. The upper deformable seal 806 is mounted on the upper sealing surface 800. In contrast to the previous embodiments, the deformable seal 806 does not comprise upward projections comprising a reference surface. Instead the sealing window 126 comprises positioning pegs 1300, 1302 for engagement in the reciprocal positioning holes 1304, 1306 located in the carrier 110. In this way the reference surfaces are separate from the deformable seal 806.. Each of the positioning pegs 1300, 1302 comprises a reference surface 1308, 1310 for aligning the sealing window 126. In this way as the sealing window is slid underneath the carrier 110 in the direction A, the pegs 1300, 1302 slot into the positioning holes 1304, 1306. The holes 1304, 1306 are blind holes and when the reference surfaces 1308, 1310 abut the end of the blind holes 1304, 1306, the sealing window 126 is in

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the correct position. The holes 1304, 1306 are deep enough such that the sealing window 126 is completely under the carrier 110, similar to the arrangement shown in the previous embodiments.

[0147] Figure 14 shows another embodiment. Figure 14 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement as shown in Figure 14 is the same as shown in Figures 8 and 9 except that the projection 1400 is formed on the carrier 110 and the notch 1402 is formed in the upper deformable seal 806. In this embodiment the projection 1400 is rigid and downwardly projects from the carrier 110. The notch 1402 is deformable and snaps into position when the notch 1402 is in positive engagement with the projection 1400 and reference surfaces are in engagement. The sealing window 126 is inserted between the carrier and the light transmissive panel 101 in the same way as discussed previously.

[0148] In alternative embodiments, the carrier 110, the light transmissive panel 101 and the sealing window 126 are assembled in a different order. The components are the same as described in reference to the previous embodiments. Turning to Figures 15a – 15d and Figure 16 the alternative method of assembly will now be discussed.

[0149] Figures 15a – 15d show a side cross section of the touch sensing apparatus 100. The light transmissive panel 101 has been omitted for clarity. The sealing window 126 is pushed towards the carrier 110 in direction B. That is, a direction which is parallel to normal axis 107. Figure 15a shows two deformable projections 1500, 1502 which have a snap-fit engagement with reciprocal grooves in the carrier. The deformable projections 1500, 1502 have a cross sectional shape that snaps into the reciprocal holes when the sealing window is seated correctly in the carrier 110.

[0150] Figure 15b shows a similar arrangement to Figure 15a except that there is a single projection 1504 which does not have a snap-fit engagement. Optionally, positive engagement is provided by the projection 1504 having a snug friction fit. When the sealing window 126 cannot move any further with respect to the carrier 110, the projection 1504 will abut the reciprocal surface of the hole in the carrier 110 and the sealing window will be seated correctly.

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[0151] Figures 15c and 15d show stepwise engagement of the same arrangement. The deformable seal 806 comprises snap-fit latches 1506, 1508 which bend and snap into place once the sealing window is fully seated in the carrier 110.

[0152] Once the sealing window 126 and the carrier 110 are assembled, then the light transmissive panel 101 is mounted in the carrier 110.

[0153] Figure 16 shows a schematic exploded perspective view of the carrier 110 and the sealing window 126. The arrangement as shown in Figure 16 is the same as shown in Figure 13, except that the relative movement of the sealing window 126 with the respect to the carrier 110 during assembly is perpendicular. That is, along direction B parallel with the normal axis 107. Similar to the embodiment as shown in Figure 13, the sealing window 126 comprises a plurality of reference surfaces which are not part of the deformable seal 806. Each of pegs 1600, 1606 and snap-fit latches 1602, 1604 comprises a reference surface for alignment. Figure 16 shows pegs 1600, 1606 for engagement with holes 1608, 1610. Figure 16 also shows resiliently deformable latches 1604, 1602 for snap-fit engagement with holes 1612 and 1614.

[0154] A further mounting unit 140 may be provided between the sealing window 126 and the light transmissive panel 101, as schematically illustrated in Fig. 5a. The mounting unit 140 may comprise a resilient material that allows the sealing window 126 to assume a secure fixed position relative the light transmissive panel 101. The sealing window 126 may have a corresponding groove into which the mounting unit 140 may be securely positioned.

[0155] A method 200 of assembling a touch sensing apparatus 100 is provided. Fig. 6 illustrates steps of the method 200. The order in which the steps of the method 200 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order. The method 200 comprises fixing 201 a substrate 106 having a plurality of light emitters 103 and detectors 103' to a carrier 110, and attaching 202 the carrier 110 around a perimeter 104 of a light transmissive panel 101. The method further comprises arranging 203 the substrate to extend in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel 101 extends, whereby the plurality of light emitters and detectors 103, 103', are arranged above the touch surface

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102. The method 200 thus provides for a facilitated assembly of the touch sensing apparatus 100 while achieving optimal alignment, robustness, and accuracy as described above in relation to Figs. 2 – 3.

[0156] As mentioned, the carrier 110 may be formed from a single monolithic piece of material, and the carrier may form a cavity 116 having walls 117 at least partly enclosing the substrate 106. At least one of the walls 117 may comprise openings 115, 115', 115''. The method 200 may comprise fixing 204 the carrier 106 to a display unit 121, 113, by fixing mounting elements 114 through the openings 115, 115', 115'', thereby providing for the above mentioned advantages.

[0157] The method 200 may comprise adjusting 205 a distance 120 between the light transmissive panel 101 and a display unit 113, 121, along the normal axis 107 by attaching 207 the carrier 110 to the display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the distance 120 is improved and facilitated, and may thereby be more easily optimized to various applications of the touch sensing apparatus 100.

[0158] The method 200 may comprise adjusting 208 a radius of curvature of the light transmissive panel 101 in the direction of the normal axis 107 by attaching 209 the carrier 110 to a display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the curvature of the light transmissive panel 101 is thus improved as described above.

[0159] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope and spirit of the invention, which is defined and limited only by the appended patent claims.

[0160] For example, the specific arrangement of emitters and detectors as illustrated and discussed in the foregoing is merely given as an example. The inventive coupling structure is useful in any touch-sensing system that operates by transmitting light, generated by a number of emitters, inside a light transmissive panel and detecting, at a number of detectors, a change in the received light caused by an interaction with the transmitted light at the point of touch.

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TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND

Field of the Invention

[0002] The present invention relates to touch-sensing apparatus that operate by propagating light by diffusive light scattering above a panel, and in particular to optical and mechanical solutions for defining the light paths and control of curvature of the panel. The present invention relates furthermore to a method of assembling a touch sensing apparatus.

Background of the Invention

[0003] In one category of touch-sensitive panels known as 'above surface optical touch systems', a set of optical emitters are arranged around the periphery of a touch surface to emit light that is reflected to travel above the touch surface. A set of light detectors are also arranged around the periphery of the touch surface to receive light from the set of emitters from above the touch surface. An object that touches the touch surface will attenuate the light on one or more propagation paths of the light and cause a change in the light received by one or more of the detectors. The location (coordinates), shape or area of the object may be determined by analysing the received light at the detectors.

[0004] In a variant of such 'above surface optical touch system', illustrated in Fig. 1a in cross-section, the emitters 301 are arranged on a substrate 304, and light from the emitters travel above the touch surface 302 of the panel 305 via reflection or scattering on an edge reflector or diffusor 303. As shown in top-down view figure 1b, the light will then continue until deflected by a corresponding edge reflector at an opposing edge of the light transmissive panel, where the light will be scattered back down through the transmissive panel and onto the detectors 306.

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[0005] Detectors 306 are distributed around the periphery of touch surface 302, to receive part of the propagating light. The light from each of emitters 301 will thereby propagate inside the transmissive panel 305 to a number of different detectors 306 on a plurality of light paths D. In the illustrated example, the apparatus 300 also includes a controller 320 which is connected to selectively control the activation of the emitters 301 and, possibly, the readout of data from the detectors 306. Depending on implementation, the emitters 301 and/or detectors 306 may be activated in sequence or concurrently. The signal processor 330 and the controller 320 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 330 and the controller 320 may be at least partially implemented by software executed by a processing unit 340.

[0006] A problem with such previous systems is the cumbersome alignment between the components thereof, which makes assembly more difficult and costly. Sub-optimal alignment results in signal loss, which moreover is an inherent problem in previous solutions due to the multiple components involved in the light scattering process. Another issue affecting the signal and scattering of the light in the touch sensing apparatus is uncontrolled glass warpage, i.e. distortions of the curvature of the light transmissive panel which will affect the light path and the detection process. While it is critical to accurately control such distortions, previous solutions incorporate complex solutions that may not allow to fully optimize glass warpage control in a mass production line without limiting the throughput of the production.

[0007] Some prior art systems rely on coupling and propagation of collimated light across the light transmissive panel. Such systems are however cumbersome to reliably implement due to the small tolerances with respect to the alignment of the components thereof. E.g. the light emitters- and detectors need to be precisely aligned in relation to various lenses and reflect the light via concave and/or convex reflection and/or refraction to get the desired collimation. Such precise alignment may be difficult to achieve in mass production. The use of collimated light, or light reflected by means of specular reflection, also adds to this complexity, which in turn results in a more expensive and less compact system. Furthermore, to reduce system cost, it may be desirable to minimize the number of electro-optical components.

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SUMMARY OF THE INVENTION

[0008] An objective is to at least partly overcome one or more of the above identified limitations of the prior art.

[0009] One objective is to provide a touch-sensitive apparatus based on "above-surface" light propagation which is robust and easy to assemble.

[0010] Another objective is to provide an "above-surface"-based touch-sensitive apparatus with efficient use of light.

[0011] One or more of these objectives, and other objectives that may appear from the description below, are at least partly achieved by means of touch-sensitive apparatuses according to the independent claims, embodiments thereof being defined by the dependent claims.

[0012] According to a first aspect, a touch sensing apparatus is provided comprising a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel. The light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the panel extends.

[0013] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0014] Preferably the substrate extends at least partly above the touch surface, whereby the plurality of light emitters and detectors are connected to a portion of the substrate extending above the touch surface.

[0015] Preferably the substrate is fixed to a carrier mounted around the perimeter of the panel.

[0016] Preferably the carrier is arranged to at least partly enclose edges the panel.

[0017] Preferably the carrier comprises fixing elements configured to attach the carrier to a display unit.

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[0018] Preferably the fixing elements are configured to attach the position of the substrate in relation to the carrier and/or in relation to the display unit.

[0019] Preferably the fixing elements are configured to interlock with a mounting element for locking the position of the carrier and/or the substrate to the display unit.

[0020] Preferably the fixing elements comprise openings, wherein the carrier forms a cavity having walls at least partly enclosing the substrate, and wherein at least one of the walls comprises at least one of said openings.

[0021] Preferably the fixing elements comprise openings arranged in the carrier and in the substrate, wherein first openings of the carrier are aligned with second openings of the substrate, the first and second openings being configured to receive a mounting element configured to lock the position of the carrier and/or the substrate to the display unit.

[0022] Preferably the carrier is configured to be attachable to the display unit at an adjustable position along a direction parallel to the normal axis, whereby a distance between the panel and the display unit along the normal axis is variable upon attaching the carrier to the display unit at at least two different adjustable positions.

[0023] Preferably the fixing elements are configured to attach the carrier to the display unit at the adjustable positions along the direction parallel to the normal axis.

[0024] Preferably the openings are separated along a direction parallel to the normal axis, and/or wherein the carrier is attachable to a plurality of second openings in a display support of the display unit, the plurality of second openings being separated along the normal axis.

[0025] Preferably the carrier is formed from a single monolithic piece of material.

[0026] Preferably the substrate extends in a longitudinal direction along the perimeter of the panel, the substrate comprising secondary fixing units configured for variably attaching the position of the substrate on the carrier along the longitudinal direction and/or in the direction of the normal axis.

[0027] Preferably vertical alignment units are arranged between adjacent substrates extending in a longitudinal direction along the perimeter of the panel, wherein the vertical alignment units are configured to variably position the adjacent substrates in the direction of the normal axis so that an angle between the adjacent substrates is adjustable.

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[0028] Preferably a plurality of substrates extend in a longitudinal direction along the perimeter of the panel, wherein a first substrate of said plurality of substrates comprises a connection unit configured to directly interlock with a subsequent connection unit of a subsequent substrate when arranged adjacent said subsequent substrate.

[0029] Preferably a sealing window is arranged around the perimeter of the panel, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, and wherein at least one of the first and second surfaces comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0030] Preferably the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and wherein the second surface comprises a light collimating surface.

[0031] According to a second aspect, a touch sensing apparatus is provided comprising a panel extending in a plane having a normal axis, the panel defining a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel, wherein the light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The touch sensing apparatus comprises a sealing window arranged around the perimeter, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and

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wherein the second surface comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0032] Preferably the first surface and/or second surface form a curved edge convex to the sealing window.

[0033] According to a third aspect, a method of assembling a touch sensing apparatus is provided comprising; attaching a substrate having a plurality of light emitters and detectors to a carrier; attaching the carrier around a perimeter of a panel and arranging the substrate to extend in a direction parallel with a normal axis of a plane in which the panel extends.

[0034] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0035] Preferably the carrier if formed from a single monolithic piece of material, the carrier forming a cavity having walls at least partly enclosing the substrate, wherein at least one of the walls comprise openings, the method comprising fixing the carrier to a display unit by fixing mounting elements through said openings.

[0036] Preferably the method comprises adjusting a distance between the panel and a display unit along the normal axis by attaching the carrier to the display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0037] Preferably the method comprises adjusting a radius of curvature of the panel in the direction of the normal axis by attaching the carrier to a display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0038] According to a fourth aspect there is provided a touch sensing apparatus, comprising: a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel and the light emitters are arranged to emit a respective beam of emitted light above the touch surface, and the light emitters are arranged to receive detection light from the emitted light, a substrate on which the plurality of light emitters and detectors are mountable; and a sealing window sealable against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

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[0039] Preferably the sealing window is sealable between the touch surface and a surface of the substrate.

[0040] Preferably the surface of substrate is a surface of a carrier for protecting components of the touch sensing apparatus.

[0041] Preferably the carrier comprises an upper portion which overlaps a portion of the perimeter of the panel and the sealing window is sealable between the touch surface and the underside of the overlapping upper portion.

[0042] Preferably the at least one reference surface is arranged to engage with a reciprocal reference surface on the substrate.

[0043] Preferably the at least one reference surface comprises a first portion for aligning in a first direction and a second portion for aligning in a second direction.

[0044] Preferably the at least one reference surface aligns the sealing window with respect to the substrate in a plane parallel with the touch surface.

[0045] Preferably the at least one reference surface aligns the sealing window with respect to the substrate at a height above the touch surface.

[0046] Preferably the sealing window comprises at least one resiliently deformable seal engagable with the substrate.

[0047] Preferably the resiliently deformable seal comprises the at least one reference surface.

[0048] Preferably the seal is extrudable along one or more surfaces of the sealing window.

[0049] Preferably the at least one reference surface substantially extends the entire length of the sealing window.

[0050] Preferably the sealing window and / or the substrate comprise a projection having a cross-sectional shape for positive engagement with a reciprocal hole in the substrate and / or sealing window and the at least one reference surface is part of the projection.

[0051] Preferably the sealing window and / or the substrate comprise a resiliently deformable projection wherein the projection comprises the at least one reference surface comprises and the projection is deformable on engagement with the substrate and / or sealing window and forms a snap-fit engagement therebetween.

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[0052] Preferably the sealing window comprises a plurality of reference surfaces.

[0053] Preferably the at least one reference surface comprises at least one discrete upstanding projection for engagement with reciprocal hole in the substrate.

[0054] Preferably the at least one upstanding projection is one or more of, pegs, hooks, latches, clamps or fasteners.

[0055] According to a fifth aspect there is provided a method of manufacture of the touch sensing apparatus comprising: mounting a plurality of light emitters and detectors to a substrate, attaching the substrate around a perimeter of a panel; and mounting a sealing window against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

[0056] Further examples of the invention are defined in the dependent claims, wherein features for the second aspect of the disclosure are as for the first aspect mutatis mutandis.

[0057] Some examples of the disclosure provide for a touch sensing apparatus that is easier to manufacture and assemble.

[0058] Some examples of the disclosure provide for a touch sensing apparatus with fewer steps of assembly.

[0059] Some examples of the disclosure provide for a touch sensing apparatus that is less costly to manufacture.

[0060] Some examples of the disclosure provide for a facilitated alignment of emitters and detectors of touch sensing apparatus.

[0061] Some examples of the disclosure provide for facilitated control of the curvature of the touch surface of a touch sensing apparatus.

[0062] Some examples of the disclosure provide for a more robust touch sensing apparatus.

[0063] Some examples of the disclosure provide for a touch sensing apparatus that is more reliable to use.

[0064] Some examples of the disclosure provide for a touch sensing apparatus that has a better signal-to-noise ratio of the detected light.

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[0065] Some examples of the disclosure provide for a more compact touch sensing apparatus.

[0066] Still other objectives, features, aspects and advantages of the present disclosure will appear from the following detailed description, from the attached claims as well as from the drawings.

[0067] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] These and other aspects, features and advantages of which examples of the invention are capable of will be apparent and elucidated from the following description of examples of the present invention, reference being made to the accompanying drawings, in which;

[0069] Fig. 1a is a section view of a touch sensing apparatus according to the prior art;

[0070] Fig. 1b is a top-down view of a touch sensing apparatus according to the prior art;

[0071] Fig. 2 is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0072] Fig. 3 is a schematic illustration, in a perspective side view, of a touch sensing apparatus according to one example;

[0073] Fig. 4a is a schematic illustration, in a side view of Fig. 2, of a touch sensing apparatus according to one example;

[0074] Fig. 4b is a schematic illustration of a magnified section of Fig. 4a, according to one example;

[0075] Fig. 4c is a schematic illustration of a magnified section of Fig. 4a, according to one example;

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[0076] Fig. 5a is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0077] Fig. 5b is a schematic illustration of a magnified section of Fig. 5a, according to one example;

[0078] Fig. 6 is a flow chart of a method of assembling a touch sensing apparatus according to one example;

[0079] Figure 7 is a schematic exploded perspective view of different layers of the touch-sensing apparatus according to one example;

[0080] Figure 8 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0081] Figure 9 is a cross sectional view of the touch sensing apparatus according to one example;

[0082] Figure 10 is a cross sectional view of the touch sensing apparatus according to one example;

[0083] Figure 11 is a cross sectional view of the touch sensing apparatus according to one example;

[0084] Figure 12 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0085] Figure 13 is a schematic perspective view of the touch sensing apparatus according to one example;

[0086] Figure 14 is a cross sectional view of the touch sensing apparatus according to one example;

[0087] Figures 15a, 15b, 15c, and 15d show magnified cross-sectional views of the touch sensing apparatus according to different examples; and

[0088] Figure 16 is a schematic perspective view of the touch sensing apparatus according to one example.

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DETAILED DESCRIPTION

[0089] In the following, embodiments of the present invention will be presented for a specific example of a touch-sensitive apparatus 100. Throughout the description, the same reference numerals are used to identify corresponding elements.

[0090] Fig. 1a schematically illustrates a variant of an 'above surface optical touch system', as discussed in the Background Art section above, where the light from the emitters 301 travel above the touch surface 302 of the panel 305 via reflection on an edge reflector 303. Figure 1b illustrates a top plan view of figure 1a in an example of a touch-sensitive apparatus 100.

[0091] Fig. 2 schematically illustrate a touch sensing apparatus 100 comprising a light transmissive panel 101 that defines a touch surface 102. In some embodiments the light transmissive panel 101 is located above a display 130 and permits light generated by the display 130 to propagate therethrough. However in other embodiments the light transmissive panel 101 can comprise light blocking material and does not permit the transmission of light therethrough. For example, the touch sensing apparatus 100, can be a trackpad or another touch interface which is remote from the display unit 130. Hereinafter the term "light transmissive panel" 101 will be used to describe either a light transmissive panel 101 or a solid, opaque panel 101.

[0092] A plurality of light emitters 103 and detectors 103' are arranged along a perimeter 104 of the light transmissive panel 101. The light emitters 103 are arranged to emit a respective beam of emitted light 105 above the touch surface 102. I.e. while the touch surface 102 extends along a plane 108, having a normal axis 107 directed towards a user performing touch operations on the touch surface 102, the emitted light 105 travels parallel with plane 108 and at a certain distance from the touch surface 102 in the direction of the normal axis 107, as schematically illustrated with respect to light beam 105, 105', in e.g. Fig. 2. Light 105, 105', can thus travel across the touch surface 102, between opposite sides thereof, without being reflected inside the light transmissive panel 101 itself.

[0093] In other embodiments, the plurality of light emitters 103 and detectors 103' are optionally arranged along a perimeter 104 of the light transmissive panel 101 at a different height. In some embodiments, the light emitters 103 and / or detectors 103' are

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arranged to emit a respective beam of emitted light 105 below the touch surface 102 and the light beams are guided around the light transmissve panel 101. The light beams can be guided around the light transmissive panel 101 with additional reflective components (not shown). For the purposes of brevity, the embodiments discussed hereinafter refer to the plurality of light emitters 103 and detectors 103' being arranged above the touch surface 102, but the embodiments also include the arrangement where the plurality of light emitters 103 and detectors 103' are mounted below the touch surface 102.

[0094] The light detectors 103' are arranged to receive detection light 105' from the emitted light 105. Fig. 2 illustrates a section of the touch sensing apparatus 100 adjacent the perimeter 104 of the light transmissive panel 101. In this section, the emitters and detectors 103, 103', are shown in the same view, as well as the emitted and detected light 105, 105', for clarity of presentation. The plurality of light emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel extends. By having the substrate 106 extending in parallel with the normal axis 107, the plurality of emitters and detectors 103, 103' are conveniently arranged, above the touch surface 102 to achieve a compact footprint in the direction of the plane 108 of the touch sensing apparatus 100 around the perimeter 104, while achieving a direct light path for the emitted or detected light 105, 105', above and across and touch surface 102. Thus, the emitted light 105 does not have to be reflected in order to diffusively spread above and across the touch surface 102, and a detector 103' may directly receive detection light 105' by being correspondingly positioned above the touch surface 102 at an opposite position anywhere around the perimeter 104. The amount of available light that can be utilized for the detection and characterization of an object touching the touch surface 102 can thus be maximized, and the signal to noise ratio can be improved. The touch sensing apparatus 100 may comprise a sealing window 126 as illustrated in Fig. 2, shielding the emitters and detectors 103, 103', from the outside. The emitted and detected light 105, 105', may thus only have to propagate through the sealing window 126 along the light path between the emitters and detectors 103, 103'. The sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the display.

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[0095] Having the substrate extending in the direction 107' being parallel with the normal axis 107 and the emitters and detectors 103, 103', arranged above the touch surface 102 provides for a less complex alignment to maximize the detection performance of the touch sensing apparatus 100. The position of the substrate 106 in the direction of the normal axis 107 can be accurately varied to achieve optical alignment with respect to the emitters and detectors 103, 103'. The ability to achieve an accurate positioning of the substrate 106, and consequently the emitters and detectors 103, 103', attached thereto, is also due to the increased accuracy by which the dimensions of the substrate 106 can be defined along the direction of the substrate 106 aligned with the normal axis 107 in Fig. 2. I.e. the substrate 106 is elongated and extends in a longitudinal direction 123 (Fig. 4a) around the perimeter 104 of the light transmissive panel 101, and it has a short-side extending in parallel with the normal axis 107. The short-side of the substrate 106, illustrated in the cross-sectional view of Fig. 2, may be manufactured to smaller tolerances, and by aligning this side with the normal axis 107, the tolerances for the alignment of the emitters and detectors 103, 103', along the normal axis 107 can be improved. The alignment can thus be both improved, and facilitated as discussed above. The latter advantage also provides for facilitated and less costly mass production of the touch sensing apparatus 100 and the various touch base display systems in which it may be implemented.

[0096] The substrate 106 may extend at least partly above the touch surface 102, whereby the plurality of light emitters and detectors 103, 103', are connected to a portion 109 of the substrate extending above the touch surface 102. This further provides for achieving a more robust alignment of the emitters and detectors 103, 103', relative to the light transmissive panel 101, by being directly joined to the substrate 106, and thereby simultaneously arranged above the touch surface 102. It may be conceivable however that the emitters and detectors 103, 103', are connected to the substrate 106 via connection elements (not shown) extending between the substrate 106 and to a position above the touch surface 102.

[0097] The substrate 106 may be fixed to a carrier 110 mounted around the perimeter 104 of the light transmissive panel 101, as schematically illustrated in Figs. 1a, 1b and 2. By directly joining the substrate 106 to the carrier 110 provided around the perimeter

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104, the assembly of the touch sensing apparatus 100 may be further facilitated, as the amount of components can be kept at a minimum. For example, the substrate 106 can be accurately fixed in relation to the carrier 110, due to the small tolerances possible in the direction of the substrate 106 aligned in parallel with the normal axis 107 in Fig. 2, as discussed above. The carrier 110 may for example comprise a cavity 116, as discussed further below, being precisely dimensioned to accommodate the width of the substrate 106 along the direction 107', i.e. the short-side of the substrate 106. Then, accurate positioning of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 is possible as the carrier 110 is mounted around the perimeter 104 thereof. The carrier 110 may extend substantially in the direction 107' parallel with the normal axis 107, as with the substrate 107, to achieve a compact mounting around the perimeter 104. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0098] Having the substrate 106 fixed to the carrier 110 allows also for having the carrier 110 wired as an electrical ground reference layer of the substrate 106.

[0099] The carrier 110 may be arranged to at least partly enclose edges 111 of the light transmissive panel 101, as shown in the example of Fig. 2. This provides for further increasing the robustness of the touch sensing apparatus 100, and improving the accuracy of the alignment of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 since the carrier 110, having the emitters and detectors 103, 103', fixed thereto, may also be directly supporting the light transmissive panel 101 around the perimeter 104. The carrier 110 may comprise a slot in which the light transmissive panel 101 is fitted around the perimeter 104.

[0100] The carrier 110 may comprise fixing elements 112 configured to attach the carrier 110 to a display unit 113, 121. The display unit may comprise a display support 121 and a display panel 113, which collectively is referred to as a display unit in the present disclosure. Having the carrier 110 attachable to the display unit 113, 121, by fixing elements 112, advantageously provides for further facilitating the assembly of the touch sensing apparatus 100 to a display unit, since the carrier 110 can be directly joined to the latter. Alignment is thus facilitated, due to the minimum amount of components needing such

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alignment to each other. The robustness of the touch sensing apparatus 100 is further improved, while mass production is made less complex due the minimized number of assembly steps. The fixing elements 112 may comprise any elements configured to provide for fixing of the position of the carrier 110 to the display unit 113, 121. In the example shown in Fig. 2, the carrier 110 has openings 115, 115', 115'', discussed further below, which may be aligned with corresponding openings 127 of a support of the display unit 121, through which mounting elements 114 may be positioned for the fixing. It is conceivable however that the carrier 110 has other types of recesses or protrusions which may interlock with a corresponding mating surface of the display unit 113, 121.

[0101] The fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the carrier 110. Thus, besides from fixing the position of the carrier 110 relative to the display unit 113, 121, the fixing elements 112 may also fix or at least support the position of the substrate 106 in relation to the carrier 110. It is conceivable that the substrate 106 may first be arranged in relation to the carrier 110, and the fixing elements 112 may be arranged to support and strengthen the fixing therebetween, while simultaneously fixing the carrier 110 to the display unit 113, 121. This may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100. From a similar aspect, the fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the display unit 113, 121. This may be seen as a consequence from the above, i.e. the fixing elements 112 contributing to the fixing of the substrate 106 to the carrier 110, which in turn is fixed to the display unit 113, 121. It is however conceivable that the fixing elements 112 may fix the substrate 106 directly to the display unit 113, 121, in which case the carrier 110 may act as a further support for the substrate 106.

[0102] In one example, as discussed further below, the substrate 106 may comprise second openings 118 which provides for such fixing or support. As mentioned, this may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100.

[0103] The fixing elements 112 may be configured to interlock with a mounting element 114 for locking the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. Figs. 2 – 3 show examples of having an elongated mounting element 114

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joining the carrier 110 and/or the substrate 106 to the display unit 113, 121. The mounting element 112 may however comprise any fastening element configured to exert a force between the carrier 110 and/or the substrate 106 to the display unit 113, 121, such as pins, bolts, screws, clips, clamps, locks, bars, rods, anchors, latches, clasps.

[0104] The fixing elements 112 may comprise openings 115, 115', 115'', as illustrated in Figs. 2 – 3. The carrier 110 may form a cavity 116 having walls 117 at least partly enclosing the substrate 106, illustrated in the example of Fig. 2. This may provide for increased stability of the fixing of the position of the substrate 106 in relation to the carrier 110. At least one of the walls 117 may comprise at least one of the openings 115, 115', 115'', as further illustrated in Fig. 2. Being able to directly fix the walls 117 of the carrier 110 enclosing the substrate 106 to the display unit 121, 113, provides for further simplifying manufacturing, and at the same time further increase the accuracy of the alignment of e.g. the emitters and detectors 103, 103', in relation to the light transmissive panel 101, since the minimized number of intermediate mounting components improves tolerance control. I.e. build-up of mounting errors in each assembly step is reduced and controlled. It is conceivable that the walls 117 may be fixed to the display unit 113, 121, by other fixing elements 112, such as recesses or protrusions interlocking with correspondingly mating surfaces of the display unit 113, 121, and/or fastening elements as exemplified above.

[0105] The fixing elements 112 may comprise openings 115, 115', 115'', 118, arranged in the carrier 110 and in the substrate 106. First openings 115, 115', 115'' of the carrier 110 may be aligned with second openings 118 of the substrate 106, as illustrated in the example of Fig. 2. The first and second openings 115, 115', 115'', 118 may be configured to receive a mounting element 114 configured to lock the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. This provides for further facilitated and improved alignment and assembly, and increased robustness. In the example of Fig. 2, the carrier 110 encloses the substrate 106 such that two opposite openings 115, 115'', of the carrier are arranged on either side of the substrate 106, but it is conceivable that the carrier 110 may be arranged on one side only of the substrate 106.

[0106] The carrier 110 may be configured to be attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis. A

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distance 120 between the light transmissive panel 101 and the display unit 113 along the normal axis 107 may thus be variable upon attaching the carrier to the display unit 113, 121 at at least two different adjustable positions 119, 119'. For example, turning to Fig. 3, the carrier 110 is attached at a first position 119 to the support of the display unit 121, via fixing unit 112. The first position 119 provides for the given distance 120 between the panel of the display unit 113. The distance 120 may then be decreased by instead attaching the carrier 110 at a second position 119' which is off-set with respect to the first position 119 in the positive direction of the normal axis 107, or the direction 107'' as illustrated in Fig. 3. If the fixing point to the support of the display unit 121 remains constant, e.g. at the opening 127 of a support 121 as illustrated, the carrier 110 will be moved in the opposite direction to the normal axis 107 and the distance 120 will be decreased. Having the carrier 110 being attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis 107, thus provides for simple and efficient adjustment of the position of the light transmissive panel 101.

[0107] Besides from overall controlling the distance 120, as discussed, such adjustment provides for efficiently controlling and varying the curvature of the light transmissive panel 101. I.e. varying the distance 120 as discussed at a second intermediate location 128', between opposite ends of the carrier 110, along the longitudinal direction 123, while maintaining the distance 120 at the opposite ends, such as at a first location 128, will affect the curvature of the carrier 110, and thereby the curvature of the light transmissive panel 101. E.g. decreasing the distance 120 at the second location 128' can produce a more concave shape, i.e. a decreased radius of curvature, of the carrier 110 and the light transmissive panel 101, in the direction of the normal axis 107. Increasing the distance 120 between the mentioned opposite ends can instead increase the radius of curvature in the direction of the normal axis 107. The curvature or warping of the light transmissive panel 101 can thus be controlled efficiently an in a facilitated manner, which is advantageous for increasing throughput in mass-production of displays incorporating the touch sensing apparatus 100 while keeping the warp of the light transmissive panel 101 under control. An optimized curvature of the light transmissive panel 101 increases the reliability and accuracy of the touch sensing apparatus 100.

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[0108] The fixing elements 112 may be configured to attach the carrier 110 to the display unit 121 at the adjustable positions 119, 119', along the direction 117'' parallel to the normal axis 107. Thus, the fixing units 112 be arranged at the different adjustable positions 119, 119', to adjust the distance 120 and the curvature of the a light transmissive panel 101 while providing for securely attaching the carrier to the display unit 113, 121. The fixing elements 112 may thus be arranged at least at the first and second locations 128, 128', along the longitudinal direction 123 as discussed above, where each of the locations in the longitudinal direction 123 may have at least two adjustable positions 119, 119', as illustrated in the example of Fig. 3.

[0109] The openings 115, 115', of the carrier 110 may be separated along a direction 117'' parallel to the normal axis 107, as illustrated in Fig. 3. Alternatively, or in addition, the carrier 110 may be attachable to a plurality of second openings 122 in a display support 121 of the display unit, where the plurality of second openings 122 are separated along the normal axis 107. Thus, the position 119, 119', may be remained fixed while the carrier 110 is attached to the support 121 at the various second openings 122, to adjust the curvature of the light transmissive panel 101 and/or the distance 120 as discussed above. Although the examples in Figs. 2 – 3, show openings 115, 115', 115'', 127, it is conceivable that the attachment between the carrier 110 and the display unit 121, 113, is provided by other fixing elements 112 as exemplified above.

[0110] The carrier 110 may be formed from a single monolithic piece of material. The structural integrity and the stability of the carrier 110 can thereby be increased, which further optimizes the parameters discussed above with respect to alignment, robustness, ease of assembly etc. One example of a possible process by which the carrier can be formed as a single piece of material is an extrusion process, but it is conceivable that the carrier 110 may be formed from other hot or cold metal or polymer working processes such as drawing, rolling, or molding processes.

[0111] The substrate 106 may extend in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. Fig. 4a illustrates a view of a plurality of substrates 106, 106', extending along the longitudinal direction 123. The light transmissive panel 101 and the carrier 110 holding the substrates have been excluded in the view for

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clarity of presentation. The substrates 106, 106', may comprise secondary fixing units 124, 124', configured for variably attaching the position of each of the substrates 106, 106', on the carrier 110 along the longitudinal direction 123 and/or in the direction of the normal axis 107. This provides for more accurately adjusting the position of the substrates 106, 106', in relation to the light transmissive panel 101. While each of the substrates 106, 106', may be within tolerances, the accumulated error obtained when several substrates 106, 106' are connected along the longitudinal direction 123 may exceed the total tolerance of the full length of the light transmissive panel 101. Such accumulation of errors may be effectively prevented by having secondary fixing units 124, 124', as elucidated above. The secondary fixing units 124, 124', may be provided on various locations on the substrates 106, 106', to allow for adjusting the position, such as on opposite ends thereof.

[0112] The touch sensing apparatus 100 may comprise vertical alignment units 135 arranged between adjacent substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. The vertical alignment units 135 are configured to variably position the adjacent substrates 106, 106', in the direction of the normal axis 107 so that an angle 136 between the adjacent substrates 106, 106', can be adjusted. Fig. 4b schematically illustrates a vertical alignment unit 135 positioned between adjacent substrates 106, 106', to vary the position thereof in the direction of the normal axis 107, i.e. along arrows 137, so that the angle 136 may be set to a desired value. The vertical alignment unit 135 thus provides for facilitating the alignment of the plurality of substrates 106, 106', to e.g. the curvature of the light transmissive panel 101. For example, if the light transmissive panel 101 is concave in the direction of the normal axis 107, initially parallel substrates 106, 106', may be angled to closely follow the concave shape of the light transmissive panel 101 by increasing the angle 136 between the substrates 106, 106', as schematically illustrated in Fig. 4b. The position of the emitters and detectors 103, 103', on the substrates 106, 106', may thus remain at an optimized vertical position relative the light transmissive panel 101 for various curvatures thereof. The vertical alignment unit 135 may comprise various units configured to change the position of the adjacent substrates 106, 106', in the direction of the normal axis 107, such as bolts, screws, pins, or any other elements that can provide an offset at the ends of the substrates 106, 106'.

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[0113] The touch sensing apparatus 100 may comprise force distributing units 138 positioned between adjacent substrates 106, 106', configured to provide a fixing force therebetween, as schematically illustrated in Fig. 4c. The force distributing units 138 may provide for improving and facilitating the fixing of the substrates 106, 106', to the carrier, without the need for dedicated fixing elements such as screws, bolts, etc to each end of respective substrates 106, 106', thereby reducing the amount of such fixing elements, which facilitates the assembly of the touch sensing apparatus 100.

[0114] The touch sensing apparatus may thus comprise a plurality of substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. A first substrate 106 of the plurality of substrates may comprises a connection unit 125 configured to directly interlock with a subsequent connection unit 125' of a subsequent substrate 106' when arranged adjacent said subsequent substrate, as schematically illustrated in Fig. 4a. It is thereby possible to directly connect subsequent substrates 106, 106', and eliminate the need for intermediate connectors, which further provides for facilitating the assembly of the touch sensing apparatus 100.

[0115] The touch sensing apparatus 100 may comprise a sealing window 126 as schematically illustrated in Figs. 5a-b. The sealing window 126 may be arranged around the perimeter 104 of the light transmissive panel 101. The sealing window 126 may comprise a first surface 129 facing the light emitters 103 or the light detectors 103', and an opposite second surface 130 arranged adjacent the touch surface 102. Emitted or detected light thus propagates between the first and second surface 129, 130. At least one of the first and second surfaces 129, 130, may comprises a light collimating surface 129, 130, configured to collimate light propagating above the touch surface 102. I.e. emitted light 105 will be collimated by the sealing window 126, so that the light propagating above the touch surface 102 will be collimated. Detectors 103' will receive the collimated light which will be focused through a corresponding sealing window 126. As the emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction parallel with a normal axis 107, it is possible to provide for a very precise and improved alignment thereof in relation to the sealing window 126, which allows for achieving collimated light in a highly optimized manner, and an associated increase in signal

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strength since more of the emitted light can be collected by the detectors 103'. The emitted light is collimated in a direction parallel with the plane 108 in which the light transmissive panel 101 extends. Collimating the light with sealing window 126 also allows for reducing the aperture of the sealing window 126, i.e. the thickness of the sealing window 126 in the direction of the normal axis 107, while still detecting a sufficient amount of light. This provides for reducing the amount of ambient light reaching the detectors 103', thus improving the signal to noise ratio.

[0116] Turning to Fig. 5b, the second surface 130 may extend in the direction of the normal axis 107 between a base surface 131 of the sealing window 126, facing the light transmissive panel 101, and an opposite top surface 132 of the sealing window 126. The base surface 131 may be offset from the top surface 132 along the direction of the plane 108 with an offset distance 133 so that the second surface 130 forms an angle 134 relative the normal axis 107. As further illustrated in Fig. 5b, the second surface may comprises the light collimating surface 130. Thus, in addition to having a convex shape as illustrated in Fig. 5b, the second surface 130 is arranged to assume a tilted configuration as provided by the offset distance 133. Having such angled configuration provides for reducing the impact of Fresnel reflexes. The Fresnel reflexes otherwise generate additional unwanted light paths that will reduce the apparent attenuation on some detection lines, especially when they run parallel to and near a sealing window 126. These Fresnel reflexes may also result in artifacts and false touch information. By having an angled and/or curved second surface 130 of the sealing window 126, the light may instead bounce off the second surface 130 with such an angle so that it leaves the plane 108, and thereby not interfere with the detection of the remaining light.

[0117] A sealing window 126 as described above can provide for the advantageous effects as described for touch sensing apparatuses having a plurality of light emitters and detectors arranged in a multitude of configurations, not limited to the configurations described in relation to Figs. 2 and 3 exemplified above. A touch sensing apparatus 100 is thus provided comprising a light transmissive panel 101 extending in a plane 108 having a normal axis 107, wherein the light transmissive panel defines a touch surface 102. The touch sensing apparatus 100 comprises a plurality of light emitters 103 and

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detectors 103' arranged along a perimeter 104 of the light transmissive panel, wherein the light emitters are arranged to emit a respective beam of emitted light 105 above the touch surface, wherein the light detectors are arranged to receive detection light 105' from the emitted light. The touch sensing apparatus 100 comprises a sealing window 126 arranged around the perimeter, wherein the sealing window comprises a first surface 129 facing the light emitters or the light detectors and an opposite second surface 130 arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface 131 of the sealing window, facing the light transmissive panel, and an opposite top surface 132 of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance 133 so that the second surface forms an angle 134 relative the normal axis, and wherein the second surface comprises a light collimating surface 130 configured to collimate light propagating above the touch surface.

[0118] The first surface 129, facing the emitters or detectors 103, 103', may also be angled, with an angle 134', as schematically illustrated in Fig. 5a, to provide for the desired light path from or towards the emitters or detectors 103, 103', respectively. The first surface 129 may also comprise a light collimating surface and have a convex shape towards the emitters or detectors 103, 103', as illustrated in Fig. 5a, in addition to being arranged at an angle 134'. The angles 134, 134', may be in the range of 2-10 degrees relative to the normal axis 107 to provide for a particularly advantageous reduction of Fresnel reflexes. An angle greater than 2 degrees avoids Fresnel reflexes and an angle of less that 10 degrees reduces the light field height.

[0119] The sealing window 126 may comprise a fixing element 139 configured to interlock to carrier 110. In the example in Fig. 5a, the fixing element comprises a protrusion 139 arranged to interlock with a corresponding recess in the carrier 110. Mounting and fixing of the sealing window 126 may thus be facilitated and improved since the fixing element 139 may snap into the carrier 110, without needing to have separate fixing units or adhesives joining the sealing window 126 to the carrier 110. In some circumstances, it is preferable not to use an adhesive because the adhesive may not be resilient in high temperatures. Use of an adhesive for fixing the sealing window 126 can be problematic because the uncured adhesive

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allows for relative movement between the components and precise alignment may be difficult. It is conceivable that the fixing element 139 may comprise any other shape, such as a recess, for interlocking with a corresponding mating surface of the carrier 110.

[0120] Alternative embodiments of the sealing window 126 will now be described in reference to Figure 7 to 16.

[0121] Figure 7 shows an exploded perspective schematic view of the touch sensing apparatus 100. The dotted line shows the normal axis 107 of the touch surface 102 at the center of the light transmissive panel 101. For the purposes of clarity, the exploded perspective view in Figure 7 shows the separate components side by side, but the dotted line of the normal axis 107 represents the order of how the components stack together. As mentioned previously the carrier 110 may extend substantially in the direction parallel with the normal axis 107. In this way the carrier 110 comprises a downwardly projecting skirt 700 from the upper surface 702.

[0122] The sealing window 126 is mountable on the carrier 110 and this will be discussed in further detail below. The sealing window 126 comprises a similar shape to the arrangement of the plurality of light emitters 103 and detectors 103' (not shown in Figure 7 for the purposes of clarity). The sealing window 126 is mounted such that the plurality of light emitters 103 and detectors 103' are between the sealing window 126 and the skirt 700. As shown in Figure 7, the sealing window 126 is a rectangular loop structure.

[0123] In some embodiments, the sealing window 126 may be formed from a single monolithic piece of material, thus providing for a robust sealing window 126 and a stable attachment to the carrier 110 and the light transmissive panel 101. The sealing window 126 may be formed by an extrusion process. In one embodiment, the sealing window is formed from two separate materials. A first material, such as a dyed PMMA or similar NIR transparent material, is used for a transparent section and a second material, such as a compressible light blocking material, is used for sealing off the E/D compartment. This may be achieved by e.g. using a co-extrusion process.

[0124] In other embodiments, the sealing window 126 is formed from a plurality of longitudinal pieces (not shown) and joined together to form a rectangular arrangement. Each longitudinal piece may be a single monolithic piece of material. Considering the sealing

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window 126 in Figure 7, the arrangement as shown in Figure 7 is formed from four pieces of extruded sealing window material 126. The four pieces are then joined together to construct the rectangular loop as shown in Figure 7. The four pieces of the extruded sealing window 126 can be adhered together with glue, or fastened together with screws, clips, clamps or any other suitable fastener. The glue can be applied and cured before the sealing window 126 is slid into the carrier 110 or the glue can be left to cure once the sealing window 126 is positioned in the carrier 110. Alternatively the four pieces are not fastened or glued together and are held in position with a friction fit.

[0125] The sealing window 126, once assembled, is sandwiched between the upper surface 702 of the carrier 110 and the light transmissive panel 101. In some embodiments, the sealing window 126 is slid into position between the carrier 110 and the light transmissive panel 101. Figure 8 shows the direction A in which the sealing window 126 is moved with respect to the carrier 110 and the light transmissive panel 101. In this embodiment the sealing window 126 is slid in a direction parallel with the plane of the light transmissive panel 101. In other embodiments, discussed in more detail below, the sealing window 126 can be inserted into the carrier 110 in a different direction such as parallel to the normal axis 107 and perpendicular to the touch surface 102.

[0126] In some embodiments the light transmissive panel 101 is not required to be light transmissive. For example the touch surface 102 can be on a medium through which light does not propagate. In some embodiments the touch surface 102 can be part of a surface which does not require light from a display unit 113, 121 to be visible there through. That is, the touch sensing apparatus 100 is remote from the display unit 113, 121 and the display unit 113, 121 is not stacked together with the other components as shown in Figure 7. In this way the light transmissive panel 101 can be considered to be a panel 101. For the purposes of clarity, the panel 101 has been referred to as a light transmissive panel 101, but all the embodiments are also applicable to a panel comprising an opaque or light blocking material.

[0127] Turning to Figure 8, the construction of the carrier 110, the sealing window 126 and the light transmissive panel will now be discussed in more detail. Figure 8 shows a partial perspective cross-sectional view of the touch sensing apparatus 100. In

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particular Figure 8 is magnified to show the arrangement between the carrier 110, the sealing window 126 and the light transmissive panel 101.

[0128] The sealing window 126 comprises a dual purpose. Firstly, the sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the edge of the light transmissive panel 101. This means that the sealing window 126 prevents ingress of dirt, water and other contaminants into the interior of the touch sensing apparatus 100. This helps protect the internal components such as the plurality of emitters and detectors 103, 103'. Secondly, the sealing window 126 allows light from the emitters and detectors 103, 103' to propagate therethrough. In some embodiments, as discussed in reference to Figure 5a, the sealing window can optionally comprise optical elements for refracting, deflecting, diverting or focusing the light beams therethrough. However in other embodiments, the sealing window is optically passive and does not comprise any optical elements for refracting, deflecting, diverting or focusing the light beams therethrough.

[0129] As can be seen from Figure 8, an upper sealing surface 800 of the sealing window 126 engages with an interior underside surface 802 of the carrier 110. The upper surface 702 of the carrier 110 is arranged to project over the light transmissive panel 101. In this way the carrier 110 overlaps a portion of the light transmissive panel 101 around the perimeter of the light transmissive panel 101. The portion 810 of the upper surface 702 that overlaps with the light transmissive panel 101 is indicated by a bracket in Figure 8. The overlapping portion 810 of the carrier 110 provides protection for the perimeter light transmissive panel 101 from shock and other physical forces. The overlapping portion 810 also provides an overhang on which the sealing window 126 can be mounted. The interior underside surface 802 of the carrier is an opposite face to the upper surface 702. A lower sealing surface 804 of the sealing window 126 engages with the touch surface 102.

[0130] In order to aid the sealing, the sealing window 126 optionally comprises one or more deformable seals or integral gaskets 806, 808 mounted on the upper sealing surface 800 and the lower sealing surface 804 respectively. The deformable seals 806, 808 are arranged to deform when the light transmissive panel 101 is urged towards the carrier 110. The deformable seals 806, 808 are extruded along the longitudinal length of the sealing

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window 126. In some embodiments the deformable seals 806, 808 are integral with the sealing window 126. As mentioned previously, in some embodiments the deformable seals 806, 808 can be manufactured at the same time as the sealing window 126 in a co-extrusion process. Alternatively the deformable seals 806, 808 are mounted and adhered to the sealing window 126 after the sealing window 126 has been extruded. In some embodiments the deformable seals 806, 808 are made from a thermoplastic elastomer (TPE). The deformable seals 806, 808 can be colored black to block transmission of light from the sealing window 126. The deformable seals 806, 808 can be any suitable color or material for absorbing light and minimizing light in-coupling.

[0131] In some embodiments the sealing window 126 is configured to be mounted between two surfaces for sealing and protecting the emitters and detectors 103, 103' from the outside environment. In some embodiments the sealing window 126 is arranged to seal against the touch surface 102 and the interior underside surface 802 of the carrier 110. In other embodiments the sealing window 126 can be mounted between any other surface to provide a sealed cavity 116 around the emitters and detectors 103, 103'. In some embodiments the sealing window 126 seals between the interior underside surface 802 and other surface. The other surface does not need to be the touch surface 102. Instead the other surface is another interior surface of the carrier 110 such as a surface on which the substrate 106 is mounted on. In some other embodiments the sealing window 126 is mounted and sealed against another components and neither of the touch surface 102 and the interior underside surface 802. In some embodiments the sealing window 126 is sealable against at least one surface of the touch sensing apparatus 100 for sealing a cavity 116 around the plurality of light emitters and detectors 103, 103'. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0132] In some embodiments the sealing window 126 comprises at least one reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The reference surface 812 will be discussed in further detail with respect to Figure 9 for the purposes of clarity.

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[0133] Figure 9 is a schematic cross-sectional view of the touch sensing apparatus 100. The sealing window 126 is inserted between the light transmissive panel 101 and the carrier 110. The upper deformable seal 806 comprises a reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The upper deformable seal 806 comprises a projection 814 which projects upwardly from the upper deformable seal 806 and the sealing window 126. In this way, the reference surface 812 is upright with respect to the sealing window 126. The projection 814 also optionally comprises a chamfer 816 in addition to the reference surface 812.

[0134] The chamfer 816 means that the deformable upper seal 806 does not snag on the carrier 110 when the sealing window 126 is inserted between the carrier 110 and the light transmissive panel 101. Accordingly as the sealing window 126 is pushed into place, the chamfer 816 urges against the interior underside surface 802 of the carrier 110. Initially, the deformable upper seal 806 is squashed between the carrier 110 and the light transmissive panel 101 when the sealing window 126 is being forced between the carrier 110 and the light transmissive panel 101.

[0135] The sealing window 126 is pushed towards a notch 820 located in the interior underside surface 802 of the carrier 110. In some embodiments, the notch 820 is a groove that extends around the periphery of the carrier 110. The notch 820 comprises a reciprocal reference surface 818 for aligning with the reference surface 812 of the projection 814. In particular, the notch 820 is a reference point for indicating that the sealing window 126 is inserted underneath the overlapping portion 810 sufficiently to form a seal and protect the internal components of the touch sensing apparatus 100. The notch 820 is positioned a predetermined distance from the edge 822 of the carrier 110. In some embodiments the predetermined distance is at least half the width of the sealing window 126.

[0136] When the sealing window 126 pushed sufficiently between the carrier 110 and the light transmissive panel 101, the deformed projection 814 is located within the notch 820. At this point when the sealing window 126 is located in the correct position with respect to the carrier 110, the reference surface 812 abuts against a reciprocal reference surface 818 in the notch 820 in the carrier 110.

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[0137] The compressed projection 814 resiles and expands once located in the notch 820. In this way, the project 814 snaps into position and positively engages with the notch 820. When the sealing window 126 is located and the projection 814 snaps into place, the sealing window 126 makes an audible "click". Additionally or alternatively the snapping of the projection 814 into position provides a tactile feedback during assembly that the sealing window 126 is seated correctly.

[0138] The size of the notch 820 is slightly larger than the dimensions of the projection 814. Accordingly the projection 814 fits snugly within the notch 820. This means that the frictional forces between the carrier 110, the light transmissive panel 101 and the sealing window 126 are sufficient to hold the sealing window 126 in place. Adhesive is not required to fix the sealing window 126 in place. However in some embodiments adhesive is optionally used in addition to the snap-fit positive engagement.

[0139] In some embodiments the reference surface 812 abuts against the reciprocal reference surface 818. This means that the sealing window 126 opposes the direction A by virtue of the engaged reference surfaces 812, 818. Removal of the sealing window 126 may only be achieved with a special tool which compresses the projection 814.

[0140] Once the sealing window 126 has been seated correctly in the carrier 110, the reference surfaces 812, 818 maintain the alignment between the carrier 110 and the sealing window 126. The deformable seals 806, 808 maintain the relative position of the sealing window 126 with respect to the carrier and prevents lateral movement in a plane parallel to the light transmissive panel 101. Furthermore, the reference surfaces 812, 818 ensure that the sealing window 126 is maintained at a certain height above the touch surface 102.

[0141] The shape and size of the deformable seal 806, 808 can be varied. Another embodiment with such a variation is shown in Figure 10. Figure 10 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement is the same as shown in reference to Figures 8 and 9, except the cross sectional shape of the deformable seal 806, 808 is different. In this embodiment the projection 1002 comprises a curved upwardly projecting bulge 1002 on the upper deformable seal 806. The bulge 1002 comprises a curved reference surface 1004 which engages with one or more reciprocal reference surfaces 818 of the notch

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820. The curved reference surface 1004 functions in a similar way to the chamfer 814 as described in reference to the previous embodiment when inserting the sealing window 126 between the light transmissive panel 101 and the carrier 110. The bulge 1002 has dimensions which are substantially the same width as the width of the notch 820 so that the sealing window 126 does not experience lateral movement in a direction parallel with the plane of the light transmissive panel 101. The lower seal 808 optionally comprises a similar bulge 1006 for engaging and sealing against the touch surface 102. By making the upper seal 806 and the lower seal 808 have the same cross section, manufacture can be simplified because the same die (not shown) can be used during extrusion of the deformable seals 806, 808.

[0142] Advantageously the shape of the projection 1002 means that the sealing window 126 can be removed with a similar magnitude of force to the force needed for insertion during assembly. Accordingly removal of the sealing window 126 may not require a tool. This can make maintenance which requires removal of the sealing window 126 easier.

[0143] Another embodiment is shown in Figure 11. Figure 11 shows a cross sectional side view of the touch sensing apparatus 100. Figure 11 is the same as shown in Figure 10 except that there is an additional projection and notch. The first notch 1100 and first bulge 1104 are substantially the same as the notch 820 and the bulge 1002 as discussed in reference to Figure 10. In addition, there is a second notch 1102 and a second bulge 1106. Likewise the lower seal 808 comprises similar first and second bulges 1108, 1110. Having two projecting bulges 1104, 1106 means that there are two points of sealing engagement between the sealing window 126 and the light transmissive panel 101 and the carrier 110 respectively. This means that there will be less rotation of the sealing window 126 about the deformable seal 806, 808. Accordingly, the tolerances needed to accommodate rotational movement of the sealing window about the longitudinal axis of the sealing window can be lower. There is also an increased surface area of the deformable seals 806, 808 and therefore the deformable seals will cool quicker during manufacture.

[0144] In another embodiment, the first and second bulges 1104, 1106 engage with a single notch 820 as shown in Figure 10. The dotted line between the first and second notches 1100, 1102 represents a single notch, similar to the notch 820 in Figure 10. In this case the first bulge 1104 engages a first reciprocal reference surface 1114 and the second

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bulge 116 engages with a second reciprocal reference surface 1112. The first and second reciprocal reference surfaces 1114, 1112 are walls of the notch 820.

[0145] Another embodiment will now be discussed in reference to Figure 12. Figure 12 shows a schematic perspective and cross-sectional view of the touch sensing apparatus 100. The arrangement as shown in Figure 12 is the same as shown in Figures 8 and 9 except that the deformable seal 806 comprises a plurality of discrete projections 1200, 1202, 1204. Each of the projections is deformable and is inserted between the light transmissive panel 101 and the carrier 110 in the same way as described with respect to the previous embodiments. The carrier 110 comprises a serious of reciprocal recesses (not shown for clarity) to receive a respective projection 1200, 1202, 1204. In this way less deformable material is required to perform the alignment function. The projections may be adhered to the deformable seal material 806 or the projections can be extruded. Each of the projections 1200, 1202, 1204 comprise a reference surface for aligning the projection and the sealing window 126 with the reciprocal recess in the carrier 110. In some embodiments the projections 1200, 1202, 1204 can comprise any suitable cross sectional shape. For example, the projections can comprise an oval curved cross section, similar to the bulges shown in the embodiments discussed in reference to Figures 10 and 11.

[0146] Figure 13 shows yet another embodiment. Figure 13 shows a schematic exploded perspective view of the touch sensing apparatus 100. For the purposes of clarity the light transmissive panel 101 is not shown. The sealing window 126 is the same as described in reference to the previous embodiments. The upper deformable seal 806 is mounted on the upper sealing surface 800. In contrast to the previous embodiments, the deformable seal 806 does not comprise upward projections comprising a reference surface. Instead the sealing window 126 comprises positioning pegs 1300, 1302 for engagement in the reciprocal positioning holes 1304, 1306 located in the carrier 110. In this way the reference surfaces are separate from the deformable seal 806.. Each of the positioning pegs 1300, 1302 comprises a reference surface 1308, 1310 for aligning the sealing window 126. In this way as the sealing window is slid underneath the carrier 110 in the direction A, the pegs 1300, 1302 slot into the positioning holes 1304, 1306. The holes 1304, 1306 are blind holes and when the reference surfaces 1308, 1310 abut the end of the blind holes 1304, 1306, the sealing window 126 is in

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the correct position. The holes 1304, 1306 are deep enough such that the sealing window 126 is completely under the carrier 110, similar to the arrangement shown in the previous embodiments.

[0147] Figure 14 shows another embodiment. Figure 14 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement as shown in Figure 14 is the same as shown in Figures 8 and 9 except that the projection 1400 is formed on the carrier 110 and the notch 1402 is formed in the upper deformable seal 806. In this embodiment the projection 1400 is rigid and downwardly projects from the carrier 110. The notch 1402 is deformable and snaps into position when the notch 1402 is in positive engagement with the projection 1400 and reference surfaces are in engagement. The sealing window 126 is inserted between the carrier and the light transmissive panel 101 in the same way as discussed previously.

[0148] In alternative embodiments, the carrier 110, the light transmissive panel 101 and the sealing window 126 are assembled in a different order. The components are the same as described in reference to the previous embodiments. Turning to Figures 15a – 15d and Figure 16 the alternative method of assembly will now be discussed.

[0149] Figures 15a – 15d show a side cross section of the touch sensing apparatus 100. The light transmissive panel 101 has been omitted for clarity. The sealing window 126 is pushed towards the carrier 110 in direction B. That is, a direction which is parallel to normal axis 107. Figure 15a shows two deformable projections 1500, 1502 which have a snap-fit engagement with reciprocal grooves in the carrier. The deformable projections 1500, 1502 have a cross sectional shape that snaps into the reciprocal holes when the sealing window is seated correctly in the carrier 110.

[0150] Figure 15b shows a similar arrangement to Figure 15a except that there is a single projection 1504 which does not have a snap-fit engagement. Optionally, positive engagement is provided by the projection 1504 having a snug friction fit. When the sealing window 126 cannot move any further with respect to the carrier 110, the projection 1504 will abut the reciprocal surface of the hole in the carrier 110 and the sealing window will be seated correctly.

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[0151] Figures 15c and 15d show stepwise engagement of the same arrangement. The deformable seal 806 comprises snap-fit latches 1506, 1508 which bend and snap into place once the sealing window is fully seated in the carrier 110.

[0152] Once the sealing window 126 and the carrier 110 are assembled, then the light transmissive panel 101 is mounted in the carrier 110.

[0153] Figure 16 shows a schematic exploded perspective view of the carrier 110 and the sealing window 126. The arrangement as shown in Figure 16 is the same as shown in Figure 13, except that the relative movement of the sealing window 126 with the respect to the carrier 110 during assembly is perpendicular. That is, along direction B parallel with the normal axis 107. Similar to the embodiment as shown in Figure 13, the sealing window 126 comprises a plurality of reference surfaces which are not part of the deformable seal 806. Each of pegs 1600, 1606 and snap-fit latches 1602, 1604 comprises a reference surface for alignment. Figure 16 shows pegs 1600, 1606 for engagement with holes 1608, 1610. Figure 16 also shows resiliently deformable latches 1604, 1602 for snap-fit engagement with holes 1612 and 1614.

[0154] A further mounting unit 140 may be provided between the sealing window 126 and the light transmissive panel 101, as schematically illustrated in Fig. 5a. The mounting unit 140 may comprise a resilient material that allows the sealing window 126 to assume a secure fixed position relative the light transmissive panel 101. The sealing window 126 may have a corresponding groove into which the mounting unit 140 may be securely positioned.

[0155] A method 200 of assembling a touch sensing apparatus 100 is provided. Fig. 6 illustrates steps of the method 200. The order in which the steps of the method 200 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order. The method 200 comprises fixing 201 a substrate 106 having a plurality of light emitters 103 and detectors 103' to a carrier 110, and attaching 202 the carrier 110 around a perimeter 104 of a light transmissive panel 101. The method further comprises arranging 203 the substrate to extend in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel 101 extends, whereby the plurality of light emitters and detectors 103, 103', are arranged above the touch surface

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102. The method 200 thus provides for a facilitated assembly of the touch sensing apparatus 100 while achieving optimal alignment, robustness, and accuracy as described above in relation to Figs. 2 – 3.

[0156] As mentioned, the carrier 110 may be formed from a single monolithic piece of material, and the carrier may form a cavity 116 having walls 117 at least partly enclosing the substrate 106. At least one of the walls 117 may comprise openings 115, 115', 115''. The method 200 may comprise fixing 204 the carrier 106 to a display unit 121, 113, by fixing mounting elements 114 through the openings 115, 115', 115'', thereby providing for the above mentioned advantages.

[0157] The method 200 may comprise adjusting 205 a distance 120 between the light transmissive panel 101 and a display unit 113, 121, along the normal axis 107 by attaching 207 the carrier 110 to the display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the distance 120 is improved and facilitated, and may thereby be more easily optimized to various applications of the touch sensing apparatus 100.

[0158] The method 200 may comprise adjusting 208 a radius of curvature of the light transmissive panel 101 in the direction of the normal axis 107 by attaching 209 the carrier 110 to a display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the curvature of the light transmissive panel 101 is thus improved as described above.

[0159] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope and spirit of the invention, which is defined and limited only by the appended patent claims.

[0160] For example, the specific arrangement of emitters and detectors as illustrated and discussed in the foregoing is merely given as an example. The inventive coupling structure is useful in any touch-sensing system that operates by transmitting light, generated by a number of emitters, inside a light transmissive panel and detecting, at a number of detectors, a change in the received light caused by an interaction with the transmitted light at the point of touch.

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Electronic Patent Application Fee Transmittal

Application Number:	
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Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
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Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4000	4000
Pages:				
Claims:				
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	FFOG054C5_ADS.pdf	1256328 e8ac5bd0ac302b46dda2a739152d455c4af5fca7	no	9
Warnings:					
Information:					
2		FFOG054C5_Specification.pdf	161407 10e15491cc7450382526ddb6a52d77c70131985a	yes	35

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	33
Claims	34	34
Abstract	35	35

Warnings:					
Information:					
3	Drawings-only black and white line drawings	FFOG054C5_Figs.pdf	715098 65908beea1579adaa0cf59933628d2ffa920c48d	no	18
Warnings:					
Information:					
4	Oath or Declaration filed	FFOG054C5_Decassign.pdf	1894171 105307b52d5e717aea3951663953b4250b4b9280	no	5
Warnings:					
Information:					
5	Power of Attorney	FFOG054C5_POA.pdf	1280032 d0d6c567ff553494505efbdf846d25c218034dd1	no	2

Warnings:					
Information:					
6	TrackOne Request	FFOG054C5_FastTrackReq.pdf	113877 661829c1e84d71cd300ef38a181e10796a056fc6	no	2
Warnings:					
Information:					
7	First Action Interview - Schedule Interview request	FFOG054C5_FAIreq.pdf	621314 5b157de611d9b5909b16be3328f3c5a3f81ec5bf	no	3
Warnings:					
Information:					
8		FFOG054C5_Preamend_revised.pdf	1016171 6bbe520e0e198a141eda8cb82dde51b533bc6ad0	yes	94

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
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9	Fee Worksheet (SB06)	fee-info.pdf	40163 39e0829dae4d11be78a8c5cb49a8eb456584fde5	no	2
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Information:	
Total Files Size (in bytes):	7098561

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Daniel		Skagmo	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Malmo	Country of Residence i	SE

Mailing Address of Inventor:

Address 1	Isbergs Gata 10A 1601
Address 2	
City	Malmo
State/Province	
Postal Code	21 119
Country i	SE

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Robert		Ehn	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Lund	Country of Residence i	SE

Mailing Address of Inventor:

Address 1	FlatFrog Laboratories AB
Address 2	Scheelevagen 15 A Alfa 2
City	Lund
State/Province	
Postal Code	223 63
Country i	SE

Inventor 3 Remove

Legal Name

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hakan		Bergstrom	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Torna-Hallestad	Country of Residence [i]	SE

Mailing Address of Inventor:

Address 1	Akestorpsvagen 42		
Address 2			
City	Torna-Hallestad	**State/Province**	
Postal Code	247 95	**Country** [i]	SE

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	20995		
Email Address	efiling@knobbe.com	Add Email	Remove Email

Application Information:

Title of the Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY		
Attorney Docket Number	FFOG.054C5	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	18	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country [i]

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	20995		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16/191177	2018-11-14
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
16/191177	Continuation of	PCT/SE2018/050109	2018-02-06

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
1730085-6	SE	2017-03-28	A5E2

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	FlatFrog Laboratories AB		
Mailing Address Information For Applicant:			
Address 1	Scheelevägen 15 A		
Address 2			
City	Lund	**State/Province**	
Country	SE	Postal Code	223 63
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

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Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Harnik Shukla/			Date (YYYY-MM-DD)	2020-03-30
First Name	Harnik	Last Name	Shukla	Registration Number	73,097

Additional Signature may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	FFOG.054C5
	Application Number	
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND

Field of the Invention

[0002] The present invention relates to touch-sensing apparatus that operate by propagating light by diffusive light scattering above a panel, and in particular to optical and mechanical solutions for defining the light paths and control of curvature of the panel. The present invention relates furthermore to a method of assembling a touch sensing apparatus.

Background of the Invention

[0003] In one category of touch-sensitive panels known as 'above surface optical touch systems', a set of optical emitters are arranged around the periphery of a touch surface to emit light that is reflected to travel above the touch surface. A set of light detectors are also arranged around the periphery of the touch surface to receive light from the set of emitters from above the touch surface. An object that touches the touch surface will attenuate the light on one or more propagation paths of the light and cause a change in the light received by one or more of the detectors. The location (coordinates), shape or area of the object may be determined by analysing the received light at the detectors.

[0004] In a variant of such 'above surface optical touch system', illustrated in Fig. 1a in cross-section, the emitters 301 are arranged on a substrate 304, and light from the emitters travel above the touch surface 302 of the panel 305 via reflection or scattering on an edge reflector or diffusor 303. As shown in top-down view figure 1b, the light will then continue until deflected by a corresponding edge reflector at an opposing edge of the light transmissive panel, where the light will be scattered back down through the transmissive panel and onto the detectors 306.

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[0005] Detectors 306 are distributed around the periphery of touch surface 302, to receive part of the propagating light. The light from each of emitters 301 will thereby propagate inside the transmissive panel 305 to a number of different detectors 306 on a plurality of light paths D. In the illustrated example, the apparatus 300 also includes a controller 320 which is connected to selectively control the activation of the emitters 301 and, possibly, the readout of data from the detectors 306. Depending on implementation, the emitters 301 and/or detectors 306 may be activated in sequence or concurrently. The signal processor 330 and the controller 320 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 330 and the controller 320 may be at least partially implemented by software executed by a processing unit 340.

[0006] A problem with such previous systems is the cumbersome alignment between the components thereof, which makes assembly more difficult and costly. Sub-optimal alignment results in signal loss, which moreover is an inherent problem in previous solutions due to the multiple components involved in the light scattering process. Another issue affecting the signal and scattering of the light in the touch sensing apparatus is uncontrolled glass warpage, i.e. distortions of the curvature of the light transmissive panel which will affect the light path and the detection process. While it is critical to accurately control such distortions, previous solutions incorporate complex solutions that may not allow to fully optimize glass warpage control in a mass production line without limiting the throughput of the production.

[0007] Some prior art systems rely on coupling and propagation of collimated light across the light transmissive panel. Such systems are however cumbersome to reliably implement due to the small tolerances with respect to the alignment of the components thereof. E.g. the light emitters- and detectors need to be precisely aligned in relation to various lenses and reflect the light via concave and/or convex reflection and/or refraction to get the desired collimation. Such precise alignment may be difficult to achieve in mass production. The use of collimated light, or light reflected by means of specular reflection, also adds to this complexity, which in turn results in a more expensive and less compact system. Furthermore, to reduce system cost, it may be desirable to minimize the number of electro-optical components.

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SUMMARY OF THE INVENTION

[0008] An objective is to at least partly overcome one or more of the above identified limitations of the prior art.

[0009] One objective is to provide a touch-sensitive apparatus based on "above-surface" light propagation which is robust and easy to assemble.

[0010] Another objective is to provide an "above-surface"-based touch-sensitive apparatus with efficient use of light.

[0011] One or more of these objectives, and other objectives that may appear from the description below, are at least partly achieved by means of touch-sensitive apparatuses according to the independent claims, embodiments thereof being defined by the dependent claims.

[0012] According to a first aspect, a touch sensing apparatus is provided comprising a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel. The light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the panel extends.

[0013] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0014] Preferably the substrate extends at least partly above the touch surface, whereby the plurality of light emitters and detectors are connected to a portion of the substrate extending above the touch surface.

[0015] Preferably the substrate is fixed to a carrier mounted around the perimeter of the panel.

[0016] Preferably the carrier is arranged to at least partly enclose edges the panel.

[0017] Preferably the carrier comprises fixing elements configured to attach the carrier to a display unit.

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Flatfrog Laboratories AB, Ex. 2002
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[0018] Preferably the fixing elements are configured to attach the position of the substrate in relation to the carrier and/or in relation to the display unit.

[0019] Preferably the fixing elements are configured to interlock with a mounting element for locking the position of the carrier and/or the substrate to the display unit.

[0020] Preferably the fixing elements comprise openings, wherein the carrier forms a cavity having walls at least partly enclosing the substrate, and wherein at least one of the walls comprises at least one of said openings.

[0021] Preferably the fixing elements comprise openings arranged in the carrier and in the substrate, wherein first openings of the carrier are aligned with second openings of the substrate, the first and second openings being configured to receive a mounting element configured to lock the position of the carrier and/or the substrate to the display unit.

[0022] Preferably the carrier is configured to be attachable to the display unit at an adjustable position along a direction parallel to the normal axis, whereby a distance between the panel and the display unit along the normal axis is variable upon attaching the carrier to the display unit at at least two different adjustable positions.

[0023] Preferably the fixing elements are configured to attach the carrier to the display unit at the adjustable positions along the direction parallel to the normal axis.

[0024] Preferably the openings are separated along a direction parallel to the normal axis, and/or wherein the carrier is attachable to a plurality of second openings in a display support of the display unit, the plurality of second openings being separated along the normal axis.

[0025] Preferably the carrier is formed from a single monolithic piece of material.

[0026] Preferably the substrate extends in a longitudinal direction along the perimeter of the panel, the substrate comprising secondary fixing units configured for variably attaching the position of the substrate on the carrier along the longitudinal direction and/or in the direction of the normal axis.

[0027] Preferably vertical alignment units are arranged between adjacent substrates extending in a longitudinal direction along the perimeter of the panel, wherein the vertical alignment units are configured to variably position the adjacent substrates in the direction of the normal axis so that an angle between the adjacent substrates is adjustable.

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[0028] Preferably a plurality of substrates extend in a longitudinal direction along the perimeter of the panel, wherein a first substrate of said plurality of substrates comprises a connection unit configured to directly interlock with a subsequent connection unit of a subsequent substrate when arranged adjacent said subsequent substrate.

[0029] Preferably a sealing window is arranged around the perimeter of the panel, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, and wherein at least one of the first and second surfaces comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0030] Preferably the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and wherein the second surface comprises a light collimating surface.

[0031] According to a second aspect, a touch sensing apparatus is provided comprising a panel extending in a plane having a normal axis, the panel defining a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel, wherein the light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The touch sensing apparatus comprises a sealing window arranged around the perimeter, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and

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wherein the second surface comprises a light collimating surface configured to collimate light propagating above the touch surface.

[0032] Preferably the first surface and/or second surface form a curved edge convex to the sealing window.

[0033] According to a third aspect, a method of assembling a touch sensing apparatus is provided comprising; attaching a substrate having a plurality of light emitters and detectors to a carrier; attaching the carrier around a perimeter of a panel and arranging the substrate to extend in a direction parallel with a normal axis of a plane in which the panel extends.

[0034] Preferably the plurality of light emitters and detectors are arranged above the touch surface.

[0035] Preferably the carrier if formed from a single monolithic piece of material, the carrier forming a cavity having walls at least partly enclosing the substrate, wherein at least one of the walls comprise openings, the method comprising fixing the carrier to a display unit by fixing mounting elements through said openings.

[0036] Preferably the method comprises adjusting a distance between the panel and a display unit along the normal axis by attaching the carrier to the display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0037] Preferably the method comprises adjusting a radius of curvature of the panel in the direction of the normal axis by attaching the carrier to a display unit at at least two different adjustable positions along a direction parallel to the normal axis.

[0038] According to a fourth aspect there is provided a touch sensing apparatus, comprising: a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel and the light emitters are arranged to emit a respective beam of emitted light above the touch surface, and the light emitters are arranged to receive detection light from the emitted light, a substrate on which the plurality of light emitters and detectors are mountable; and a sealing window sealable against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

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[0039] Preferably the sealing window is sealable between the touch surface and a surface of the substrate.

[0040] Preferably the surface of substrate is a surface of a carrier for protecting components of the touch sensing apparatus.

[0041] Preferably the carrier comprises an upper portion which overlaps a portion of the perimeter of the panel and the sealing window is sealable between the touch surface and the underside of the overlapping upper portion.

[0042] Preferably the at least one reference surface is arranged to engage with a reciprocal reference surface on the substrate.

[0043] Preferably the at least one reference surface comprises a first portion for aligning in a first direction and a second portion for aligning in a second direction.

[0044] Preferably the at least one reference surface aligns the sealing window with respect to the substrate in a plane parallel with the touch surface.

[0045] Preferably the at least one reference surface aligns the sealing window with respect to the substrate at a height above the touch surface.

[0046] Preferably the sealing window comprises at least one resiliently deformable seal engagable with the substrate.

[0047] Preferably the resiliently deformable seal comprises the at least one reference surface.

[0048] Preferably the seal is extrudable along one or more surfaces of the sealing window.

[0049] Preferably the at least one reference surface substantially extends the entire length of the sealing window.

[0050] Preferably the sealing window and / or the substrate comprise a projection having a cross-sectional shape for positive engagement with a reciprocal hole in the substrate and / or sealing window and the at least one reference surface is part of the projection.

[0051] Preferably the sealing window and / or the substrate comprise a resiliently deformable projection wherein the projection comprises the at least one reference surface comprises and the projection is deformable on engagement with the substrate and / or sealing window and forms a snap-fit engagement therebetween.

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[0052] Preferably the sealing window comprises a plurality of reference surfaces.

[0053] Preferably the at least one reference surface comprises at least one discrete upstanding projection for engagement with reciprocal hole in the substrate.

[0054] Preferably the at least one upstanding projection is one or more of, pegs, hooks, latches, clamps or fasteners.

[0055] According to a fifth aspect there is provided a method of manufacture of the touch sensing apparatus comprising: mounting a plurality of light emitters and detectors to a substrate, attaching the substrate around a perimeter of a panel; and mounting a sealing window against at least one surface of the touch sensing apparatus for sealing a cavity around the plurality of light emitters and detectors wherein the sealing window comprises at least one reference surface for aligning the substrate with respect to the sealing window.

[0056] Further examples of the invention are defined in the dependent claims, wherein features for the second aspect of the disclosure are as for the first aspect mutatis mutandis.

[0057] Some examples of the disclosure provide for a touch sensing apparatus that is easier to manufacture and assemble.

[0058] Some examples of the disclosure provide for a touch sensing apparatus with fewer steps of assembly.

[0059] Some examples of the disclosure provide for a touch sensing apparatus that is less costly to manufacture.

[0060] Some examples of the disclosure provide for a facilitated alignment of emitters and detectors of touch sensing apparatus.

[0061] Some examples of the disclosure provide for facilitated control of the curvature of the touch surface of a touch sensing apparatus.

[0062] Some examples of the disclosure provide for a more robust touch sensing apparatus.

[0063] Some examples of the disclosure provide for a touch sensing apparatus that is more reliable to use.

[0064] Some examples of the disclosure provide for a touch sensing apparatus that has a better signal-to-noise ratio of the detected light.

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[0065] Some examples of the disclosure provide for a more compact touch sensing apparatus.

[0066] Still other objectives, features, aspects and advantages of the present disclosure will appear from the following detailed description, from the attached claims as well as from the drawings.

[0067] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] These and other aspects, features and advantages of which examples of the invention are capable of will be apparent and elucidated from the following description of examples of the present invention, reference being made to the accompanying drawings, in which;

[0069] Fig. 1a is a section view of a touch sensing apparatus according to the prior art;

[0070] Fig. 1b is a top-down view of a touch sensing apparatus according to the prior art;

[0071] Fig. 2 is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0072] Fig. 3 is a schematic illustration, in a perspective side view, of a touch sensing apparatus according to one example;

[0073] Fig. 4a is a schematic illustration, in a side view of Fig. 2, of a touch sensing apparatus according to one example;

[0074] Fig. 4b is a schematic illustration of a magnified section of Fig. 4a, according to one example;

[0075] Fig. 4c is a schematic illustration of a magnified section of Fig. 4a, according to one example;

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[0076] Fig. 5a is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

[0077] Fig. 5b is a schematic illustration of a magnified section of Fig. 5a, according to one example;

[0078] Fig. 6 is a flow chart of a method of assembling a touch sensing apparatus according to one example;

[0079] Figure 7 is a schematic exploded perspective view of different layers of the touch-sensing apparatus according to one example;

[0080] Figure 8 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0081] Figure 9 is a cross sectional view of the touch sensing apparatus according to one example;

[0082] Figure 10 is a cross sectional view of the touch sensing apparatus according to one example;

[0083] Figure 11 is a cross sectional view of the touch sensing apparatus according to one example;

[0084] Figure 12 is a perspective schematic view of through a cross section of the touch sensing apparatus according to one example;

[0085] Figure 13 is a schematic perspective view of the touch sensing apparatus according to one example;

[0086] Figure 14 is a cross sectional view of the touch sensing apparatus according to one example;

[0087] Figures 15a to 15d are magnified cross-sectional views of the touch sensing apparatus according to different examples; and

[0088] Figure 16 is a schematic perspective view of the touch sensing apparatus according to one example.

DETAILED DESCRIPTION

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[0089] In the following, embodiments of the present invention will be presented for a specific example of a touch-sensitive apparatus 100. Throughout the description, the same reference numerals are used to identify corresponding elements.

[0090] Fig. 1 schematically illustrates a variant of an 'above surface optical touch system', as discussed in the Background Art section above ,where the light from the emitters 301 travel above the touch surface 302 of the panel 305 via reflection on an edge reflector 303. Figure 1b illustrates a top plan view of figure 1a in an example of a touch-sensitive apparatus 100.

[0091] Fig. 2 schematically illustrate a touch sensing apparatus 100 comprising a light transmissive panel 101 that defines a touch surface 102. In some embodiments the light transmissive panel 101 is located above a display 130 and permits light generated by the display 130 to propagate therethrough. However in other embodiments the light transmissive panel 101 can comprise light blocking material and does not permit the transmission of light therethrough. For example, the touch sensing apparatus 100, can be a trackpad or another touch interface which is remote from the display unit 130. Hereinafter the term "light transmissive panel" 101 will be used to describe either a light transmissive panel 101 or a solid, opaque panel 101.

[0092] A plurality of light emitters 103 and detectors 103' are arranged along a perimeter 104 of the light transmissive panel 101. The light emitters 103 are arranged to emit a respective beam of emitted light 105 above the touch surface 102. I.e. while the touch surface 102 extends along a plane 108, having a normal axis 107 directed towards a user performing touch operations on the touch surface 102, the emitted light 105 travels parallel with plane 108 and at a certain distance from the touch surface 102 in the direction of the normal axis 107, as schematically illustrated with respect to light beam 105, 105', in e.g. Fig. 2. Light 105, 105', can thus travel across the touch surface 102, between opposite sides thereof, without being reflected inside the light transmissive panel 101 itself.

[0093] In other embodiments, the plurality of light emitters 103 and detectors 103' are optionally arranged along a perimeter 104 of the light transmissive panel 101 at a different height. In some embodiments, the light emitters 103 and / or detectors 103' are arranged to emit a respective beam of emitted light 105 below the touch surface 102 and the

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light beams are guided around the light transmissve panel 101. The light beams can be guided around the light transmissive panel 101 with additional reflective components (not shown). For the purposes of brevity, the embodiments discussed hereinafter refer to the plurality of light emitters 103 and detectors 103' being arranged above the touch surface 102, but the embodiments also include the arrangement where the plurality of light emitters 103 and detectors 103' are mounted below the touch surface 102.

[0094] The light detectors 103' are arranged to receive detection light 105' from the emitted light 105. Fig. 2 illustrates a section of the touch sensing apparatus 100 adjacent the perimeter 104 of the light transmissive panel 101. In this section, the emitters and detectors 103, 103', are shown in the same view, as well as the emitted and detected light 105, 105', for clarity of presentation. The plurality of light emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel extends. By having the substrate 106 extending in parallel with the normal axis 107, the plurality of emitters and detectors 103, 103' are conveniently arranged, above the touch surface 102 to achieve a compact footprint in the direction of the plane 108 of the touch sensing apparatus 100 around the perimeter 104, while achieving a direct light path for the emitted or detected light 105, 105', above and across and touch surface 102. Thus, the emitted light 105 does not have to be reflected in order to diffusively spread above and across the touch surface 102, and a detector 103' may directly receive detection light 105' by being correspondingly positioned above the touch surface 102 at an opposite position anywhere around the perimeter 104. The amount of available light that can be utilized for the detection and characterization of an object touching the touch surface 102 can thus be maximized, and the signal to noise ratio can be improved. The touch sensing apparatus 100 may comprise a sealing window 126 as illustrated in Fig. 2, shielding the emitters and detectors 103, 103', from the outside. The emitted and detected light 105, 105', may thus only have to propagate through the sealing window 126 along the light path between the emitters and detectors 103, 103'. The sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the display.

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[0095] Having the substrate extending in the direction 107' being parallel with the normal axis 107 and the emitters and detectors 103, 103', arranged above the touch surface 102 provides for a less complex alignment to maximize the detection performance of the touch sensing apparatus 100. The position of the substrate 106 in the direction of the normal axis 107 can be accurately varied to achieve optical alignment with respect to the emitters and detectors 103, 103'. The ability to achieve an accurate positioning of the substrate 106, and consequently the emitters and detectors 103, 103', attached thereto, is also due to the increased accuracy by which the dimensions of the substrate 106 can be defined along the direction of the substrate 106 aligned with the normal axis 107 in Fig. 2. I.e. the substrate 106 is elongated and extends in a longitudinal direction 123 (Fig. 4a) around the perimeter 104 of the light transmissive panel 101, and it has a short-side extending in parallel with the normal axis 107. The short-side of the substrate 106, illustrated in the cross-sectional view of Fig. 2, may be manufactured to smaller tolerances, and by aligning this side with the normal axis 107, the tolerances for the alignment of the emitters and detectors 103, 103', along the normal axis 107 can be improved. The alignment can thus be both improved, and facilitated as discussed above. The latter advantage also provides for facilitated and less costly mass production of the touch sensing apparatus 100 and the various touch base display systems in which it may be implemented.

[0096] The substrate 106 may extend at least partly above the touch surface 102, whereby the plurality of light emitters and detectors 103, 103', are connected to a portion 109 of the substrate extending above the touch surface 102. This further provides for achieving a more robust alignment of the emitters and detectors 103, 103', relative to the light transmissive panel 101, by being directly joined to the substrate 106, and thereby simultaneously arranged above the touch surface 102. It may be conceivable however that the emitters and detectors 103, 103', are connected to the substrate 106 via connection elements (not shown) extending between the substrate 106 and to a position above the touch surface 102.

[0097] The substrate 106 may be fixed to a carrier 110 mounted around the perimeter 104 of the light transmissive panel 101, as schematically illustrated in Figs. 1 – 2. By directly joining the substrate 106 to the carrier 110 provided around the perimeter 104, the

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assembly of the touch sensing apparatus 100 may be further facilitated, as the amount of components can be kept at a minimum. For example, the substrate 106 can be accurately fixed in relation to the carrier 110, due to the small tolerances possible in the direction of the substrate 106 aligned in parallel with the normal axis 107 in Fig. 1, as discussed above. The carrier 110 may for example comprise a cavity 116, as discussed further below, being precisely dimensioned to accommodate the width of the substrate 106 along the direction 107', i.e. the short-side of the substrate 106. Then, accurate positioning of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 is possible as the carrier 110 is mounted around the perimeter 104 thereof. The carrier 110 may extend substantially in the direction 107' parallel with the normal axis 107, as with the substrate 107, to achieve a compact mounting around the perimeter 104. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0098] Having the substrate 106 fixed to the carrier 110 allows also for having the carrier 110 wired as an electrical ground reference layer of the substrate 106.

[0099] The carrier 110 may be arranged to at least partly enclose edges 111 of the light transmissive panel 101, as shown in the example of Fig. 1. This provides for further increasing the robustness of the touch sensing apparatus 100, and improving the accuracy of the alignment of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 since the carrier 110, having the emitters and detectors 103, 103', fixed thereto, may also be directly supporting the light transmissive panel 101 around the perimeter 104. The carrier 110 may comprise a slot in which the light transmissive panel 101 is fitted around the perimeter 104.

[0100] The carrier 110 may comprise fixing elements 112 configured to attach the carrier 110 to a display unit 113, 121. The display unit may comprise a display support 121 and a display panel 113, which collectively is referred to as a display unit in the present disclosure. Having the carrier 110 attachable to the display unit 113, 121, by fixing elements 112, advantageously provides for further facilitating the assembly of the touch sensing apparatus 100 to a display unit, since the carrier 110 can be directly joined to the latter. Alignment is thus facilitated, due to the minimum amount of components needing such

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alignment to each other. The robustness of the touch sensing apparatus 100 is further improved, while mass production is made less complex due the minimized number of assembly steps. The fixing elements 112 may comprise any elements configured to provide for fixing of the position of the carrier 110 to the display unit 113, 121. In the examples shown in Figs. 1 - 2, the carrier 110 has openings 115, 115', 115'', discussed further below, which may be aligned with corresponding openings 127 of a support of the display unit 121, through which mounting elements 114 may be positioned for the fixing. It is conceivable however that the carrier 110 has other types of recesses or protrusions which may interlock with a corresponding mating surface of the display unit 113, 121.

[0101] The fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the carrier 110. Thus, besides from fixing the position of the carrier 110 relative to the display unit 113, 121, the fixing elements 112 may also fix or at least support the position of the substrate 106 in relation to the carrier 110. It is conceivable that the substrate 106 may first be arranged in relation to the carrier 110, and the fixing elements 112 may be arranged to support and strengthen the fixing therebetween, while simultaneously fixing the carrier 110 to the display unit 113, 121. This may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100. From a similar aspect, the fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the display unit 113, 121. This may be seen as a consequence from the above, i.e. the fixing elements 112 contributing to the fixing of the substrate 106 to the carrier 110, which in turn is fixed to the display unit 113, 121. It is however conceivable that the fixing elements 112 may fix the substrate 106 directly to the display unit 113, 121, in which case the carrier 110 may act as a further support for the substrate 106.

[0102] In one example, as discussed further below, the substrate 106 may comprise second openings 118 which provides for such fixing or support. As mentioned, this may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100.

[0103] The fixing elements 112 may be configured to interlock with a mounting element 114 for locking the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. Figs. 2 – 3 show examples of having an elongated mounting element 114

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joining the carrier 110 and/or the substrate 106 to the display unit 113, 121. The mounting element 112 may however comprise any fastening element configured to exert a force between the carrier 110 and/or the substrate 106 to the display unit 113, 121, such as pins, bolts, screws, clips, clamps, locks, bars, rods, anchors, latches, clasps.

[0104] The fixing elements 112 may comprise openings 115, 115', 115'', as illustrated in Figs. 2 – 3. The carrier 110 may form a cavity 116 having walls 117 at least partly enclosing the substrate 106, illustrated in the example of Fig. 2. This may provide for increased stability of the fixing of the position of the substrate 106 in relation to the carrier 110. At least one of the walls 117 may comprise at least one of the openings 115, 115', 115'', as further illustrated in Fig. 2. Being able to directly fix the walls 117 of the carrier 110 enclosing the substrate 106 to the display unit 121, 113, provides for further simplifying manufacturing, and at the same time further increase the accuracy of the alignment of e.g. the emitters and detectors 103, 103', in relation to the light transmissive panel 101, since the minimized number of intermediate mounting components improves tolerance control. I.e. build-up of mounting errors in each assembly step is reduced and controlled. It is conceivable that the walls 117 may be fixed to the display unit 113, 121, by other fixing elements 112, such as recesses or protrusions interlocking with correspondingly mating surfaces of the display unit 113, 121, and/or fastening elements as exemplified above.

[0105] The fixing elements 112 may comprise openings 115, 115', 115'', 118, arranged in the carrier 110 and in the substrate 106. First openings 115, 115', 115'' of the carrier 110 may be aligned with second openings 118 of the substrate 106, as illustrated in the example of Fig. 2. The first and second openings 115, 115', 115'', 118 may be configured to receive a mounting element 114 configured to lock the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. This provides for further facilitated and improved alignment and assembly, and increased robustness. In the example of Fig. 2, the carrier 110 encloses the substrate 106 such that two opposite openings 115, 115'', of the carrier are arranged on either side of the substrate 106, but it is conceivable that the carrier 110 may be arranged on one side only of the substrate 106.

[0106] The carrier 110 may be configured to be attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis. A

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distance 120 between the light transmissive panel 101 and the display unit 113 along the normal axis 107 may thus be variable upon attaching the carrier to the display unit 113, 121 at at least two different adjustable positions 119, 119'. For example, turning to Fig. 3, the carrier 110 is attached at a first position 119 to the support of the display unit 121, via fixing unit 112. The first position 119 provides for the given distance 120 between the panel of the display unit 113. The distance 120 may then be decreased by instead attaching the carrier 110 at a second position 119' which is off-set with respect to the first position 119 in the positive direction of the normal axis 107, or the direction 107'' as illustrated in Fig. 3. If the fixing point to the support of the display unit 121 remains constant, e.g. at the opening 127 of a support 121 as illustrated, the carrier 110 will be moved in the opposite direction to the normal axis 107 and the distance 120 will be decreased. Having the carrier 110 being attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis 107, thus provides for simple and efficient adjustment of the position of the light transmissive panel 101.

[0107] Besides from overall controlling the distance 120, as discussed, such adjustment provides for efficiently controlling and varying the curvature of the light transmissive panel 101. I.e. varying the distance 120 as discussed at a second intermediate location 128', between opposite ends of the carrier 110, along the longitudinal direction 123, while maintaining the distance 120 at the opposite ends, such as at a first location 128, will affect the curvature of the carrier 110, and thereby the curvature of the light transmissive panel 101. E.g. decreasing the distance 120 at the second location 128' can produce a more concave shape, i.e. a decreased radius of curvature, of the carrier 110 and the light transmissive panel 101, in the direction of the normal axis 107. Increasing the distance 120 between the mentioned opposite ends can instead increase the radius of curvature in the direction of the normal axis 107. The curvature or warping of the light transmissive panel 101 can thus be controlled efficiently an in a facilitated manner, which is advantageous for increasing throughput in mass-production of displays incorporating the touch sensing apparatus 100 while keeping the warp of the light transmissive panel 101 under control. An optimized curvature of the light transmissive panel 101 increases the reliability and accuracy of the touch sensing apparatus 100.

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[0108] The fixing elements 112 may be configured to attach the carrier 110 to the display unit 121 at the adjustable positions 119, 119', along the direction 117'' parallel to the normal axis 107. Thus, the fixing units 112 be arranged at the different adjustable positions 119, 119', to adjust the distance 120 and the curvature of the a light transmissive panel 101 while providing for securely attaching the carrier to the display unit 113, 121. The fixing elements 112 may thus be arranged at least at the first and second locations 128, 128', along the longitudinal direction 123 as discussed above, where each of the locations in the longitudinal direction 123 may have at least two adjustable positions 119, 119', as illustrated in the example of Fig. 3.

[0109] The openings 115, 115', of the carrier 110 may be separated along a direction 117'' parallel to the normal axis 107, as illustrated in Fig. 3. Alternatively, or in addition, the carrier 110 may be attachable to a plurality of second openings 122 in a display support 121 of the display unit, where the plurality of second openings 122 are separated along the normal axis 107. Thus, the position 119, 119', may be remained fixed while the carrier 110 is attached to the support 121 at the various second openings 122, to adjust the curvature of the light transmissive panel 101 and/or the distance 120 as discussed above. Although the examples in Figs. 2 – 3, show openings 115, 115', 115'', 127, it is conceivable that the attachment between the carrier 110 and the display unit 121, 113, is provided by other fixing elements 112 as exemplified above.

[0110] The carrier 110 may be formed from a single monolithic piece of material. The structural integrity and the stability of the carrier 110 can thereby be increased, which further optimizes the parameters discussed above with respect to alignment, robustness, ease of assembly etc. One example of a possible process by which the carrier can be formed as a single piece of material is an extrusion process, but it is conceivable that the carrier 110 may be formed from other hot or cold metal or polymer working processes such as drawing, rolling, or molding processes.

[0111] The substrate 106 may extend in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. Fig. 4a illustrates a view of a plurality of substrates 106, 106', extending along the longitudinal direction 123. The light transmissive panel 101 and the carrier 110 holding the substrates have been excluded in the view for

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clarity of presentation. The substrates 106, 106', may comprise secondary fixing units 124, 124', configured for variably attaching the position of each of the substrates 106, 106', on the carrier 110 along the longitudinal direction 123 and/or in the direction of the normal axis 107. This provides for more accurately adjusting the position of the substrates 106, 106', in relation to the light transmissive panel 101. While each of the substrates 106, 106', may be within tolerances, the accumulated error obtained when several substrates 106, 106' are connected along the longitudinal direction 123 may exceed the total tolerance of the full length of the light transmissive panel 101. Such accumulation of errors may be effectively prevented by having secondary fixing units 124, 124', as elucidated above. The secondary fixing units 124, 124', may be provided on various locations on the substrates 106, 106', to allow for adjusting the position, such as on opposite ends thereof.

[0112] The touch sensing apparatus 100 may comprise vertical alignment units 135 arranged between adjacent substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. The vertical alignment units 135 are configured to variably position the adjacent substrates 106, 106', in the direction of the normal axis 107 so that an angle 136 between the adjacent substrates 106, 106', can be adjusted. Fig. 4b schematically illustrates a vertical alignment unit 135 positioned between adjacent substrates 106, 106', to vary the position thereof in the direction of the normal axis 107, i.e. along arrows 137, so that the angle 136 may be set to a desired value. The vertical alignment unit 135 thus provides for facilitating the alignment of the plurality of substrates 106, 106', to e.g. the curvature of the light transmissive panel 101. For example, if the light transmissive panel 101 is concave in the direction of the normal axis 107, initially parallel substrates 106, 106', may be angled to closely follow the concave shape of the light transmissive panel 101 by increasing the angle 136 between the substrates 106, 106', as schematically illustrated in Fig. 4b. The position of the emitters and detectors 103, 103', on the substrates 106, 106', may thus remain at an optimized vertical position relative the light transmissive panel 101 for various curvatures thereof. The vertical alignment unit 135 may comprise various units configured to change the position of the adjacent substrates 106, 106', in the direction of the normal axis 107, such as bolts, screws, pins, or any other elements that can provide an offset at the ends of the substrates 106, 106'.

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[0113] The touch sensing apparatus 100 may comprise force distributing units 138 positioned between adjacent substrates 106, 106', configured to provide a fixing force therebetween, as schematically illustrated in Fig. 4c. The force distributing units 138 may provide for improving and facilitating the fixing of the substrates 106, 106', to the carrier, without the need for dedicated fixing elements such as screws, bolts, etc to each end of respective substrates 106, 106', thereby reducing the amount of such fixing elements, which facilitates the assembly of the touch sensing apparatus 100.

[0114] The touch sensing apparatus may thus comprise a plurality of substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. A first substrate 106 of the plurality of substrates may comprises a connection unit 125 configured to directly interlock with a subsequent connection unit 125' of a subsequent substrate 106' when arranged adjacent said subsequent substrate, as schematically illustrated in Fig. 4a. It is thereby possible to directly connect subsequent substrates 106, 106', and eliminate the need for intermediate connectors, which further provides for facilitating the assembly of the touch sensing apparatus 100.

[0115] The touch sensing apparatus 100 may comprise a sealing window 126 as schematically illustrated in Figs. 5a-b. The sealing window 126 may be arranged around the perimeter 104 of the light transmissive panel 101. The sealing window 126 may comprise a first surface 129 facing the light emitters 103 or the light detectors 103', and an opposite second surface 130 arranged adjacent the touch surface 102. Emitted or detected light thus propagates between the first and second surface 129, 130. At least one of the first and second surfaces 129, 130, may comprises a light collimating surface 129, 130, configured to collimate light propagating above the touch surface 102. I.e. emitted light 105 will be collimated by the sealing window 126, so that the light propagating above the touch surface 102 will be collimated. Detectors 103' will receive the collimated light which will be focused through a corresponding sealing window 126. As the emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction parallel with a normal axis 107, it is possible to provide for a very precise and improved alignment thereof in relation to the sealing window 126, which allows for achieving collimated light in a highly optimized manner, and an associated increase in signal

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strength since more of the emitted light can be collected by the detectors 103'. The emitted light is collimated in a direction parallel with the plane 108 in which the light transmissive panel 101 extends. Collimating the light with sealing window 126 also allows for reducing the aperture of the sealing window 126, i.e. the thickness of the sealing window 126 in the direction of the normal axis 107, while still detecting a sufficient amount of light. This provides for reducing the amount of ambient light reaching the detectors 103', thus improving the signal to noise ratio.

[0116] Turning to Fig. 5b, the second surface 130 may extend in the direction of the normal axis 107 between a base surface 131 of the sealing window 126, facing the light transmissive panel 101, and an opposite top surface 132 of the sealing window 126. The base surface 131 may be offset from the top surface 132 along the direction of the plane 108 with an offset distance 133 so that the second surface 130 forms an angle 134 relative the normal axis 107. As further illustrated in Fig. 5b, the second surface may comprises the light collimating surface 130. Thus, in addition to having a convex shape as illustrated in Fig. 5b, the second surface 130 is arranged to assume a tilted configuration as provided by the offset distance 133. Having such angled configuration provides for reducing the impact of Fresnel reflexes. The Fresnel reflexes otherwise generate additional unwanted light paths that will reduce the apparent attenuation on some detection lines, especially when they run parallel to and near a sealing window 126. These Fresnel reflexes may also result in artifacts and false touch information. By having an angled and/or curved second surface 130 of the sealing window 126, the light may instead bounce off the second surface 130 with such an angle so that it leaves the plane 108, and thereby not interfere with the detection of the remaining light.

[0117] A sealing window 126 as described above can provide for the advantageous effects as described for touch sensing apparatuses having a plurality of light emitters and detectors arranged in a multitude of configurations, not limited to the configurations described in relation to Figs. 2 and 3 exemplified above. A touch sensing apparatus 100 is thus provided comprising a light transmissive panel 101 extending in a plane 108 having a normal axis 107, wherein the light transmissive panel defines a touch surface 102. The touch sensing apparatus 100 comprises a plurality of light emitters 103 and

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detectors 103' arranged along a perimeter 104 of the light transmissive panel, wherein the light emitters are arranged to emit a respective beam of emitted light 105 above the touch surface, wherein the light detectors are arranged to receive detection light 105' from the emitted light. The touch sensing apparatus 100 comprises a sealing window 126 arranged around the perimeter, wherein the sealing window comprises a first surface 129 facing the light emitters or the light detectors and an opposite second surface 130 arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface 131 of the sealing window, facing the light transmissive panel, and an opposite top surface 132 of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance 133 so that the second surface forms an angle 134 relative the normal axis, and wherein the second surface comprises a light collimating surface 130 configured to collimate light propagating above the touch surface.

[0118] The first surface 129, facing the emitters or detectors 103, 103', may also be angled, with an angle 134', as schematically illustrated in Fig. 5a, to provide for the desired light path from or towards the emitters or detectors 103, 103', respectively. The first surface 129 may also comprise a light collimating surface and have a convex shape towards the emitters or detectors 103, 103', as illustrated in Fig. 5a, in addition to being arranged at an angle 134'. The angles 134, 134', may be in the range of 2-10 degrees relative to the normal axis 107 to provide for a particularly advantageous reduction of Fresnel reflexes. An angle greater than 2 degrees avoids Fresnel reflexes and an angle of less that 10 degrees reduces the light field height.

[0119] The sealing window 126 may comprise a fixing element 139 configured to interlock to carrier 110. In the example in Fig. 5a, the fixing element comprises a protrusion 139 arranged to interlock with a corresponding recess in the carrier 110. Mounting and fixing of the sealing window 126 may thus be facilitated and improved since the fixing element 139 may snap into the carrier 110, without needing to have separate fixing units or adhesives joining the sealing window 126 to the carrier 110. In some circumstances, it is preferable not to use an adhesive because the adhesive may not be resilient in high temperatures. Use of an adhesive for fixing the sealing window 126 can be problematic because the uncured adhesive

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allows for relative movement between the components and precise alignment may be difficult. It is conceivable that the fixing element 139 may comprise any other shape, such as a recess, for interlocking with a corresponding mating surface of the carrier 110.

[0120] Alternative embodiments of the sealing window 126 will now be described in reference to Figure 7 to 16.

[0121] Figure 7 shows an exploded perspective schematic view of the touch sensing apparatus 100. The dotted line shows the normal axis 107 of the touch surface 102 at the center of the light transmissive panel 101. For the purposes of clarity, the exploded perspective view in Figure 7 shows the separate components side by side, but the dotted line of the normal axis 107 represents the order of how the components stack together. As mentioned previously the carrier 110 may extend substantially in the direction parallel with the normal axis 107. In this way the carrier 110 comprises a downwardly projecting skirt 700 from the upper surface 702.

[0122] The sealing window 126 is mountable on the carrier 110 and this will be discussed in further detail below. The sealing window 126 comprises a similar shape to the arrangement of the plurality of light emitters 103 and detectors 103' (not shown in Figure 7 for the purposes of clarity). The sealing window 126 is mounted such that the plurality of light emitters 103 and detectors 103' are between the sealing window 126 and the skirt 700. As shown in Figure 7, the sealing window 126 is a rectangular loop structure.

[0123] In some embodiments, the sealing window 126 may be formed from a single monolithic piece of material, thus providing for a robust sealing window 126 and a stable attachment to the carrier 110 and the light transmissive panel 101. The sealing window 126 may be formed by an extrusion process. In one embodiment, the sealing window is formed from two separate materials. A first material, such as a dyed PMMA or similar NIR transparent material, is used for a transparent section and a second material, such as a compressible light blocking material, is used for sealing off the E/D compartment. This may be achieved by e.g. using a co-extrusion process.

[0124] In other embodiments, the sealing window 126 is formed from a plurality of longitudinal pieces (not shown) and joined together to form a rectangular arrangement. Each longitudinal piece may be a single monolithic piece of material. Considering the sealing

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window 126 in Figure 7, the arrangement as shown in Figure 7 is formed from four pieces of extruded sealing window material 126. The four pieces are then joined together to construct the rectangular loop as shown in Figure 7. The four pieces of the extruded sealing window 126 can be adhered together with glue, or fastened together with screws, clips, clamps or any other suitable fastener. The glue can be applied and cured before the sealing window 126 is slid into the carrier 110 or the glue can be left to cure once the sealing window 126 is positioned in the carrier 110. Alternatively the four pieces are not fastened or glued together and are held in position with a friction fit.

[0125] The sealing window 126, once assembled, is sandwiched between the upper surface 702 of the carrier 110 and the light transmissive panel 101. In some embodiments, the sealing window 126 is slid into position between the carrier 110 and the light transmissive panel 101. Figure 8 shows the direction A in which the sealing window 126 is moved with respect to the carrier 110 and the light transmissive panel 101. In this embodiment the sealing window 126 is slid in a direction parallel with the plane of the light transmissive panel 101. In other embodiments, discussed in more detail below, the sealing window 126 can be inserted into the carrier 110 in a different direction such as parallel to the normal axis 107 and perpendicular to the touch surface 102.

[0126] In some embodiments the light transmissive panel 101 is not required to be light transmissive. For example the touch surface 102 can be on a medium through which light does not propagate. In some embodiments the touch surface 102 can be part of a surface which does not require light from a display unit 113, 121 to be visible there through. That is, the touch sensing apparatus 100 is remote from the display unit 113, 121 and the display unit 113, 121 is not stacked together with the other components as shown in Figure 7. In this way the light transmissive panel 101 can be considered to be a panel 101. For the purposes of clarity, the panel 101 has been referred to as a light transmissive panel 101, but all the embodiments are also applicable to a panel comprising an opaque or light blocking material.

[0127] Turning to Figure 8, the construction of the carrier 110, the sealing window 126 and the light transmissive panel will now be discussed in more detail. Figure 8 shows a partial perspective cross-sectional view of the touch sensing apparatus 100. In

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particular Figure 8 is magnified to show the arrangement between the carrier 110, the sealing window 126 and the light transmissive panel 101.

[0128] The sealing window 126 comprises a dual purpose. Firstly, the sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the edge of the light transmissive panel 101. This means that the sealing window 126 prevents ingress of dirt, water and other contaminants into the interior of the touch sensing apparatus 100. This helps protect the internal components such as the plurality of emitters and detectors 103, 103'. Secondly, the sealing window 126 allows light from the emitters and detectors 103, 103' to propagate therethrough. In some embodiments, as discussed in reference to Figure 5a, the sealing window can optionally comprise optical elements for refracting, deflecting, diverting or focusing the light beams therethrough. However in other embodiments, the sealing window is optically passive and does not comprise any optical elements for refracting, deflecting, diverting or focusing the light beams therethrough.

[0129] As can be seen from Figure 8, an upper sealing surface 800 of the sealing window 126 engages with an interior underside surface 802 of the carrier 110. The upper surface 702 of the carrier 110 is arranged to project over the light transmissive panel 101. In this way the carrier 110 overlaps a portion of the light transmissive panel 101 around the perimeter of the light transmissive panel 101. The portion 810 of the upper surface 702 that overlaps with the light transmissive panel 101 is indicated by a bracket in Figure 8. The overlapping portion 810 of the carrier 110 provides protection for the perimeter light transmissive panel 101 from shock and other physical forces. The overlapping portion 810 also provides an overhang on which the sealing window 126 can be mounted. The interior underside surface 802 of the carrier is an opposite face to the upper surface 702. A lower sealing surface 804 of the sealing window 126 engages with the touch surface 102.

[0130] In order to aid the sealing, the sealing window 126 optionally comprises one or more deformable seals or integral gaskets 806, 808 mounted on the upper sealing surface 800 and the lower sealing surface 804 respectively. The deformable seals 806, 808 are arranged to deform when the light transmissive panel 101 is urged towards the carrier 110. The deformable seals 806, 808 are extruded along the longitudinal length of the sealing

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window 126. In some embodiments the deformable seals 806, 808 are integral with the sealing window 126. As mentioned previously, in some embodiments the deformable seals 806, 808 can be manufactured at the same time as the sealing window 126 in a co-extrusion process. Alternatively the deformable seals 806, 808 are mounted and adhered to the sealing window 126 after the sealing window 126 has been extruded. In some embodiments the deformable seals 806, 808 are made from a thermoplastic elastomer (TPE). The deformable seals 806, 808 can be colored black to block transmission of light from the sealing window 126. The deformable seals 806, 808 can be any suitable color or material for absorbing light and minimizing light in-coupling.

[0131] In some embodiments the sealing window 126 is configured to be mounted between two surfaces for sealing and protecting the emitters and detectors 103, 103' from the outside environment. In some embodiments the sealing window 126 is arranged to seal against the touch surface 102 and the interior underside surface 802 of the carrier 110. In other embodiments the sealing window 126 can be mounted between any other surface to provide a sealed cavity 116 around the emitters and detectors 103, 103'. In some embodiments the sealing window 126 seals between the interior underside surface 802 and other surface. The other surface does not need to be the touch surface 102. Instead the other surface is another interior surface of the carrier 110 such as a surface on which the substrate 106 is mounted on. In some other embodiments the sealing window 126 is mounted and sealed against another components and neither of the touch surface 102 and the interior underside surface 802. In some embodiments the sealing window 126 is sealable against at least one surface of the touch sensing apparatus 100 for sealing a cavity 116 around the plurality of light emitters and detectors 103, 103'. In some embodiments the carrier 110 may also be the substrate 106 or the emitters and detectors 103, 103' are mounted directly to the carrier 110.

[0132] In some embodiments the sealing window 126 comprises at least one reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The reference surface 812 will be discussed in further detail with respect to Figure 9 for the purposes of clarity.

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[0133] Figure 9 is a schematic cross-sectional view of the touch sensing apparatus 100. The sealing window 126 is inserted between the light transmissive panel 101 and the carrier 110. The upper deformable seal 806 comprises a reference surface 812 for aligning the sealing window 126 with respect to the carrier 110. The upper deformable seal 806 comprises a projection 814 which projects upwardly from the upper deformable seal 806 and the sealing window 126. In this way, the reference surface 812 is upright with respect to the sealing window 126. The projection 814 also optionally comprises a chamfer 816 in addition to the reference surface 812.

[0134] The chamfer 816 means that the deformable upper seal 806 does not snag on the carrier 110 when the sealing window 126 is inserted between the carrier 110 and the light transmissive panel 101. Accordingly as the sealing window 126 is pushed into place, the chamfer 816 urges against the interior underside surface 802 of the carrier 110. Initially, the deformable upper seal 806 is squashed between the carrier 110 and the light transmissive panel 101 when the sealing window 126 is being forced between the carrier 110 and the light transmissive panel 101.

[0135] The sealing window 126 is pushed towards a notch 820 located in the interior underside surface 802 of the carrier 110. In some embodiments, the notch 820 is a groove that extends around the periphery of the carrier 110. The notch 820 comprises a reciprocal reference surface 818 for aligning with the reference surface 812 of the projection 814. In particular, the notch 820 is a reference point for indicating that the sealing window 126 is inserted underneath the overlapping portion 810 sufficiently to form a seal and protect the internal components of the touch sensing apparatus 100. The notch 820 is positioned a predetermined distance from the edge 822 of the carrier 110. In some embodiments the predetermined distance is at least half the width of the sealing window 126.

[0136] When the sealing window 126 pushed sufficiently between the carrier 110 and the light transmissive panel 101, the deformed projection 814 is located within the notch 820. At this point when the sealing window 126 is located in the correct position with respect to the carrier 110, the reference surface 812 abuts against a reciprocal reference surface 818 in the notch 820 in the carrier 110.

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[0137] The compressed projection 814 resiles and expands once located in the notch 820. In this way, the project 814 snaps into position and positively engages with the notch 820. When the sealing window 126 is located and the projection 814 snaps into place, the sealing window 126 makes an audible "click". Additionally or alternatively the snapping of the projection 814 into position provides a tactile feedback during assembly that the sealing window 126 is seated correctly.

[0138] The size of the notch 820 is slightly larger than the dimensions of the projection 814. Accordingly the projection 814 fits snugly within the notch 820. This means that the frictional forces between the carrier 110, the light transmissive panel 101 and the sealing window 126 are sufficient to hold the sealing window 126 in place. Adhesive is not required to fix the sealing window 126 in place. However in some embodiments adhesive is optionally used in addition to the snap-fit positive engagement.

[0139] In some embodiments the reference surface 812 abuts against the reciprocal reference surface 818. This means that the sealing window 126 opposes the direction A by virtue of the engaged reference surfaces 812, 818. Removal of the sealing window 126 may only be achieved with a special tool which compresses the projection 814.

[0140] Once the sealing window 126 has been seated correctly in the carrier 110, the reference surfaces 812, 818 maintain the alignment between the carrier 110 and the sealing window 126. The deformable seals 806, 808 maintain the relative position of the sealing window 126 with respect to the carrier and prevents lateral movement in a plane parallel to the light transmissive panel 101. Furthermore, the reference surfaces 812, 818 ensure that the sealing window 126 is maintained at a certain height above the touch surface 102.

[0141] The shape and size of the deformable seal 806, 808 can be varied. Another embodiment with such a variation is shown in Figure 10. Figure 10 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement is the same as shown in reference to Figures 8 and 9, except the cross sectional shape of the deformable seal 806, 808 is different. In this embodiment the projection 1002 comprises a curved upwardly projecting bulge 1002 on the upper deformable seal 806. The bulge 1002 comprises a curved reference surface 1004 which engages with one or more reciprocal reference surfaces 818 of the notch

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820. The curved reference surface 1004 functions in a similar way to the chamfer 814 as described in reference to the previous embodiment when inserting the sealing window 126 between the light transmissive panel 101 and the carrier 110. The bulge 1002 has dimensions which are substantially the same width as the width of the notch 820 so that the sealing window 126 does not experience lateral movement in a direction parallel with the plane of the light transmissive panel 101. The lower seal 808 optionally comprises a similar bulge 1006 for engaging and sealing against the touch surface 102. By making the upper seal 806 and the lower seal 808 have the same cross section, manufacture can be simplified because the same die (not shown) can be used during extrusion of the deformable seals 806, 808.

[0142] Advantageously the shape of the projection 1002 means that the sealing window 126 can be removed with a similar magnitude of force to the force needed for insertion during assembly. Accordingly removal of the sealing window 126 may not require a tool. This can make maintenance which requires removal of the sealing window 126 easier.

[0143] Another embodiment is shown in Figure 11. Figure 11 shows a cross sectional side view of the touch sensing apparatus 100. Figure 11 is the same as shown in Figure 10 except that there is an additional projection and notch. The first notch 1100 and first bulge 1104 are substantially the same as the notch 820 and the bulge 1002 as discussed in reference to Figure 10. In addition, there is a second notch 1102 and a second bulge 1106. Likewise the lower seal 808 comprises similar first and second bulges 1108, 1110. Having two projecting bulges 1104, 1106 means that there are two points of sealing engagement between the sealing window 126 and the light transmissive panel 101 and the carrier 110 respectively. This means that there will be less rotation of the sealing window 126 about the deformable seal 806, 808. Accordingly, the tolerances needed to accommodate rotational movement of the sealing window about the longitudinal axis of the sealing window can be lower. There is also an increased surface area of the deformable seals 806, 808 and therefore the deformable seals will cool quicker during manufacture.

[0144] In another embodiment, the first and second bulges 1104, 1106 engage with a single notch 820 as shown in Figure 10. The dotted line between the first and second notches 1100, 1102 represents a single notch, similar to the notch 820 in Figure 10. In this case the first bulge 1104 engages a first reciprocal reference surface 1114 and the second

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bulge 116 engages with a second reciprocal reference surface 1112. The first and second reciprocal reference surfaces 1114, 1112 are walls of the notch 820.

[0145] Another embodiment will now be discussed in reference to Figure 12. Figure 12 shows a schematic perspective and cross-sectional view of the touch sensing apparatus 100. The arrangement as shown in Figure 12 is the same as shown in Figures 8 and 9 except that the deformable seal 806 comprises a plurality of discrete projections 1200, 1202, 1204. Each of the projections is deformable and is inserted between the light transmissive panel 101 and the carrier 110 in the same way as described with respect to the previous embodiments. The carrier 110 comprises a serious of reciprocal recesses (not shown for clarity) to receive a respective projection 1200, 1202, 1204. In this way less deformable material is required to perform the alignment function. The projections may be adhered to the deformable seal material 806 or the projections can be extruded. Each of the projections 1200, 1202, 1204 comprise a reference surface for aligning the projection and the sealing window 126 with the reciprocal recess in the carrier 110. In some embodiments the projections 1200, 1202, 1204 can comprise any suitable cross sectional shape. For example, the projections can comprise an oval curved cross section, similar to the bulges shown in the embodiments discussed in reference to Figures 10 and 11.

[0146] Figure 13 shows yet another embodiment. Figure 13 shows a schematic exploded perspective view of the touch sensing apparatus 100. For the purposes of clarity the light transmissive panel 101 is not shown. The sealing window 126 is the same as described in reference to the previous embodiments. The upper deformable seal 806 is mounted on the upper sealing surface 800. In contrast to the previous embodiments, the deformable seal 806 does not comprise upward projections comprising a reference surface. Instead the sealing window 126 comprises positioning pegs 1300, 1302 for engagement in the reciprocal positioning holes 1304, 1306 located in the carrier 110. In this way the reference surfaces are separate from the deformable seal 806.. Each of the positioning pegs 1300, 1302 comprises a reference surface 1308, 1310 for aligning the sealing window 126. In this way as the sealing window is slid underneath the carrier 110 in the direction A, the pegs 1300, 1302 slot into the positioning holes 1304, 1306. The holes 1304, 1306 are blind holes and when the reference surfaces 1308, 1310 abut the end of the blind holes 1304, 1306, the sealing window 126 is in

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the correct position. The holes 1304, 1306 are deep enough such that the sealing window 126 is completely under the carrier 110, similar to the arrangement shown in the previous embodiments.

[0147] Figure 14 shows another embodiment. Figure 14 shows a cross sectional side view of the touch sensing apparatus 100. The arrangement as shown in Figure 14 is the same as shown in Figures 8 and 9 except that the projection 1400 is formed on the carrier 110 and the notch 1402 is formed in the upper deformable seal 806. In this embodiment the projection 1400 is rigid and downwardly projects from the carrier 110. The notch 1402 is deformable and snaps into position when the notch 1402 is in positive engagement with the projection 1400 and reference surfaces are in engagement. The sealing window 126 is inserted between the carrier and the light transmissive panel 101 in the same way as discussed previously.

[0148] In alternative embodiments, the carrier 110, the light transmissive panel 101 and the sealing window 126 are assembled in a different order. The components are the same as described in reference to the previous embodiments. Turning to Figures 15a – 15d and Figure 16 the alternative method of assembly will now be discussed.

[0149] Figures 15a – 15d show a side cross section of the touch sensing apparatus 100. The light transmissive panel 101 has been omitted for clarity. The sealing window 126 is pushed towards the carrier 110 in direction B. That is, a direction which is parallel to normal axis 107. Figure 15a shows two deformable projections 1500, 1502 which have a snap-fit engagement with reciprocal grooves in the carrier. The deformable projections 1500, 1502 have a cross sectional shape that snaps into the reciprocal holes when the sealing window is seated correctly in the carrier 110.

[0150] Figure 15b shows a similar arrangement to Figure 15a except that there is a single projection 1504 which does not have a snap-fit engagement. Optionally, positive engagement is provided by the projection 1504 having a snug friction fit. When the sealing window 126 cannot move any further with respect to the carrier 110, the projection 1504 will abut the reciprocal surface of the hole in the carrier 110 and the sealing window will be seated correctly.

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[0151] Figures 15c and 15d show stepwise engagement of the same arrangement. The deformable seal 806 comprises snap-fit latches 1506, 1508 which bend and snap into place once the sealing window is fully seated in the carrier 110.

[0152] Once the sealing window 126 and the carrier 110 are assembled, then the light transmissive panel 101 is mounted in the carrier 110.

[0153] Figure 16 shows a schematic exploded perspective view of the carrier 110 and the sealing window 126. The arrangement as shown in Figure 16 is the same as shown in Figure 13, except that the relative movement of the sealing window 126 with the respect to the carrier 110 during assembly is perpendicular. That is, along direction B parallel with the normal axis 107. Similar to the embodiment as shown in Figure 13, the sealing window 126 comprises a plurality of reference surfaces which are not part of the deformable seal 806. Each of pegs 1600, 1606 and snap-fit latches 1602, 1604 comprises a reference surface for alignment. Figure 16 shows pegs 1600, 1606 for engagement with holes 1608, 1610. Figure 16 also shows resiliently deformable latches 1604, 1602 for snap-fit engagement with holes 1612 and 1614.

[0154] A further mounting unit 140 may be provided between the sealing window 126 and the light transmissive panel 101, as schematically illustrated in Fig. 5a. The mounting unit 140 may comprise a resilient material that allows the sealing window 126 to assume a secure fixed position relative the light transmissive panel 101. The sealing window 126 may have a corresponding groove into which the mounting unit 140 may be securely positioned.

[0155] A method 200 of assembling a touch sensing apparatus 100 is provided. Fig. 6 illustrates steps of the method 200. The order in which the steps of the method 200 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order. The method 200 comprises fixing 201 a substrate 106 having a plurality of light emitters 103 and detectors 103' to a carrier 110, and attaching 202 the carrier 110 around a perimeter 104 of a light transmissive panel 101. The method further comprises arranging 203 the substrate to extend in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel 101 extends, whereby the plurality of light emitters and detectors 103, 103', are arranged above the touch surface

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102. The method 200 thus provides for a facilitated assembly of the touch sensing apparatus 100 while achieving optimal alignment, robustness, and accuracy as described above in relation to Figs. 2 – 3.

[0156] As mentioned, the carrier 110 may be formed from a single monolithic piece of material, and the carrier may form a cavity 116 having walls 117 at least partly enclosing the substrate 106. At least one of the walls 117 may comprise openings 115, 115', 115''. The method 200 may comprise fixing 204 the carrier 106 to a display unit 121, 113, by fixing mounting elements 114 through the openings 115, 115', 115'', thereby providing for the above mentioned advantages.

[0157] The method 200 may comprise adjusting 205 a distance 120 between the light transmissive panel 101 and a display unit 113, 121, along the normal axis 107 by attaching 207 the carrier 110 to the display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the distance 120 is improved and facilitated, and may thereby be more easily optimized to various applications of the touch sensing apparatus 100.

[0158] The method 200 may comprise adjusting 208 a radius of curvature of the light transmissive panel 101 in the direction of the normal axis 107 by attaching 209 the carrier 110 to a display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the curvature of the light transmissive panel 101 is thus improved as described above.

[0159] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope and spirit of the invention, which is defined and limited only by the appended patent claims.

[0160] For example, the specific arrangement of emitters and detectors as illustrated and discussed in the foregoing is merely given as an example. The inventive coupling structure is useful in any touch-sensing system that operates by transmitting light, generated by a number of emitters, inside a light transmissive panel and detecting, at a number of detectors, a change in the received light caused by an interaction with the transmitted light at the point of touch.

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WHAT IS CLAIMED IS:

1. A touch sensing apparatus, comprising:

a plate comprising a touch surface, a back surface, and an edge surface;

a support structure extending parallel to the edge surface of the plate, said support structure extending above the touch surface, said support structure configured to support an emitter, wherein the emitter is positioned on the support structure to transmit light in a plane above the touch surface and perpendicular to a normal of the touch surface; and

an optical element positioned above the touch surface, said optical element comprising a first surface configured to receive the transmitted light directly from the emitter and a second surface configured to receive light propagating across a touch interacting portion of the touch surface.

2. The touch sensing apparatus of Claim 1, wherein the first surface of the optical element comprises a light collimating surface.

3. The touch sensing apparatus of Claim 1, wherein the optical element comprises glass or plastic.

4. The touch sensing apparatus of Claim 1, wherein the support structure is one element of a frame assembly, wherein the frame assembly comprises a plurality of frame elements.

5. The touch sensing apparatus of Claim 4, wherein the plurality of frame elements comprise a first element including:

a first portion extending parallel to the edge surface of the plate in a direction perpendicular to a normal of the touch surface;

a second portion extending parallel to the touch surface and covering a portion of the touch surface, wherein the second portion is separated from the touch surface by a spacing; and

a retaining member in the second portion, wherein the retaining member is configured to secure the optical element in the spacing between the first element and the touch surface.

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ABSTRACT OF THE DISCLOSURE

A touch sensing apparatus is disclosed comprising a panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the panel. The light emitters are arranged to emit a respective beam of emitted light that travels above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are arranged above the touch surface and are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the panel extends. A method of assembling a touch sensing apparatus is also disclosed.

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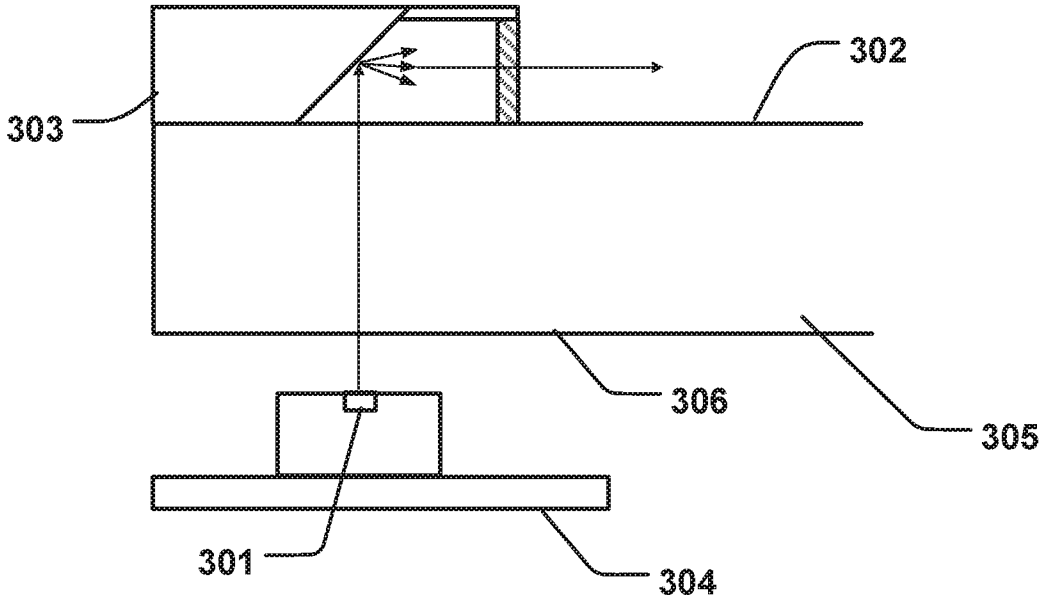


Fig. 1

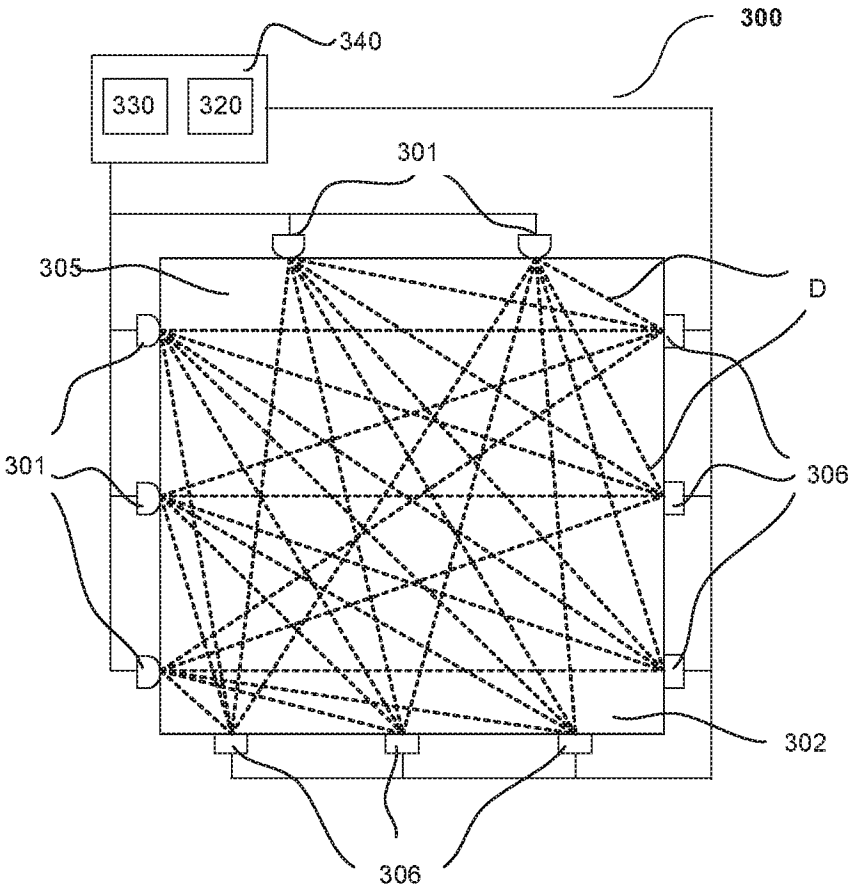


Fig. 1b

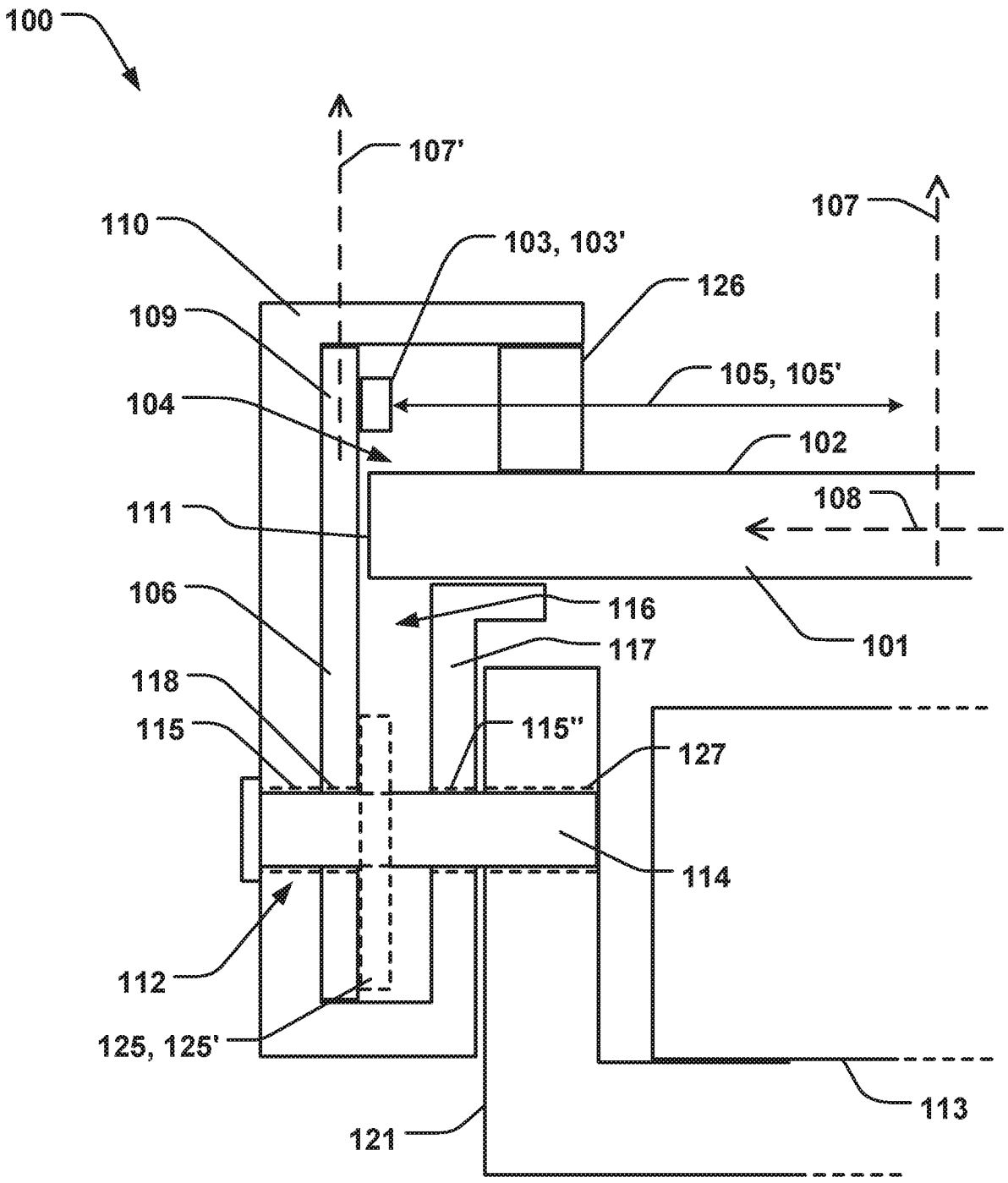

100
107'
107
110
103, 103'
126
109
105, 105'
104
102
108
111
106
116
117
101
118
115
115''
127
114
112
125, 125'
113
121

Fig. 2

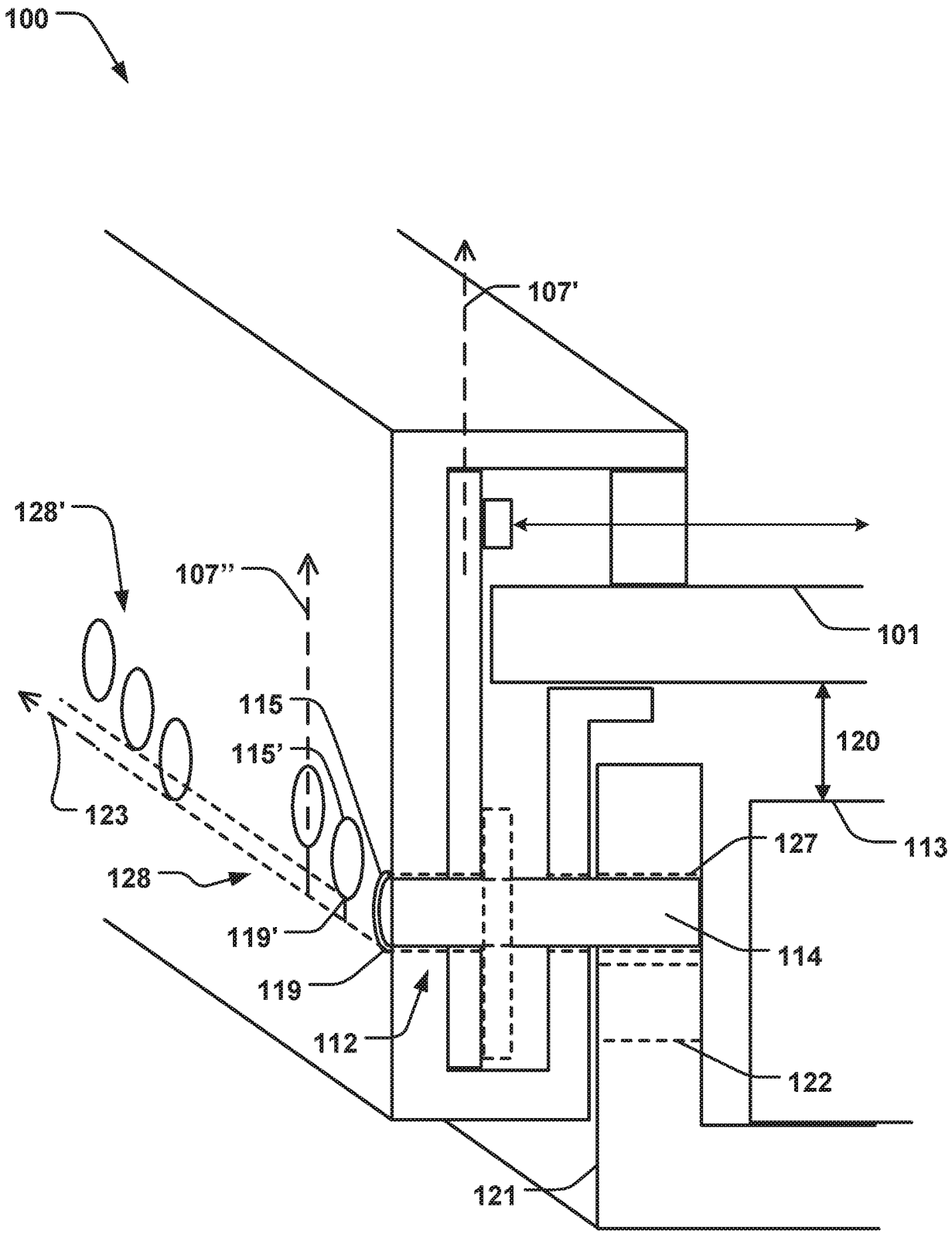

100
107'
128'
107''
101
115
115'
120
123
113
127
128
119'
114
119
112
122
121

Fig. 3

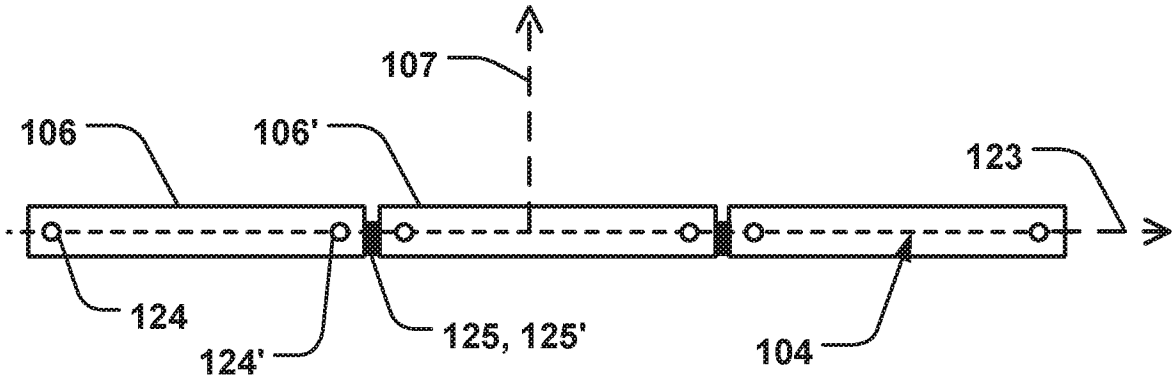


Fig. 4a

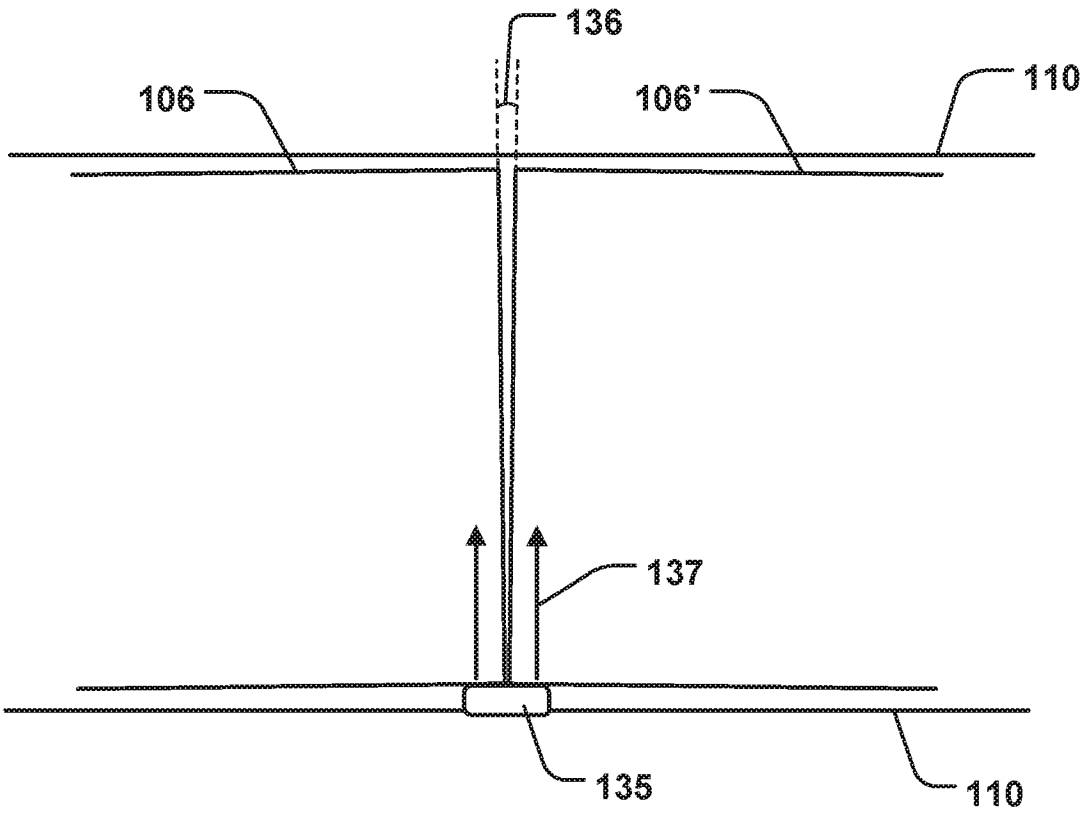


Fig. 4b

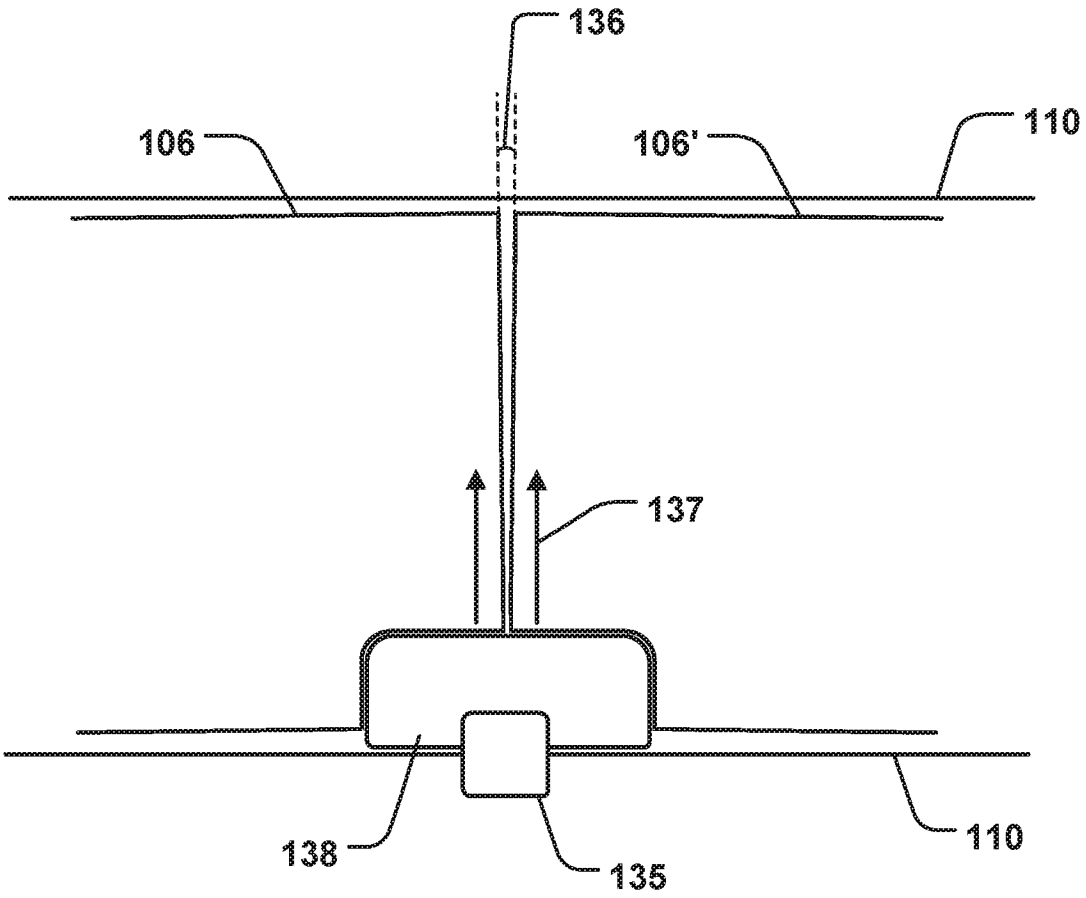


Fig. 4c

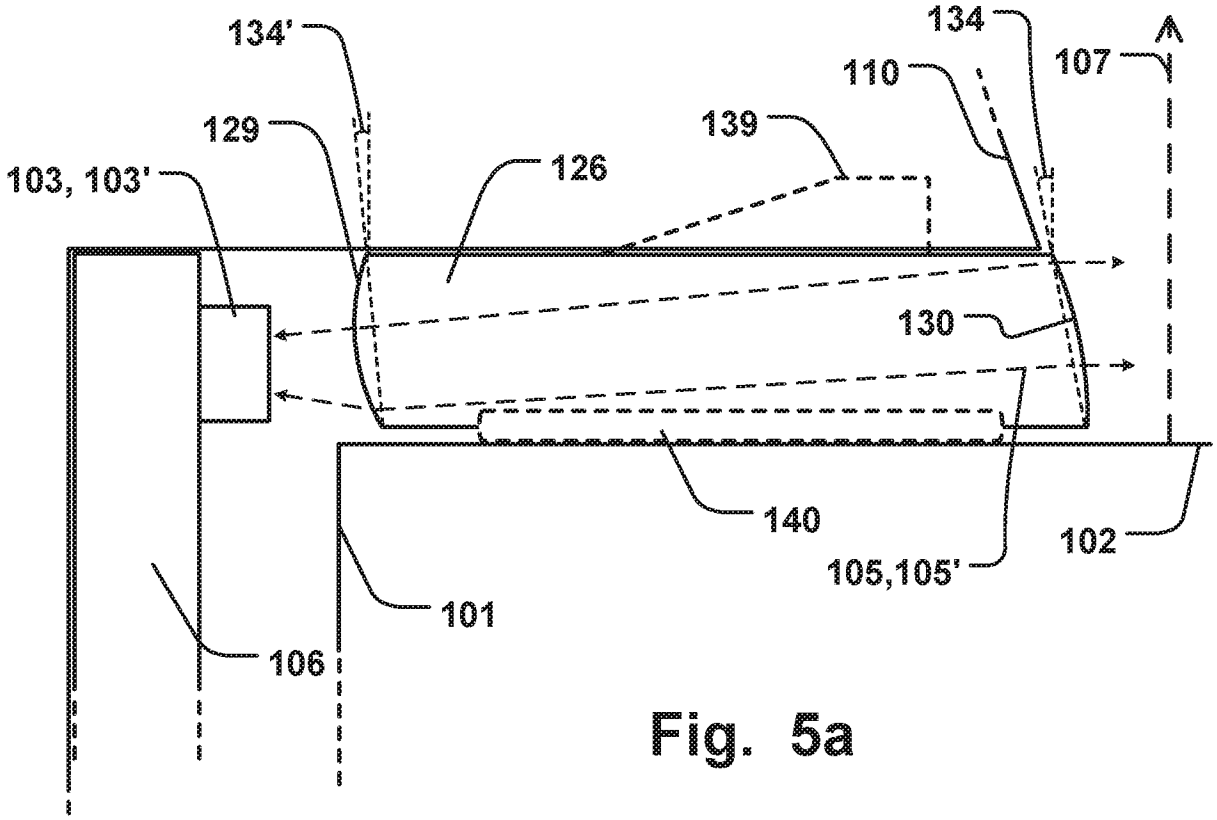

134'
134
107
110
129
139
103, 103'
126
130
140
102
105,105'
101
106

Fig. 5a

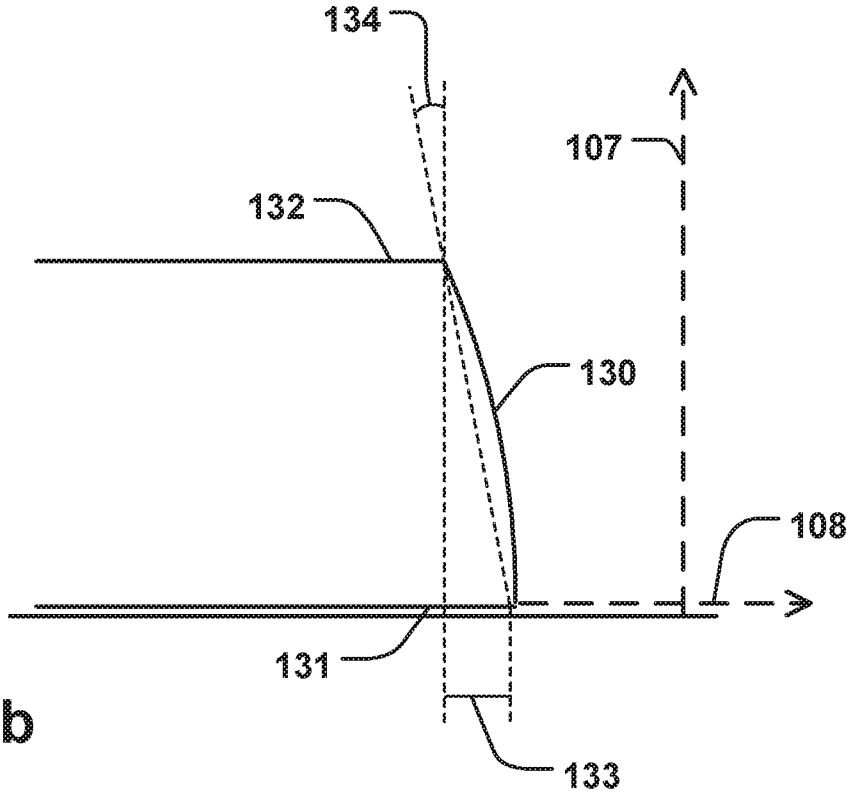

134
107
132
130
108
131
133

Fig. 5b

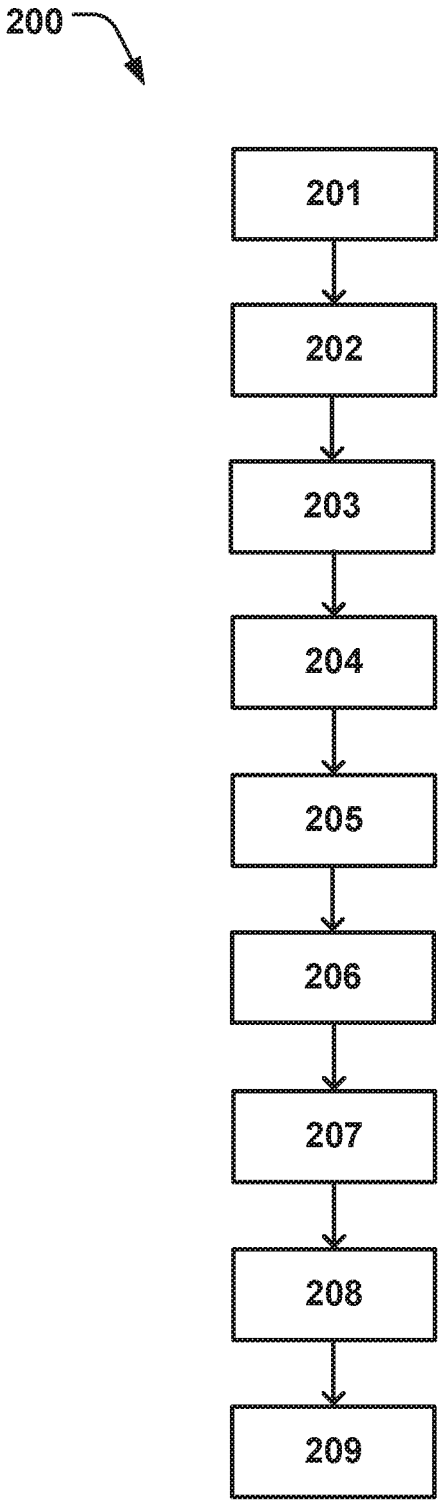


Fig. 6

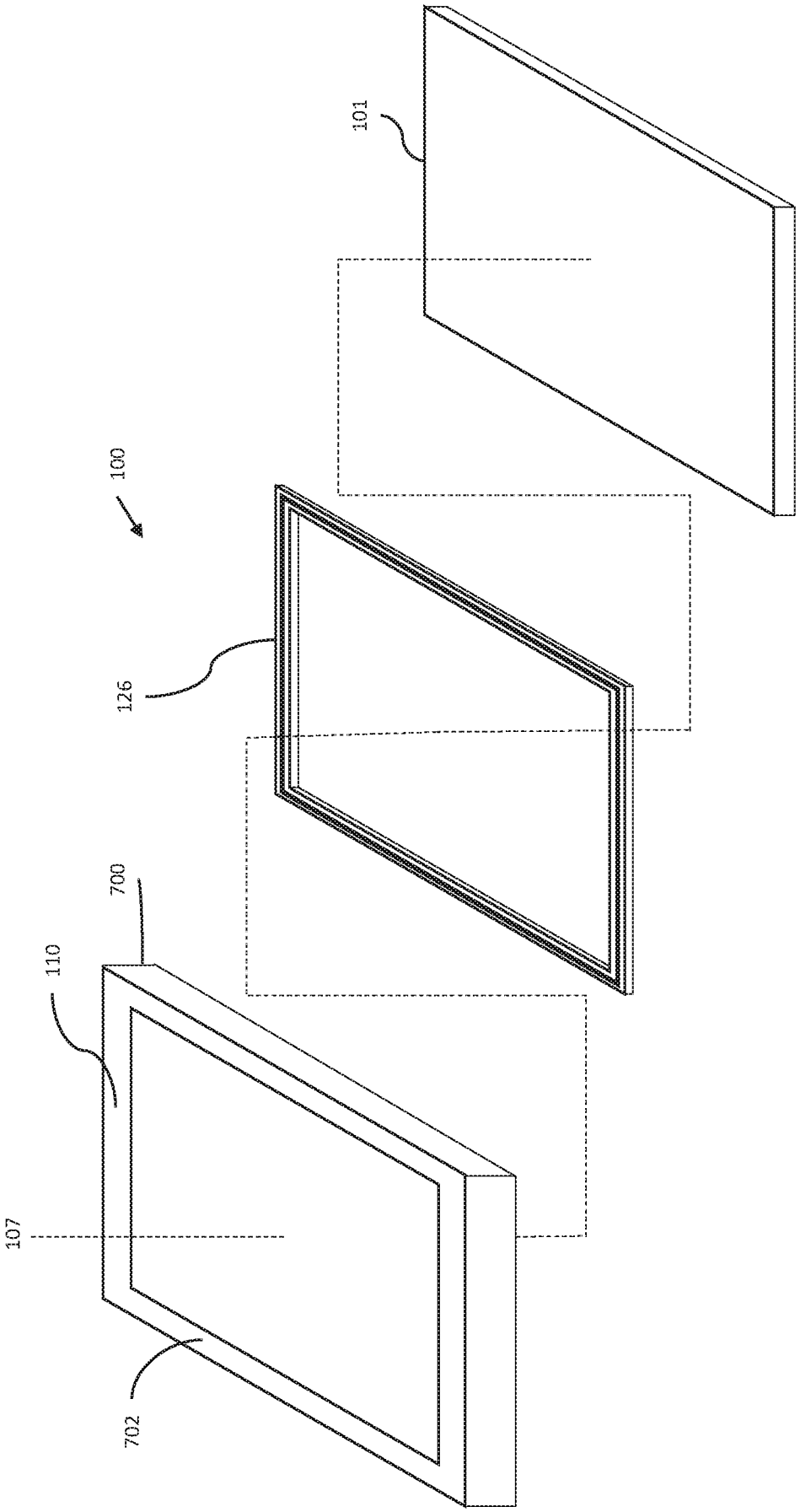


Figure 7

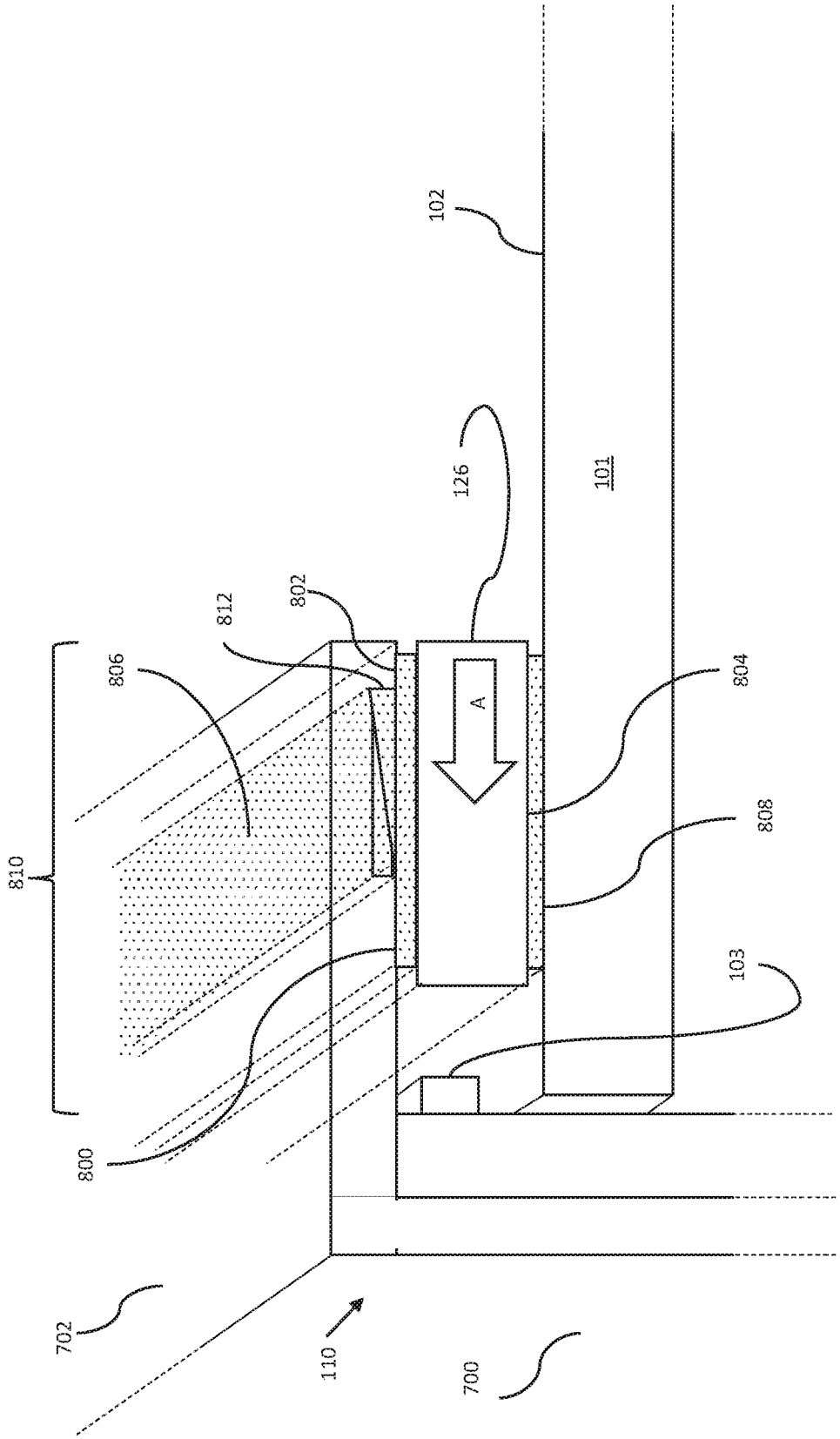


Figure 8

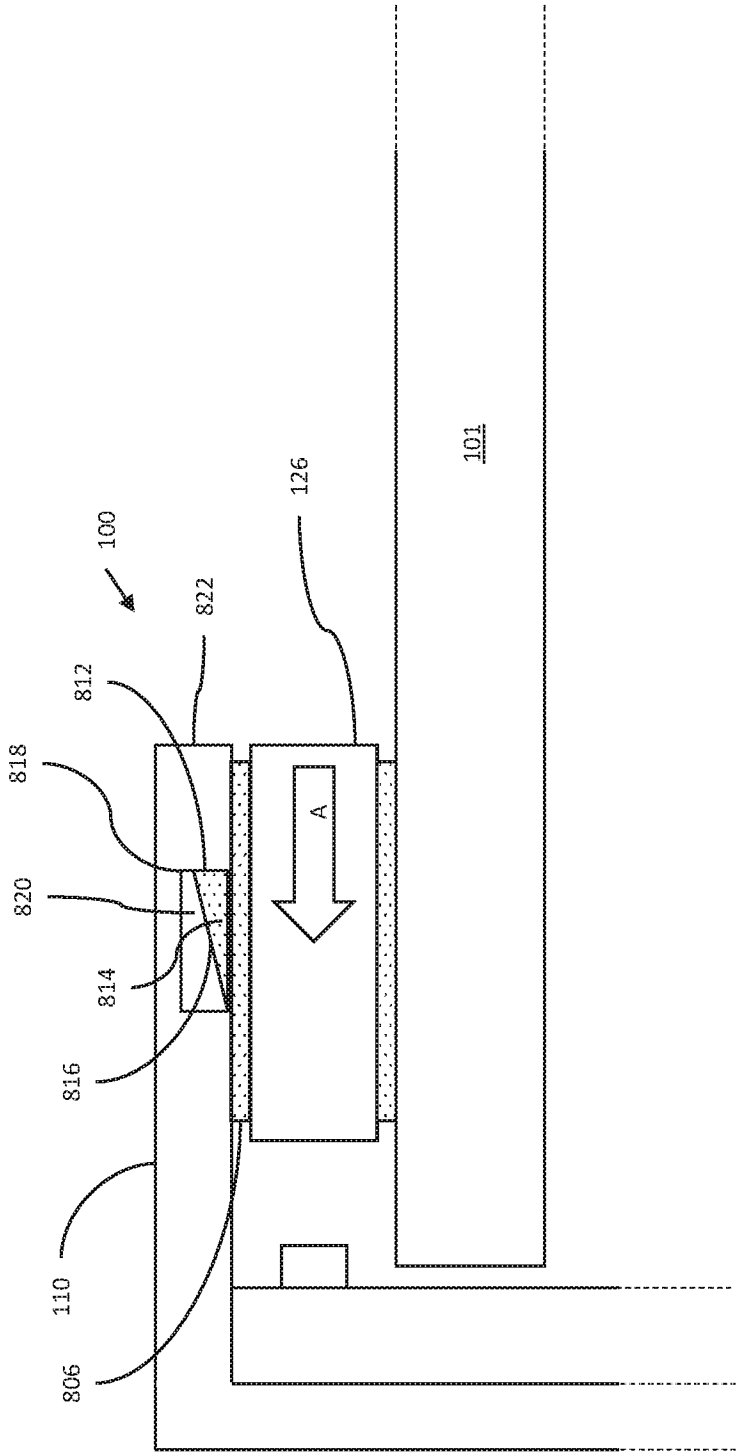


Figure 9

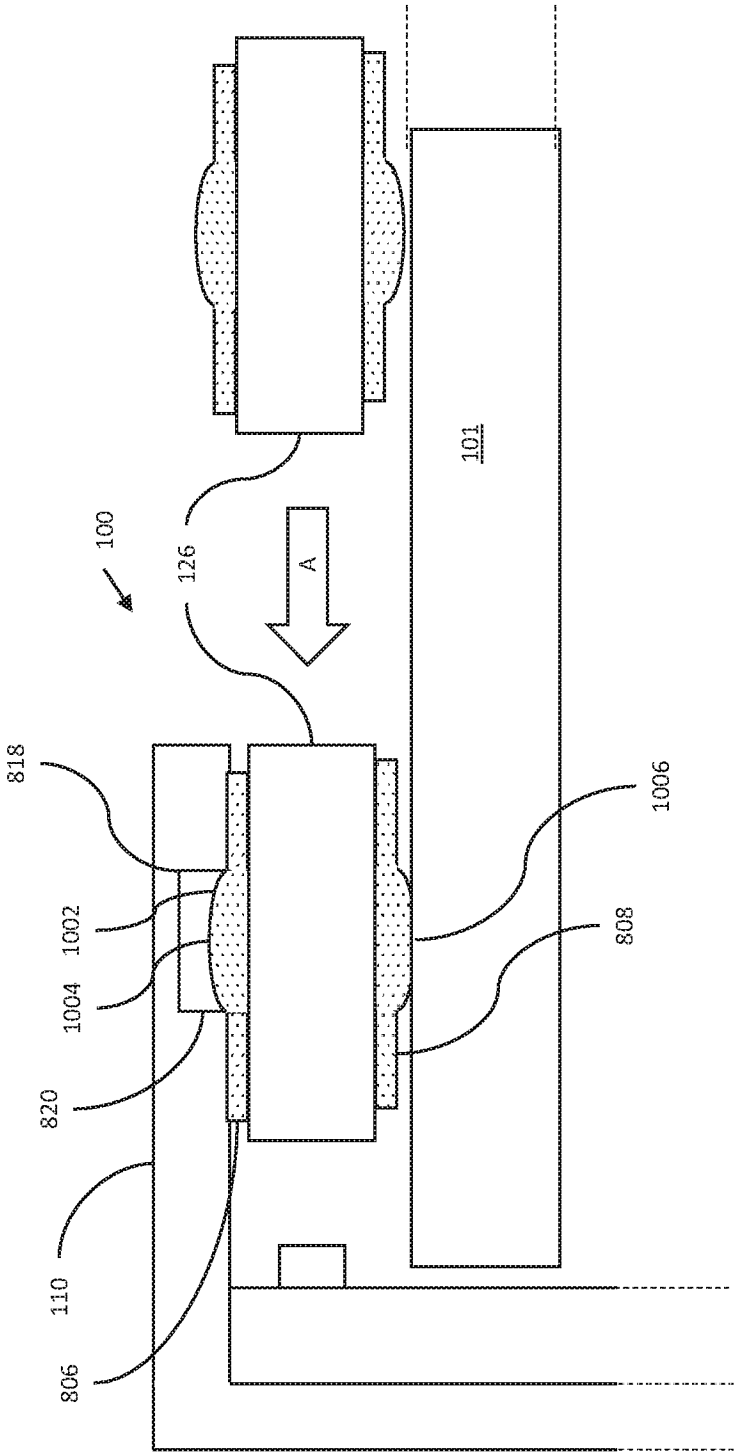


Figure 10

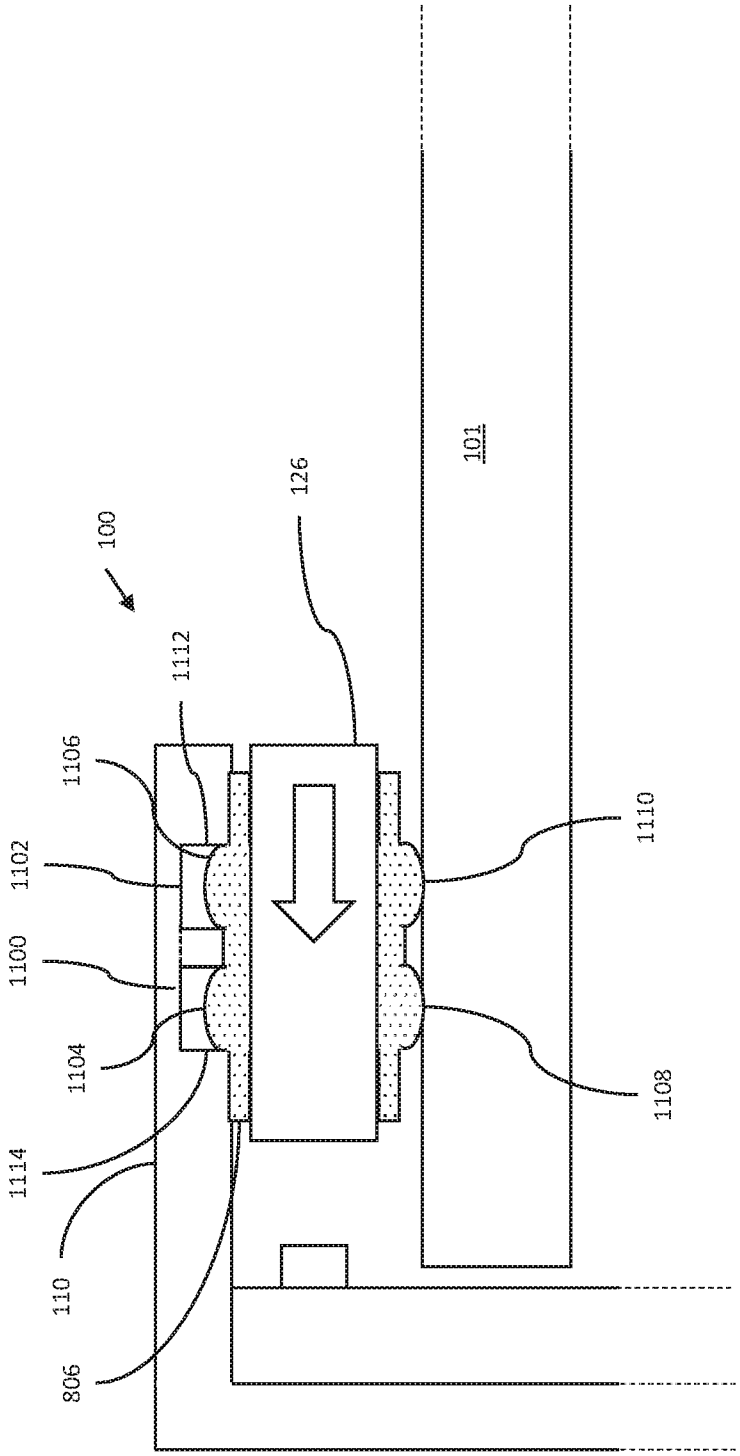


Figure 11

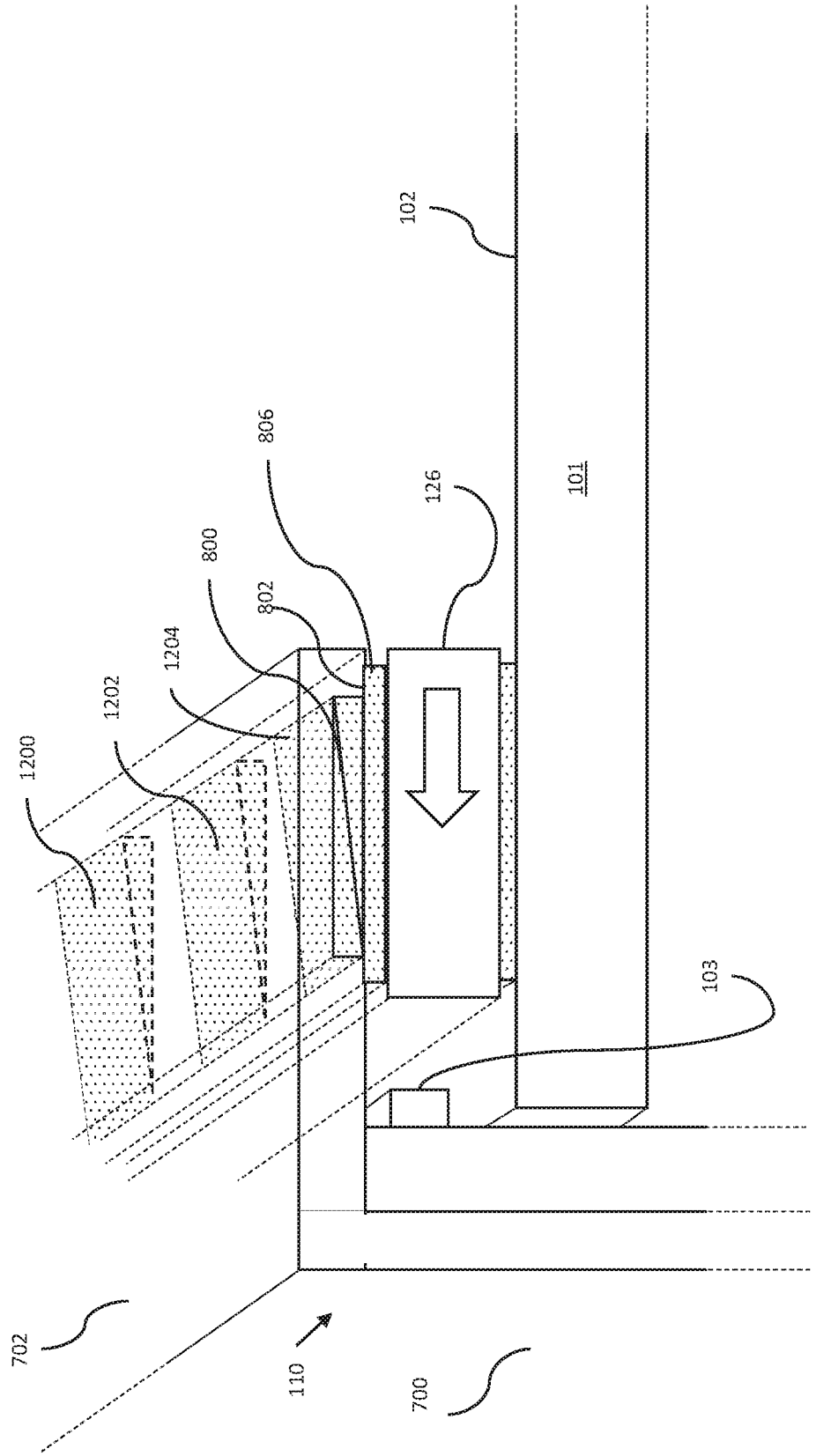


Figure 12

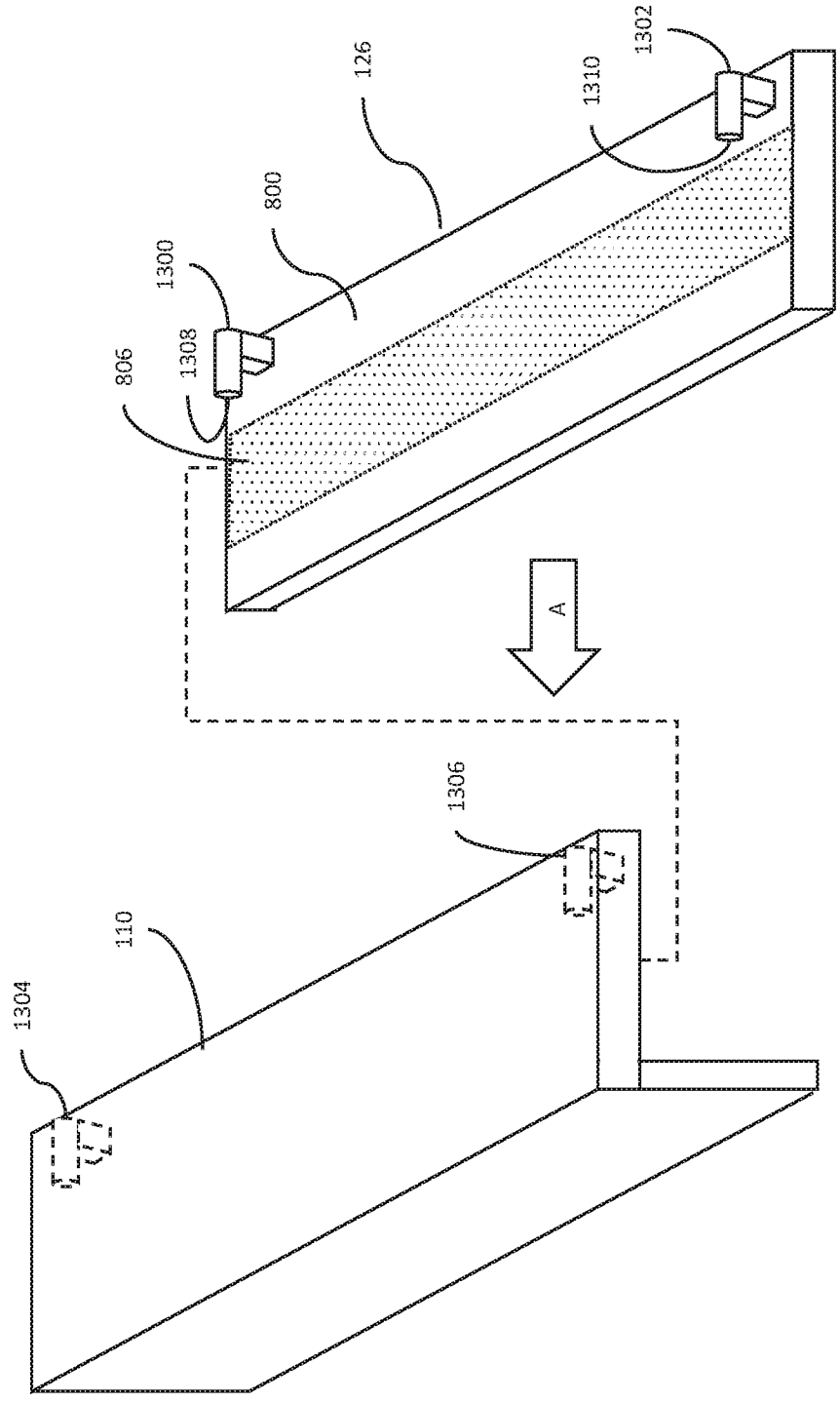


Figure 13

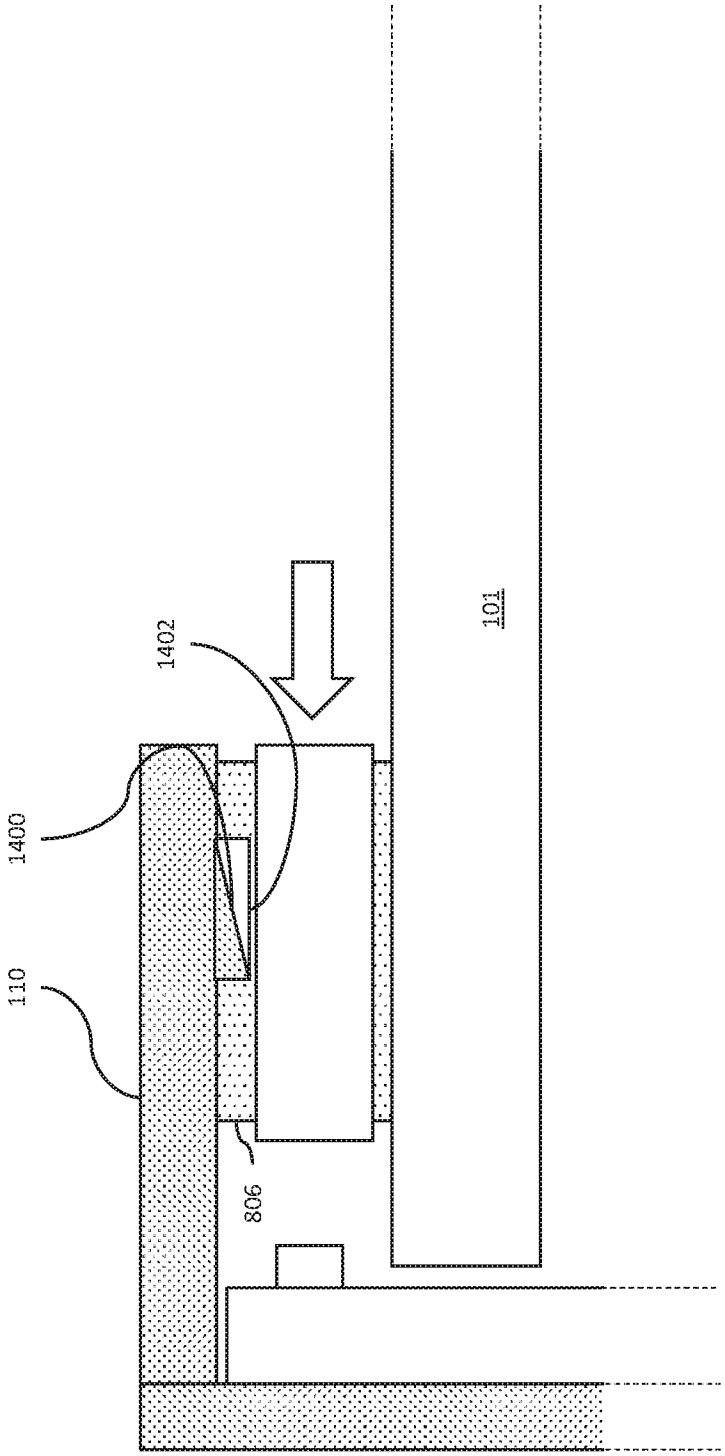


Figure 14

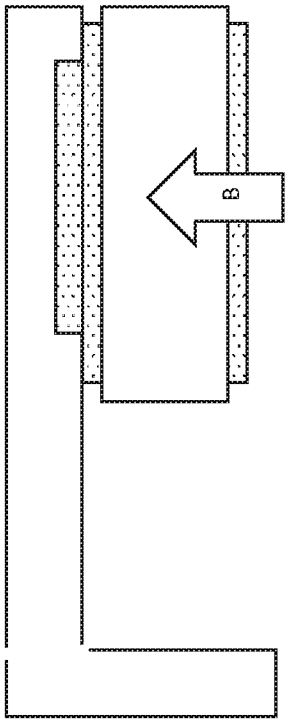


Figure 15b

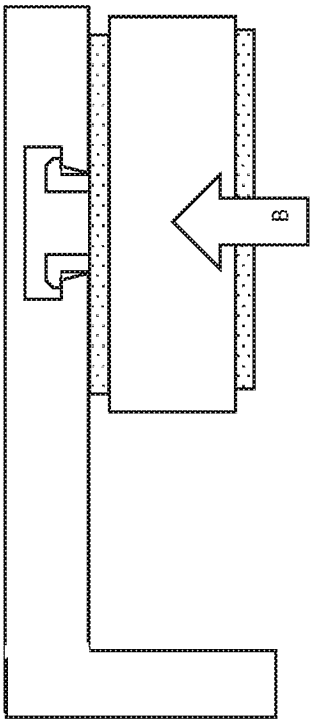


Figure 15d

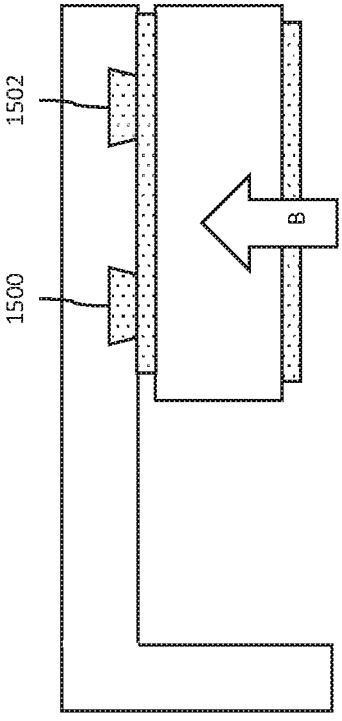


Figure 15a

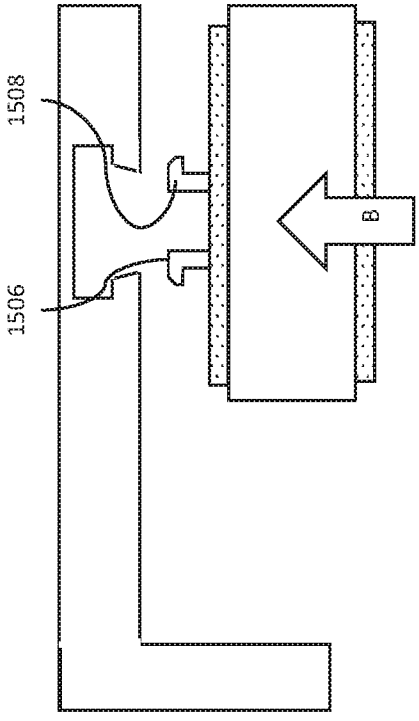


Figure 15c

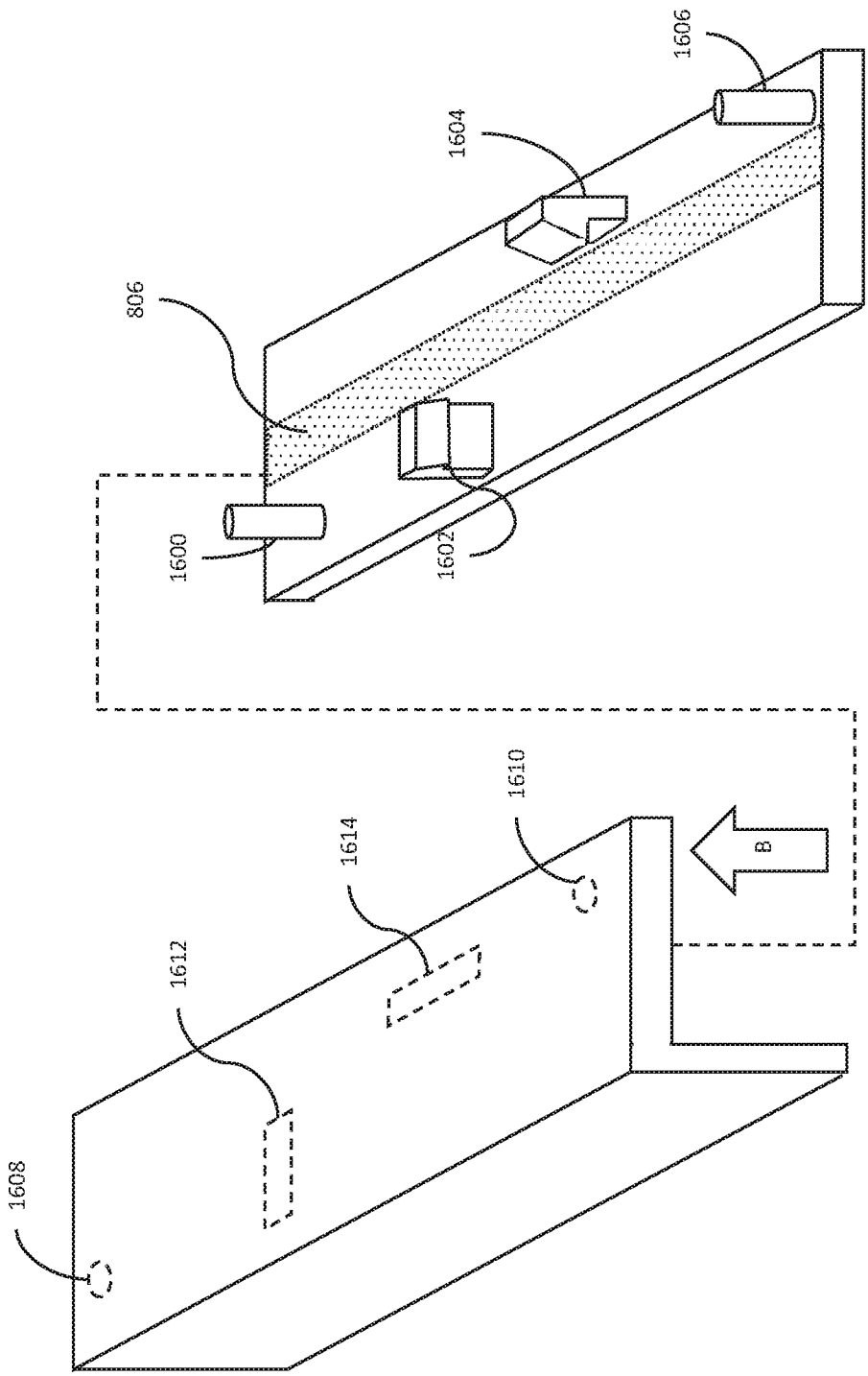


Figure 16

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))

Application Data Sheet filed previously or concurrently

Docket No.: FFOG.054C2

Title: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

Inventors: Daniel Skagmo, Robert Ehn, Hakan Bergstrom

Declaration

This Declaration is directed to U.S. or International Application No. **16/191177**, filed November 14, 2018 and incorporating any amendments made thereto prior to the signature date of this Declaration.

As a named inventor, I declare that:

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 USC 1001 by fine or imprisonment of not more than five (5) years, or both.

I have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

Assignment from Inventors

WHEREAS, **above-identified inventors** (individual(s) hereinafter "ASSIGNOR") invented certain new and useful improvements, technology, inventions, developments, ideas, ornamental designs, or discoveries related to **TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY** (collectively hereinafter referred to as the "Work") for which an application for Letters Patent in the United States (identified above) has been filed or prepared for filing with the United States Patent and Trademark Office (hereinafter the "Application"), and ASSIGNOR desires to assign or confirm assignment of the Work and the Application to the below identified Assignee.

AND WHEREAS, **FlatFrog Laboratories AB,** with its principal place of business at **Scheelevägen 15 A Lund SE 223 63** (hereinafter the "ASSIGNEE"), desires to acquire or confirm ownership of the entire right, title, and interest in and to the Application and the Work.

NOW, THEREFORE, for good and valuable consideration of which receipt is hereby acknowledged, ASSIGNOR hereby acknowledges that ASSIGNOR has sold, assigned, transferred, and set over, and by these presents does hereby sell, assign, transfer, and set over, unto said ASSIGNEE, **its** successors, legal representatives, and assigns, the entire right, title, and interest throughout the world in and to the Application and the Work, including: all provisional applications relating to the Work and the Application (including but not limited to Sweden Application No(s). **SE 1730085-6**, filed **March 28, 2017** (respectively if plural applications)); all nonprovisional applications claiming priority to aforementioned provisional(s) and/or the Application, including, all divisions, continuations, continuations-in-part, and reissues, and all Letters Patent of the United States which may be granted thereon and all reissues and extensions thereof; and all rights of priority under International Conventions and any related Letters Patent which may hereafter be granted or filed in any country or countries foreign to the United States, all extensions, renewals, and reissues thereof.

ASSIGNOR hereby authorizes and requests the Commissioner of Patents of the United States, and any Official of any country or countries foreign to the United States, whose duty it is to issue patents on applications as aforesaid, to issue all related Letters Patent to the ASSIGNEE, **its** successors, legal representatives, and assigns.

AND ASSIGNOR DOES HEREBY sell, assign, transfer, and convey to ASSIGNEE, **its** successors, legal representatives, and assigns all claims for damages and all remedies arising out of any violation of the rights assigned hereby that may have accrued prior to the date of assignment to ASSIGNEE, or may accrue hereafter, including, but not limited to, the right to sue for, collect, and retain damages for past infringements of said Letters Patent before or after issuance.

AND ASSIGNOR DOES HEREBY covenant and agree that ASSIGNOR will: communicate to said ASSIGNEE, **its** successors, legal representatives, and assigns any facts known to ASSIGNOR respecting the Work; testify in any legal proceeding; assist in the preparation of any other Patent Property relating to the Application and the Work or any improvements made thereto; sign/execute all lawful papers; authorize the filing of, execute, and make all rightful oaths and/or declarations in connection with the Application and the Work including any improvements made thereto, any patent applications filed therefrom, and any continuing application filed from any of the aforementioned applications; and generally do everything possible to aid the ASSIGNEE, **its** successors, legal representatives, and assigns, to obtain and enforce proper patent protection for the Work in all countries.

Legal Name of Inventor: Daniel Skagmo

Signature: Daniel Skagmo Date: Feb 17, 2020

Witnessed by: _____

Witness Name (printed): _____

Legal Name of Inventor: Robert Ehn

Signature: _____ Date: Feb 17, 2020

Witnessed by: _____

Witness Name (printed): _____

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))

Application Data Sheet filed previously or concurrently

Docket No.: FFOG.054C2

Title: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

Inventors: Daniel Skagmo, Robert Ehn, Hakan Bergstrom

Legal Name of Inventor: Hakan Bergstrom

Signature: Håkan Bergström Håkan Bergström (Feb 18, 2020) Date: Feb 18, 2020

Witnessed by: _____

Witness Name (printed): _____

32212076

AMENDMENTS TO THE DRAWINGS

Applicant has amended Figs. 1A-16. Replacement sheets are submitted herewith.

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 165 of 1254

REMARKS

Applicant has canceled claims 1-5 and added new claims 6-21. No new matter has been added. Please enter the amendments prior to examination on the merits.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

Co-Pending Applications of Assignee

Applicant wishes to draw the Examiner's attention to the following co-pending applications of the present application's assignee.

Docket No.	Serial No.	Title	Filed
FFOG.054C3	16/191195	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	November 14, 2018
FFOG.054C4	16/191255	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	November 14, 2018

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 166 of 1254

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: March 30, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 721-5278

32520960

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 167 of 1254

PTO/AIA/82A (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	Unknown
Filing Date	Herewith
First Named Inventor	Daniel Skagmo
Title	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Art Unit	Unassigned
Examiner Name	Unassigned
Attorney Docket Number	FFOG.054C5

SIGNATURE of Applicant or Patent Practitioner

Signature	/Harnik Shukla/	Date (Optional)	
Name	Harnik Shukla	Registration Number	73,097
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 20995

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

FlatFrog Laboratories AB

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	
Name	Dhwani Vyas		
Title	CEO		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Daniel Skagmo	Nonprovisional Application Number (if known):	
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Harnik Shukla/	Date 3/30/2020
Name (Print/Typed) HARNIK SHUKLA	Practitioner Registration Number 73097

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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Doc Code: FAI.REQ
Document Description: Request First Action Interview

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REQUEST FOR FIRST ACTION INTERVIEW (FULL PILOT PROGRAM)

Attorney Docket Number: FFOG.054C5	Application Number (if known):	Filing date: Herewith
First Named Inventor: Daniel Skagmo	Title: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY	

APPLICANT HEREBY REQUESTS A FIRST ACTION INTERVIEW IN THE ABOVE-IDENTIFIED APPLICATION. See Instruction Sheet on page 2.

1. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims.

2. The application must not contain any multiple dependent claims.

3. By filing this request:

   Applicant is agreeing to make an election without traverse if the Office determines that the claims are not obviously directed to a single invention; and

   Applicant is agreeing not to request for a refund of the search fee and any excess claims fee paid in the application after the mailing or notification of the pre-interview communication prepared by the examiner.

4. Other attachments: _____

Signature /Harnik Shukla/	Date 3/30/2020
Name (Print/Typed) Harnik Shukla	Registration Number 73,097

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.*

■ *Total of 1 forms are submitted.

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(Not to be Submitted to the USPTO)

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2. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims. The application may not contain any multiple dependent claims.

3. The request must be filed electronically using the Office's electronic filing system, EFS-Web.

4. The claims must be directed to a single invention. If the Office determines that the claims are directed to multiple inventions (*e.g.*, in a restriction requirement), the applicant must make an election without traverse.

5. The request must be filed at least one day before a first Office action on the merits of the application appears in the Patent Application Information Retrieval (PAIR) system (*i.e.*, at least one day prior to the date when a first Office action on the merits, notice of allowability or allowance, or action under Ex parte Quayle, 1935 Dec. Comm'r Pat. 11 (1935) appears in the PAIR system). Applicant may check the status of the application using the PAIR system.

6. The request for a first action interview must include a statement that applicant agrees not to file a request for a refund of the search fee and any excess claims fees paid in the application after the mailing or notification of the Pre-Interview Communication. Any petition for express abandonment under 37 CFR 1.138(d), and request for a refund of the search fee and any excess claims fees, filed after the mailing or notification of the Pre-Interview Communication will not be granted.

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Swedish Patent Application

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(71)	Sökande Applicant (s)	FlatFrog Laboratories AB, Lund, SE
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Marie Nilsson

Touch sensing apparatus

Technical Field

The present invention relates to touch-sensing apparatus that operate by propagating light by diffusive light scattering above a thin light transmissive panel, and in particular to optical and mechanical solutions for defining the light paths and control of curvature of the light transmissive panel. The present invention relates furthermore to a method of assembling a touch sensing apparatus.

Background Art

In one category of touch-sensitive panels known as 'above surface optical touch systems', a set of optical emitters are arranged around the periphery of a touch surface to emit light that is reflected to travel and travel above the touch surface. A set of light detectors are also arranged around the periphery of the touch surface to receive light from the set of emitters from above the touch surface. An object that touches the touch surface will attenuate the light on one or more propagation paths of the light and cause a change in the light received by one or more of the detectors. The location (coordinates), shape or area of the object may be determined by analysing the received light at the detectors.

In a variant of such 'above surface optical touch system', illustrated in Fig. 1, the emitters 301 are arranged on a substrate 304, and light from the emitters travel above the touch surface 302 of the panel 305 via reflection or scattering on an edge reflector or diffusor 303. The light will then continue until deflected by a corresponding edge reflector at an opposing edge of the light transmissive panel, where the light will be scattered back down through the transmissive panel and onto the detectors. A problem with such previous systems is the cumbersome alignment between the components thereof, which makes assembly more difficult and costly. Sub-optimal alignment results in signal loss, which moreover is an inherent problem in previous solutions due to the multiple components involved in the light scattering process. Another issue affecting the signal and scattering of the light in the touch sensing apparatus is uncontrolled glass warpage, i.e. distortions of the curvature of the light transmissive panel which will affect the light path and the detection process. While it is critical to accurately control such distortions, previous solutions incorporate complex

solutions that may not allow to fully optimize glass warpage control in a mass production line without limiting the throughput of the production.

Some prior art systems rely on coupling and propagation of collimated light across the light transmissive panel. Such systems are however cumbersome to reliably implement due to the small tolerances with respect to the alignment of the components thereof. E.g. the light emitters- and detectors need to be precisely aligned in relation to various lenses and reflect the light via concave and/or convex reflection and/or refraction to get the desired collimation. Such precise alignment may be difficult to achieve in mass production. The use of collimated light, or light reflected by means of specular reflection, also adds to this complexity, which in turn results in a more expensive and less compact system. Furthermore, to reduce system cost, it may be desirable to minimize the number of electro-optical components.

Summary

An objective is to at least partly overcome one or more of the above identified limitations of the prior art.

One objective is to provide a touch-sensitive apparatus based on “above-surface” light propagation which is robust and easy to assemble.

Another objective is to provide an “above-surface”-based touch-sensitive apparatus with efficient use of light.

One or more of these objectives, and other objectives that may appear from the description below, are at least partly achieved by means of touch-sensitive apparatuses according to the independent claims, embodiments thereof being defined by the dependent claims.

According to a first aspect a touch sensing apparatus is provided comprising a light transmissive panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the light transmissive panel. The light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are arranged above the touch surface and are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the light transmissive panel extends.

According to a second aspect a touch sensing apparatus is provided comprising a light transmissive panel extending in a plane having a normal axis, the light transmissive panel defining a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the light transmissive panel,

wherein the light emitters are arranged to emit a respective beam of emitted light above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The touch sensing apparatus comprises a sealing window arranged around the perimeter, wherein the sealing window comprises a first surface facing the light emitters or the light detectors and an opposite second surface arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface of the sealing window, facing the light transmissive panel, and an opposite top surface of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance so that the second surface forms an angle relative the normal axis, and wherein the second surface comprises a light collimating surface configured to collimate light propagating above the touch surface.

According to a third aspect a method of assembling a touch sensing apparatus is provided comprising; attaching a substrate having a plurality of light emitters and detectors to a carrier; attaching the carrier around a perimeter of a light transmissive panel and arranging the substrate to extend in a direction parallel with a normal axis of a plane in which the light transmissive panel extends, whereby the plurality of light emitters and detectors are arranged above the touch surface.

Further examples of the invention are defined in the dependent claims, wherein features for the second aspect of the disclosure are as for the first aspect mutatis mutandis.

Some examples of the disclosure provide for a touch sensing apparatus that is easier to manufacture and assemble.

Some examples of the disclosure provide for a touch sensing apparatus with fewer steps of assembly.

Some examples of the disclosure provide for a touch sensing apparatus that is less costly to manufacture.

Some examples of the disclosure provide for a facilitated alignment of emitters and detectors of touch sensing apparatus.

Some examples of the disclosure provide for facilitated control of the curvature of the touch surface of a touch sensing apparatus.

Some examples of the disclosure provide for a more robust touch sensing apparatus.

Some examples of the disclosure provide for a touch sensing apparatus that is more reliable to use.

Some examples of the disclosure provide for a touch sensing apparatus that has a better signal-to-noise ratio of the detected light.

Some examples of the disclosure provide for a more compact touch sensing apparatus.

Still other objectives, features, aspects and advantages of the present disclosure will appear from the following detailed description, from the attached claims as well as from the drawings.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Brief Description of Drawings

These and other aspects, features and advantages of which examples of the invention are capable of will be apparent and elucidated from the following description of examples of the present invention, reference being made to the accompanying drawings, in which;

Fig. 1 is a section view of a touch sensing apparatus according to the prior art;

Fig. 2 is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

Fig. 3 is a schematic illustration, in a perspective side view, of a touch sensing apparatus according to one example;

Fig. 4a is a schematic illustration, in a side view of Fig. 2, of a touch sensing apparatus according to one example;

Fig. 4b is a schematic illustration of a magnified section of Fig. 4a, according to one example;

Fig. 4c is a schematic illustration of a magnified section of Fig. 4a, according to one example;

Fig. 5a is a schematic illustration, in a cross-sectional side view, of a touch sensing apparatus according to one example;

Fig. 5b is a schematic illustration of a magnified section of Fig. 5a, according to one example;

Fig. 6 is a flow chart of a method of assembling a touch sensing apparatus according to one example.

Detailed Description of Example Embodiments

In the following, embodiments of the present invention will be presented for a specific example of a touch-sensitive apparatus. Throughout the description, the same reference numerals are used to identify corresponding elements.

Fig. 1 schematically illustrates a variant of an 'above surface optical touch system', as discussed in the Background Art section above ,where the light from the emitters 301 travel above the touch surface 302 of the panel 305 via reflection on an edge reflector 303.

Fig. 2 schematically illustrate a touch sensing apparatus 100 comprising a light transmissive panel 101 that defines a touch surface 102. A plurality of light emitters 103 and detectors 103' are arranged along a perimeter 104 of the light transmissive panel 101. The light emitters 103 are arranged to emit a respective beam of emitted light 105 above the touch surface 102. I.e. while the touch surface 102 extends along a plane 108, having a normal axis 107 directed towards a user performing touch operations on the touch surface 102, the emitted light 105 travels along the plane 108 but at a certain distance from the touch surface 102 in the direction of the normal axis 107, as schematically illustrated with respect to light beam 105, 105', in e.g. Fig. 2. Light 105, 105', can thus travel across the touch surface 102, between opposite sides thereof, without being reflected inside the light transmissive panel 101 itself. The light detectors 103' are arranged to receive detection light 105' from the emitted light 105. Fig. 2 illustrates a section of the touch sensing apparatus 100 adjacent the perimeter 104 of the light transmissive panel 101. In this section, the emitters and detectors 103, 103', are shown in the same view, as well as the emitted and detected light 105, 105', for clarity of presentation. The plurality of light emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel extends. By having the substrate 106 extending in parallel with the normal axis 107 it is provided for conveniently arranging the plurality of emitters and detectors 103, 103', above the touch surface 102 to achieve a compact footprint in the direction of the plane 108 of the touch sensing apparatus 100 around the perimeter 104 while achieving a direct light path of the emitted or detected light 105, 105', above and across and touch surface 102. Thus, the emitted light 105 does not have to be reflected in order to diffusively spread above and across the touch surface 102, and a detector 103' may directly receive detection light 105' by being correspondingly positioned above the touch surface 102 at an opposite position anywhere around the perimeter 104. The amount of available light that can be utilized for the detection and characterization of an object

touching the touch surface 102 can thus be maximized, and the signal to noise ratio can be improved. The touch sensing apparatus 100 may comprise a sealing window 126 as illustrated in Fig. 2, shielding the emitters and detectors 103, 103', from the outside. The emitted and detected light 105, 105', may thus only have to propagate through the sealing window 126 along the light path between the emitters and detectors 103, 103'. The sealing window 126 provides sealing around the perimeter 104 of the light transmissive panel 101 and protects the emitters and detectors 103, 103' and the display.

Having the substrate extending in the direction 107' being parallel with the normal axis 107 and the emitters and detectors 103, 103', arranged above the touch surface 102 provides for a less complex alignment to maximize the detection performance of the touch sensing apparatus 100. The position of the substrate 106 in the direction of the normal axis 107 can be accurately varied to achieve optical alignment with respect to the emitters and detectors 103, 103'. The ability to achieve an accurate positioning of the substrate 106, and consequently the emitters and detectors 103, 103', attached thereto, is also due to the increased accuracy by which the dimensions of the substrate 106 can be defined along the direction of the substrate 106 aligned with the normal axis 107 in Fig. 2. I.e. the substrate 106 is elongated and extends in a longitudinal direction 123 (Fig. 4a) around the perimeter 104 of the light transmissive panel 101, and it has a short-side extending in parallel with the normal axis 107. The short-side of the substrate 106, illustrated in the cross-sectional view of Fig. 2, may be manufactured to smaller tolerances, and by aligning this side with the normal axis 107, the tolerances for the alignment of the emitters and detectors 103, 103', along the normal axis 107 can be improved. The alignment can thus be both improved, and facilitated as discussed above. The latter advantage also provides for facilitated and less costly mass production of the touch sensing apparatus 100 and the various touch base display systems in which it may be implemented.

The substrate 106 may extend at least partly above the touch surface 102, whereby the plurality of light emitters and detectors 103, 103', are connected to a portion 109 of the substrate extending above the touch surface 102. This further provides for achieving a more robust alignment of the emitters and detectors 103, 103', relative to the light transmissive panel 101, by being directly joined to the substrate 106, and thereby simultaneously arranged above the touch surface 102. It may be conceivable however that the emitters and detectors 103, 103', are connected to the substrate 106 via connection elements (not shown) extending between the substrate 106 and to a position above the touch surface 102.

The substrate 106 may be fixed to a carrier 110 mounted around the perimeter 104 of the light transmissive panel 101, as schematically illustrated in Figs. 1 – 2. By directly joining the substrate 106 to the carrier 110 provided around the perimeter 104, the assembly of the touch sensing apparatus 100 may be further facilitated, as the amount of components can be kept at a minimum. For example, the substrate 106 can be accurately fixed in relation to the carrier 110, due to the small tolerances possible in the direction of the substrate 106 aligned in parallel with the normal axis 107 in Fig. 1, as discussed above. The carrier 110 may for example comprise a cavity 116, as discussed further below, being precisely dimensioned to accommodate the width of the substrate 106 along the direction 107', i.e. the short-side of the substrate 106. Then, accurate positioning of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 is possible as the carrier 110 is mounted around the perimeter 104 thereof. The carrier 110 may extend substantially in the direction 107' parallel with the normal axis 107, as with the substrate 107, to achieve a compact mounting around the perimeter 104.

Having the substrate 106 fixed to the carrier 110 allows also for having the carrier 110 wired as an electrical ground reference layer of the substrate 106.

The carrier 110 may be arranged to at least partly enclose edges 111 of the light transmissive panel 101, as shown in the example of Fig. 1. This provides for further increasing the robustness of the touch sensing apparatus 100, and improving the accuracy of the alignment of the emitters and detectors 103, 103', in relation to the light transmissive panel 101 since the carrier 110, having the emitters and detectors 103, 103', fixed thereto, may also be directly supporting the light transmissive panel 101 around the perimeter 104. The carrier 110 may comprise a slot in which the light transmissive panel 101 is fitted around the perimeter 104.

The carrier 110 may comprise fixing elements 112 configured to attach the carrier 110 to a display unit 113, 121. The display unit may comprise a display support 121 and a display panel 113, which collectively is referred to as a display unit in the present disclosure. Having the carrier 110 attachable to the display unit 113, 121, by fixing elements 112, advantageously provides for further facilitating the assembly of the touch sensing apparatus 100 to a display unit, since the carrier 110 can be directly joined to the latter. Alignment is thus facilitated, due to the minimum amount of components needing such alignment to each other. The robustness of the touch sensing apparatus 100 is further improved, while mass production is made less complex due the minimized number of assembly steps. The fixing elements 112 may comprise any elements configured to provide for fixing of the position of the carrier 110 to the

display unit 113, 121. In the examples shown in Figs. 1 - 2, the carrier 110 has openings 115, 115', 115'', discussed further below, which may be aligned with corresponding openings 127 of a support of the display unit 121, through which mounting elements 114 may be positioned for the fixing. It is conceivable however that the carrier 110 has other types of recesses or protrusions which may interlock with a corresponding mating surface of the display unit 113, 121.

The fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the carrier 110. Thus, besides from fixing the position of the carrier 110 relative to the display unit 113, 121, the fixing elements 112 may also fix or at least support the position of the substrate 106 in relation to the carrier 110. It is conceivable that the substrate 106 may first be arranged in relation to the carrier 110, and the fixing elements 112 may be arranged to support and strengthen the fixing therebetween, while simultaneously fixing the carrier 110 to the display unit 113, 121. This may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100. From a similar aspect, the fixing elements 112 may be configured to fix the position of the substrate 106 in relation to the display unit 113, 121. This may be seen as a consequence from the above, i.e. the fixing elements 112 contributing to the fixing of the substrate 106 to the carrier 110, which in turn is fixed to the display unit 113, 121. It is however conceivable that the fixing elements 112 may fix the substrate 106 directly to the display unit 113, 121, in which case the carrier 110 may act as a further support for the substrate 106.

In one example, as discussed further below, the substrate 106 may comprise second openings 118 which provides for such fixing or support. As mentioned, this may further provide for increasing the stability and ultimately accuracy of the touch sensing apparatus 100.

The fixing elements 112 may be configured to interlock with a mounting element 114 for locking the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. Figs. 2 – 3 show examples of having an elongated mounting element 114 joining the carrier 110 and/or the substrate 106 to the display unit 113, 121. The mounting element 112 may however comprise any fastening element configured to exert a force between the carrier 110 and/or the substrate 106 to the display unit 113, 121, such as pins, bolts, screws, clips, clamps, locks, bars, rods, anchors, latches, clasps.

The fixing elements 112 may comprise openings 115, 115', 115'', as illustrated in Figs. 2 – 3. The carrier 110 may form a cavity 116 having walls 117 at least partly enclosing the substrate 106, illustrated in the example of Fig. 2. This may provide for increased stability of the fixing of the position of the

substrate 106 in relation to the carrier 110. At least one of the walls 117 may comprise at least one of the openings 115, 115', 115'', as further illustrated in Fig. 2. Being able to directly fix the walls 117 of the carrier 110 enclosing the substrate 106 to the display unit 121, 113, provides for further simplifying manufacturing, and at the same time further increase the accuracy of the alignment of e.g. the emitters and detectors 103, 103', in relation to the light transmissive panel 101, since the minimized number of intermediate mounting components improves tolerance control. I.e. build-up of mounting errors in each assembly step is reduced and controlled. It is conceivable that the walls 117 may be fixed to the display unit 113, 121, by other fixing elements 112, such as recesses or protrusions interlocking with correspondingly mating surfaces of the display unit 113, 121, and/or fastening elements as exemplified above.

The fixing elements 112 may comprise openings 115, 115', 115'', 118, arranged in the carrier 110 and in the substrate 106. First openings 115, 115', 115'' of the carrier 110 may be aligned with second openings 118 of the substrate 106, as illustrated in the example of Fig. 2. The first and second openings 115, 115', 115'', 118 may be configured to receive a mounting element 114 configured to lock the position of the carrier 110 and/or the substrate 106 to the display unit 113, 121. This provides for further facilitated and improved alignment and assembly, and increased robustness. In the example of Fig. 2, the carrier 110 encloses the substrate 106 such that two opposite openings 115, 115'', of the carrier are arranged on either side of the substrate 106, but it is conceivable that the carrier 110 may be arranged on one side only of the substrate 106.

The carrier 110 may be configured to be attachable to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis. A distance 120 between the light transmissive panel 101 and the display unit 113 along the normal axis 107 may thus be variable upon attaching the carrier to the display unit 113, 121 at at least two different adjustable positions 119, 119'. For example, turning to Fig. 3, the carrier 110 is attached at a first position 119 to the support of the display unit 121, via fixing unit 112. The first position 119 provides for the given distance 120 between the panel of the display unit 113. The distance 120 may then be decreased by instead attaching the carrier 110 at a second position 119' which is off-set with respect to the first position 119 in the positive direction of the normal axis 107, or the direction 107'' as illustrated in Fig. 3. If the fixing point to the support of the display unit 121 remains constant, e.g. at the opening 127 of a support 121 as illustrated, the carrier 110 will be moved in the opposite direction to the normal axis 107 and the distance 120 will be decreased. Having the carrier 110 being attachable

to the display unit 121, 113, at an adjustable position 119, 119', along a direction 117'' parallel to the normal axis 107, thus provides for simple and efficient adjustment of the position of the light transmissive panel 101.

Besides from overall controlling the distance 120, as discussed, such adjustment provides for efficiently controlling and varying the curvature of the light transmissive panel 101. I.e. varying the distance 120 as discussed at a second intermediate location 128', between opposite ends of the carrier 110, along the longitudinal direction 123, while maintaining the distance 120 at the opposite ends, such as at a first location 128, will affect the curvature of the carrier 110, and thereby the curvature of the light transmissive panel 101. E.g. decreasing the distance 120 at the second location 128' can produce a more concave shape, i.e. a decreased radius of curvature, of the carrier 110 and the light transmissive panel 101, in the direction of the normal axis 107. Increasing the distance 120 between the mentioned opposite ends can instead increase the radius of curvature in the direction of the normal axis 107. The curvature or warping of the light transmissive panel 101 can thus be controlled efficiently an in a facilitated manner, which is advantageous for increasing throughput in mass-production of displays incorporating the touch sensing apparatus 100 while keeping the warp of the light transmissive panel 101 under control. An optimized curvature of the light transmissive panel 101 increases the reliability and accuracy of the touch sensing apparatus 100.

The fixing elements 112 may be configured to attach the carrier 110 to the display unit 121 at the adjustable positions 119, 119', along the direction 117'' parallel to the normal axis 107. Thus, the fixing units 112 be arranged at the different adjustable positions 119, 119', to adjust the distance 120 and the curvature of the a light transmissive panel 101 while providing for securely attaching the carrier to the display unit 113, 121. The fixing elements 112 may thus be arranged at least at the first and second locations 128, 128', along the longitudinal direction 123 as discussed above, where each of the locations in the longitudinal direction 123 may have at least two adjustable positions 119, 119', as illustrated in the example of Fig. 3.

The openings 115, 115', of the carrier 110 may be separated along a direction 117'' parallel to the normal axis 107, as illustrated in Fig. 3. Alternatively, or in addition, the carrier 110 may be attachable to a plurality of second openings 122 in a display support 121 of the display unit, where the plurality of second openings 122 are separated along the normal axis 107. Thus, the position 119, 119', may be remained fixed while the carrier 110 is attached to the support 121 at the various second openings 122, to adjust the curvature of the light transmissive panel 101 and/or the distance 120 as

discussed above. Although the examples in Figs. 2 – 3, show openings 115, 115', 115'', 127, it is conceivable that the attachment between the carrier 110 and the display unit 121, 113, is provided by other fixing elements 112 as exemplified above.

The carrier 110 may be formed from a single monolithic piece of material. The structural integrity and the stability of the carrier 110 can thereby be increased, which further optimizes the parameters discussed above with respect to alignment, robustness, ease of assembly etc. One example of a possible process by which the carrier can be formed as a single piece of material is an extrusion process, but it is conceivable that the carrier 110 may be formed from other hot or cold metal or polymer working processes such as drawing, rolling, or molding processes.

The substrate 106 may extend in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. Fig. 4a illustrates a view of a plurality of substrates 106, 106', extending along the longitudinal direction 123. The light transmissive panel 101 and the carrier 110 holding the substrates have been excluded in the view for clarity of presentation. The substrates 106, 106', may comprise secondary fixing units 124, 124', configured for variably attaching the position of each of the substrates 106, 106', on the carrier 110 along the longitudinal direction 123 and/or in the direction of the normal axis 107. This provides for more accurately adjusting the position of the substrates 106, 106', in relation to the light transmissive panel 101. While each of the substrates 106, 106', may be within tolerances, the accumulated error obtained when several substrates 106, 106' are connected along the longitudinal direction 123 may exceed the total tolerance of the full length of the light transmissive panel 101. Such accumulation of errors may be effectively prevented by having secondary fixing units 124, 124', as elucidated above. The secondary fixing units 124, 124', may be provided on various locations on the substrates 106, 106', to allow for adjusting the position, such as on opposite ends thereof.

The touch sensing apparatus 100 may comprise vertical alignment units 135 arranged between adjacent substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. The vertical alignment units 135 are configured to variably position the adjacent substrates 106, 106', in the direction of the normal axis 107 so that an angle 136 between the adjacent substrates 106, 106', can be adjusted. Fig. 4b schematically illustrates a vertical alignment unit 135 positioned between adjacent substrates 106, 106', to vary the position thereof in the direction of the normal axis 107, i.e. along arrows 137, so that the angle 136 may be set to a

desired value. The vertical alignment unit 135 thus provides for facilitating the alignment of the plurality of substrates 106, 106', to e.g. the curvature of the light transmissive panel 101. For example, if the light transmissive panel 101 is concave in the direction of the normal axis 107, initially parallel substrates 106, 106', may be angled to closely follow the concave shape of the light transmissive panel 101 by increasing the angle 136 between the substrates 106, 106', as schematically illustrated in Fig. 4b. The position of the emitters and detectors 103, 103', on the substrates 106, 106', may thus remain at an optimized vertical position relative the light transmissive panel 101 for various curvatures thereof. The vertical alignment unit 135 may comprise various units configured to change the position of the adjacent substrates 106, 106', in the direction of the normal axis 107, such as bolts, screws, pins, or any other elements that can provide an offset at the ends of the substrates 106, 106'.

The touch sensing apparatus 100 may comprise force distributing units 138 positioned between adjacent substrates 106, 106', configured to provide a fixing force therebetween, as schematically illustrated in Fig. 4c. The force distributing units 138 may provide for improving and facilitating the fixing of the substrates 106, 106', to the carrier, without the need for dedicated fixing elements such as screws, bolts, etc to each end of respective substrates 106, 106', thereby reducing the amount of such fixing elements, which facilitates the assembly of the touch sensing apparatus 100.

The touch sensing apparatus may thus comprise a plurality of substrates 106, 106', extending in a longitudinal direction 123 along the perimeter 104 of the light transmissive panel 101. A first substrate 106 of the plurality of substrates may comprises a connection unit 125 configured to directly interlock with a subsequent connection unit 125' of a subsequent substrate 106' when arranged adjacent said subsequent substrate, as schematically illustrated in Fig. 4a. It is thereby possible to directly connect subsequent substrates 106, 106', and eliminate the need for intermediate connectors, which further provides for facilitating the assembly of the touch sensing apparatus 100.

The touch sensing apparatus 100 may comprise a sealing window 126 as schematically illustrated in Figs. 5a-b. The sealing window 126 may be arranged around the perimeter 104 of the light transmissive panel 101. The sealing window 126 may comprise a first surface 129 facing the light emitters 103 or the light detectors 103', and an opposite second surface 130 arranged adjacent the touch surface 102. Emitted or detected light thus propagates between the first and second surface 129, 130. At least one of the first and second surfaces 129, 130, may comprises a light collimating surface 129, 130, configured to collimate light propagating above the touch surface 102. I.e.

emitted light 105 will be collimated by the sealing window 126, so that the light propagating above the touch surface 102 will be collimated. Detectors 103' will receive the collimated light which will be focused through a corresponding sealing window 126. As the emitters and detectors 103, 103', are arranged above the touch surface 102 and are connected to a substrate 106 extending in a direction parallel with a normal axis 107, it is possible to provide for a very precise and improved alignment thereof in relation to the sealing window 126, which allows for achieving collimated light in a highly optimized manner, and an associated increase in signal strength since more of the emitted light can be collected by the detectors 103'. The emitted light is collimated in a direction parallel with the plane 108 in which the light transmissive panel 101 extends. Collimating the light with sealing window 126 also allows for reducing the aperture of the sealing window 126, i.e. the thickness of the sealing window 126 in the direction of the normal axis 107, while still detecting a sufficient amount of light. This provides for reducing the amount of ambient light reaching the detectors 103', thus improving the signal to noise ratio.

Turning to Fig. 5b, the second surface 130 may extend in the direction of the normal axis 107 between a base surface 131 of the sealing window 126, facing the light transmissive panel 101, and an opposite top surface 132 of the sealing window 126. The base surface 131 may be offset from the top surface 132 along the direction of the plane 108 with an offset distance 133 so that the second surface 130 forms an angle 134 relative the normal axis 107. As further illustrated in Fig. 5b, the second surface may comprises the light collimating surface 130. Thus, in addition to having a convex shape as illustrated in Fig. 5b, the second surface 130 is arranged to assume a tilted configuration as provided by the offset distance 133. Having such angled configuration provides for reducing the impact of Fresnel reflexes. The Fresnel reflexes otherwise generate additional unwanted light paths that will reduce the apparent attenuation on some detection lines, especially when they run parallel to and near a sealing window 126. These Fresnel reflexes may also result in artifacts and false touch information. By having an angled and/or curved second surface 130 of the sealing window 126, the light may instead bounce off the second surface 130 with such an angle so that it leaves the plane 108, and thereby not interfere with the detection of the remaining light.

A sealing window 126 as described above can provide for the advantageous effects as described for touch sensing apparatuses having a plurality of light emitters and detectors arranged in a multitude of configurations, not limited to the configurations described in relation to Figs. 2 and 3 exemplified above. A touch sensing apparatus 100 is thus provided comprising

a light transmissive panel 101 extending in a plane 108 having a normal axis 107, wherein the light transmissive panel defines a touch surface 102. The touch sensing apparatus 100 comprises a plurality of light emitters 103 and detectors 103' arranged along a perimeter 104 of the light transmissive panel, wherein the light emitters are arranged to emit a respective beam of emitted light 105 above the touch surface, wherein the light detectors are arranged to receive detection light 105' from the emitted light. The touch sensing apparatus 100 comprises a sealing window 126 arranged around the perimeter, wherein the sealing window comprises a first surface 129 facing the light emitters or the light detectors and an opposite second surface 130 arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, wherein the second surface extends in the direction of the normal axis between a base surface 131 of the sealing window, facing the light transmissive panel, and an opposite top surface 132 of the sealing window, wherein the base surface is offset from the top surface along the direction of the plane with an offset distance 133 so that the second surface forms an angle 134 relative the normal axis, and wherein the second surface comprises a light collimating surface 130 configured to collimate light propagating above the touch surface.

The first surface 129, facing the emitters or detectors 103, 103', may also be angled, with an angle 134', as schematically illustrated in Fig. 5a, to provide for the desired light path from or towards the emitters or detectors 103, 103', respectively. The first surface 129 may also comprise a light collimating surface and have a convex shape towards the emitters or detectors 103, 103', as illustrated in Fig. 5a, in addition to being arranged at an angle 134'. The angles 134, 134', may be in the range of 2-10 degrees relative to the normal axis 107 to provide for a particularly advantageous reduction of Fresnel reflexes. An angle greater than 2 degrees avoids Fresnel reflexes and an angle of less that 10 degrees reduces the light field height.

The sealing window 126 may comprise a fixing element 139 configured to interlock to carrier 110. In the example in Fig. 5a, the fixing element comprises a protrusion 139 arranged to interlock with a corresponding recess in the carrier 110. Mounting and fixing of the sealing window 126 may thus be facilitated and improved since the fixing element 139 may snap into the carrier 110, without needing to have separate fixing units or adhesives joining the sealing window 126 to the carrier 110. It is conceivable that the fixing element 139 may comprise any other shape, such as a recess, for interlocking with a corresponding mating surface of the carrier 110.

The sealing window 126 may be formed from a single monolithic piece of material, thus providing for a robust sealing window 126 and a stable attachment to the carrier 110 and the light transmissive panel 101. The sealing window 126 may be formed by an extrusion process. In one embodiment, the sealing window is formed from two separate materials. A first material, such as a dyed PMMA or similar NIR transparent material, is used for a transparent section and a second material, such as a compressible light blocking material, is used for for sealing off the E/D compartment. This may be achieved by e.g. using a co-extrusion process.

A further mounting unit 140 may be provided between the sealing window 126 and the light transmissive panel 101, as schematically illustrated in Fig. 5a. The mounting unit 140 may comprise a resilient material that allows the sealing window 126 to assume a secure fixed position relative the light transmissive panel 101. The sealing window 126 may have a corresponding groove into which the mounting unit 140 may be securely positioned.

A method 200 of assembling a touch sensing apparatus 100 is provided. Fig. 6 illustrates steps of the method 200. The order in which the steps of the method 200 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order. The method 200 comprises fixing 201 a substrate 106 having a plurality of light emitters 103 and detectors 103' to a carrier 110, and attaching 202 the carrier 110 around a perimeter 104 of a light transmissive panel 101. The method further comprises arranging 203 the substrate to extend in a direction 107' parallel with a normal axis 107 of a plane 108 in which the light transmissive panel 101 extends, whereby the plurality of light emitters and detectors 103, 103', are arranged above the touch surface 102. The method 200 thus provides for a facilitated assembly of the touch sensing apparatus 100 while achieving optimal alignment, robustness, and accuracy as described above in relation to Figs. 2 – 3.

As mentioned, the carrier 110 may be formed from a single monolithic piece of material, and the carrier may form a cavity 116 having walls 117 at least partly enclosing the substrate 106. At least one of the walls 117 may comprise openings 115, 115', 115''. The method 200 may comprise fixing 204 the carrier 106 to a display unit 121, 113, by fixing mounting elements 114 through the openings 115, 115', 115'', thereby providing for the above mentioned advantages.

The method 200 may comprise adjusting 205 a distance 120 between the light transmissive panel 101 and a display unit 113, 121, along the normal axis 107 by attaching 207 the carrier 110 to the display unit 113, 121, at at least two

different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the distance 120 is improved and facilitated, and may thereby be more easily optimized to various applications of the touch sensing apparatus 100.

The method 200 may comprise adjusting 208 a radius of curvature of the light transmissive panel 101 in the direction of the normal axis 107 by attaching 209 the carrier 110 to a display unit 113, 121, at at least two different adjustable positions 119, 119', along a direction 117'' parallel to the normal axis 107. Control of the curvature of the light transmissive panel 101 is thus improved as described above.

The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope and spirit of the invention, which is defined and limited only by the appended patent claims.

For example, the specific arrangement of emitters and detectors as illustrated and discussed in the foregoing is merely given as an example. The inventive coupling structure is useful in any touch-sensing system that operates by transmitting light, generated by a number of emitters, inside a light transmissive panel and detecting, at a number of detectors, a change in the received light caused by an interaction with the transmitted light at the point of touch.

CLAIMS

1. A touch sensing apparatus (100), comprising:

a light transmissive panel (101) that defines a touch surface (102),

a plurality of light emitters (103) and detectors (103') arranged along a perimeter (104) of the light transmissive panel,

wherein the light emitters are arranged to emit a respective beam of emitted light (105) above the touch surface, wherein the light detectors are arranged to receive detection light (105') from the emitted light,

wherein the plurality of light emitters and detectors are arranged above the touch surface and are connected to a substrate (106) extending in a direction (107') parallel with a normal axis (107) of a plane (108) in which the light transmissive panel extends.

2. Touch sensing apparatus according to claim 1, wherein the substrate extends at least partly above the touch surface, whereby the plurality of light emitters and detectors are connected to a portion (109) of the substrate extending above the touch surface.

3. Touch sensing apparatus according to claim 1 or 2, wherein the substrate is fixed to a carrier (110) mounted around the perimeter of the light transmissive panel.

4. Touch sensing apparatus according to claim 3, wherein the carrier is arranged to at least partly enclose edges (111) of the light transmissive panel.

5. Touch sensing apparatus according to claim 3 or 4, wherein the carrier comprises fixing elements (112) configured to attach the carrier to a display unit (113, 121).

6. Touch sensing apparatus according to claim 5, wherein the fixing elements are configured to attach the position of the substrate in relation to the carrier and/or in relation to the display unit.

7. Touch sensing apparatus according to any of claims 5 - 6, wherein the fixing elements are configured to interlock with a mounting element (114) for locking the position of the carrier and/or the substrate to the display unit.

8. Touch sensing apparatus according to any of claims 5 - 7, wherein the fixing elements comprise openings (115, 115', 115''), wherein the carrier forms a cavity (116) having walls (117) at least partly enclosing the substrate, and wherein at least one of the walls comprises at least one of said openings.

9. Touch sensing apparatus according to any of claims 5 – 6, or 8, wherein the fixing elements comprise openings (115, 115', 115'', 118) arranged in the carrier and in the substrate, wherein first openings (115, 115', 115'') of the carrier are aligned with second openings (118) of the substrate, the first and second openings being configured to receive a mounting element (114) configured to lock the position of the carrier and/or the substrate to the display unit.

10. Touch sensing apparatus according to any of claims 5 - 9, wherein the carrier is configured to be attachable to the display unit at an adjustable position (119, 119') along a direction (117'') parallel to the normal axis, whereby a distance (120) between the light transmissive panel and the display unit along the normal axis is variable upon attaching the carrier to the display unit at at least two different adjustable positions (119, 119').

11. Touch sensing apparatus according to claim 10, wherein the fixing elements are configured to attach the carrier to the display unit at the adjustable positions along the direction (117'') parallel to the normal axis.

12. Touch sensing apparatus according to claim 8 or 9, wherein the openings (115, 115') are separated along a direction (117'') parallel to the normal axis, and/or

wherein the carrier is attachable to a plurality of second openings (122) in a display support (121) of the display unit, the plurality of second openings being separated along the normal axis.

13. Touch sensing apparatus according to any of claims 3 - 12, wherein the carrier is formed from a single monolithic piece of material.

14. Touch sensing apparatus according to any of claims 1 – 13, wherein the substrate extends in a longitudinal direction (123) along the perimeter of the light transmissive panel, the substrate comprising secondary fixing units (124, 124') configured for variably attaching the position of the substrate on the carrier along the longitudinal direction and/or in the direction of the normal axis.

15. Touch sensing apparatus according to any of claims 1 - 14, comprising vertical alignment units (135) arranged between adjacent substrates (106, 106') extending in a longitudinal direction (123) along the perimeter of the light transmissive panel, wherein the vertical alignment units are configured to variably position the adjacent substrates in the direction of the normal axis so that an angle (136) between the adjacent substrates is adjustable.

16. Touch sensing apparatus according to any of claims 1 - 15, comprising a plurality of substrates (106, 106') extending in a longitudinal direction (123) along the perimeter of the light transmissive panel, wherein a first substrate (106) of said plurality of substrates comprises a connection unit (125) configured to directly interlock with a subsequent connection unit (125') of a subsequent substrate (106') when arranged adjacent said subsequent substrate.

17. Touch sensing apparatus according to any of claims 1 - 16, comprising a sealing window (126) arranged around the perimeter of the light transmissive panel, wherein the sealing window comprises a first surface (129) facing the light emitters or the light detectors and an opposite second surface (130) arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface, and

wherein at least one of the first and second surfaces comprises a light collimating surface (129, 130) configured to collimate light propagating above the touch surface.

18. Touch sensing apparatus according to claim 17, wherein the second surface extends in the direction of the normal axis between a base surface (131) of the sealing window, facing the light transmissive panel, and an opposite top surface (132) of the sealing window,

wherein the base surface is offset from the top surface along the direction of the plane with an offset distance (133) so that the second surface forms an angle (134) relative the normal axis, and wherein the second surface comprises a light collimating surface (130).

19. A touch sensing apparatus (100), comprising:

a light transmissive panel (101) extending in a plane (108) having a normal axis (107), the light transmissive panel defining a touch surface (102),

a plurality of light emitters (103) and detectors (103') arranged along a perimeter (104) of the light transmissive panel, wherein the light emitters are arranged to emit a respective beam of emitted light (105) above the touch surface, wherein the light detectors are arranged to receive detection light (105') from the emitted light,

a sealing window (126) arranged around the perimeter, wherein the sealing window comprises a first surface (129) facing the light emitters or the light detectors and an opposite second surface (130) arranged adjacent the touch surface, whereby the emitted or detected light propagates between the first and second surface,

wherein the second surface extends in the direction of the normal axis between a base surface (131) of the sealing window, facing the light transmissive panel, and an opposite top surface (132) of the sealing window,

wherein the base surface is offset from the top surface along the direction of the plane with an offset distance (133) so that the second surface forms an angle (134) relative the normal axis, and wherein the second surface comprises a light collimating surface (130) configured to collimate light propagating above the touch surface.

20. Touch sensing apparatus according to claim 19, wherein the first surface and/or second surface form a curved edge convex to the sealing window (126).

21. A method (200) of assembling a touch sensing apparatus (100), comprising:

attaching (201) a substrate (106) having a plurality of light emitters (103) and detectors (103') to a carrier (110),

attaching (202) the carrier around a perimeter (104) of a light transmissive panel (101) and arranging (203) the substrate to extend in a direction (107') parallel with a normal axis (107) of a plane (108) in which the light transmissive panel extends, whereby the plurality of light emitters and detectors are arranged above the touch surface.

22. Method according to claim 21, wherein the carrier if formed from a single monolithic piece of material, the carrier forming a cavity (116) having walls (117) at least partly enclosing the substrate, wherein at least one of the walls comprise openings (115, 115', 115''), the method comprising

fixing (204) the carrier to a display unit (121, 113) by fixing mounting elements (114) through said openings.

23. Method according to claim 21 or 22, comprising

adjusting (205) a distance (120) between the light transmissive panel and a display unit (121, 113) along the normal axis by

attaching (207) the carrier to the display unit at at least two different adjustable positions (119, 119') along a direction (117'') parallel to the normal axis.

24. Method according to any of claims 21 - 23, comprising

adjusting (208) a radius of curvature of the light transmissive panel in the direction of the normal axis by

attaching (209) the carrier to a display unit at at least two different adjustable positions (119, 119') along a direction (117'') parallel to the normal axis.

ABSTRACT

A touch sensing apparatus is disclosed comprising a light transmissive panel that defines a touch surface, a plurality of light emitters and detectors arranged along a perimeter of the light transmissive panel. The light emitters are arranged to emit a respective beam of emitted light that travels above the touch surface, wherein the light detectors are arranged to receive detection light from the emitted light. The plurality of light emitters and detectors are arranged above the touch surface and are connected to a substrate extending in a direction parallel with a normal axis of a plane in which the light transmissive panel extends. A method of assembling a touch sensing apparatus is also disclosed.

Elected for publication: Fig. 2

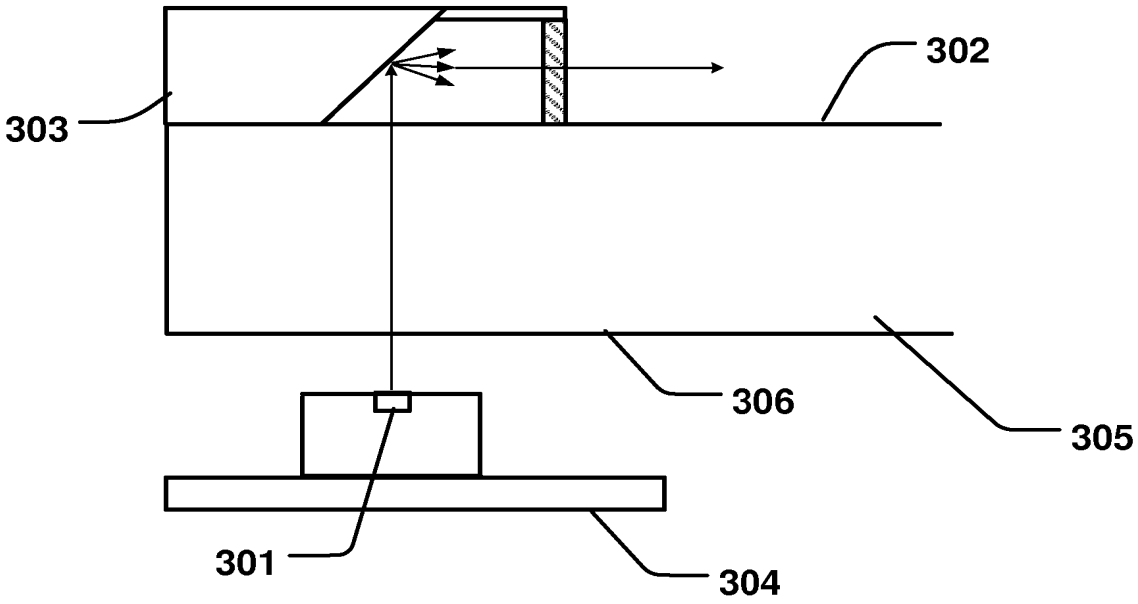


Fig. 1

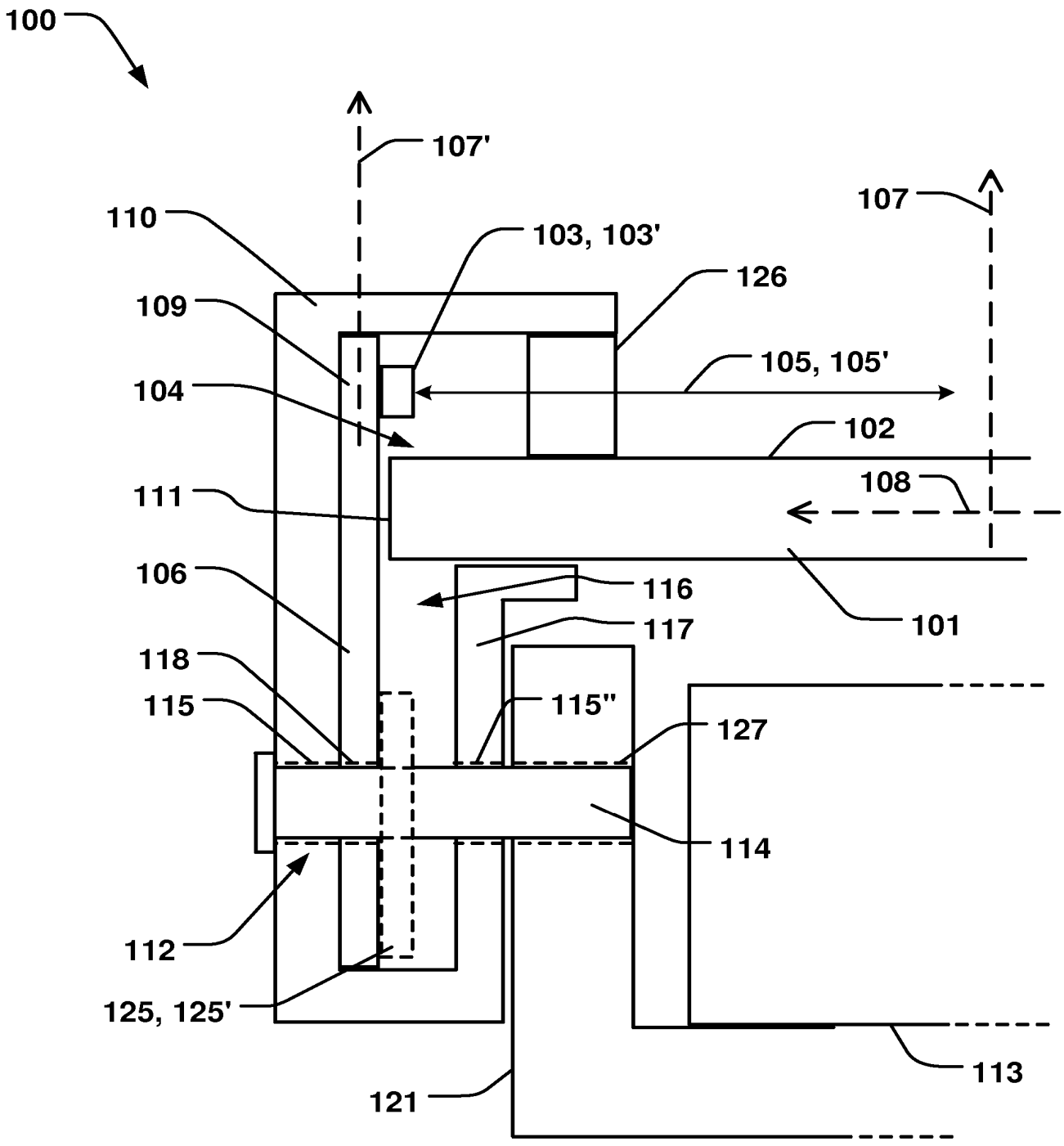

100
107'
107
110
103, 103'
126
109
105, 105'
104
102
108
111
106
116
117
101
118
115
115"
127
114
112
125, 125'
113
121

Fig. 2

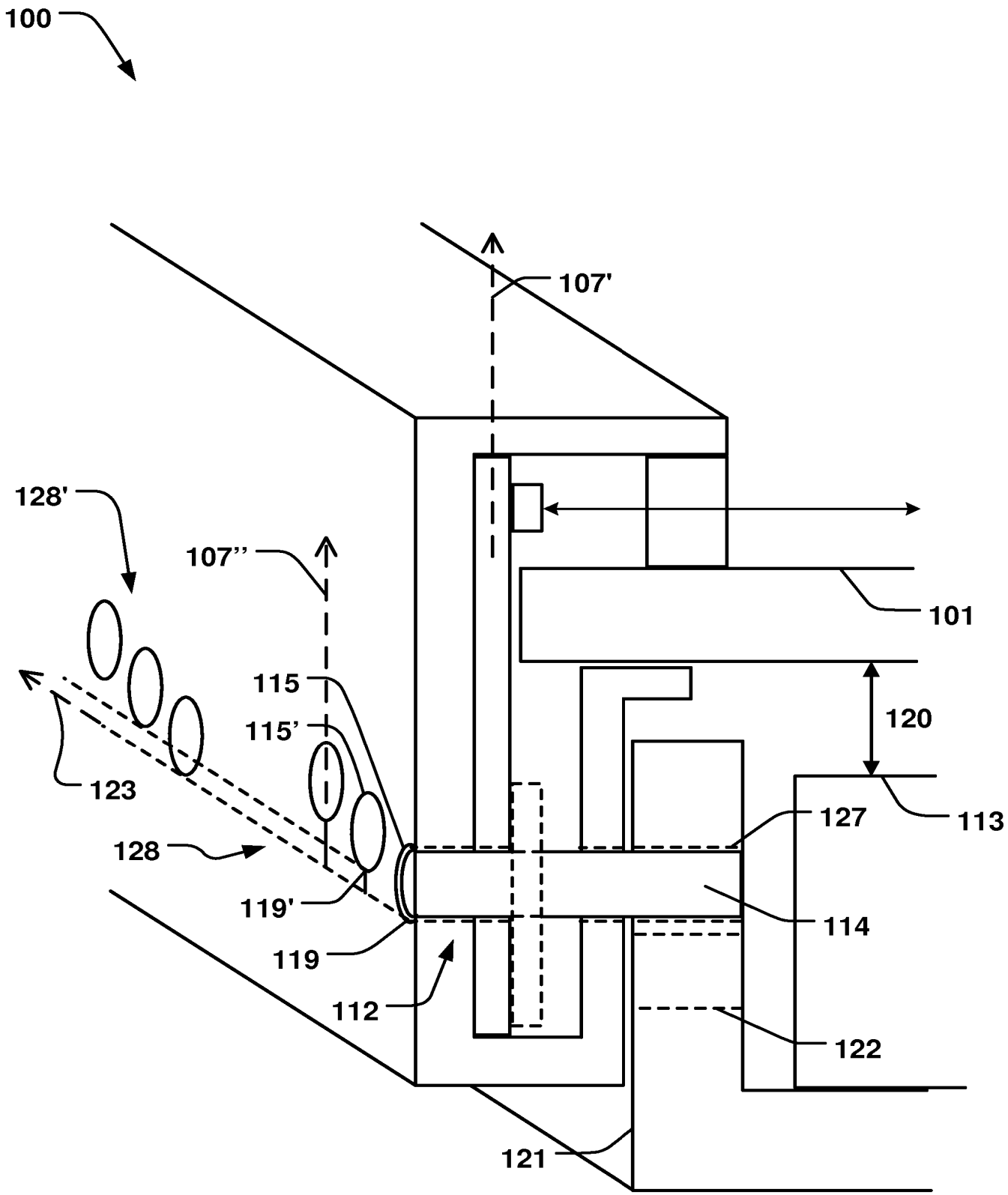

100
107'
128'
107''
101
115
115'
120
123
127
113
128
119'
114
119
112
122
121

Fig. 3

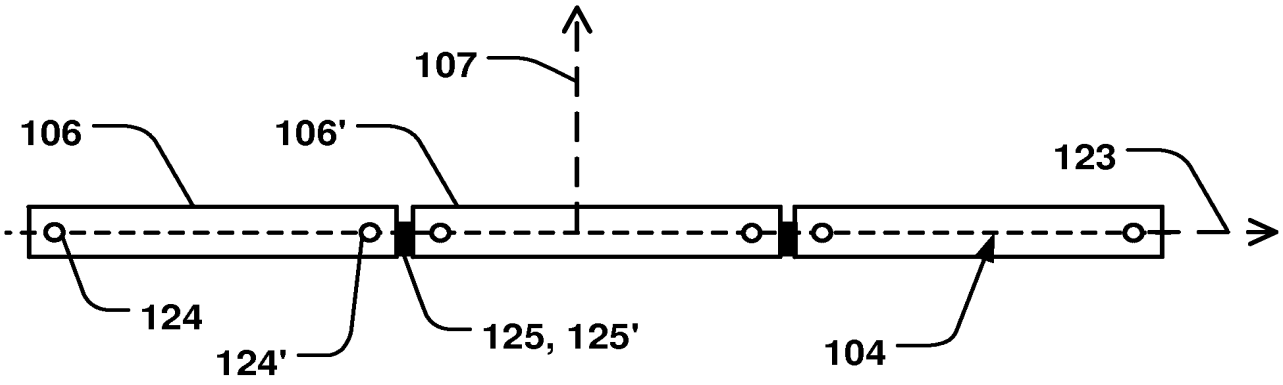


Fig. 4a

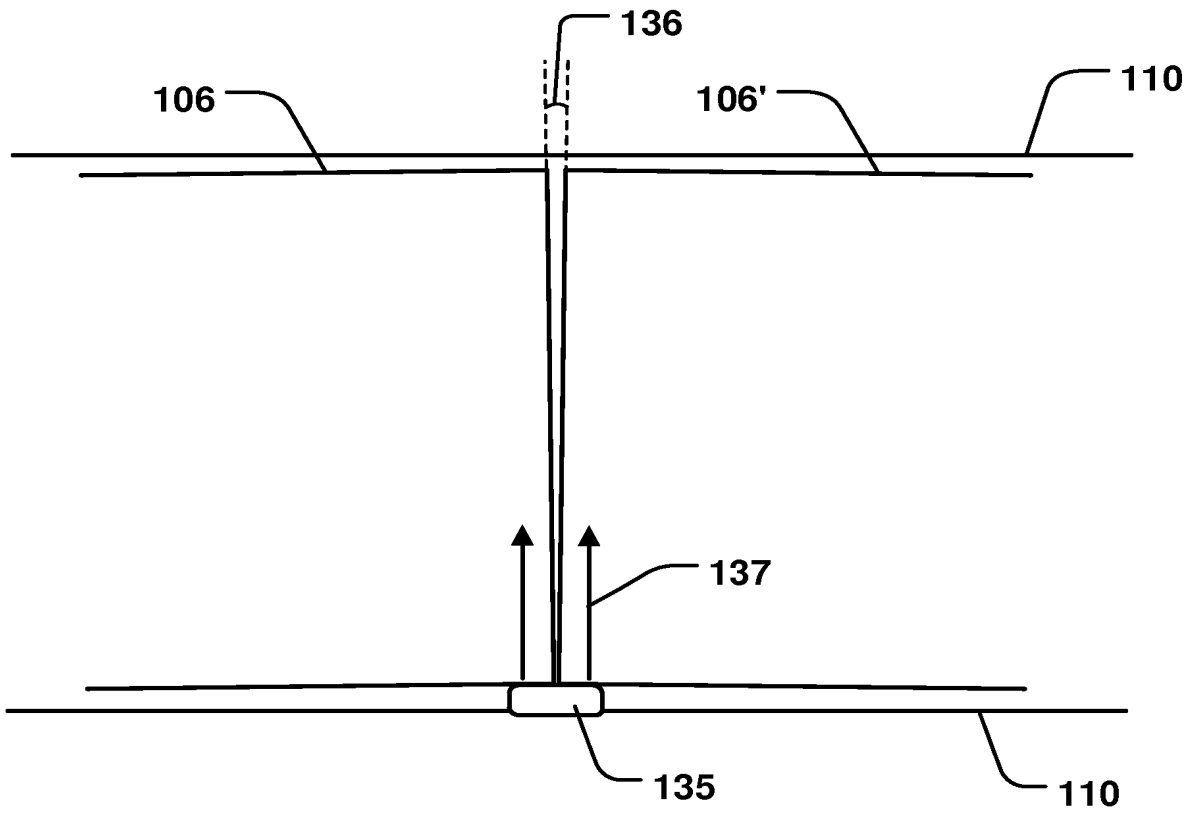


Fig. 4b

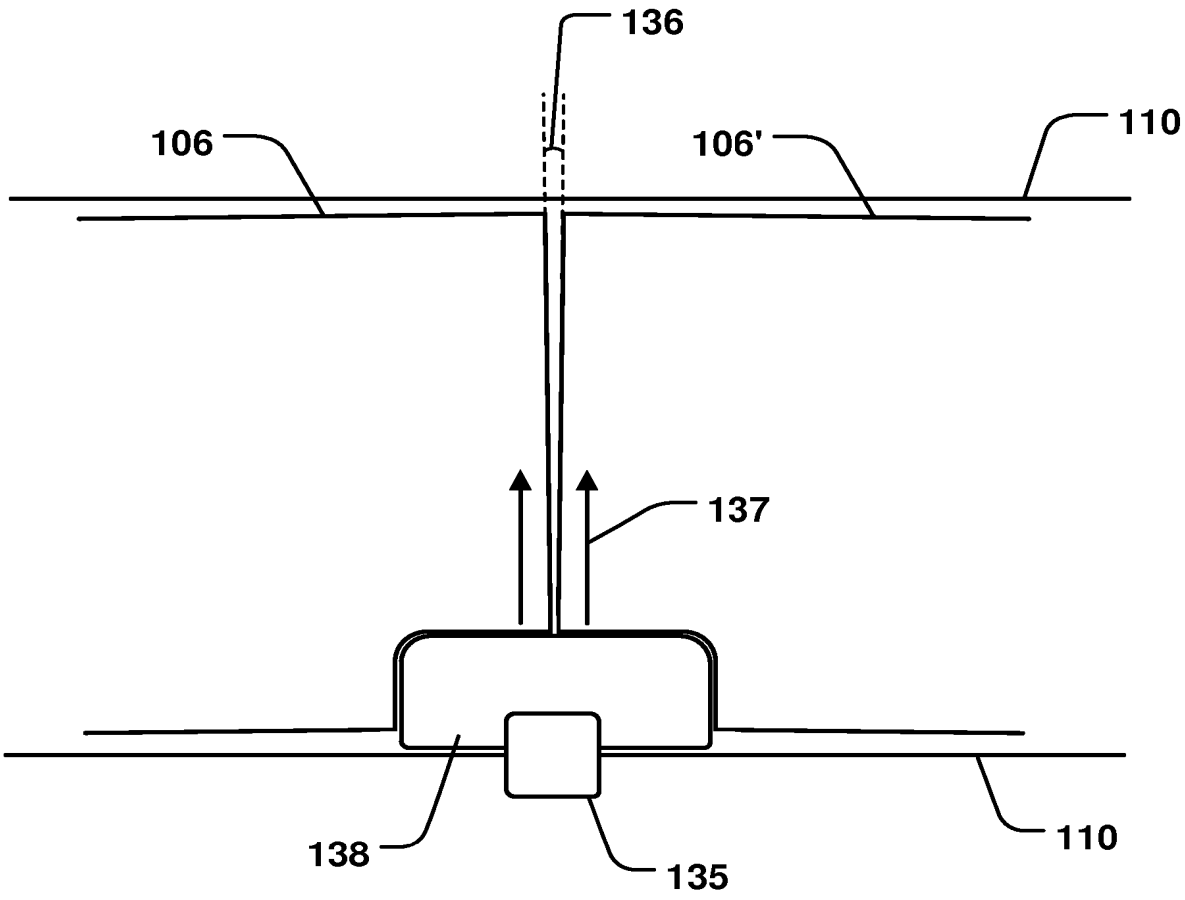


Fig. 4c

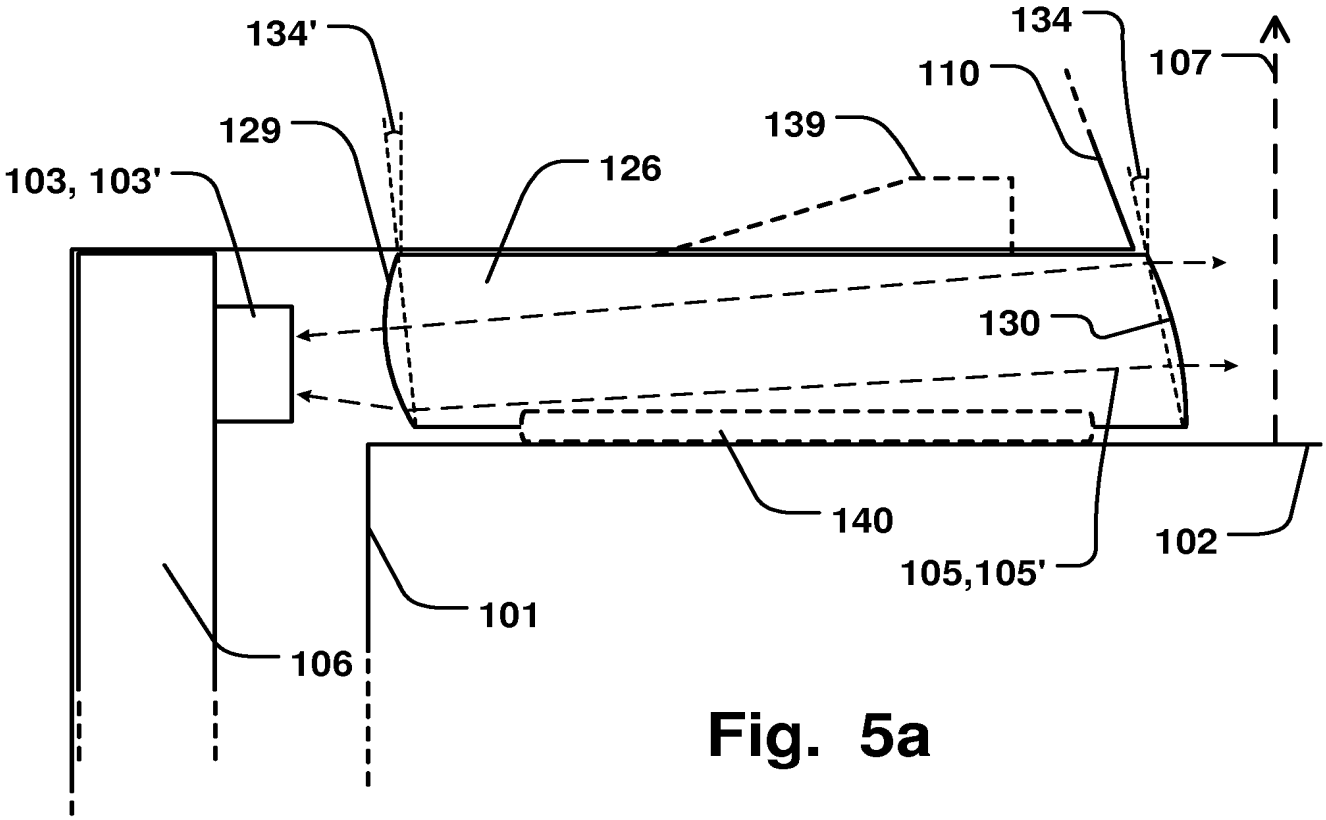

134'
134
107
110
129
139
103, 103'
126
130
140
102
105,105'
101
106

Fig. 5a

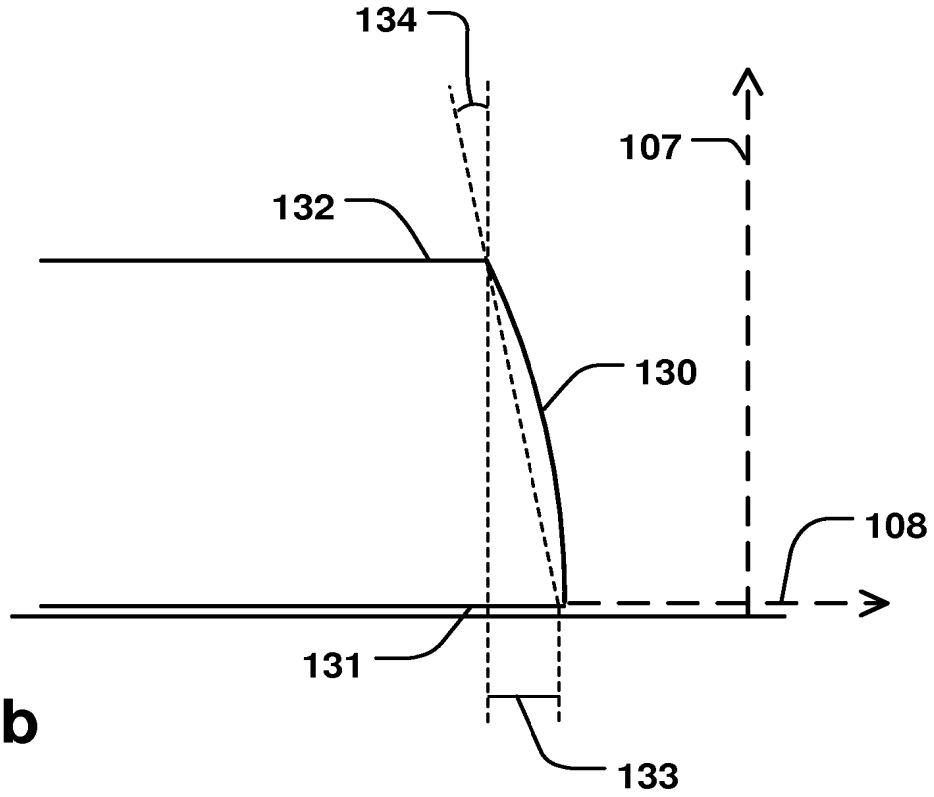

134
107
132
130
108
131
133

Fig. 5b

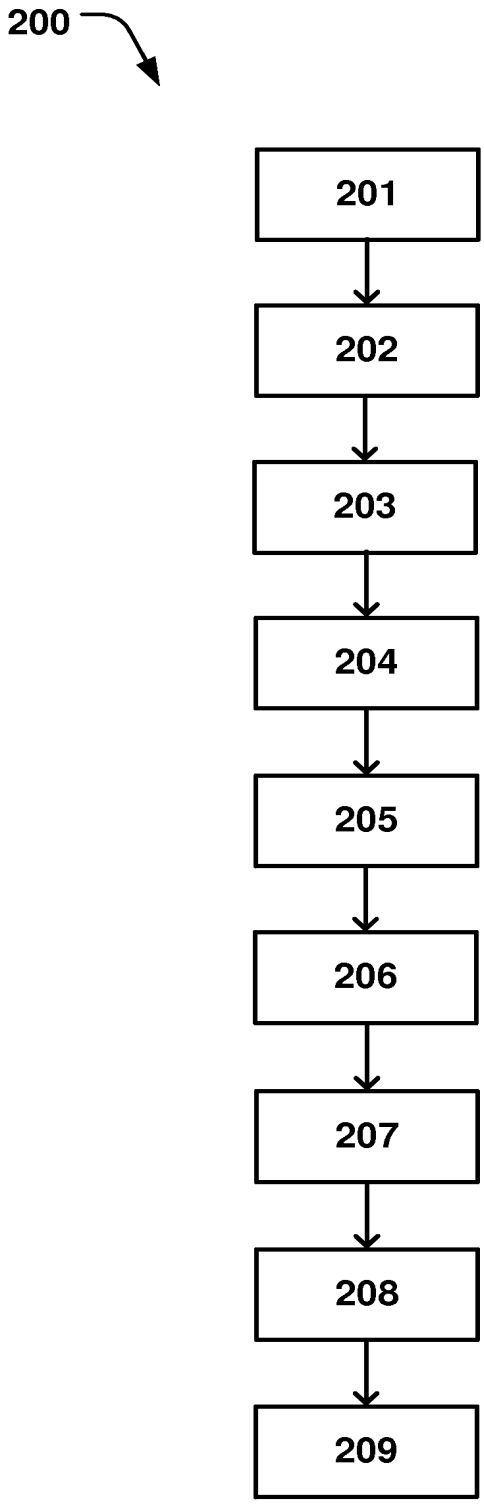


Fig. 6

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/834,905

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	16 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*				x 460 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						400
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2120

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/834,905	03/30/2020	1794	2120	FFOG.054C5	16	1

CONFIRMATION NO. 1516

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

FILING RECEIPT

OC000000118072029

Date Mailed: 04/09/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Daniel Skagmo, Malmo, SWEDEN;
Robert Ehn, Lund, SWEDEN;
Hakan Bergstrom, Torna-Hallestad, SWEDEN;

Applicant(s)

FlatFrog Laboratories AB, Lund, SWEDEN;

Power of Attorney: The patent practitioners associated with Customer Number 20995

Domestic Priority data as claimed by applicant

This application is a CON of 16/191,177 11/14/2018 PAT 10606416
which is a CON of PCT/SE2018/050109 02/06/2018

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
SWEDEN 1730085-6 03/28/2017 Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 208 of 1254

Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

If Required, Foreign Filing License Granted: 04/08/2020
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/834,905**
Projected Publication Date: 07/16/2020
Non-Publication Request: No
Early Publication Request: No
Title

TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

Preliminary Class

204

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

20995 7590 04/14/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	

ART UNIT	PAPER NUMBER
2694	

NOTIFICATION DATE	DELIVERY MODE
04/14/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

efiling@knobbe.com
jayna.cartee@knobbe.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 16/834,905	**Applicant(s)** Skagmo et al.	
	Examiner BRIAN W BROWN	**Art Unit** OPET	**AIA (FITF) Status** Yes

1. THE REQUEST FILED 30 March 2020 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination

A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to BRIAN BROWN at (571)272-5338. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/BRIAN W BROWN/ Petitions Examiner, OPET	

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

20995 7590 05/01/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
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IRVINE, CA 92614

EXAMINER	
GIESY, ADAM	

ART UNIT	PAPER NUMBER
2694	

NOTIFICATION DATE	DELIVERY MODE
05/01/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

efiling@knobbe.com
jayna.cartee@knobbe.com

First Action Interview Pilot Program Pre-Interview Communication	**Application No.** 16/834,905	**Applicant(s)** Skagmo et al.	
	Examiner ADAM R GIESY	**Art Unit** 2694	**AIA (FITF) Status** Yes

-The MAILING OR NOTIFICATION DATE of this communication appears on the cover sheet with the correspondence address -

THE SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE **ONE MONTH OR THIRTY (30) DAYS,** WHICHEVER IS LONGER, FROM THE MAILING OR NOTIFICATION DATE OF THIS COMMUNICATION.

This time period for reply is extendable under 37 CFR 1.136(a) for only ONE additional MONTH.

This communication constitutes notice under 37 CFR 1.136(a)(1)(i).

Applicant must, within the time period for reply, file: (1) A letter requesting not to have a first action interview; (2) A reply under 37 CFR 1.111 waiving the first action interview and First Action Interview Office Action; or (3) An Applicant Initiated Interview Request Form (PTOL-413A) electronically via EFS-Web, accompanied by a proposed amendment or arguments, and schedule the interview within 2 months from the filing of the request. A failure to respond to this communication will be treated as a request not to have an interview. If applicant waives the First Action Interview Office Action, the instant Pre-Interview Communication is deemed the first Office Action on the Merits. The next subsequent Office action may be made final if appropriate. See MPEP 706.07(a).

Status

1) ☑ Responsive to communication(s) filed on 3/30/2020 .

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____ .

Disposition of Claims

2) ☑ Claim(s) 6-21 is/are pending in the application.

2a) Of the above claim(s) _____ is/are withdrawn from consideration.

3) ☐ Claim(s) _____ is/are allowed.

4) ☑ Claim(s) 6-21 is/are rejected.

5) ☐ Claim(s) _____ is/are objected to.

6) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

7) ☐ The specification is objected to by the Examiner.

8) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

9) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a) ☐ All b) ☐ Some * c) ☐ None of:

1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

*See the attached detailed Office action for a list of the certified copies not received.

Contact Information

Examiner's Telephone Number: (571)272-7555

Examiner's Typical Work Schedule: Mon-Fri 8-6

Supervisor's Name: Patrick Edouard

Supervisor's Telephone Number: 5712727603

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____ .

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____ .

First Action Interview Pilot Program Pre-Interview Communication	**Application No.** 16/834,905	**Applicant(s)** Skagmo et al.	
	Examiner ADAM R GIESY	**Art Unit** 2694	**AIA (FITF) Status** Yes

Notification of Rejection(s) and/or Objection(s)

#	Claim(s)	Reference(s) (if applicable)	Rejection Statutory Basis	Brief Explanation of Rejection
1	20		Objection - minor	"wherein the at mating portion" should be --wherein the mating portion--
2	6-9	A	Obvious Double Patenting	Claims 6-9 of instant application rejected by claim 5 of USPN 10606416
3	6-21	B	102	Claims 6-21 are rejected (see Figures 4, 5, and 9, elements 122, 301, 921, 922); see also paragraph 0102)
4	6-9,13-16 and 19-21	C	102	Claims 6-21 are rejected (see Figures 6-15) note that the lens in from of the emitter

Expanded Discussion/Commentary

DATE: 27 April 2020	/ADAM R. GIESY/ Primary Examiner, Art Unit 2694	

Notice of References Cited	Application/Control No. 16/834,905	Applicant(s)/Patent Under Reexamination Skagmo et al.	
	Examiner ADAM R GIESY	Art Unit 2694	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-10606416-B2	03-2020	Skagmo; Daniel	G06F3/0428	1/1
*	B	US-20140210793-A1	07-2014	Eriksson; Thomas	F24C7/083	345/175
*	C	US-20150131010-A1	05-2015	SUGIYAMA; Koichi	G06F3/0428	349/12
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/834,905	Skagmo et al.
	Examiner	Art Unit
	ADAM R GIESY	2694

CPC - Searched*		
Symbol	Date	Examiner
(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	04/26/2020	ARG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor search performed	04/26/2020	ARG
EAST search included	04/27/2020	ARG

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

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Flatfrog Laboratories AB, Ex. 2002
Page 218 of 1254

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	34265	(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 13:33
L2	30	1 and (((optical near2 element) lens) same emitter same (surface)) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3 translat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 13:38
L3	329	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) lens) same emitter) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3 translat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:00
L4	148	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) lens) same emitter) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:00
L5	198	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) and (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) (light near2 guide) light-guide lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:11

L6	30	1 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) and (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) (light near2 guide) light-guide lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:13
L8	14	1 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) same (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:28
L9	255	1 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) same (((optical near2 element) (light near2 guide) light-guide lens) same (engag$5 coupl$3 mat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:29
L10	12	("20080080811" | "20100315379" | "20110134079" | "20110141062" | "20120170056" | "20130300714" | "20150131010" | "20190025984" | "20190196657" | "20190196658" | "20190196659" | "9001086").PN.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:33
S1	0	16/191251	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/25 13:24
S2	28284	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 08:33
S3	209	(("3440426") or ("3553680") or ("3673327") or ("4129384") or ("4180702") or ("4209255") or ("4213707") or ("4254333") or ("4254407") or ("4294543") or ("4346376") or ("4420261") or ("4484179") or ("4507557") or ("4521112") or ("4542375") or ("4550250") or ("4593191") or ("4673918") or ("4688933") or ("4688993") or ("4692809") or ("4710760") or ("4736191") or ("4737626") or ("4746770") or ("4752655") or ("4772763") or ("4782328") or ("4812833") or ("4837430") or ("4868912") or ("4891829") or ("4916712") or ("4933544") or ("4949079") or ("4986662") or ("4988983")	US-PGPUB; USPAT	OR	OFF	2019/04/29 08:34

		or ("5065185") or ("5073770") or ("5105186") or ("5159322") or ("5166668") or ("5227622") or ("5248856") or ("5254407") or ("5345490") or ("5383022") or ("5483261") or ("5484966") or ("5499098") or ("5502568") or ("5525764") or ("5526422") or ("5539514") or ("5570181") or ("5572251") or ("5577501") or ("5600105") or ("5608550") or ("5672852") or ("5679930") or ("5686942") or ("5688933") or ("5729249") or ("5736686") or ("5740224") or ("5764223") or ("5767517") or ("5775792") or ("5945980") or ("5945981") or ("5959617") or ("6061177") or ("6067079") or ("6122394") or ("6141104") or ("6172667") or ("6175999") or ("6227667") or ("6229529") or ("6333735") or ("6366276") or ("6380732") or ("6380740") or ("6390370") or ("6429857") or ("6452996") or ("6476797") or ("6492633") or ("6495832") or ("6504143") or ("6529327") or ("6538644") or ("6587099") or ("6648485") or ("6660964") or ("6664498") or ("6664952") or ("6690363") or ("6707027") or ("6738051") or ("6748098") or ("6784948") or ("6799141") or ("6806871") or ("6927384") or ("6940286") or ("6965836") or ("6972753") or ("6985137") or ("7042444") or ("7084859") or ("7087907") or ("7133031") or ("7176904") or ("7199932") or ("7359041") or ("7397418") or ("7432893") or ("7435940") or ("7436443") or ("7442914") or ("7465914") or ("7613375") or ("7629968") or ("7646833") or ("7653883") or ("7655901") or ("7705835") or ("7729056") or ("7847789") or ("7855716") or ("7859519") or ("7924272") or ("7932899") or ("7969410") or ("7995039") or ("8013845") or ("8031186") or ("8077147") or ("8093545") or ("8094136") or ("8094910") or ("8149211") or ("8218154") or ("8274495") or ("8325158") or ("8339379") or ("8350827")).PN. or (("8384010") or ("8407606") or ("8441467") or ("8445834") or ("8466901") or ("8482547") or ("8542217") or ("8567257") or ("8581884") or ("8624858") or				

		("8686974") or ("8692807") or ("8716614") or ("8727581") or ("8745514") or ("8780066") or ("8830181") or ("8860696") or ("8872098") or ("8872801") or ("8884900") or ("8890843") or ("8890849") or ("8928590") or ("8963886") or ("8982084") or ("9024916") or ("9035909") or ("9063617") or ("9086763") or ("9134854") or ("9158401") or ("9158415") or ("9213445") or ("9274645") or ("9317168") or ("9323396") or ("9366565") or ("9377884") or ("9389732") or ("9411444") or ("9411464") or ("9430079") or ("9442574") or ("9547393") or ("9552103") or ("9557846") or ("9588619") or ("9594467") or ("9618682") or ("9626018") or ("9626040") or ("9639210") or ("9678602") or ("9684414") or ("9710101") or ("9874978") or ("10013107") or ("10019113")).PN.				
S4	372	(("20010002694") or ("20010005004") or ("20010005308") or ("20010030642") or ("20020067348") or ("20020075243") or ("20020118177") or ("20020158823") or ("20020158853") or ("20020163505") or ("20030016450") or ("20030034439") or ("20030034935") or ("20030048257") or ("20030052257") or ("20030095399") or ("20030107748") or ("20030137494") or ("20030156100") or ("20030160155") or ("20030210537") or ("20030214486") or ("20040027339") or ("20040032401") or ("20040090432") or ("20040130338") or ("20040174541") or ("20040201579") or ("20040212603") or ("20040238627") or ("20040239702") or ("20040245438") or ("20040252091") or ("20040252867") or ("20050012714") or ("20050041013") or ("20050057903") or ("20050073508") or ("20050083293") or ("20050128190") or ("20050143923") or ("20050156914") or ("20050162398") or ("20050179977") or ("20050200613") or ("20050212774") or ("20050248540") or ("20050253834") or ("20050276053") or ("20060001650") or ("20060001653") or ("20060007185") or ("20060008164") or ("20060017706") or ("20060017709") or ("20060033725") or	US-PGPUB; USPAT	OR	OFF	2019/04/29 08:34

		("20060038698") or ("20060061861") or ("20060114237") or ("20060132454") or ("20060139340") or ("20060158437") or ("20060170658") or ("20060202974") or ("20060227120") or ("20060255248") or ("20060256092") or ("20060279558") or ("20060281543") or ("20060290684") or ("20070014486") or ("20070024598") or ("20070034783") or ("20070038691") or ("20070052684") or ("20070070056") or ("20070075648") or ("20070120833") or ("20070125937") or ("20070152985") or ("20070201042") or ("20070296688") or ("20080006766") or ("20080007540") or ("20080007541") or ("20080007542") or ("20080011944") or ("20080029691") or ("20080036743") or ("20080062150") or ("20080068691") or ("20080074401") or ("20080088603") or ("20080121442") or ("20080122792") or ("20080122803") or ("20080130979") or ("20080150846") or ("20080150848") or ("20080151126") or ("20080158176") or ("20080189046") or ("20080192025") or ("20080238433") or ("20080246388") or ("20080252619") or ("20080266266") or ("20080278460") or ("20080284925") or ("20080291668") or ("20080297482") or ("20080133265") or ("20090002340") or ("20090006292") or ("20090040786") or ("20090066647") or ("20090067178") or ("20090073142")).PN. or (("20090077501") or ("20090085894") or ("20090091554") or ("20090115919") or ("20090122020") or ("20090122027") or ("20090128508") or ("20090135162") or ("20090143141") or ("20090153519") or ("20090161026") or ("20090168459") or ("20090187842") or ("20090189857") or ("20090189874") or ("20090189878") or ("20090219256") or ("20090229892") or ("20090251439") or ("20090256817") or ("20090259967") or ("20090267919") or ("20090273794") or ("20090278816") or ("20090297009") or ("20100033444") or ("20100045629") or ("20100060896") or ("20100066016") or ("20100066704") or ("20100073318") or ("20100078545") or ("20100079407") or ("20100079408") or ("20100097345") or ("20100097348") or				

		("20100097353") or ("20100125438") or ("20100127975") or ("20100134435") or ("20100142823") or ("20100187422") or ("20100193259") or ("20100229091") or ("20100238139") or ("20100245292") or ("20100265170") or ("20100277436") or ("20100283785") or ("20100284596") or ("20100289754") or ("20100295821") or ("20100302196") or ("20100302209") or ("20100302210") or ("20100302240") or ("20100315379") or ("20100321328") or ("20100322550") or ("20110043490") or ("20110049388") or ("20110050649") or ("20110051394") or ("20110068256") or ("20110069039") or ("20110069807") or ("20110074725") or ("20110074734") or ("20110074735") or ("20110090176") or ("20110102374") or ("20110115748") or ("20110121323") or ("20110122075") or ("20110122091") or ("20110122094") or ("20110134079") or ("20110147569") or ("20110157095") or ("20110157096") or ("20110163996") or ("20110163997") or ("20110163998") or ("20110169780") or ("20110175852") or ("20110205186") or ("20110216042") or ("20110221705") or ("20110221997") or ("20110227036") or ("20110227874") or ("20110234537") or ("20110254864") or ("20110261020") or ("20110267296") or ("20110291989") or ("20110298743") or ("20110309325") or ("20110310045") or ("20120019448") or ("20120026408") or ("20120038593") or ("20120062474") or ("20120068973") or ("20120086673") or ("20120089348") or ("20120110447") or ("20120131490") or ("20120141001") or ("20120146930") or ("20120153134") or ("20120154338") or ("20120162142") or ("20120162144") or ("20120169672") or ("20120181419") or ("20120182266") or ("20120188206")).PN. or (("20120191993") or ("20120200532") or ("20120200538") or ("20120212441") or ("20120217882") or ("20120249478") or ("20120256882") or ("20120268403") or ("20120268427") or ("20120274559") or ("20120305755") or ("20130021300") or ("20130021302") or ("20130027404") or ("20130044073") or ("20130055080") or				

("20130076697") or ("20130082980") or
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("20130275082") or ("20130285920") or
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("20140139467") or ("20140160762") or
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("20140237422") or ("20140253831") or
("20140267124") or ("20140292701") or
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("20150346911") or ("20150363042") or
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("20160050746") or ("20160070415") or
("20160070416") or ("20160124546") or
("20160124551") or ("20160154531") or
("20160154532") or ("20160202841") or
("20160216844") or ("20160224144") or
("20160299593") or ("20160328090") or

		("20160328091") or ("20160334942") or ("20160342282") or ("20160357348")).PN. or (("20170010688") or ("20170090090") or ("20170102827") or ("20170115235") or ("20170115823") or ("20170139541") or ("20170177163") or ("20170185230") or ("20170293392") or ("20170344185") or ("20180031753") or ("20180129354") or ("20180210572") or ("20180225006") or ("20180267672") or ("20180275788") or ("20180275830") or ("20180275831")).PN.				
S5	4272	(G06F3/0421).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:35
S6	260	S5 and (collimat$3 near2 beam)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:35
S7	65	S5 and ((collimat$3 near2 beam) same parallel same surface)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:48
S8	55	S5 and ((collimat$3 near2 beam) same (across parallel) with surface) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 10:51
S9	55	S5 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 10:51
S10	42	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2019/04/29 11:11
S11	56	S2 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 11:13
S12	1	S11 not S9	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 11:21
S13	4289	(G06F3/0421).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 09:41

S14	49	S13 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and ((emitter light) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 09:41
S16	50	S13 and ((emitter LED diode) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:05
S17	5480	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:15
S18	52	S17 and ((emitter LED diode) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:15
S19	169	S17 and ((emitter LED diode) with (above near3 (surface plane)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:25
S20	121	S19 not S18	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:26
S21	190	S17 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:54
S22	29597	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:55
S23	21	S21 not S19	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:55
S24	266	S22 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:59
S25	76	S24 not S21	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:59
S26	29531	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:38

S27	274	S26 and ((emitter LED diode) with ((atop (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:38
S28	266	S26 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:39
S29	8	S27 not S28	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:39
S31	146	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 14:16
S32	153	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:04
S33	7	S32 not S31	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:18
S34	1879	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23
S35	5476	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23
S36	1313	S35 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23

S37	1440	S34 not S36	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:24
S38	346	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:27
S39	375	S35 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:27
S40	180	S39 not S38	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:28
S41	2	((optical adj2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light adj2 source)) and (support$3 frame mount$3)) and ((light beam) adj5 (over across atop) adj3 (surface plane cover panel))).clm.	US-PGPUB	OR	ON	2019/05/27 18:31
S42	1	16/191177	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:47
S43	3	(("9207800") or ("20150339000") or ("20160306501")).PN.	US-PGPUB; USPAT	OR	OFF	2019/12/23 05:52
S44	154	(US-20010002694-$ | US-20010005004-$ | US-20010005308-$ | US-20010030642-$ | US-20020067348-$ | US-20020075243-$ | US-20020118177-$ | US-20020158823-$ | US-20020158853-$ | US-20020163505-$ | US-20030016450-$ | US-20030034439-$ | US-20030034935-$ | US-20030048257-$ | US-20030052257-$ | US-20030095399-$ | US-20030107748-$ | US-20030137494-$ | US-20030156100-$ | US-20030160155-$ | US-20030210537-$ | US-20030214486-$ |	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		US-20040027339-$ | US-20040032401-$ | US-20040090432-$ | US-20040130338-$ | US-20040174541-$ | US-20040201579-$ | US-20040212603-$ | US-20040238627-$ | US-20040239702-$ | US-20040245438-$ | US-20040252091-$ | US-20040252867-$ | US-20050012714-$ | US-20050041013-$ | US-20050057903-$ | US-20050073508-$ | US-20050083293-$ | US-20050128190-$ | US-20050143923-$ | US-20050156914-$ | US-20050162398-$ | US-20050179977-$ | US-20050200613-$ | US-20050212774-$ | US-20050248540-$ | US-20050253834-$ | US-20050276053-$ | US-20060001650-$ | US-20060001653-$ | US-20060007185-$ | US-20060008164-$ | US-20060017706-$ | US-20060017709-$ | US-20060033725-$ | US-20060038698-$ | US-20060061861-$ | US-20060114237-$ | US-20060132454-$ | US-20060139340-$ | US-20060158437-$ | US-20060170658-$ | US-20060202974-$ | US-20060227120-$ | US-20060255248-$ | US-20060256092-$ | US-20060279558-$ | US-20060281543-$ | US-20060290684-$ | US-20070014486-$ | US-20070024598-$ | US-20070034783-$ | US-20070038691-$ | US-20070052684-$ | US-20070070056-$ | US-20070075648-$ | US-20070120833-$ | US-20070125937-$ | US-20070152985-$ | US-20070201042-$ | US-20070296688-$ | US-20080006766-$ | US-20080007540-$ | US-20080007541-$ | US-20080007542-$ | US-20080011944-$ | US-20080029691-$ | US-20080036743-$ | US-20080062150-$ | US-20080068691-$ | US-20080074401-$ | US-20080088603-$ | US-20080121442-$ | US-20080122792-$ | US-20080122803-$ | US-20080130979-$ | US-20080133265-$ | US-20080150846-$ | US-20080150848-$ | US-20080151126-$ | US-20080158176-$ | US-20080189046-$ | US-20080192025-$ | US-20080238433-$ | US-20080246388-$ | US-20080252619-$ | US-20080266266-$ | US-20080278460-$ | US-20080284925-$ | US-20080291668-$ | US-20080297482-$ | US-20090002340-$ | US-20090006292-$ | US-20090040786-$ | US-20090066647-$ | US-20090067178-$ | US-20090073142-$ | US-20090077501-$ | US-20090085894-$ |			

		US-20090091554-$ | US-20090115919-$ | US-20090122020-$ | US-20090122027-$ | US-20090128508-$ | US-20090135162-$ | US-20090143141-$ | US-20090153519-$ | US-20090161026-$ | US-20090168459-$ | US-20090187842-$ | US-20090189857-$ | US-20090189874-$ | US-20090189878-$ | US-20090219256-$ | US-20090229892-$ | US-20090251439-$ | US-20090256817-$ | US-20090259967-$ | US-20090267919-$ | US-20090273794-$ | US-20090278816-$ | US-20090297009-$ | US-20100033444-$ | US-20100045629-$ | US-20100060896-$ | US-20100066016-$ | US-20100066704-$ | US-20100073318-$ | US-20100078545-$ | US-20100079407-$ | US-20100079408-$ | US-20100097345-$ | US-20100097348-$).DID.				
S45	154	(US-20100097353-$ | US-20100125438-$ | US-20100127975-$ | US-20100134435-$ | US-20100142823-$ | US-20100187422-$ | US-20100193259-$ | US-20100229091-$ | US-20100238139-$ | US-20100245292-$ | US-20100265170-$ | US-20100277436-$ | US-20100283785-$ | US-20100284596-$ | US-20100289754-$ | US-20100295821-$ | US-20100302196-$ | US-20100302209-$ | US-20100302210-$ | US-20100302240-$ | US-20100315379-$ | US-20100321328-$ | US-20100322550-$ | US-20110043490-$ | US-20110049388-$ | US-20110050649-$ | US-20110051394-$ | US-20110068256-$ | US-20110069039-$ | US-20110069807-$ | US-20110074725-$ | US-20110074734-$ | US-20110074735-$ | US-20110090176-$ | US-20110102374-$ | US-20110115748-$ | US-20110121323-$ | US-20110122075-$ | US-20110122091-$ | US-20110122094-$ | US-20110134079-$ | US-20110147569-$ | US-20110157095-$ | US-20110157096-$ | US-20110163996-$ | US-20110163997-$ | US-20110163998-$ | US-20110169780-$ | US-20110175852-$ | US-20110205186-$ | US-20110216042-$ | US-20110221705-$ | US-20110221997-$ | US-20110227036-$ | US-20110227874-$ | US-20110234537-$ | US-20110254864-$ | US-20110261020-$ | US-20110267296-$ | US-20110291989-$ |	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		US-20110298743-$ | US-20110309325-$ | US-20110310045-$ | US-20120019448-$ | US-20120026408-$ | US-20120038593-$ | US-20120062474-$ | US-20120068973-$ | US-20120086673-$ | US-20120089348-$ | US-20120110447-$ | US-20120131490-$ | US-20120141001-$ | US-20120146930-$ | US-20120153134-$ | US-20120154338-$ | US-20120162142-$ | US-20120162144-$ | US-20120169672-$ | US-20120181419-$ | US-20120182266-$ | US-20120188206-$ | US-20120191993-$ | US-20120200532-$ | US-20120200538-$ | US-20120212441-$ | US-20120217882-$ | US-20120249478-$ | US-20120256882-$ | US-20120268403-$ | US-20120268427-$ | US-20120274559-$ | US-20120305755-$ | US-20130021300-$ | US-20130021302-$ | US-20130027404-$ | US-20130044073-$ | US-20130055080-$ | US-20130076697-$ | US-20130082980-$ | US-20130107569-$ | US-20130113715-$ | US-20130120320-$ | US-20130125016-$ | US-20130127790-$ | US-20130135258-$ | US-20130135259-$ | US-20130141388-$ | US-20130154983-$ | US-20130155027-$ | US-20130158504-$ | US-20130181896-$ | US-20130187891-$ | US-20130201142-$ | US-20130222346-$ | US-20130241887-$ | US-20130249833-$ | US-20130269867-$ | US-20130275082-$ | US-20130285920-$ | US-20130285968-$ | US-20130300716-$ | US-20130307795-$ | US-20130342490-$ | US-20140002400-$ | US-20140028575-$ | US-20140028604-$ | US-20140028629-$ | US-20140036203-$ | US-20140055421-$ | US-20140063853-$ | US-20140071653-$ | US-20140085241-$ | US-20140092052-$ | US-20140098032-$ | US-20140098058-$ | US-20140109219-$ | US-20140125633-$ | US-20140139467-$ | US-20140160762-$ | US-20140192023-$ | US-20140232669-$ | US-20140237401-$ | US-20140237408-$ | US-20140237422-$ | US-20140253831-$ | US-20140267124-$ | US-20140292701-$ | US-20140300572-$ | US-20140320460-$ | US-20140347325-$ | US-20140362046-$ | US-20140368471-$ | US-20140375607-$).DID.				

S46	179	(US-20150002386-$ | US-20150009687-$ | US-20150015497-$ | US-20150035774-$ | US-20150035803-$ | US-20150053850-$ | US-20150054759-$ | US-20150083891-$ | US-20150103013-$ | US-20150130769-$ | US-20150138105-$ | US-20150138158-$ | US-20150138161-$ | US-20150205441-$ | US-20150215450-$ | US-20150242055-$ | US-20150271481-$ | US-20150286698-$ | US-20150317036-$ | US-20150324028-$ | US-20150331544-$ | US-20150331545-$ | US-20150331546-$ | US-20150331547-$ | US-20150332655-$ | US-20150346856-$ | US-20150346911-$ | US-20150363042-$ | US-20160026337-$ | US-20160034099-$ | US-20160050746-$ | US-20160070415-$ | US-20160070416-$ | US-20160124546-$ | US-20160124551-$ | US-20160154531-$ | US-20160154532-$ | US-20160202841-$ | US-20160216844-$ | US-20160224144-$ | US-20160299593-$ | US-20160328090-$ | US-20160328091-$ | US-20160334942-$ | US-20160342282-$ | US-20160357348-$ | US-20170010688-$ | US-20170090090-$ | US-20170102827-$ | US-20170115235-$ | US-20170115823-$ | US-20170139541-$ | US-20170177163-$ | US-20170185230-$ | US-20170293392-$ | US-20170344185-$ | US-20180031753-$ | US-20180129354-$ | US-20180210572-$ | US-20180225006-$ | US-20180267672-$ | US-20180275788-$ | US-20180275830-$ | US-0001650-$ | US-0001653-$ | US-0002340-$ | US-0002386-$ | US-0002400-$ | US-0002694-$ | US-0005004-$ | US-0005308-$ | US-0006292-$ | US-0006766-$ | US-0007185-$ | US-0007540-$ | US-0007541-$ | US-0007542-$ | US-0008164-$ | US-0009687-$ | US-0010688-$ | US-0011944-$ | US-0012714-$ | US-0014486-$ | US-0015497-$ | US-0016450-$ | US-0017706-$ | US-0017709-$ | US-0019448-$ | US-0021300-$ | US-0021302-$ | US-0024598-$ | US-0026337-$ | US-0026408-$ | US-0027339-$ | US-0027404-$ | US-0028575-$ | US-0028604-$ | US-0028629-$ | US-0029691-$ | US-0030642-$ | US-0031753-$ | US-0032401-$ | US-0033444-$ | US-0033725-$ | US-0034099-$ | US-0034439-$ | US-0034783-$	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		| US-0034935-$ | US-0035774-$ | US-0035803-$ | US-0036203-$ | US-0036743-$ | US-0038593-$ | US-0038691-$ | US-0038698-$ | US-0040786-$ | US-0041013-$ | US-0043490-$ | US-0044073-$ | US-0045629-$ | US-0048257-$ | US-0049388-$ | US-0050649-$ | US-0050746-$ | US-0051394-$ | US-0052257-$ | US-0052684-$ | US-0053850-$ | US-0054759-$ | US-0055080-$ | US-0055421-$ | US-0057903-$ | US-0060896-$ | US-0061861-$ | US-0062150-$ | US-0062474-$ | US-0063853-$ | US-0066016-$ | US-0066647-$ | US-0066704-$ | US-0067178-$ | US-0067348-$ | US-0068256-$ | US-0068691-$ | US-0068973-$ | US-0069039-$ | US-0069807-$ | US-0070056-$ | US-0070415-$ | US-0070416-$ | US-0071653-$ | US-0073142-$ | US-0073318-$ | US-0073508-$ | US-0074401-$ | US-0074725-$ | US-0074734-$ | US-0074735-$ | US-0075243-$ | US-0075648-$ | US-0076697-$ | US-0077501-$ | US-0078545-$ | US-0079407-$ | US-0079408-$ | US-0082980-$ | US-0083293-$ | US-0083891-$ | US-0085241-$ | US-0085894-$ | US-0086673-$ | US-0088603-$ | US-0089348-$ | US-0090090-$ | US-0090176-$ | US-0090432-$ | US-0091554-$ | US-0092052-$ | US-0095399-$).DID.				
S47	194	(US-0097345-$ | US-0097348-$ | US-0097353-$ | US-0098032-$ | US-0098058-$ | US-0102374-$ | US-0102827-$ | US-0103013-$ | US-0107569-$ | US-0107748-$ | US-0109219-$ | US-0110447-$ | US-0113715-$ | US-0114237-$ | US-0115235-$ | US-0115748-$ | US-0115823-$ | US-0115919-$ | US-0118177-$ | US-0120320-$ | US-0120833-$ | US-0121323-$ | US-0121442-$ | US-0122020-$ | US-0122027-$ | US-0122075-$ | US-0122091-$ | US-0122094-$ | US-0122792-$ | US-0122803-$ | US-0124546-$ | US-0124551-$ | US-0125016-$ | US-0125438-$ | US-0125633-$ | US-0125937-$ | US-0127790-$ | US-0127975-$ | US-0128190-$ | US-0128508-$ | US-0129354-$ | US-0130338-$ | US-0130769-$ | US-0130979-$ | US-0131490-$ | US-0132454-$ | US-0133265-$ | US-	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		0134079-$ | US-0134435-$ | US-0135162-$ | US-0135258-$ | US-0135259-$ | US-0137494-$ | US-0138105-$ | US-0138158-$ | US-0138161-$ | US-0139340-$ | US-0139467-$ | US-0139541-$ | US-0141001-$ | US-0141388-$ | US-0142823-$ | US-0143141-$ | US-0143923-$ | US-0146930-$ | US-0147569-$ | US-0150846-$ | US-0150848-$ | US-0151126-$ | US-0152985-$ | US-0153134-$ | US-0153519-$ | US-0154338-$ | US-0154531-$ | US-0154532-$ | US-0154983-$ | US-0155027-$ | US-0156100-$ | US-0156914-$ | US-0157095-$ | US-0157096-$ | US-0158176-$ | US-0158437-$ | US-0158504-$ | US-0158823-$ | US-0158853-$ | US-0160155-$ | US-0160762-$ | US-0161026-$ | US-0162142-$ | US-0162144-$ | US-0162398-$ | US-0163505-$ | US-0163996-$ | US-0163997-$ | US-0163998-$ | US-0168459-$ | US-0169672-$ | US-0169780-$ | US-0170658-$ | US-0174541-$ | US-0175852-$ | US-0177163-$ | US-0179977-$ | US-0181419-$ | US-0181896-$ | US-0182266-$ | US-0185230-$ | US-0187422-$ | US-0187842-$ | US-0187891-$ | US-0188206-$ | US-0189046-$ | US-0189857-$ | US-0189874-$ | US-0189878-$ | US-0191993-$ | US-0192023-$ | US-0192025-$ | US-0193259-$ | US-0200532-$ | US-0200538-$ | US-0200613-$ | US-0201042-$ | US-0201142-$ | US-0201579-$ | US-0202841-$ | US-0202974-$ | US-0205186-$ | US-0205441-$ | US-0210537-$ | US-0210572-$ | US-0212441-$ | US-0212603-$ | US-0212774-$ | US-0214486-$ | US-0215450-$ | US-0216042-$ | US-0216844-$ | US-0217882-$ | US-0219256-$ | US-0221705-$ | US-0221997-$ | US-0222346-$ | US-0224144-$ | US-0225006-$ | US-0227036-$ | US-0227120-$ | US-0227874-$ | US-0229091-$ | US-0229892-$ | US-0232669-$ | US-0234537-$ | US-0237401-$ | US-0237408-$ | US-0237422-$ | US-0238139-$ | US-0238433-$ | US-0238627-$ | US-0239702-$ | US-0241887-$ | US-0242055-$ | US-0245292-$ | US-0245438-$ | US-0246388-$ | US-0248540-$ | US-0249478-$ | US-0249833-$ | US-0251439-$ | US-0252091-$			

		| US-0252619-$ | US-0252867-$ | US-0253831-$ | US-0253834-$ | US-0254864-$ | US-0255248-$ | US-0256092-$ | US-0256817-$ | US-0256882-$ | US-0259967-$ | US-0261020-$ | US-0265170-$ | US-0266266-$ | US-0267124-$ | US-0267296-$ | US-0267672-$ | US-0267919-$ | US-0268403-$ | US-0268427-$ | US-0269867-$ | US-0271481-$ | US-0273794-$ | US-0274559-$ | US-0275082-$ | US-0275788-$ | US-0275830-$).DID.				
S48	196	(US-0276053-$ | US-0277436-$ | US-0278460-$ | US-0278816-$ | US-0279558-$ | US-0281543-$ | US-0283785-$ | US-0284596-$ | US-0284925-$ | US-0285920-$ | US-0285968-$ | US-0286698-$ | US-0289754-$ | US-0290684-$ | US-0291668-$ | US-0291989-$ | US-0292701-$ | US-0293392-$ | US-0295821-$ | US-0296688-$ | US-0297009-$ | US-0297482-$ | US-0298743-$ | US-0299593-$ | US-0300572-$ | US-0300716-$ | US-0302196-$ | US-0302209-$ | US-0302210-$ | US-0302240-$ | US-0305755-$ | US-0307795-$ | US-0309325-$ | US-0310045-$ | US-0315379-$ | US-0317036-$ | US-0320460-$ | US-0321328-$ | US-0322550-$ | US-0324028-$ | US-0328090-$ | US-0328091-$ | US-0331544-$ | US-0331545-$ | US-0331546-$ | US-0331547-$ | US-0332655-$ | US-0334942-$ | US-0342282-$ | US-0342490-$ | US-0344185-$ | US-0346856-$ | US-0346911-$ | US-0347325-$ | US-0357348-$ | US-0362046-$ | US-0363042-$ | US-0368471-$ | US-0375607-$ | US-1234567-$ | US-10013107-$ | US-10019113-$ | US-3440426-$ | US-3553680-$ | US-3673327-$ | US-4129384-$ | US-4180702-$ | US-4209255-$ | US-4213707-$ | US-4254333-$ | US-4254407-$ | US-4294543-$ | US-4346376-$ | US-4420261-$ | US-4484179-$ | US-4507557-$ | US-4521112-$ | US-4542375-$ | US-4550250-$ | US-4593191-$ | US-4673918-$ | US-4688933-$ | US-4688993-$ | US-4692809-$ | US-4710760-$ | US-4736191-$ | US-4737626-$ | US-4746770-$ | US-4752655-$ | US-4772763-$ | US-4782328-$ | US-4812833-$ | US-	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:59

		4837430-$ | US-4868912-$ | US-4891829-$ | US-4916712-$ | US-4933544-$ | US-4949079-$ | US-4986662-$ | US-4988983-$ | US-5065185-$ | US-5073770-$ | US-5105186-$ | US-5159322-$ | US-5166668-$ | US-5227622-$ | US-5248856-$ | US-5254407-$ | US-5345490-$ | US-5383022-$ | US-5483261-$ | US-5484966-$ | US-5499098-$ | US-5502568-$ | US-5525764-$ | US-5526422-$ | US-5539514-$ | US-5570181-$ | US-5572251-$ | US-5577501-$ | US-5600105-$ | US-5608550-$ | US-5672852-$ | US-5679930-$ | US-5686942-$ | US-5688933-$ | US-5729249-$ | US-5736686-$ | US-5740224-$ | US-5764223-$ | US-5767517-$ | US-5775792-$ | US-5945980-$ | US-5945981-$ | US-5959617-$ | US-6061177-$ | US-6067079-$ | US-6122394-$ | US-6141104-$ | US-6172667-$ | US-6175999-$ | US-6227667-$ | US-6229529-$ | US-6333735-$ | US-6366276-$ | US-6380732-$ | US-6380740-$ | US-6390370-$ | US-6429857-$ | US-6452996-$ | US-6476797-$ | US-6492633-$ | US-6495832-$ | US-6504143-$ | US-6529327-$ | US-6538644-$ | US-6587099-$ | US-6648485-$ | US-6660964-$ | US-6664498-$ | US-6664952-$ | US-6690363-$ | US-6707027-$ | US-6738051-$ | US-6748098-$ | US-6784948-$ | US-6799141-$ | US-6806871-$ | US-6927384-$ | US-6940286-$ | US-6965836-$ | US-6972753-$ | US-6985137-$ | US-7042444-$ | US-7084859-$ | US-7087907-$ | US-7133031-$ | US-7176904-$ | US-7199932-$ | US-7359041-$ | US-7397418-$ | US-7432893-$ | US-7435940-$ | US-7436443-$ | US-7442914-$ | US-7465914-$ | US-7613375-$ | US-7629968-$ | US-7646833-$ | US-7653883-$ | US-7655901-$ | US-7705835-$ | US-7729056-$ | US-7847789-$ | US-7855716-$ | US-7859519-$).DID.				
S49	73	(US-7924272-$ | US-7932899-$ | US-7969410-$ | US-7995039-$ | US-8013845-$ | US-8031186-$ | US-8077147-$ | US-8093545-$ | US-8094136-$ | US-8094910-$ | US-8149211-$ | US-8218154-$ | US-8274495-$ | US-8325158-$ | US-8339379-$	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:59

		| US-8350827-$ | US-8384010-$ | US-8407606-$ | US-8441467-$ | US-8445834-$ | US-8466901-$ | US-8482547-$ | US-8542217-$ | US-8567257-$ | US-8581884-$ | US-8624858-$ | US-8686974-$ | US-8692807-$ | US-8716614-$ | US-8727581-$ | US-8745514-$ | US-8780066-$ | US-8830181-$ | US-8860696-$ | US-8872098-$ | US-8872801-$ | US-8884900-$ | US-8890843-$ | US-8890849-$ | US-8928590-$ | US-8963886-$ | US-8982084-$ | US-9024916-$ | US-9035909-$ | US-9063617-$ | US-9086763-$ | US-9134854-$ | US-9158401-$ | US-9158415-$ | US-9213445-$ | US-9274645-$ | US-9317168-$ | US-9323396-$ | US-9366565-$ | US-9377884-$ | US-9389732-$ | US-9411444-$ | US-9411464-$ | US-9430079-$ | US-9442574-$ | US-9547393-$ | US-9552103-$ | US-9557846-$ | US-9588619-$ | US-9594467-$ | US-9618682-$ | US-9626018-$ | US-9626040-$ | US-9639210-$ | US-9678602-$ | US-9684414-$ | US-9710101-$ | US-9874978-$).DID.				
S50	6	(("4751379") or ("6100538") or ("20070165008") or ("20130234991") or ("8913035") or ("20130300714")).PN.	US-PGPUB; USPAT	OR	OFF	2019/12/23 06:04
S51	32685	(G06F3/0428 or G06F3/0421 or G06F2203/04108 or G06F2203/04107 or G06F2203/04103 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:05
S52	5737	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S53	378	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58

S54	397	S52 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S55	186	S54 not S53	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S56	151	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S57	31612	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:59
S58	56	S57 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:59
S59	53	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2019/12/23 07:08
S60	56	S51 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09
S61	158	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09
S62	7	S61 not S56	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09

S63	12	(US-20080080811-$ | US-20100315379-$ | US-20110134079-$ | US-20110141062-$ | US-20120170056-$ | US-20130300714-$ | US-20150131010-$ | US-20190025984-$ | US-20190196657-$ | US-20190196658-$ | US-20190196659-$ | US-9001086-$).DID.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:45
S64	152	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:51
S65	33069	(G06F3/0428 or G06F3/0421 or G06F2203/04108 or G06F2203/04107 or G06F2203/04103 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S66	56	S65 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S67	159	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S68	7	S67 not S64	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S69	2	((optical adj2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light adj2 source)) and (support$3 frame mount$3)) and ((light beam) adj5 (over across atop) adj3 (surface plane cover panel))).clm.	US-PGPUB	OR	ON	2020/02/03 09:55

S70	0	16/834905	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/26 22:26
S71	56	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2020/04/26 22:27
S72	34265	(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/26 22:32

4/27/2020 2:52:43 PM
C:\Users\agiesy\Documents\EAST\Workspaces\16834905.wsp

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 2	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	2015/0373864 A1	12-24-2015	Jung	
	2	2013/0321740 A1	12-5-2013	An et al.	
	3	2016/0154533 A1	06-02-2016	Eriksson et al.	
	4	2011/0080361 A1	04-07-2011	Miller et al.	
	5	2019/0235701 A1	08-01-2019	Han et al.	
	6	9,024,896 B2	05-05-2015	Chen	
	7	4,751,379	06-14-1988	Sasaki et al.	
	8	2013/0234991 A1	09-12-2013	Sparf	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	9	WO 2014/065601	05-01-2014	LG Electronics Inc.		
	10	WO 2018/106176	06-14-2018	FlatFrog Laboratories AB		
	11	EP 3535640 A1	09-11-2019	FlatFrog Laboratories AB		
	12	EP 2765622 A2	08-13-2014	LG Electronics Inc.		
	13	WO 2013/159472	10-31-2013	Shenzhen Timelink Technology Co., LTD.		X

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	14	Report on the Filing or Determination of an Action Regarding a Patent or Trademark. For U.S. Patent No. 10,282,035, U.S. District of Delaware, dated December 10, 2019, in 1 page.	
	15	Civil Cover Sheet FLATFROG LABORATORIES AB v. PROMETHEAN LTD. and PROMETHEAN INC., dated December 10, 2019, in 1 page.	
	16	Complaint for Patent Infringement, FLATFROG LABORATORIES AB v. PROMETHEAN LTD. and PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019, in 83 pages.	
	17	Executed Summons in a Civil Action to PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	
	18	Summons in a Civil Action to PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 2	Attorney Docket No.	FFOG.054C5

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	19	Summons in a Civil Action to Promethean Ltd., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	
	20	Defendants' Answer to Second Amended Complaint and Defendant Promethean Inc.'s Counterclaims Against FlatFrog Laboratories AB., C.A. No. 19-2246, dated May 22, 2020, in 29 pages.	

32896878

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT

First Inventor	:	Daniel Skagmo
App. No.	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted. Any foreign references may also include English abstract(s) and/or machine translation(s), but no representation is made as to their accuracy.

If the Examiner would like additional information regarding these references or if anything is unclear, the Examiner is invited to contact the undersigned for assistance.

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Notification of Related Litigation Filing

Submitted herewith in the above-identified application is an Information Disclosure Statement listing references for consideration. These references are being submitted pursuant to MPEP § 2001.06(c) in that U.S. Patent Nos. 10,282,035, 10,606,414, and 10,606,416, are currently involved in litigation, namely, *FLATFROG LABORATORIES AB vs. PROMETHEAN LTD. AND PROMETHEAN INC.*, (C.A. No.

19-2246-MN). One or more of these patents may be related, or claimed as part of the priority claim of the present application, or may claim a priority benefit of applications and patents that are part of the present application's claim for priority under 35 U.S.C. § 120.

To the best of the undersigned's understanding, the references submitted herewith represent documents or document portions that are non-confidential as defined by any protective order governing information exchanged between the parties to the litigation mentioned above.

Timing of Disclosure

This Information Disclosure Statement is being filed within three months of the filing date or date of national phase entry, with an RCE or before receipt of a First Office Action after an RCE, and no fee is believed to be required.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: May 29, 2020

By: /Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 721-5278

32896880

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 245 of 1254

Doc Code: M865 or FAI.REQ.INTV

PTOL-413A (07-16)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Applicant Initiated Interview Request Form

Application No.: 16/834905 First Named Applicant: FlatFrog Laboratories AB
Examiner: Adam Giesy Art Unit: 2694 Status of Application: Pending

Tentative Participants:
(1) Examiner Giesy (2) Harnik Shukla
(3)_____ (4)_____

Proposed Date of Interview: June 5, 2020 **Proposed Time:** 1:00 (◉AM ◉PM)

Type of Interview Requested:
(1) ☑ Telephonic (2) ☐ Personal (3) ☐ Video Conference

Exhibit To Be Shown or Demonstrated: ☐ YES ☑ NO
If yes, provide brief description:_____

Issues To Be Discussed

Issues (Rej., Obj., etc)	Claims/ Fig. #s	Prior Art	Discussed	Agreed	Not Agreed
(1)_____	_____	_____	☐	☐	☐
(2)_____	_____	_____	☐	☐	☐
(3)_____	_____	_____	☐	☐	☐
(4)_____	_____	_____	☐	☐	☐

☐ Continuation Sheet Attached ☑ Proposed Amendment or Arguments Attached

Brief Description of Arguments to be Presented:_____

An interview was conducted on the above-identified application on _____

NOTE: This form should be completed and filed by applicant in advance of the interview (see MPEP § 713.01). If this form is signed by a registered practitioner not of record, the Office will accept this as an indication that he or she is authorized to conduct an interview on behalf of the principal (37 CFR 1.32(a)(3)) pursuant to 37 CFR 1.34. This is not a power of attorney to any above named practitioner. See the Instruction Sheet for this form, which is incorporated by reference. By signing this form, applicant or practitioner is certifying that he or she has read the Instruction Sheet. After the interview is conducted, applicant is advised to file a statement of the substance of this interview (37 CFR 1.133(b)) as soon as possible. This application will not be delayed from issue because of applicant's failure to submit a written record of this interview.

/Harnik Shukla/
Applicant/Applicant's Representative Signature

_____
Examiner/SPE Signature

Harnik Shukla
Typed/Printed Name of Applicant or Representative

9497215278
Applicant's/Applicant's Representative's Telephone Number

73097
Registration Number, if applicable

This collection of information is required by 37 CFR 1.133. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 24 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTOL-413A (08-10)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Instruction Sheet for:
APPLICANT INITIATED INTERVIEW REQUEST FORM

(Not to be Submitted to the USPTO)

1. If this form is signed by a registered practitioner not of record, the authority to submit the Applicant Initiated Interview Request Form is pursuant to limited authority to act in a representative capacity under 37 CFR 1.34 and further proof of authority to act in a representative capacity may be required. *See* 37 CFR 1.34.

   The Office will accept the signed form as an indication that the registered practitioner not of record is authorized to conduct an interview on behalf of the principal in pursuant to 37 CFR 1.34.

   For more information, see the "Conducting an Interview with a Registered Practitioner Acting in a Representative Capacity" notice which is available on the USPTO Web site at: http://www.uspto.gov/patents/law/notices/2010.jsp.

2. This is not a power of attorney to any named practitioner. Accordingly, any registered practitioner not of record named on the form does not have authority to sign a request to change the correspondence address, a request for express abandonment, a disclaimer, a power of attorney, or other document requiring the signature of the applicant, assignee of the entire interest or an attorney of record. If appropriate, a separate power of attorney to the named practitioner should be executed and filed in the US Patent and Trademark Office.

3. Any interview concerning an unpublished application under 35 U.S.C. § 122(b) with a registered practitioner not of record who obtains authorization through use of the PTOL-413A will be conducted based on the information and files supplied by the practitioner in view of the confidentiality requirements of 35 U.S.C. § 122(a).

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor	:	Daniel Skagmo
App. No	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

INTERVIEW AGENDA

Dear Examiner Giesy:

Thank you for the Pre-Interview Communication dated May 1, 2020. Please find below proposed amendments to Claim 6 of the application that I would like to discuss in regard to the above-captioned matter.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: May 29, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 760-0404

32900193

FOR INTERVIEW PURPOSES ONLY - PLEASE DO NOT ENTER

6. (Proposed Amendment) A touch sensing apparatus, comprising:

a panel that defines a touch surface;

a plurality of light emitters and detectors arranged along a perimeter of the panel;

a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a receptacle; and

an optical element configured to be slidably fitted in the space between the panel and the first portion and seals the plurality of light emitters from contaminants from the touch surface, said optical element comprising a mating portion configured to engage with the receptacle of the first portion responsive to when the optical element is slid in a direction parallel to a plane of the touch surface.

FOR INTERVIEW PURPOSES ONLY - PLEASE DO NOT ENTER

Present Application

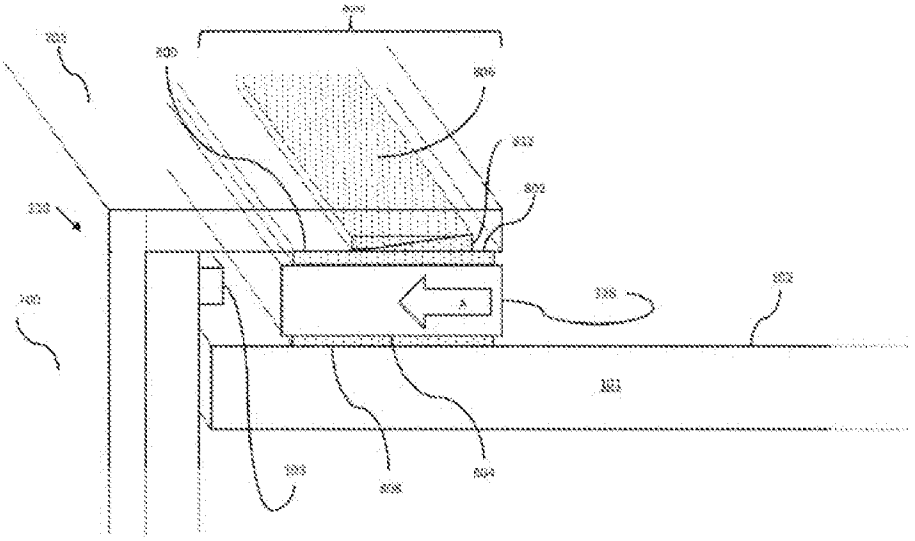


FIG. 8

Cited Art

US 20140210793 (Eriksson)

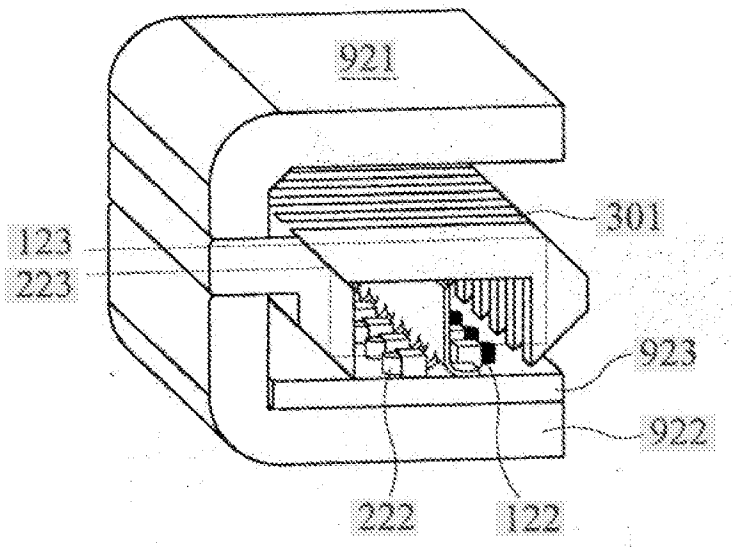
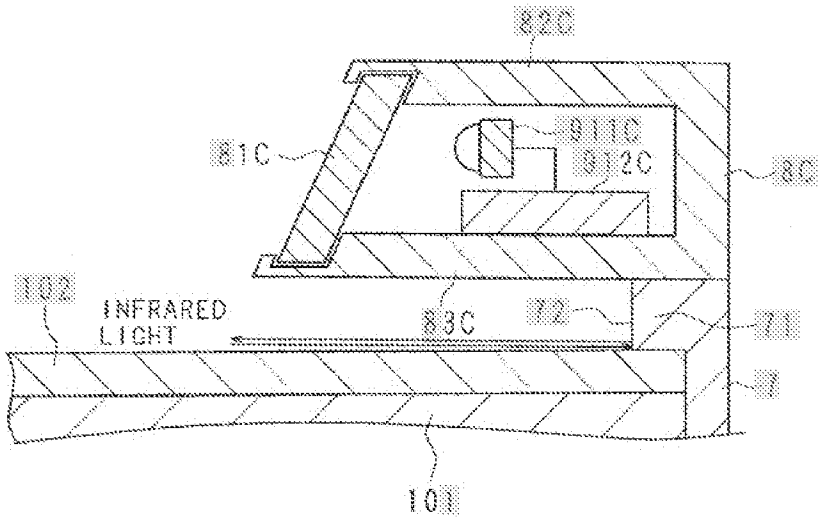


FIG. 7

FOR INTERVIEW PURPOSES ONLY - PLEASE DO NOT ENTER

US 2015/0131010 Sugiyama

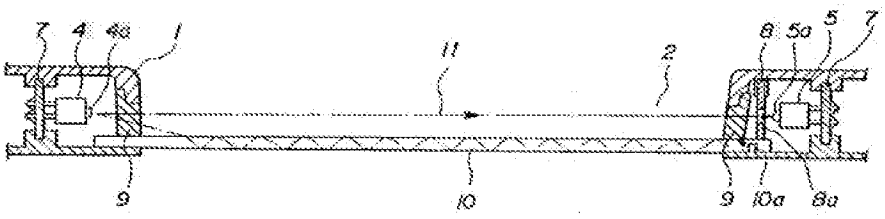
FIG. 14



Additional Art from Litigation

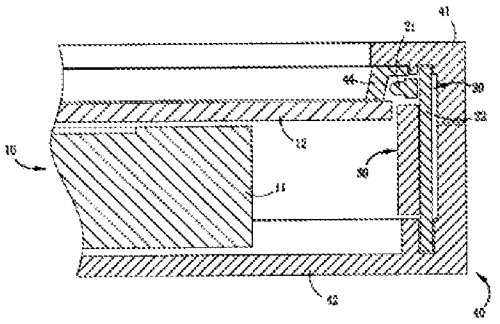
US 4751379 to Sasaki

FIG. 2



FOR INTERVIEW PURPOSES ONLY - PLEASE DO NOT ENTER

WO2013159472



[0093] [illegible]

US 2013/023499 (Sparf)

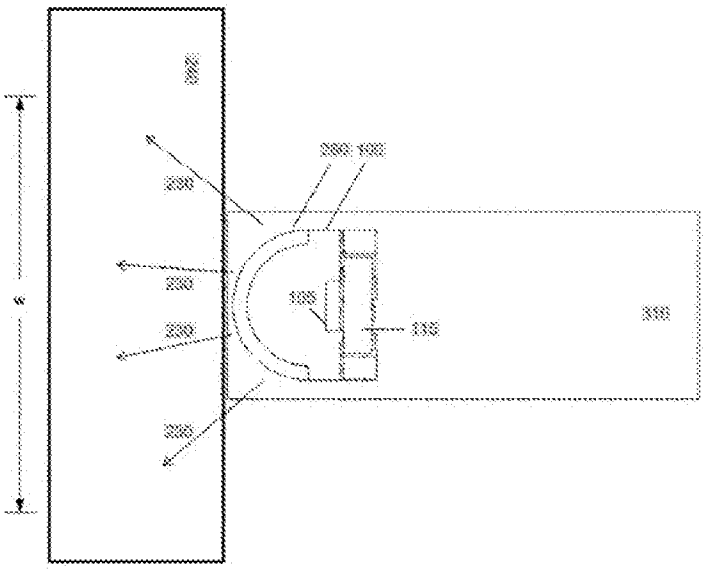


FIG. 4

Electronic Acknowledgement Receipt

EFS ID:	39579268
Application Number:	16834905
International Application Number:	
Confirmation Number:	1516
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Customer Number:	20995
Filer:	Harnik Shukla/Wendy Castorena
Filer Authorized By:	Harnik Shukla
Attorney Docket Number:	FFOG.054C5
Receipt Date:	29-MAY-2020
Filing Date:	30-MAR-2020
Time Stamp:	17:35:28
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	Civil_Cover_Sheet_12-10-2019.pdf	896949 773f4e80c82a3acd50457340569800fb342d485b	no	1

Warnings:

Information:					
2	Non Patent Literature	Complaint_Patent_Infringement_12-10-2019.pdf	8421510 a0c527c04d82abffb1ba621897ceb3798db89309	no	83
Warnings:					
Information:					
3	Non Patent Literature	Defendant_Answer_to_Second_Amended_Complaint.pdf	243662 068e7e9778ffb00ea15a167b206033904e97f286	no	29
Warnings:					
Information:					
4	Foreign Reference	EP_2765622A2.pdf	1317864 a4423a5c371d18d46e6371395636e8a70d79241f	no	16
Warnings:					
Information:					
5	Foreign Reference	EP_3535640A1_eq_WO2018_106176.pdf	4694401 4157792d205fd2563da4135d45bf2db141dbc5e4	no	97
Warnings:					
Information:					
6	Non Patent Literature	Executed_Summons_Civil_Action_12-10-2019.pdf	196209 7f4e1552c59e247fb6dd3dadfc0a4e16cbc0f863	no	2
Warnings:					
Information:					
7	Non Patent Literature	Rpt_on_Filing_Pat_10282035_12-10-2019.pdf	449958 c509b1714667a4ee63962c7e952dddab86e29410	no	1
Warnings:					
Information:					
8	Non Patent Literature	Summons_Civil_Action_Promethean_Inc_12-10-2019.pdf	455675 41c8359fcffe458b47baf286c8aab5834214dc48	no	2
Warnings:					
Information:					

9	Non Patent Literature	Summons_Civil_Action_Promethean_Ltd_12-10-2019.pdf	448784 49b0b8722386174655adb944f1b4f5e1fcd59fa7	no	2
Warnings:					
Information:					
10	Foreign Reference	WO_2013159472.pdf	836659 b691b0072236ffdc06d1413e7e7367c80cc9ad8c	no	22
Warnings:					
Information:					
11	Foreign Reference	WO_2014065601A1.pdf	10530514 73e7b21a891c3b227398c3dd1ae75e4aca4a7d83	no	54
Warnings:					
Information:					
12	Foreign Reference	WO_2018106176.pdf	4662685 181b3a8876fa547661e13456f92b6ab702bda68e	no	96
Warnings:					
Information:					
13		054C5.pdf	55111 026753ba4db378aa06bde4c40d525ee5e63aef15	yes	4

Multipart Description/PDF files in .zip description

Document Description	Start	End
Information Disclosure Statement (IDS) Form (SB08)	3	4
Transmittal Letter	1	2

Warnings:					
Information:					
14	Miscellaneous Incoming Letter	054C5_intagenda.pdf	310384 8e1e3e22cdace32c75166e794b60144a8e558ca9	no	5
Warnings:					
Information:					

15	First Action Interview - Schedule Interview request	054C5_interview_request.pdf	311159 1132b8f8917e5579548beacdaed7ecf1b197a808	no	3

Warnings:	
Information:	
Total Files Size (in bytes):	33831524

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New Applications Under 35 U.S.C. 111

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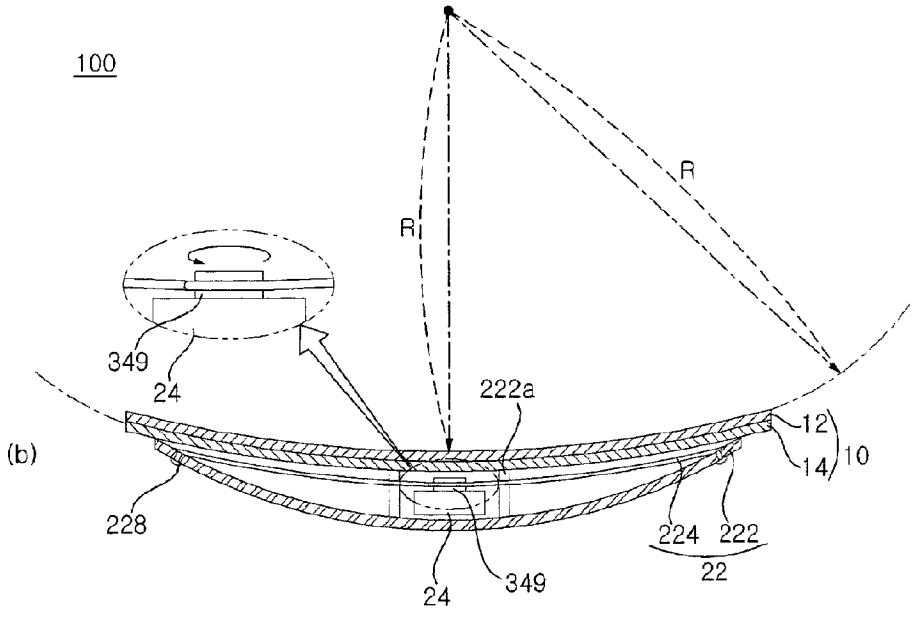
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(54) Display apparatus

(57) A display apparatus includes a display module including a flexible display panel for displaying an image, and a variable member for varying a shape of the flexible display panel. The variable member includes a variable section capable of bending in shape. The variable member also includes a driver for supplying mechanical energy to bend the shape of the variable section, where the flexible display panel is varied in shape by the bending in shape of the variable section.

FIG. 5



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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of Korean Patent Application No. 10-2013-0014478 filed on February 8, 2013 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field of the disclosure

[0002] The present disclosure relates to a display apparatus, and more particularly to a display apparatus with an improved structure.

2. Description of the Related Art

[0003] Various types of display apparatuses are used to display images. For example, there are various displays such as a liquid crystal display panel, a plasma display panel, and an organic light emitting diode display panel.

[0004] In accordance with recent expansion of application fields of display apparatuses, diverse characteristics of display apparatuses are now required in the application fields. In particular, such requirements have been increased in association with characteristics related not only to simple display of images, but also to display of images taking into consideration three-dimensional effects and sensory immersion. In order to meet such various requirements, research is being conducted to provide various display apparatuses having improved structures.

SUMMARY

[0005] Therefore, one object is to provide a display apparatus having an improved structure capable of achieving an enhancement in sensory immersion of a user.

[0006] In accordance with one aspect, the above and other objects may be accomplished by the provision of a display apparatus including a display module including a flexible display panel for displaying an image, and a variable member for varying a shape of the flexible display panel, wherein the variable member includes at least one variable section capable of varying in shape, and at least one driver for supplying mechanical energy to bend the shape of the variable section, where the flexible display panel is varied in shape by the bending in shape of the variable section.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and other objects, features and other advantages will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a front perspective view of a display apparatus according to an exemplary embodiment of the present invention;

FIG. 2 is an exploded rear perspective view of the display apparatus according to an exemplary embodiment of the present invention;

FIG. 3 is a perspective view illustrating a driver of the display apparatus according to an exemplary embodiment of the present invention;

FIG. 4 is a cross-sectional perspective view of the driver corresponding to FIG. 3;

FIGS. 5(a) and 5(b) are views explaining shape variation of the display apparatus according to an exemplary embodiment of the present invention; and

FIG. 6 is an exploded perspective view of a display apparatus according to another exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] Reference will now be made in detail to preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. These embodiments are not intended to limit the present invention. Other embodiments may also be provided.

[0009] Constituent elements other than elements constituting essential features of the present invention may be omitted from the drawings, for clarity of description. Like reference numerals refer to like elements throughout. In the drawings, the widths, thicknesses, and etc., of constituent elements may be exaggerated or reduced for clarity and convenience of illustration. The present invention is not limited to the illustrated thicknesses, widths, and etc.

[0010] It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. In addition, in the description of the embodiments, it will be understood that when a layer (or film), a region, a pad, a pattern or a structure is referred to as being disposed 'on/above/over' another layer, region, pad, pattern or structure, it can be directly in contact with another layer, region, pad, pattern or structure, or one or more intervening layers, regions, pads, patterns or structures may also be present. In addition, it will also be understood that when a layer (or

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film), a region, a pad, a pattern or a structure are referred to as being disposed 'between' two layers, two regions, two pads, two patterns or two structures, it can be the only layer, region, pad, pattern or structure between the two layers, the two regions, the two pads, the two patterns and the two structures or one or more intervening layers, regions, pads, patterns or structures may also be present.

[0011] Hereinafter, a display apparatus according to an exemplary embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0012] FIG. 1 is a front perspective view of a display apparatus according to an exemplary embodiment of the present invention. FIG. 2 is an exploded rear perspective view of the display apparatus according to an exemplary embodiment of the present invention.

[0013] Referring to FIGS. 1 and 2, the display apparatus of the illustrated embodiment, which is designated by reference numeral "100", includes a display module 10 for displaying an image, and a variable member 20 for varying the shape of the display module 10. The display apparatus 100 also includes a rear cover 30 for covering a rear surface of the display module 10. This will be described in more detail.

[0014] The display module 10 may include a display panel 12 for displaying an image, a support member 14 disposed at a rear surface of the display panel 12, to support the display panel 12, and a panel driver (not shown) fixed to the support member 14, to provide signals for driving of the display panel 12. Although not shown, the display module 10 may further include frames for enclosing edges of the display panel 12 and support member 14.

[0015] In an exemplary embodiment, the display panel 12 may be a panel not only having various structures and types capable of displaying an image, but also having flexibility, to be varied in shape by the variable member 20.

[0016] For example, the display panel 12 may be an organic light emitting display panel using organic light emitting diodes (OLEDs). Such an organic light emitting display panel is a self-luminous display panel in which electrons and holes are combined in a fluorescent or phosphorescent organic thin film when current flows through the organic thin film, thereby generating light. The organic light emitting display panel has various advantages such as excellent picture quality capable of providing bright and crisp images, no restriction as to viewing angle, and low power consumption. In particular, the organic light emitting display panel exhibits excellent flexibility in that it can be manufactured through lamination of organic thin films. Of course, the present invention is not limited to such a display panel. For the display panel 12, various display panels having various structures and types may be employed.

[0017] The support member 14, which is disposed at the rear surface of the display panel 12, supports the display panel 12. The panel driver and variable member 20 may be fixed to a rear surface of the support member 14. As described above, the panel driver drives the display panel 12. To this end, the support member 14 not only has strength to firmly support the display panel 12, panel driver and variable member 20, but also has flexibility and elasticity to be varied in shape in accordance with variation in the shape of the display panel 12. In order to avoid thermal stress, the support member 14 may have a coefficient of thermal expansion similar to that of the display panel 12.

[0018] For example, in an exemplary embodiment, the support member 14 may include a composite material such as reinforced plastic. Here, the composite material is a material obtained by artificially combining two or more kinds of materials, to exhibit excellent characteristics. For example, the support member 14 may include carbon fiber reinforced plastic (CFRP), glass fiber reinforced plastic (GFRP) or the like. In this case, the support member 14 may exhibit not only characteristics of lightness and flexibility by virtue of the plastic, but also high strength, high elasticity and excellent wear resistance by virtue of the fiber type reinforcing material. The support member 14 may be constituted by a single composite material layer or may be constituted by a plurality composite material layers, to exhibit excellent strength.

[0019] The support member 14 may be fixed to the rear surface of the display panel 12 by an adhesive (for example, a double-sided tape). Of course, the present invention is not limited to such a fixing method. The display panel 12 and support member 14 may be fixed to each other, using various fixing methods.

[0020] The panel driver fixed to the rear surface of the support member 14 includes a circuit board (not shown) including various wirings and elements to provide signals for driving the display panel 12. The panel driver may be fixed to the support member 14 by a bracket (not shown) or the like. For example, the bracket may be fixed to the support member 14 at a middle portion thereof in order to minimize force required to vary the shape of the display panel 12. Of course, the present invention is not limited to such a structure, and various alternatives may be employed. For example, the panel driver may be partially or completely disposed at the outside of the display module 10. In an exemplary embodiment, the panel driver may include wirings, elements, and etc., for driving the variable member 20.

[0021] In addition, frames may be provided to protect the edges of the display panel 12 and support member 14. Such frames not only protect the display panel 12 and support member 14, but also support the rear cover 30. That is, the rear cover 30 may be fastened to the frames by fastening members (not shown). The frames may have various shapes, and various fastening structures and methods may be employed to fasten the rear cover to the frames and, as such, no detailed description thereof will be given.

[0022] The variable member 20 is disposed at the dis-

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play module 10 (in this embodiment, the variable member 20 is disposed at the rear surface of the support member 14), to vary the shape of the display panel 12. The variable member 20 may include a variable section 22, and a driver 24 for supplying mechanical energy to vary the shape of the variable section 22. For example, the driver 24 varies the shape of the variable section 22 by bending in shape the variable section 22.

[0023] In an exemplary embodiment, the variable section 22 may be elongated in one direction (for example, a lateral direction of the display apparatus 100). Upon receiving mechanical energy from the driver 24, the variable section 22 may be varied in shape such that opposite end portions thereof protrude forward with respect to the middle portion(comment: since the middle portion is fixed to the display panel, see Figs. 2 and 5, it does not appear to retract rearward). As a result, the display module 10 may be bent throughout the entirety thereof, to have a predetermined radius of curvature (for example, "R" in FIG. 5(b)) in a lateral direction of the display module 10. In this state in FIG. 5(b), there is no difference in the distance from the eyes of the user to the display panel 12 between the middle and lateral end portions of the display panel 12. Even if there is a distance difference, such difference may be minute. Thus, it is possible to achieve an enhancement in sensory immersion of the user. Of course, the present invention is not limited to the above-described embodiment. For example, the varied shape of the variable section 22 may be different from the above-described shape and, as such, the varied shape of the display module 10 may also be different from the above-described shape.

[0024] In the illustrated embodiment, two variable sections 22 are provided such that one variable section 22 is disposed at an upper portion of the display module 10, and the other variable section 22 is disposed at a lower portion of the display module 10. While two or more variable section 22 are preferred, a single variable section 22 may be disposed at an intermediate portion of the display module 10, although insufficient shape variation may occur at lateral edge portions of the display module 10. Taking into such consideration, in this embodiment, two variable sections 22 are implemented. When a plurality of variable sections 22 are provided, it is possible to achieve uniform shape variation throughout the entirety of the display module 10. Of course, the present invention is not limited to the two variable sections 22, and various alternatives may be employed. For example, only one variable section 22 is provided for cost reduction and structure simplification.

[0025] Each variable section 22 may include a first portion 222 fixed to the support member 14 of the display module 10, and a second portion 224 disposed between the support member 14 and the first portion 222. The second portion 224 is fixed, at opposite ends thereof, to opposite ends of the first portion 222, respectively.

[0026] The second portion 224 is fixed, at a certain region thereof, for example, a central region, to the driver 24 and, as such, the second portion 224 has a connection length (that is, a rectilinear length between the opposite ends of the first portion 222 connected with the second portion 224) variable by mechanical energy supplied from the driver 24. When the connection length of the second portion 224 varies, the shape of the first portion 222 is varied. This will be described in more detail later with reference to FIGS. 5(a) and 5(b). When the shape of the first portion 222 varies, the first portion 222 applies force to the display module 10, thereby causing the shape of the display module 10 to be correspondingly varied.

[0027] Thus, the first portion 222 is a portion which is varied in shape by force received from the second portion 224, thereby varying the shape of the display module 10. In this regard, the first portion 222 may include a material having flexibility and excellent strength. In addition, the material of the first portion 222 may be light in weight in order to reduce the weight of the display apparatus 100.

[0028] For example, the first portion 222 may include a single layer structure or a multilayer structure, which includes a composite material, for example, reinforced plastic (CFRP, GFRP or the like). Of course, the present invention is not limited to such materials, and the first portion 222 may be made of various materials. The first portion 222 may have an elongated band shape having a certain width W. Accordingly, it is possible to more effectively apply force to the display module 10. Of course, the present invention is not limited to such a shape, and the first portion 222 may have various shapes.

[0029] The first portion 222 is fixed, at a central region thereof, to the display module 10 (in this embodiment, the support member 14) such that it cannot move at the central region. In this case, the first portion 222 is movable at opposite end regions thereof. Since the first portion 222 is movable (in this case, forward and rearward) at the opposite end regions thereof while being fixed at the central region thereof, the shape of the first portion 222 is variable.

[0030] The first portion 222 is fixed at the central region thereof by fixing members 222a such that it cannot move. The distance between the central region of the first portion 222 and the support member 14 may be greater than the distance between each end region of the first portion 222 and the support member 14. For example, the first portion 222 may be disposed on the support member 14 such that the central region of the first portion 222 is further protruded rearward from the display module 10, as compared to other regions of the first portion 222 and, as such, the first portion 222 has a curved structure. Then, as an example in accordance with FIG. 5(b), when the display module 10 is varied in shape to have a predetermined radius of curvature R throughout the entirety thereof in accordance with variation in the length of the second portion 224 by the driver 24, the shape variation can be more easily achieved. Each fixing member 222a may be constituted by a fastener such as a PEM nut or a screw. Using a PEM nut or a screw, it is possible to achieve simple and easy fastening. Of course, the

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present invention is not limited to the above-described structures, and various fixing methods and structures may be employed for fixing of the first portion 222 to the support member 14.

[0031] The opposite end regions of the first portion 222 may be movably held by guide members 226 fixed to the support member 14, respectively. Accordingly, it is possible to movably hold the first portion 222 while preventing the first portion 222 from being downwardly bent at the opposite end regions thereof.

[0032] Each guide member 226 includes an upper portion 226a spaced from the support member 14, to form a predetermined space therebetween, and side portions 226b bent from the upper portion 226a, to be disposed adjacent to the support member 14. The side portions 226b are fixed to the support member 14 by fastening members 226c. For example, fixing of each guide member 226 to the support member 14 may be achieved by mounting PEM nuts 142 to the support member 14, and fastening the fastening members 226c, which may be screws, to the PEM nuts 142 through fastening holes formed at the side portions 226b. Using the PEM nuts and screws as described above, it is possible to easily and simply achieve fastening. Of course, the present invention is not limited to the above-described structures, and various fixing methods and structures may be employed for fixing of the side portions 226b to the support member 14.

[0033] The second portion 224 may have a wire structure, and may be fixed, at opposite ends thereof, to the opposite ends of the first portion 222, respectively. The second portion 224 is coupled to a rotating shaft 349 of the driver 24, and a portion of the second portion 224 can be wound on or unwound from the rotating shaft 349, to vary the connection length of the second portion 224. This will be described in more detail later.

[0034] Each end of the second portion 224 may be fixed to the first portion 222 by a fixing member 228 such as an adhesive or a seal after extending through a hole 222b formed at the corresponding end of the first portion 222. Of course, the present invention is not limited to the above-described method, and various fixing methods may be employed for fixing of the second portion 224 to the first portion 222.

[0035] The second portion 224 may be made of a material exhibiting little or no stretchability even under diverse conditions while having high yield strength. When the second portion 224 is stretchable, it is difficult to accurately vary the connection length of the second portion 224. In addition, it may be necessary to provide increased mechanical energy. For example, the second portion 224 may include a metal steel wire (for example, a stainless wire), an aramid fiber, a carbon steel wire or the like. The second portion 224 may have a diameter of 0.5 to 10mm. When the diameter of the second portion 224 is less than 0.5mm, there may be a problem in that the second portion 224 may snap or deform upon receiving energy from the driver 24. On the other hand, when the diameter of the second portion 224 exceeds 10mm, there may be problems of increased costs and complicated configurations because mechanical energy required to vary the connection length of the second portion 224 should be increased. Of course, the present invention is not limited to the above-described embodiment, and the second portion 224 may include various materials and may have various diameters. Although only one second portion 224 is provided in association with the first portion 222 in the illustrated embodiment, a plurality of second portions 224 may be provided. That is, various alternatives may be employed.

[0036] The driver 24 which supplies mechanical energy may have various configurations capable of varying the shape of the variable section 22. Since the driver 24 varies the shape of the variable section 22, using mechanical energy, it is possible to easily vary the shape of the variable section 22 while accurately controlling the variation degree and variation time of the variable section 22. The driver 24 will be described in more detail with reference to FIGS. 3 and 4.

[0037] FIG. 3 is a perspective view illustrating a configuration of the driver of the display apparatus according to an exemplary embodiment of the present invention. FIG. 4 is a cross-sectional perspective view of the driver corresponding to FIG. 3.

[0038] In the illustrated embodiment, the driver 24 may include a motor 242 for supplying rotational energy. As the motor 242, an ultrasonic motor may be employed. The ultrasonic motor is a motor in which frictional force generated between a vibration body vibrating using ultrasonic vibration and a mover is converted into rotational force. This motor is also called a "piezoelectric motor" in that it utilizes piezoelectric effects of piezoelectric ceramics.

[0039] The ultrasonic motor may generate great force while exhibiting a rapid response rate that is 10 times or more than that of existing electromagnetic motors. The ultrasonic motor does not generate noise during operation because it employs ultrasonic waves within an inaudible range. In addition, the ultrasonic motor may have a small size because the structure thereof is simple. The ultrasonic motor has no adverse influence on the display module 10 during operation of the display apparatus 100 because it does not include a magnet. The holding torque of the ultrasonic motor, namely, the torque to stop the ultrasonic motor, is great and, as such, no reverse rotation is generated even when no voltage is applied. Accordingly, it is possible to maintain the display module 10 in a shape-varied state without supplying separate electric power or the like. Thus, it is possible to achieve an enhancement in stability during shape variation of the display module 10. In addition, it is possible to achieve a simplified configuration because it is unnecessary to provide a separate configuration for maintaining the shape-varied state.

[0040] The driver 24 may further include a reducer 244 for reducing the speed of the motor 242, for example,

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using reduction ratios, thereby increasing rotational energy supplied by the motor 242. Using the reducer 244, it is also possible to greatly reduce the size of the motor 242. The reduction ratios may be performed using gears. The reduction ratio of the reducer 244 may be 1:2 to 1:300. This range is a range within which the motor 242 can supply mechanical energy capable of sufficiently varying the shape of the variable section 22 while having a minimum size. Of course, the reduction ratio of the reducer 244 may be varied in accordance with the kind of the motor 242, the structure and system of the variable section 22, or the like.

[0041] In the illustrated embodiment, the motor 242 and reducer 244 are disposed within a housing 246.

[0042] When the housing 246 is employed, it is possible to simplify the structure of the driver 24. Fixing of the driver 24 can be easily achieved by coupling fastening members 246b into fastening holes 246a of the housing 246, thereby fastening the housing 246 to the support member 14. In this case, PEM nuts (not shown), to which the fastening members 246b will be fastened, may be provided at the support member 14. In the illustrated case, the housing 246 includes a first housing section 247, in which the motor 242 is disposed, and a second housing section 248, in which the reducer 244 is disposed. Accordingly, the motor 242 and reducer 244 are prevented from interfering with each other. Of course, the present invention is not limited to the illustrated embodiment, and various alternatives may be employed. For example, both the motor 242 and the reducer 244 may be accommodated within a single housing section.

[0043] It is possible to reduce the thickness of the driver 24 by arranging the motor 242 and reducer 244 in parallel in the housing 246. In this case, accordingly, it is possible to install the driver 24 without increasing the thickness of the display apparatus 100. For example, in an exemplary embodiment, a part of the housing 246, in particular, the housing section accommodating the reducer 244, may be interposed between the display module 10 and the first portion 222 of the corresponding variable section 22. In this case, the second portion 224 of the variable section 22 is coupled to the rotating shaft 349 of the reducer 244 and, as such, it is possible to adjust the connection length of the second portion 224 by winding or unwinding a portion of the second portion 224 on or from the rotating shaft 349. In this arrangement, there is also an advantage in terms of space. Of course, the present invention is not limited to such an arrangement. For example, the driver 24 may be spaced from the variable section 22. This will be described in more detail later.

[0044] The motor 242 includes a motor gear 341. The reducer 246 includes a ring gear 343 engaged with the motor gear 341, a plurality of planetary gears 345 engaged with the ring gear 343 within the ring gear 343, and a sun gear 347 engaged with the planetary gears 345. The rotating shaft 349, which is also included in the reducer 246, is coupled to the sun gear 347. The rotating shaft 349 includes a fixing portion 349a to which the second portion 224 is fixed. When the motor gear 341 of the motor 24 rotates, the ring gear 343 engaged with the motor gear 341 rotates, thereby rotating the planetary gears 345 and sun gear 347. Accordingly, the rotating shaft 349 is rotated. The planetary gears 345 may be arranged in multi-layers so as to achieve an increase in reduction ratio.

[0045] The rotating shaft 349 is protruded outwards of the housing 246 toward the display module 10. A recessed fixing portion 349a is formed at a protruded end of the rotating shaft 349. The second portion 224 is engaged, at a central region thereof, in the recessed fixing portion 349a. Accordingly, the second portion 224 is coupled to the rotating shaft 349. Thus, it is possible to easily couple the second portion 224 to the rotating shaft 349 without a separate configuration by forming the recessed fixing portion 349a at the rotating shaft 349. Of course, the present invention is not limited to the above-described embodiment, and various alternatives may be employed. For example, the fixing portion 349a may have various structures. The fixing portion 349a may also be provided separately from the rotating shaft 349.

[0046] Although not shown, a guide path to guide winding of the second portion 224 may be formed on an outer surface of the rotating shaft 349. In this case, the second section 224 can be more stably wound on the rotating shaft 349 using the guide path.

[0047] Although one driver 24 is provided for each of the plural variable sections 22 in the illustrated embodiment, the present invention is not limited thereto. Alternatively, the plural variable sections 22 may be driven by one driver 24. This will be described in more detail later with reference to FIG. 6. Although a planetary gear reducer is employed as the reducer 244 in the illustrated embodiment, various structure and systems may be employed for the reducer 244.

[0048] The rear cover 30 is disposed in rear of the display module 10 and variable member 20. The rear cover 30 protects the display module 10, panel driver, and etc., from external impact while providing a space where the panel driver, and etc., are disposed. The rear cover 30 also covers the panel driver, and etc., to prevent an inner configuration of the display module 10 from being outwardly exposed, and thus to achieve an enhancement in appearance. For example, the rear cover 30 has a surface gently curved throughout the rear cover 30, to secure a sufficient space and to achieve an enhancement in appearance. In an exemplary embodiment, the rear cover 30 includes a material, a structure, or the like capable of coping with a variation in shape of the display module 10.

[0049] The above-described shape variation of the display apparatus 100 will be described in more detail with reference to FIGS. 5(a) and 5(b). FIGS. 5(a) and 5(b) are views explaining shape variation of the display apparatus 100 according to an exemplary embodiment of the present invention. For reference, FIGS. 5(a) and 5(b) are cross-sectional views taken along the line V -V of FIG. 2. For simplicity and convenience of description, illustra-

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tion of the guide member 226 and rear cover 30 is omitted from FIGS. 5(a) and 5(b). For convenience of description, the following description will be given in conjunction with one variable section 22.

[0050] The display module 10 is kept in a flat state, as shown in FIG. 5(a), when there is no force applied to the display module 10.

[0051] The first portion 222 of the variable section 22 is fixed at the central region thereof by the fixing members 222a such that it cannot move. The first portion 222 is also disposed such that the central region of the first portion 222 is further protruded rearward from the display module 10, as compared to other regions of the first portion 222. In accordance with this structure, shape variation of the display module 10 can be more easily achieved. The opposite end regions of the first portion 222 are movably held by the guide members ("226" in FIG. 2), respectively. The second portion 224 is fixed to the fixing portion ("349a" in FIG. 2) of the rotating shaft 349 in the driver 24.

[0052] When the user inputs a command to vary the shape of the display apparatus 100, the driver 24 is driven by an element, for example, included in the panel driver to drive the driver 24. For example, the motor 242 rotates to rotate the rotating shaft 349 of the reducer 244. Accordingly, the second portion 224 fixed to the rotating shaft 349 is rotated together with the rotating shaft 349 and, as such, a portion of the second portion 224 is wound on the rotating shaft 349. As a result, the connection length of the second portion 224 is reduced, thereby reducing the rectilinear distance between the opposite ends of the first portion 222. Thus, the first portion 222 is bent throughout the entirety thereof such that the opposite end regions thereof protrude forward and, as such, the shape of the display module 10 is also varied. For example, the display module 10 is varied into a curved structure having a uniform radius of curvature R in the lateral direction of the display module 10, as shown in FIG. 5(b). Thus, the display module 10 provides an enhancement in sensory immersion of the user.

[0053] When the user inputs a command again to revert the shape of the display module 10 back to its the original shape, the portion of the second portion 224 wound on the rotating shaft 349 is unwound. As such, the length of the second portion 224 is increased to its original length, and the display module 10 reverts to a flat state, as shown in FIG. 5(a). Accordingly, the variable section 22 is returned to an original state thereof.

[0054] Thus, in the illustrated embodiment, it is possible to vary the shape of the display module 10 in order to achieve an enhancement in sensory immersion of the user. Using the driver 24 which supplies mechanical energy for shape variation of the display module 10, it is possible to easily vary the shape of the variable section 22 while accurately controlling the shape variation degree and time of the variable section 22. In addition, since the motor 242 (in particular, the ultrasonic motor) and reducer 244 are employed for the driver 24, the driver 24 can have a small size. It is also possible to vary the shape of the display module 10 without generation of noise.

[0055] For reference, the command to vary the shape of the display apparatus 100 may be input to the display apparatus 100 by various methods. For example, the user may input the comment by pushing or pressing a button of the display apparatus, by using a device for a remote control (for example, a remote controller of the display apparatus 100), by moving a body of the user (such as, moving eyes of the user or applauding), and so on.

[0056] Hereinafter, a display apparatus according to another exemplary embodiment of the present invention will be described with reference to FIG. 6. With regard to the following embodiment, no description will be given of matters identical or very similar to those of the above-described embodiments, and only the different matters will be described in detail.

[0057] FIG. 6 is an exploded perspective view of a display apparatus according to another exemplary embodiment of the present invention.

[0058] Referring to FIG. 6, in this embodiment, a plurality of variable sections 22 are provided, and one driver 24 drives the plural variable sections 22. For example, in this embodiment, the driver 24 is disposed to be spaced from the plural variable sections 22. A path change member 28 is disposed between each variable section 22 and the display module 10, to change a movement path of the second section 224 toward the driver 24. In the illustrated embodiment, the path change member 28 protrudes from the support member 14. The path change member 28 has a cylindrical shape, and does not rotate. The path change member 28 may be mounted to the support member 14, using a PEM nut, a screw or the like. Of course, the path change member 28 may be mounted to the support member 14 in accordance with various methods.

[0059] The path change member 28 may be formed with a first guide 282 to guide movement of one part of the second portion 224 extending between one end region of the first portion 222 and the driver 24, and a second guide 284 to guide movement of the other part of the second portion 224 extending between the other end region of the first portion 222 and the driver 24. Accordingly, the two parts of the second portion 224 do not interfere with each other during movement thereof. The first and second guides 282 and 284 may be grooves formed on an outer surface of the path change member 28, as shown in an enlarged circle of FIG. 6. Each second portions 224 of the variable sections 22 may be fixed to the rotating shaft ("349" in FIG. 2) of the driver 24 under the condition that they are connected together. Thus, the connection lengths of each second portions 224 are simultaneously reduced or increased in accordance with rotation of the rotating shaft 349. Of course, the present invention is not limited to the above-described arrangement. In another exemplary embodiment, the second portions 224 of a plurality of the variable sections 22 may be connected together. In this instance, the second por-

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tions 224 connected together may be connected to the driver 24 under the condition that only the movement paths thereof are guided by the path change members 28. Alternatively, each path change member 28 may be rotatably mounted to the support member 14. Of course, various alternatives may be employed.

[0060] When a plurality of variable sections 22 are driven by one driver 24, as described above, it is possible to easily vary the shape of the display module 10 while achieving structure simplification.

[0061] As apparent from the above description, in the display apparatus according to the above-described embodiment, it is possible to vary the shape of the display module so as to achieve an enhancement in sensory immersion of the user. Using the driver which supplies mechanical energy for shape variation of the display module, it is possible to easily vary the shape of the variable section while accurately controlling the shape variation degree and time of the variable section. In addition, since the motor (in particular, the ultrasonic motor) and reducer are employed for the driver, the driver can have a small size. It is also possible to vary the shape of the display module without generation of noise.

[0062] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. A display apparatus comprising:

   a display module including a flexible display panel to display an image; and
   a variable member to vary a shape of the flexible display panel,
   wherein the variable member comprises
   at least one variable section capable of bending in shape, and
   at least one driver to supply mechanical energy to bend the shape of the variable section,
   wherein, the flexible display panel is varied in shape by the bending in shape of the variable section.

2. The display apparatus according to claim 1, wherein the flexible display panel is varied by the variable member to correspond to the shape of the variable section.

3. The display apparatus according to claim 1, wherein the variable section comprises a first portion located at the display module, and a second portion located at the first portion, the second portion having a connection length variable by the driver to thereby bend a shape of the first portion.

4. The display apparatus according to claim 3, wherein:

   the first portion has a band shape;
   the second portion has a wire shape; and
   the second portion is fixed, at opposite ends thereof, to opposite ends of the first portion, respectively.

5. The display apparatus according to claim 3, wherein:

   the first portion comprises a composite material; and
   the second portion comprises one of a metal wire, a non-metal wire, or a composite wire.

6. The display apparatus according to claim 1, wherein:

   the variable section is elongated in one direction; and
   the variable section is fixed, at a central region thereof, at the display module such that the variable section does not move at the central region.

7. The display apparatus according to claim 6, wherein the variable section is movably fixed, at end regions thereof, by guide members fixed at the display module, respectively.

8. The display apparatus according to claim 1, wherein the driver comprises a motor.

9. The display apparatus according to claim 8, wherein the motor comprises an ultrasonic motor.

10. The display apparatus according to claim 8, wherein:

    the variable section comprises a first portion located at the display module, and a second portion located at the first portion;
    the driver comprises a rotating shaft rotatable by a rotating force from the motor;
    the second portion is fixed on the rotating shaft, and has a connection length variable in accordance with winding or unwinding of a portion of the second portion on or from the rotating shaft.

11. The display apparatus according to claim 10, wherein:

    the rotating shaft is formed with a fixing portion at an end of the rotating shaft disposed toward the display module; and
    the second portion is fixed on the fixing portion.

12. The display apparatus according to claim 8,

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wherein the driver further comprises a reducer connected to the motor.

13. The display apparatus according to claim 12, wherein the motor and the reducer are disposed in parallel at the display module.

14. The display apparatus according to claim 1, wherein:

the at least one variable section comprises a plurality of variable sections and the at least one driver comprises a plurality of drivers respectively corresponding to the plurality of variable sections, and/or
wherein:

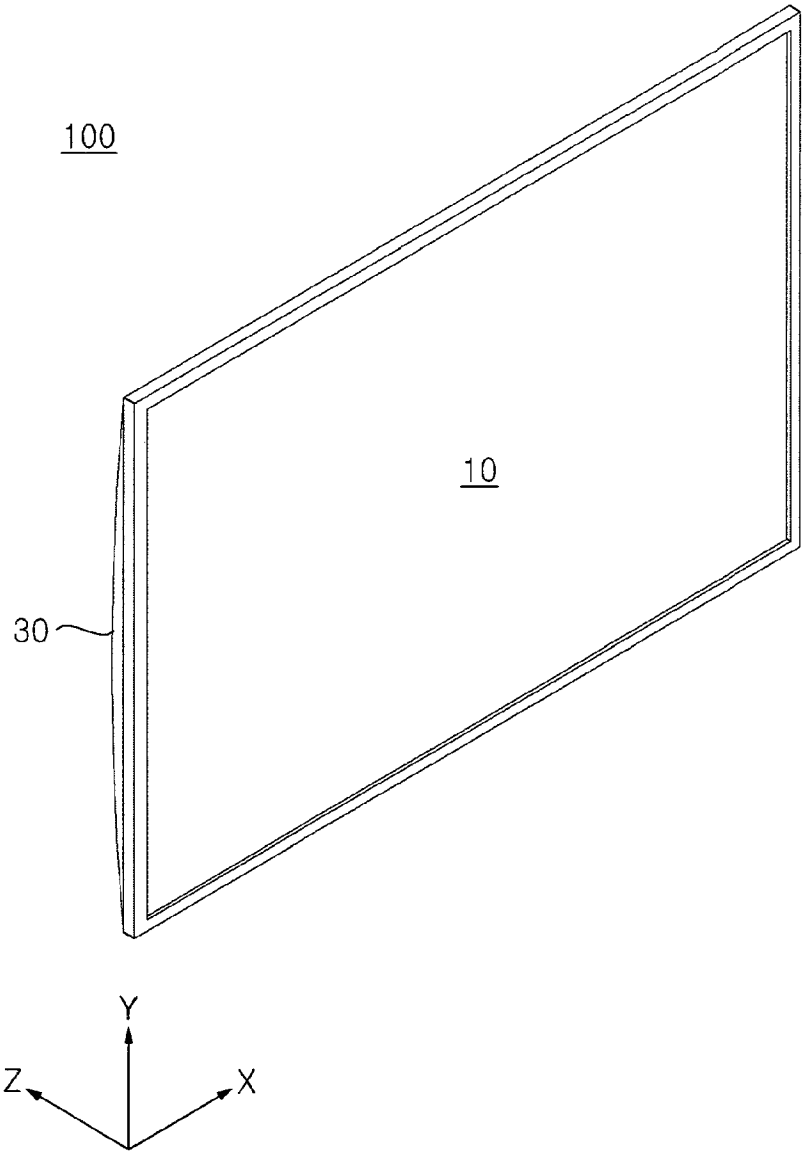
the at least one variable section comprises a plurality of variable sections, and the at least one driver comprises a driver to drive the plurality of variable sections.

15. The display apparatus according to claim 1, wherein:

the at least one variable section comprises a plurality of variable sections;
the at least one driver comprises a driver to drive the plurality of variable sections;
the at least one variable section comprises a first portion fixed on the display module, and a second portion disposed between the display module and the first portion, and fixed on the first portion;
the driver is spaced from the variable section; and
a path change member is disposed between the at least one variable section and the display module, to change a movement path of the second portion toward the driver.

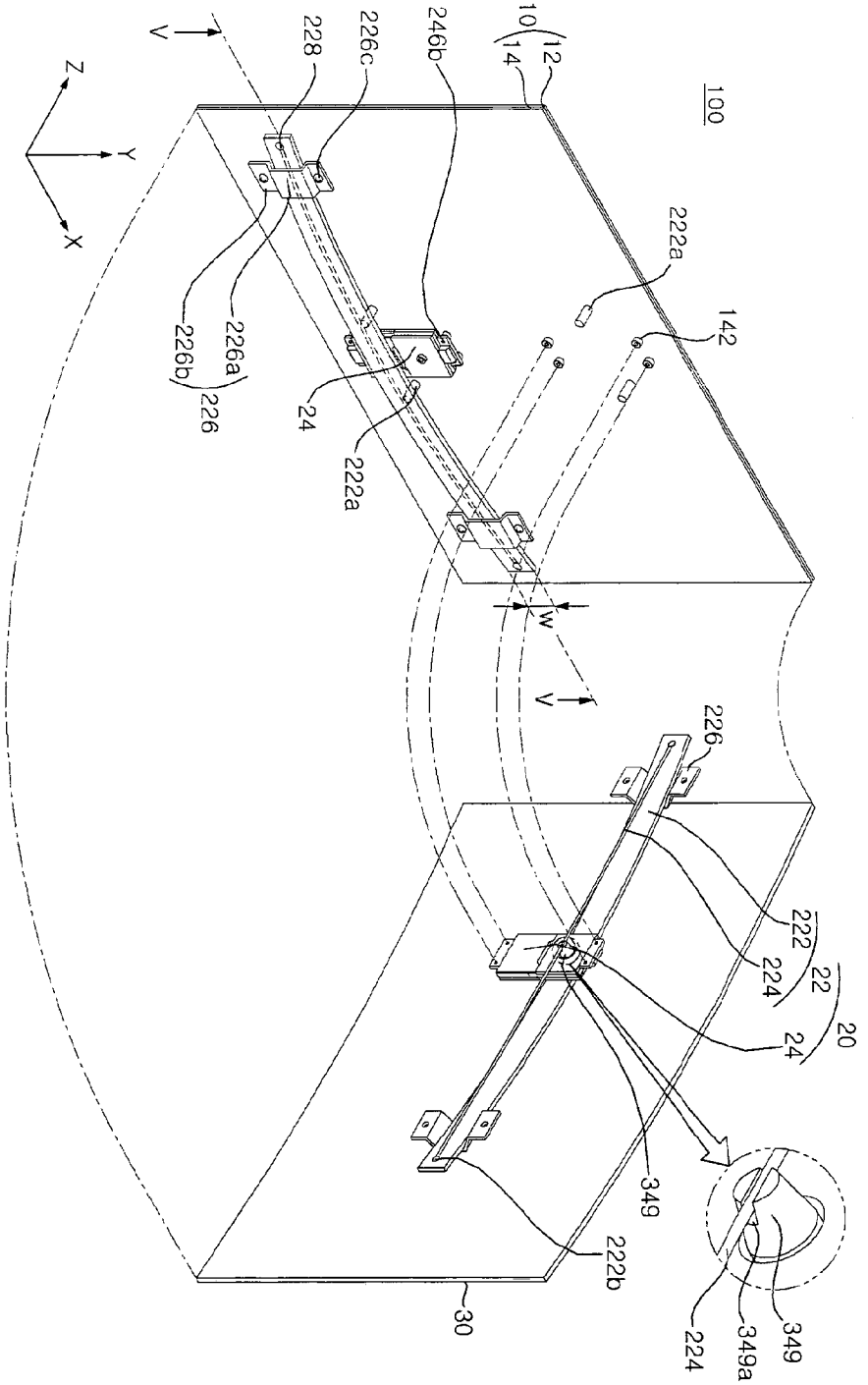
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FIG. 1



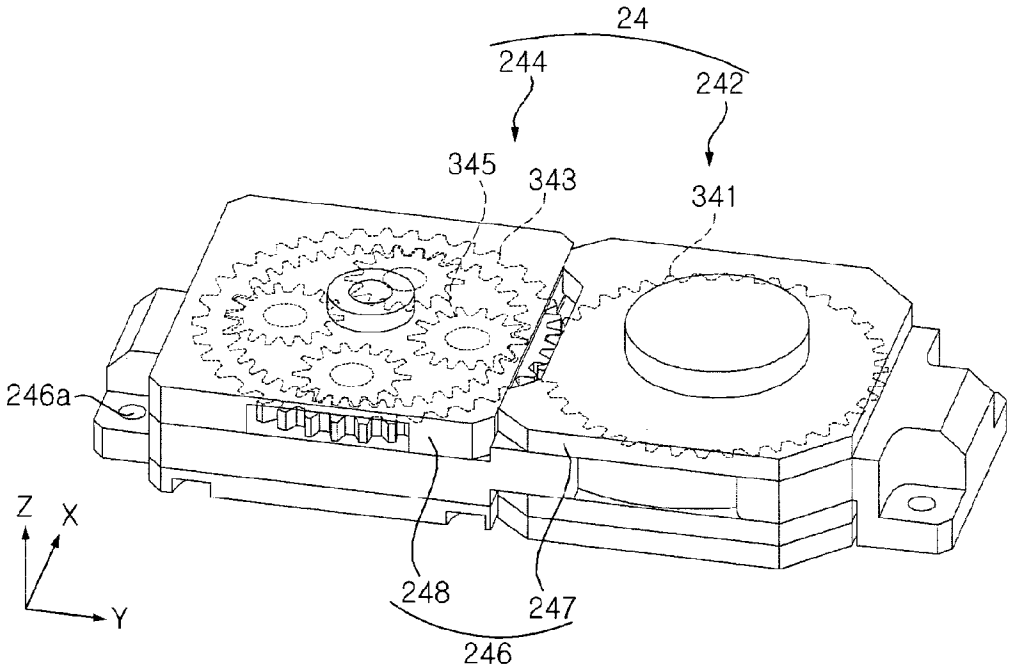
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FIG. 2



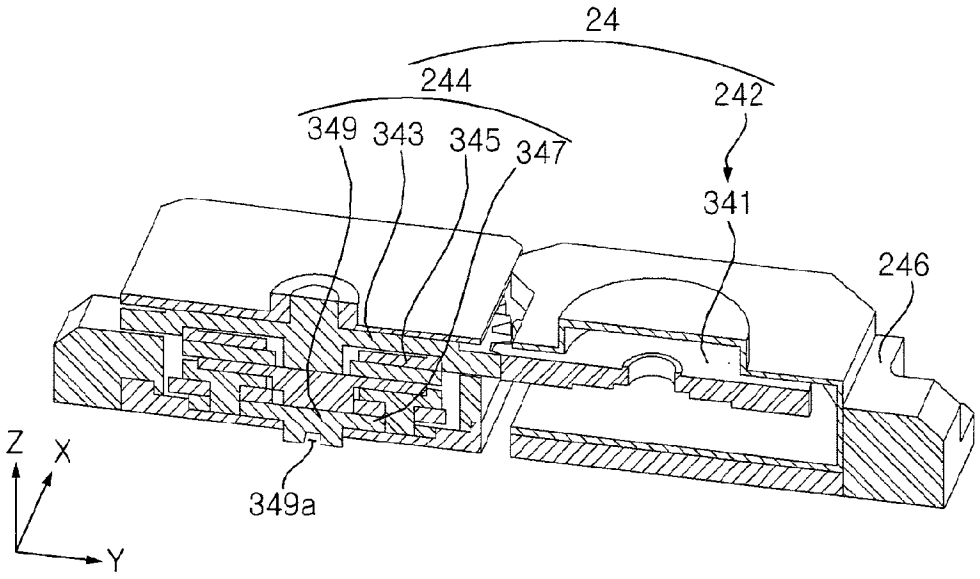
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FIG. 3



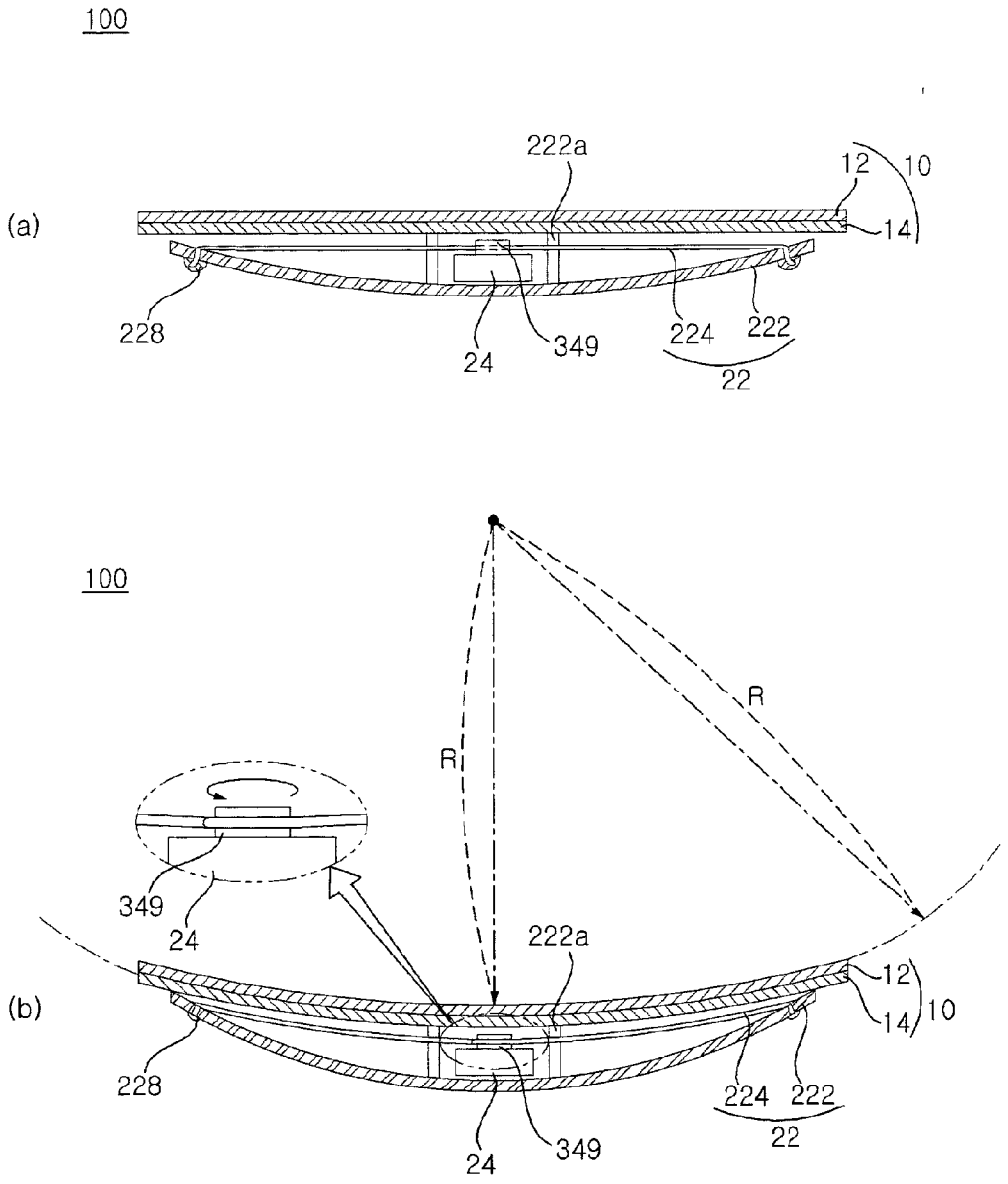
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FIG. 4



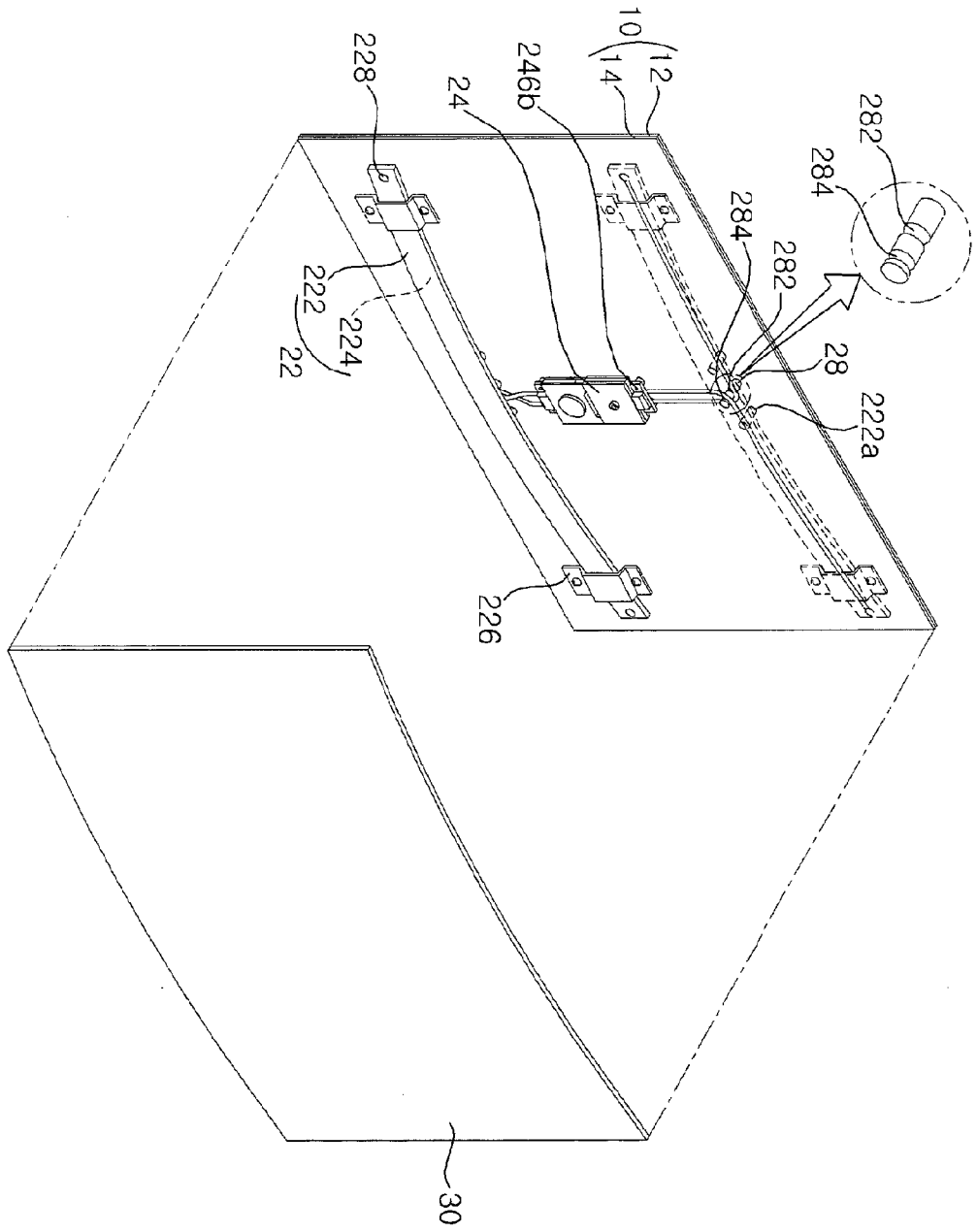
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FIG. 5



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FIG. 6



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REFERENCES CITED IN THE DESCRIPTION

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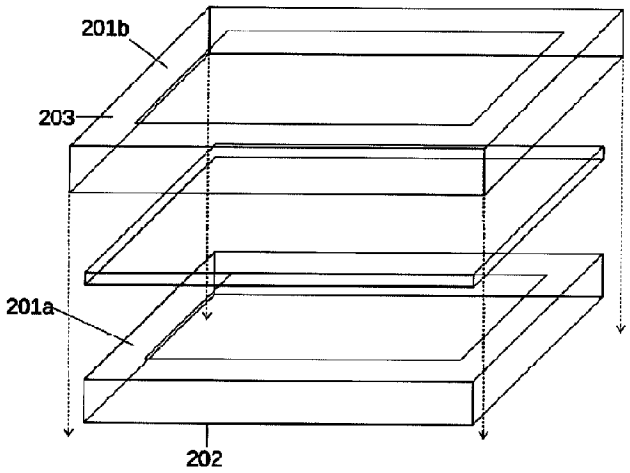


Figure 5b

(57) Abstract: An assembly for holding and controlling curvature of a glass plate for an optical touch sensitive system is described. The assembly comprising a first frame element extending in a first plane and configured to extend at least partially around a panel; at least one second frame element extending in a second plane and forming a support portion for the plate, and at least one spacing element positioned at least partially between the support portion and the first frame element. The spacing element us configured to control a curvature of the first frame element and wherein the at least one second frame element is configured to engage the plate at the support portion, is attached to the first frame element, and is tiltable, by controlling the curvature of the first frame element with said spacing element, to control a curvature of the plate.

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AN IMPROVED TOUCH DEVICE

Field of the Invention

This invention relates in general to the field of optical touch sensitive systems. More particularly, the invention relates to a curved plate and an assembly for holding a plate of the system, such as a glass plate, relative to a panel such that curvature of the plate is controlled. The invention also relates to a method for assembling a plate of an optical touch sensitive system with a panel (such as a display panel) in such a way that curvature is controlled.

Background of the Invention

In one category of touch sensitive panels known as above surface optical touch systems and known from e.g. US4459476, a plurality of optical emitters and optical receivers are arranged around the periphery of a touch surface to create a grid of intersecting light paths above the touch surface. Each light path extends between a respective emitter/receiver pair. An object that touches the touch surface will block certain ones of the light paths. Based on the identity of the receivers detecting a blocked light path, a processor can determine the location of the intercept between the blocked light paths. This type of system is only capable of reliably detecting the location of one object (single-touch detection). Further, the required number of emitters and receivers, and thus cost and complexity, increases rapidly with increasing surface area and/or spatial resolution of the touch panel.

In a variant, e.g. shown in WO2006/095320, each optical emitter emits a beam of light that diverges across the touch surface, and each beam is detected by more than one optical receiver positioned around the periphery of the touch surface.

These systems typically direct light to travel across the surface of the touch surface at a height of up to 5 mm.

Other above surface touch sensitive systems use tomographic touch imaging for sensing a touch, e.g. as described in WO2016/130074. Such systems allow for directing the light much closer to the touch surface, which in turn allows for significant improvements in accuracy and requires a lower light budget. The light is typically directed at a height of up to about 1 mm above the plate.

Typically, the touch surface is a glass plate. In systems where the light is directed closer to the touch surface, distortions in the plate have a disproportionally large effect on the light signal. Therefore, glass plates as used in previously known above surface optical touch systems are unsuitable when the light is transmitted closer to the plate, since the accuracy of the system is impaired by the distortions in the plate.

Additionally, a frame for assembly of the plate of the optical touch sensitive system and a panel, such as an LCD panel, may introduce distortion in the form of uncontrolled warpage, i.e. a twist or curve in the plate is introduced even if it is usually flat. The uncontrolled warpage may even block the light transmitted across the plate. This is due to uncontrolled twisting of the frame as such when it is attached to the panel.

Although not described in relation to touch systems, methods of minimizing glass warpage are known from the window industry and from the display panel industry. Such solutions include pre-bent glass in order to control warpage. However, such solutions are unsuitable/insufficient for touch sensitive systems since they typically require bulky frames at the border of the glass and/or pressure points closer to the center of the panel where force may be applied to control the shape of the glass. These solutions are unsuitable where a minimal/lightweight border bezel is required, and no supporting objects may touch the glass further in than at the borders. Additionally, pre-bent glass is expensive and fragile to transport.

Therefore, an improved frame assembly for holding a plate of an optical touch sensitive system relative to a panel would be advantageous and in particular allowing for improved precision, increased compactness, cost-effectiveness, and/or controlled curvature would be advantageous. Further, a touch panel having a shape conducive to transmitting as much light from the emitters as possible to the detectors is needed.

Summary of the Invention

Accordingly, embodiments of the present invention preferably seek to mitigate, alleviate or eliminate one or more deficiencies, disadvantages or issues in the art, such as the above-identified, singly or in any combination by providing an assembly, a method for assembling, and a kit of frame elements according to the appended patent claims.

A first embodiment of the invention describes an assembly for holding and controlling curvature of a plate for an optical touch sensitive system, comprising a first frame element extending in a first plane and configured to extend at least partially around a panel; at least one second frame element extending in a second plane and forming a support portion for the plate, and at least one spacing element positioned at least partially between the support portion and the first frame element, the spacing element being configured to control a curvature of the first frame element, and wherein the at least one second frame element is configured to engage the plate at the support portion, is attached to the first frame element, and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element with said spacing element, to control a curvature of the plate.

A second embodiment of the invention describes a method for assembling a panel and a plate for an optical touch sensitive system, comprising: providing a first frame element extending in a first plane and configured to extend at least partially around a panel; providing at least one second frame element forming a support portion for the plate; supporting the plate by the support portion; attaching the second frame element to the first frame element such that the support portion extends at least partially in a second plane generally opposite at least a portion of the first frame element and is spaced apart from the first plane; and controlling a curvature of the first frame element with a spacing element attached to the first frame element and thereby tilting the support portion to control a curvature of the plate.

A third embodiment of the invention describes a kit of frame elements for assembling a panel and a plate for a touch sensitive system, comprising: a first frame element extending in a first plane; at least one second frame element forming a support portion for the plate and being attachable to the first frame element, and a spacing element adjustably attachable to the first frame element; wherein at least a portion of the support portion is tiltable, by the spacing element, relative to the first frame element to extend in the second plane, which is curved.

Some embodiments of the invention provide for controlling curvature of a plate for an optical touch sensitive system such that it does not occur when the plate is assembled with a panel. This prevents distortion in the plate from affecting a light signal transmitted across the plate, which in turn allows improvements in accuracy and lower light budget of the system. Additionally, or alternatively, embodiments provide for controlling curvature such that the field of view, for a detector receiving light from a light emitter of the touch sensitive system, is increased compared to a substantially flat plate. Again, the improved field of view provides for improved accuracy of the touch sensitive system and allows for a better light budget. Furthermore, embodiments provide for an assembly that is compact at the same time as curvature may be controlled. Also, the curvature may be controlled without contacting the center of the plate.

A fourth embodiment of the invention describes a touch sensing apparatus, comprising a touch surface; a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface, a set of light detectors arranged around the touch surface to receive light from the first set of emitters, wherein each light detector is arranged to receive light from more than one emitter; a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface, wherein the touch surface is curved in a first axis according to a first parabola.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Brief Description of the Drawings

These and other aspects, features and advantages of which embodiments of the invention are capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which:

Figure 1 is a top view of the first frame element showing cross-sectional axes A-A and B-B;

Figures 2a-2d are cross-sectional views of embodiments of assemblies;

Figure 3a is a schematic illustration showing the cross-section axis B-B of figure 1 of the assembly with the second frame element relative to the first frame element and holding the plate in a flat plane;

Figure 3b is a schematic illustration showing the cross-section axis A-A of figure 1 of the assembly with the second frame element relative to the first frame element and holding the plate in a flat plane;

Figure 3c is a schematic view (cross section) showing the cross-section axis B-B of figure 1 of the assembly with the second frame element warped relative to the first frame element and holding the plate in a curved plane that is concave;

Figure 3d is a schematic view (cross section) showing the cross-section axis A-A of figure 1 of the assembly with the second frame element warped relative to the first frame element and holding the plate in a curved plane that is concave;

Figure 4a is a perspective view of the first frame element;

Figure 4b is a schematic illustration of the panel in a convex shape and the frame of the first frame element in a concave shape, including plate 2 also controlled into a concave shape;

Figure 4c is a side view showing screws 116a and 116b;

Figures 5a-5h are side views and perspective views of an embodiment of the assembly comprising a screw arrangement for configuring frame shape; and

Figures 6 is a schematic cross section from a first direction of an embodiment of the assembly;

Figure 7 is a schematic side-view of another embodiment for providing curvature of plate 2;

Figure 8 shows an isometric view of a variation of the embodiment of figures 5a-5g;

Figure 9 is a diagram showing a top down view of an optical touch system and corresponding detection lines;

Figure 10a shows an isometric view of a flat touch surface of an optical touch system;

Figure 10b shows a section view of an optical touch system with a flat touch surface;

Figure 11a shows an isometric view of a touch surface of an optical touch system having a curved profile in the x-axis;

Figure 11b shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis;

Figure 11c shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis;

Figure 11d shows an example of types of warpage that a touch panel may exhibit.

Figure 12a shows top view of a touch surface of an optical touch system;

Figure 12b shows an isometric view of a touch surface of an optical touch system having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 12c shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 12d shows a section view along the y-axis of an optical touch system with a touch surface having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 13a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 13b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 14a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 14b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 15a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 15b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 16a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 16b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 17a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 17b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 18a shows a curvature of a real touch surface vs a parabolic curved surface along an x-axis;

Figure 18b shows a deviation between a real touch surface vs a parabolic curved surface along an x-axis;

Figure 19a shows a curvature of a real touch surface vs a parabolic curved surface along an x-axis;

Figure 19b shows a deviation between a real touch surface vs a parabolic curved surface along an x-axis;

Figure 20a shows top view of displacement contours for a touch surface according to an embodiment;

Figure 20b shows curvature of a touch surface along an x-axis according to the embodiment of figure 20a;

Figure 20c shows curvature of a touch surface along a y-axis according to the embodiment of figure 20a;

Figure 20d shows curvature of a touch surface along a diagonal line according to the embodiment of figure 20a;

Figure 21a shows top view of displacement contours for a touch surface according to another embodiment;

Figure 21b shows curvature of a touch surface along an x-axis line according to the embodiment of figure 21a;

Figure 21c shows curvature of a touch surface along a y-axis line according to the embodiment of figure 21a;

Figure 21d shows curvature of a touch surface along a diagonal line according to the embodiment of figure 21a.

Description of Embodiments

Specific embodiments of the invention will now be described with reference to the accompanying drawings. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

In optical touch sensitive systems, a plate 2 of the system, such as a glass plate may be arranged opposite a panel 1, such as an LCD panel or additional frame. The plate 2 is normally substantially flat. The perimeter of the plate 2 after integration is a concern: the four sides/edges of the plate 2 must all be plane or slightly concave as seen from the touch surface, i.e. the side of the plate 2 above which light is transmitted. An aspect of this is to ensure that the mechanical parts that hold or support the perimeter of the plate 2 are free from convexity. Sometimes, there are several components that are involved in holding the plate 2 (back cover, carriers, edge cover, screw bosses etc.) The stiffer component of the assembly, the more it will govern the final shape of the plate 2.

In prior art solutions, the frame that holds the plate 2 at the edge/perimeter may introduce some twist (the corners will not lay perfectly on a flat plane) to the plate. Twist may induce convexity along the plate diagonals and should thus be minimized or avoided. The twist tolerance depends, e.g., on glass specification, product, size, shape of integrated glass perimeter, and on how a VESA mount is attached.

Figure 1 shows an embodiment of a frame assembly 100, 200 that prevents inducement of convexity along the plate, such as along the plate edges and/or diagonals. Some embodiments avoid convexity and may even induce concavity to further improve the touch system. Frame 109 is formed from first frame element 102. Attachment element 112 and spacing element 116 are described in the embodiments below.

According to some embodiments of the invention, an assembly 100, 200, which is configured to hold or support the plate 2 and the panel 1, applies a controlled force to the plate 2 such that curvature of the plate 2 is controlled. In the embodiments illustrated in figures 2a-2c and 3a-3d, the force applies a torque to a support portion 101a, 101b for the plate 2. In the embodiments of figures 4a-4c, the force is substantially straight and perpendicular to the plate 2. In the following, the embodiments of figures 2a-2c, 3a-3d, 4a-4c, and 5a-5g will be described separately. However, these embodiments may be combined to provide further embodiments, such as the combination illustrated in figures 6a-6c.

Figures 2a-2d illustrate embodiments wherein the frame assembly 100 comprises a first frame element 102 and at least one second frame element 103a, 103b. The first frame element 102 may form a rear bracket frame that extends at least partially over the backside of the panel 1. The second frame element 103a, 103b may form a holder or support bracket. Furthermore, second frame element 103a, 103b may extend along at least a portion of a perimeter of the plate 2 and/or the panel 1. Separate second frame elements 103a, 103b may extend at least partially along the perimeter of different sides of the plate 2 and/or panel 1. For example, two second frame elements 103a, 103b may extend along opposing perimeters of the plate 2 and/or panel 1. Alternatively, four second frame elements 103a, 103b may extend along the perimeter of the plate 2 and/or panel 1, i.e. one along each side of a rectangular plate 2 and/or panel 1.

As is illustrated in figures 4a-4c, the panel 1 may be held between the first frame element 102 and the second frame element 103a, 103b. The plate 2 may be supported or held at a first side of a portion of the second frame element 103a, 103b forming the support portion 101a, 101b. The panel 1 may be held or supported by a second side of the support portion 101a, 101b, which forms a support portion for the panel 1. An adhesive 104, such as an adhesive tape, may be arranged between the support portion 101a, 101b and the plate 2. A gasket 105 may be arranged between the support portion 101a, 101b and the panel 1.

In one embodiment, elements 102, 103 (shown in the figure as comprising elements 103a and 103b) are formed from a single piece.

The second frame element 103a, 103b may be attached to the first frame element 102.

In the embodiments of figures 2a-2c and 3a-3d, the second frame element 103a, 103b, is attached to the first frame element 102 by at least one attachment member 106a, 106b, such as a screw, a weld, a rivet etc. Therefore, the second frame element 103a, 103b may be rigidly attached to the first frame element 102.

The first frame element 102 may comprise a flange 107a, 107b that extends at the perimeter of the first frame element 102. Similarly, the second frame element 103a, 103b may comprise a flange 108a, 108b. When assembled, the flange 107a, 107b of the first frame element 102 may be arranged in abutment with the flange 108a, 108b of the second frame element 103a, 103b. The flange 107a, 107b of the first frame element 102 may be held together with the flange 108a, 108b of the second frame element 103a, 103b by the attachment member 106a, 106b.

The first frame element 102 may form a frame 109 (shown in figure 1) that extends in a first plane. The frame 109 is configured to extend at least partially around a first side of a panel 1. The first side of the panel 1 may be the backside of the panel 1. In some embodiments, the frame 109 has a width, such as 3-10 cm. The frame 109 may extend from the edges of the first side towards the center of the first side of the panel 1. Therefore, the frame 109 may be rectangular, and made from a single piece of material.

As is illustrated in figures 3a and 3b, the assembly 100 may comprise at least one support area 110a, 110b for supporting a back cover 111. The support area 110a, 110b may extend in a plane that is substantially parallel to the first plane, in which the frame 109 extends. The support area 110a, 110b may be located further away from the support portion 101a, 101b of the second frame element 103a, 103b than the frame 109, such that the frame 109 and the back cover 111 are spaced apart. In the illustrated embodiment, the support area 110a, 110b is provided between the flange 107a, 107b and the frame 109 of the first frame element 102. The back cover 111 may be attached to the support area 110a, 110b, e.g. by attachment elements, such as screws.

In other embodiments, the support area 110a, 110b is provided by the flange 108a, 108b of the second frame element 103a, 103b. The flange 107a, 107b of the first frame element 102 may be connected to the second frame element 103a, 103b between the flange 108a, 108b and the support portion 101a, 101b of the second frame element 103a, 103b.

The second frame element 103a, 103b may form the support portion 101a, 101b. For example, the second frame element 103a, 103b may form an elongated member that is at least partly L-shaped in cross-section. When assembled, the second frame element 103a, 103b may extend along the perimeter of the panel 1, and wrap around the perimeter of the panel such that the support portion 101a, 101b extends at least partially in a second plane generally opposite the frame 109 and spaced apart from the first plane. Thereby the second frame element 103a, 103b is configured to extend at least partially at a second side of the panel 1, e.g. at a front side of the panel 1.

In some embodiments, the second frame element 103a, 103b has a first portion and a second portion. The first portion may be provided at an angle relative to the second portion. The second portion may form the support portion 101a, 101b and be configured to extend in the second plane opposite the frame 109. The first portion may extend between the second portion and the first frame element 102. Also, the first portion may extend along the edge or side surface of the plate 2 when assembled. The first frame element 102 may be connected to the first portion of the second frame element 103a, 103b. The first portion may be substantially perpendicular to the second portion.

As is illustrated in figures 3a-3d, the first frame element 102 may be attached to the first portion of the second frame element 103a, 103b such they are fixed relative to each other. Furthermore, the second frame element 103 is tiltable relative to the first frame element 102. A force applied to the first frame element 102 is transferred to the second frame element 103 such that the support portion 101a, 101b is tilted towards the first frame element 102. Thus, a torque may control tilt of the second portion of the second frame element 103a, 103b, i.e. the support portion 101a, 101b that supports the plate 2, relative to the first frame element 102, which is illustrated with a curved arrow in figure 3c and 3d. In some embodiments, the angle of tilt of the support portion 101a, 101b is controlled to be neutral, i.e. the angle of tilt of the support portion 101a, 101b is controlled such that it is substantially parallel with the panel 1 and/or controls the plate 2 to be in a flat plane, as is illustrated in figures 3a and 3b. In other embodiments, the angle of tilt of the support portion 101a, 101b is controlled to be negative relative to the touch surface, i.e. the angle of tilt of the support portion 101a, 101b is controlled such that the free end of the support portion 101a, 101b is tilted towards the frame 109, as is illustrated in figure 3c and 3d. In the latter case, the plate 2 is given a slightly concave shape, i.e. in the direction from the touch surface of the plate 2 towards the panel 1. In each of these cases curvature is controlled such that the field of view, for a detector receiving light from a light emitter of the touch sensitive system, is improved since convexity in the plate is avoided. Again, improved field of view provides for improved accuracy of the touch sensitive system and allows for lower light budget. Furthermore, since the support portion 101a, 101b only needs to extend a short distance over the plate 2 at the perimeter the assembly is compact at the same time as curvature may be controlled. Also, curvature may be controlled without contacting the center of the plate. When the concavity is applied, the sensitivity of the system may be even further improved.

Figures 2a-2d and 3a-3d illustrate embodiments of an attachment element 112 for attaching the first frame element 102 to the panel. A plurality of attachment elements 112 (e.g. as shown in triplicate as elements 112a, 112b, and 112c) may be arranged around

the frame 109, such as at each corner of the frame 109, which is illustrated as circles in figure 4a. Each attachment element may comprise a group of screws 112a, 112b, 112c, 113a, 113b. Each screw may be arranged in a hole of the frame 109, which may be threaded. Each attachment element may comprise at least two screws 112a, 112b, 112c, 113a, 113b. At least one of the screws 112a, 113a may be arranged to displace the frame 109 away from panel 1, which is indicated with an arrow in figure 2d e.g. by having a thread in the frame 109 and pushing on the panel 1. At least one other of the screws 112b, 112c, 113b may be arranged to displace the frame 109 towards the panel 1, which is also indicated with an arrow in figure 2d. e.g. by having a thread in the panel and a hole in frame 109.

Figure 2a illustrates an embodiment wherein each attachment element comprises at least three screws 112a, 112b, 112c. All three screws 112a, 112b, 112c are arranged closer to a center of the first frame element 102 than a perimeter of the support portion 101a, 101b, i.e. an imaginary extension 114a, 114b, 114c of the longitudinal axis of each screw 112a, 112b, 112c passes outside the support portion 101a, 101b when viewed in cross-section, as is illustrated in figure 2a. In the illustrated embodiment, a first screw 112a is arranged between a second screw 112b and a third screw 112c. Figure 2a only illustrates one group of screws. However, a group of screws may be arranged at any location around the frame 109 to attach the first frame element 102 to the panel 1.

Figure 2b illustrates an embodiment wherein each group of screws consists of only two screws 113a, 113b. A first screw 113a is arranged opposing the support portion 101a, 101b, i.e. an imaginary extension 115a of the longitudinal axis of the first screw 113a passes through the support portion 101b when viewed in cross-section, such as through the center thereof, as is illustrated in figure 2b. A second screw 113b of the two screws is arranged closer to a center of the first frame element 102 than a perimeter of the support portion 101b, i.e. an imaginary extension 115b of the longitudinal axis of the first screw 113b passes outside the support portion 101b when viewed in cross-section, as is illustrated in figure 2b.

As shown in figure 2d, the first screw 112a is arranged to displace the frame 109 away from panel 1. This may be enabled by a threaded hole 112i in the frame 102 which the first screw engages while a head of the screw abuts the panel 1. The second screw 112b is arranged to displace the frame 109 towards the panel. This may be enabled by a threaded hole 112f in the panel 1, which the second screw 112b engages while the head of the second screw 112b abuts the surface of the frame. By using screw 112a and/or 112b, forces may be applied to frame 102 and/or panel 2 to control bending or rotation of the frame/panel.

Since the first screw 113b is aligned over the support portion 101a, 101b in the embodiment of figure 2b, only two screws are required to control bending or rotation of the frame.

In figures 2a-2b, only one group of screws is illustrated. However, a group of screws may be arranged at any location around the frame 109 to support the plate 2 and the panel 1.

figure 2c illustrates that a combination the embodiment of figures 2a and 2b, i.e. groups of screws with two as well as three screws may be arranged around the frame 109. Therefore, flexibility is provided for.

As is illustrated in figures 2a-2c and 3c and 3d, each group of screws 112a, 112b, 112c, 113a, 113b may apply a force to the frame 109. Therefore, a torque may be applied at the second frame element 103a, 103b via controlling the curvature of the frame 109 such that tilt of the support portion 101a, 101b, and thereby curvature of the plate, is controlled. In the assembly illustrated in figure 3a, a net force is applied such that the frame is substantially flat and parallel with the panel 1. In the assembly illustrated in figure 3c and 3d, a net force away from the support portion 101a, 101b is provided to the frame 109, which will be slightly concave when viewed from the touch surface of the plate 2. As a consequence, a torque will be provided at to the second frame element 103a, 103b, which will tilt the support portion 101a, 101b along the edge or perimeter of the plate 2. Therefore, controlling the curvature of the first frame element 109 may control curvature of the plate. The plate 2 may become concave as viewed from the touch surface of the plate 2.

Figures 4a-4c, 5a-5g and 6a-6c illustrate embodiments wherein an alternative or additional control of the shape of the frame 109 may be introduced. As shown in figure 4a, attachment elements 112 may be arranged at the corners of the frame 109. The attachment elements 112 may comprise the group of screws 112a, 112b, 112c, 113a, 113b as described above with regard to figures 2a-2c and 3a-3d. The attachment elements 112 may be arranged to pull the panel 1 towards the frame 109. This may be done with or without tilting the support portion 101a, 101b as described above. At least one spacing element 116 (where spacing element 116 may comprise screw 112 and a separate spacing component) may be arranged along the perimeter of the frame 109 between two attachment elements 112. The spacing element 116 is arranged in the assembly to apply a force to the frame 109 directed away from the panel 1. Thereby, a force applied by the spacing element 112 may be transferred to the second frame element 103a, 103b such that the support 101a, 101b is tilted as described above, whereby curvature of the plate 2 is controlled.

As is illustrated in figure 4b, the general shape of the frame 109 will be concave, whereas the general shape of the panel 1 may be convex. The panel may also remain substantially plane depending on its rigidity. The resulting shape of the plate 2 will be concave. Therefore, each side of the frame 109 may be controlled to follow a curved path. The curvature may be controlled by adjusting the force applied by each spacing element 116 and/or via the number of spacing elements 116 along each side of the frame 109. As a result, the support portion 101a, 101b, at least at the free end of the support portion 101a, 101b, may also follow a curved path. Therefore, at least a portion of the support portion 101a, 101b may extend in a plane that is curved.

When the second frame element 103a, 103b is disassembled or only attached to the first frame element 102, it may have a relaxed state. In the relaxed state, the support portion 101a, 101b extends in a plane that is substantially flat. The second frame element 103a, 103b may be deflectable from the relaxed state to a deflected state or stressed state, such as by the attachment elements 112 and spacing elements 116. The level of tilt at the opposing ends of the support 101a, 101b where the attachment elements 112 are provided may be less than the level of tilt between the ends where spacing element(s) 116 is/are provided. As consequence, the second frame element 103a, 103b may be deflected to the deflected or stressed state. In the deflected or stressed state, the support portion 101a, 101b extends, along its length, in a plane that is curved. A cross section of this plane taken along the support portion 101a, 101b, such as at the free end or tip of the support portion 101a, 101b may form a parabolic concave curve along at least a portion of the length of the support portion 101a, 101b. A combination of the attachment element 112 and the spacing element 116, that together may form a screw arrangement, may hold the second frame element 103a, 103b in the deflected or stressed state when assembled with the first frame element 102.

The spacing element 116 may be provided by a single screw that engages a thread in the frame 109 while its tip engages or abuts a surface on panel 1. Alternatively, panel 1 comprises a threaded hole into which spacing element 116 is threaded so that spacing element 116 can be used to displace the frame 109 towards panel 11. Additionally, element 116 may comprise a spacer component such as a washer, spacer, etc. In figure 3a and 3b and figure 6a, two spacing elements 116a, 116b are shown for illustrative purposes and may form separate embodiments. A single-spacing element 116a, 116b may be used in other embodiments. The head of the spacing element 116a, 116b may abut the back cover 111 while the spacing element 116a, 116b may engage the frame 109, wherein the frame 109 may be pulled towards the back cover 111. As a result, the frame 109 becomes concave. In some embodiments, the spacing element 116a does not abut or engage the

panel 1, wherein the panel 1 may be unaffected by the force applied to the frame 109. In other embodiments, the spacing element 116b is sufficiently long such that a tip of the spacing element 116b abuts a surface of the panel 1. This adds further control of the shape of the plate 2.

In some of the embodiments, the frame assembly 100 comprises a plurality of spacing elements 116 arranged spaced apart from corners of the frame 109. One or several spacing elements 116 may be arranged along each perimeter or side of the frame 109. If a single spacing element 116 is arranged along each side, it is preferably centered between the corners of the frame 109.

Each spacing element 116 may comprise a screw with a predefined length. This means that the screw can be fully seated such that the head and tip abut respective surfaces, whereby a predefined curvature of the plate 2 is obtained. The level of curvature may be adjusted by one or several spacers arranged between the head and the surface which the head engages. This is particularly useful if multiple spacing elements 116 are arranged along a single side, or if different sides have different lengths. The more spacers provided, the less force will be applied to the frame 109. Alternatively, as shown in figure 5h, predefined height differences may be generated via other methods, e.g. by milling the frame to the predefined heights, allowing a more continuous support structure.

Figures 5a-5h illustrate embodiments of an assembly 200, which may be combined with the first frame element 102 described above. The embodiments shown in figures 5a-5h are shown inverted relative to the embodiments shown previously, with the plate 2 at the top.

As shown in figures 5a and 5b, the frame assembly 200 may comprise a first frame element 202, and a second frame element 203. The first frame element 202 and the second frame element 203 may be elongated members, each having a support portion 201a, 201b. The first frame element 202 and the second frame element 203 may e.g. be L-shaped in cross section. A first portion of each of the first frame element 202 and the second frame element 203 may be configured to extend along the edge of the panel 1. A second portion of each of the first frame element 202 and the second element 203 forms the support portion 201a, 201b, and may be configured to extend from the perimeter of the plate 2 a short distance, such as a 1-3 cm, over the surface of the plate 2 when assembled. Furthermore, the second frame element 203 may be arranged on top of the first frame element 202 and such that the perimeter of the plate 2 is arranged between the second portion of each of the frame elements 202, 203 when assembled. Therefore, each support portion 201a, 201b may support or engage opposing surfaces of the plate 2, such as is illustrated in figure 5g.

In some embodiments, such as illustrated in figures 5c-5d, a gasket 205 (e.g. gaskets 205a, 205b, 205c, 205d, 205e) is arranged between the first frame element 202 and the second frame element 203. The gasket may e.g. be arranged on the support portion 201a of the first frame element 202. Also, a sealing 204a may be arranged on the support portion 201b of the second frame element 203.

The gasket 205 may have a varying thickness along its length, i.e. also along the length of the first frame element 202. This provides for obtaining a desired curved shape of the perimeter of the plate 2 when captured between the first frame element 202 and the second frame element 203, as is illustrated in figures 5f-5g. For example, the gasket 205 has opposing ends and may be thinner between the opposing ends than at said ends. This provides for obtaining a predefined concavity of the perimeter of the plate 2. The gasket is sufficiently stiff that it is thicker at the ends even when compressed. The gasket 205 may be about 1.5-2.0mm at the ends and about 1 mm thinner at the center.

In some embodiments, the gasket 205 has a plurality of sections along its length. The thickness of each section may vary. For example, a first section 205a of the gasket is provided at one of its ends and a second section 205b of the gasket at the other of its ends. The first section 205a and the second section 205b may have a first thickness that may be equal at each section. At least a third section 205c of the gasket is arranged between the first section 205a and the second section 205b. The third section 205c has a second thickness. The first thickness is thicker than the second thickness. For example, difference in thickness is about 0.5-2mm, preferably about 1.0mm. The difference in thickness may vary depending on the length of the gasket 205 and the edge of the plate 2 at which the concavity is to be introduced. In some embodiments, fourth and fifth sections 205d, 205e may be provided between the first and second sections 205a, 205b and the third section 205c, respectively. The fourth and fifth sections 205d, 205e may add further control of the shape of the concave curve provided by the arrangement 200. The length of each the first and second sections 205a, 205b may be about 2-20% of the total length of the gasket 205. The length of the third section may be about 60-96% of the total length of the gasket 205. The length of each of the fourth and fifth sections 205d, 205e may be about 10-20% of the total length of the gasket 205. In some embodiments the total length of the fourth and fifth sections 205d, 205e is shorter than the length of the third section 205c, and the total length of the first and second sections 205a, 205a is shorter than total length of the fourth and fifth sections 205d, 205e. This provides for a parabolic concave curve along the length of the frame assembly 200.

A distance between the support portion 201a of the first frame element 202 and the support portion 201b of the second frame element 203 may be discontinuous in an assembled state, as can be seen in figure 5e.

In order to maintain the concavity of the plate 2, the first frame element 202 and the second frame element 203 may be held together such that the distance between the support portions 201a, 201b is maintained in the assembled state. The first frame element 202 has a first hole 217a and a second hole 217b arranged at opposing ends of the first frame element 202, such as at the second portion of the first frame element 202. The first and the second hole 217a, 217b are arranged in a first plane. A third hole 217c is arranged between the first hole 217a and the second hole, such as centered between the first hole 217a and the second hole 217b. The third hole 217c is provided in a plane that is different from the first plane. The distance or offset between the plane in which the first and second holes 217a, 217b are arranged and the plane in which the third hole 217c is arranged may be substantially the same as the difference in thickness between the first and second sections 205a, 205b and the third section 205c, i.e. about 0.5-2mm. In some embodiments the first and second holes 217a, 217b are centered in each of the first and second sections 205a, 205b of the gasket 205 along the length of the first frame element 202.

Similarly, the second frame element 203 may comprise a first hole 218a and a second hole 218b arranged at opposing ends of the second frame element 203. A third hole 218c may be arranged between the first hole 218a and the second hole 218b of the second frame element 203. The first hole 218a, the second hole 218b, and the third hole 218c of the second frame element 203 is generally arranged in the same plane when the second frame element 203 is disconnected from the first frame element 202. The second frame element 203 may be less stiff or weaker than the first frame element 202 and be deflectable such that each hole 218a, 218b, 218c of the second frame element 203 is aligned with the holes 217a, 217b, 217c of first frame element 202. Therefore, the support portion 201b of the second frame element 203 may be deflected such that it extends in plane, which is curved in the assembled state of the frame assembly 200. Screws 219a, 219b, 219c may be inserted through the aligned holes 217a, 217b, 217c; 218a, 218b, 218c and may directly engage the panel or engage a threaded hole in the panel 1, which will hold the frame elements 202, 203 in the assembled state. Other relative arrangements of the holes 217a, 217b, 217c; 218a, 218b, 218c are foreseen, wherein the center holes 217c, 218c of each frame element 202, 203 are misaligned in the relaxed state of the second frame element 203 but aligned in the deflected or stressed state of the second frame element 203.

In some embodiments, the first frame element 202 forms a frame side, and the second frame element 203 forms an edge cover. If used together with the frame 109 discussed with regard to figures 4a-4c, the frame side may replace the second frame element of the embodiments of figures 4a-4c. Therefore, the frame side comprises the support portion 201a with a support surface generally opposing the frame 109 and is configured to support the gasket 205.

As illustrated in figure 6, a component (e.g. a sealing component 204a) may be provided between the support portion 201a and the plate 2. Figure 6 illustrates the resulting forces and torque generated when a force 220 is applied to second frame element 203a. A second force 221 is applied to support portion 201. Therefore, a net torque 222 is generated, i.e. counter-clockwise in the illustrated arrangement. The plate 2 will assume a curved path, as is illustrated with dotted line 223.

In an embodiment shown in figure 7, an alternative arrangement is provided for providing curvature of plate 2. In this embodiment, support block 301 is arranged to support glass plate 2. Support block 301 has a surface portion comprising a tapered edge 303 at an angle from second frame element 103A. Plate 2 is pressed against the top surface of support block 301 from pressure 201b from first frame element 102 and sealing 204a. Pressure 201b causes plate 2 to follow the contour of the top surface of block 301 and plate 2 is forced into a curving plane at an angle to the plane of second frame element 103A. The resulting path of plate 2 is shown by curvature path 310. Tapered surface portion 303 is angled between 0.5 degrees and 3 degrees from second frame element 103A.

In an embodiment shown in figure 8, a variation of the embodiment shown in figures 5a-5g is provided. In this embodiment, second frame element 203 has been modified, such that a portion 410 has been removed from the edge portion 203c of second frame element 203. This reduces the force required to bend second frame element 203 in a manner that results in a curvature of plate 2. Portion 410 may be removed by a milling process, by a carving or cutting process, or second frame element 203 may be formed without portion 410 via a molding process or similar. Portion 410 preferably reduces the depth of second frame element 203 at the narrowest point by between 5-20%.

The frame elements of the embodiments of the assembly may be made from sheet metal and given a desired design, thickness, and/or be made from different materials such that the forces, shapes, torques, etc. discussed above are obtained.

Embodiments comprise a method for assembling the panel 1 and the plate 2 for the optical touch sensitive system. The method may comprise providing the frame elements according to the embodiments presented herein. The method further comprises

attaching the first frame element to the second frame element, supporting the plate at a support portion of the assembly, and attaching at least one of the first frame assembly and the second frame assembly to the panel such that the support portion extends in flat or curved plane. Also, the method comprises attaching the second frame element to the first frame element such that the support portion extends at least partially in a second plane generally opposite at least a portion of the first frame element and is spaced apart from the first plane. A curvature of the first frame element may be controlled with a spacing element attached to the first frame element and may thereby tilt the support portion to control a curvature of the plate.

Figure 9 illustrates a top plan view of an example of a touch-sensitive apparatus 99. Emitters 30a are distributed around the periphery of touch plate 10, to propagating light across touch surface 20. Detectors 30b are distributed around the periphery of touch surface 20, to receive part of the propagating light. The light from each of emitters 30a will propagate to a number of different detectors 30b on a plurality of light paths 50.

The embodiments above describe methods of achieving control of plate shape and curvature. The following embodiments describe desirable shapes of the plate for achieving improved performance of a touch sensor system. Light paths 50 may conceptually be represented as "detection lines" that extend across the touch surface 20 between pairs of emitters 30a and detectors 30b. The emitters 30a and detectors 30b collectively define a grid of detection lines 50 ("detection grid") on the touch surface 20, as seen in a top plan view. The spacing of intersections in the detection grid define the spatial resolution of the touch-sensitive apparatus 99, i.e. the smallest object that can be detected on the touch surface 20. The width of the detection line is a function of the width of the emitters and corresponding detectors. A wide detector detecting light from a wide emitter provides a wide detection line with a broader surface coverage, minimizing the space in between detection lines which provide no touch coverage. A disadvantage of broad detection lines may be a reduced ability to differentiate between separate objects and a lower signal to noise ratio.

As used herein, the emitters 30a may be any type of device capable of emitting radiation in a desired wavelength range, for example a diode laser, a VCSEL (vertical-cavity surface-emitting laser), an LED (light-emitting diode), an incandescent lamp, a halogen lamp, etc. The emitters 30a may also be formed by the end of an optical fiber. The emitters 30a may generate light in any wavelength range. The following examples presume that the light is generated in the infrared (IR), i.e. at wavelengths above about 750 nm. Analogously, the detectors 30b may be any device capable of converting light (in the same wavelength range) into an electrical signal, such as a photo-detector, a CCD device, a CMOS device, etc.

The detectors 30b collectively provide an output signal, which is received and sampled by a signal processor 130. The output signal contains a number of sub-signals, also denoted "projection signals", each representing the energy of light received by one of light detectors 30b from one of light emitters 30a. Depending on implementation, the signal processor 130 may need to process the output signal for separation of the individual projection signals. The projection signals represent the received energy, intensity or power of light received by the detectors 30b on the individual detection lines 50. Whenever an object partially or completely occludes detection line 50, the received energy on this detection line is decreased or "attenuated".

The signal processor 130 may be configured to process the projection signals so as to determine a property of the touching objects, such as a position (e.g. in a x, y coordinate system), a shape, or an area. This determination may involve a straight-forward triangulation based on the attenuated detection lines, e.g. as disclosed in US7432893 and WO2010/015408, or a more advanced processing to recreate a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 20, where each attenuation value represents a local degree of light attenuation. The attenuation pattern may be further processed by the signal processor 130 or by a separate device (not shown) for determination of a position, shape or area of touching objects. The attenuation pattern may be generated e.g. by any available algorithm for image reconstruction based on projection signal values, including tomographic reconstruction methods such as Filtered Back Projection, FFT-based algorithms, ART (Algebraic Reconstruction Technique), SART (Simultaneous Algebraic Reconstruction Technique), etc. Alternatively, the attenuation pattern may be generated by adapting one or more basis functions and/or by statistical methods such as Bayesian inversion. Examples of such reconstruction functions designed for use in touch determination are found in WO2009/077962, WO2011/049511, WO2011/139213, WO2012/050510, and WO2013/062471, all of which are incorporated herein by reference.

In the illustrated example, the apparatus 99 also includes a controller 120 which is connected to selectively control the activation of the emitters 30a and, possibly, the readout of data from the detectors 30b. Depending on implementation, the emitters 30a and/or detectors 30b may be activated in sequence or concurrently, e.g. as disclosed in US8581884. The signal processor 130 and the controller 120 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 130 and the controller 120 may be at least partially implemented by software executed by a processing unit 140.

Figure 10a illustrates a substantially flat rectangular touch plate 10 according to the prior art. In this example, the touch plate is made of glass, plastic, or any other materials such as PMMA (Poly(methyl methacrylate)). Two axes are defined in figure 10a. The x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle and along the flat surface of the touch surface. The y-axis is defined as the axis running parallel to and equidistant from the pair of short edges of the rectangle and along the flat surface of the touch surface. At least a portion of the top surface of touch plate 10 comprises touch surface 20.

Figure 10b illustrates an example of a touch apparatus according to the prior art. Figure 10b shows the touch apparatus in cross section wherein the cross section runs along the x-axis of the plate 10. Light is emitted by emitter 30a, passes through transmissive plate 10 through touch surface 20 and is reflected by reflector surface 80 of edge reflector 70 to travel in a plane substantially parallel with touch surface 20. The light will then continue until deflected by reflector surface 80 of the edge reflector 70 at an opposing edge of the transmissive plate 10, wherein the light will be deflected back down through transmissive plate 10 and onto detectors 30b. Where an object is applied to touch surface 20, some of the light above the touch surface 20 is occluded. This occlusion is detected by the touch apparatus and used to determine the presence, size, and/or shape of the object. The emitters and detectors may be arranged in a number of other configurations such that the light from the emitters is delivered to the touch surface and delivered from the touch surface to the detectors. Other known arrangements are that of arranging the emitters and detectors above the touch surface and transmitting and receiving the light directly without the use of reflecting surfaces. The light may also be delivered to the touch surface by means of a wave guide, fiber optic cable, or other optical component.

Figure 11a illustrates an embodiment of touch plate 10 similar to that shown in figure 10a but wherein the touch plate 10 is curved. In this embodiment, the plate remains substantially flat in the direction of the y-axis but is curved in a concave direction relative to the x-axis. In this embodiment, the x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle. The vertex of the parabola or paraboloid of the touch surface is where the touch surface is deepest relative to the edges of the touch plate. Where the x-axis is positioned at the height of the edge of the touch plate, the curvature of the plate can be measured using the distance of the touch surface from the x-axis. Figure 11b shows a cross-section view along the x-axis of the touch plate 10 of figure 11a.

Figure 11c shows an example embodiment of a curved touch plate 10. The touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. In this example embodiment, the glass is shaped such that the touch surface follows a parabolic curve relative to the x-axis. The midpoint O of touch surface 20 is the center of the touch surface and the midpoint of the x-axis. Where the curvature of the touch surface 20 is parabolic, the maximum distance a between the touch surface and the x-axis is at the center point O of the touch surface.

Figure 11d shows the maximum allowed concave distance a and maximum allowed convexity b. The maximum allowed convexity b may be a significant consideration as a portion of the touch surface that is substantially convex may result in occlusion of the light between the emitters and detectors and significant loss of touch signal. The maximum allowed convexity b is a negative number in the present examples.

In one embodiment, the range of the distance a for vertically orientated touch plate is limited in order to improve the yield and performance of touch systems. The range is set dependent on the size of the touch system. A smallest value is needed to assure that non-parabolic deviations in the glass shape and convexity in the integration doesn't result in a convex integrated touch surface. A largest value is needed in order to assure that the height of the light field for the final touch system is kept reasonably low in order to enable better contact detection and lift-off detection for touch objects. Preferably, range of the distance a is 0-2.5 mm.

The maximum distance a is a positive number for a concave glass in the present examples. The curvature of the touch surface may therefore be modelled as:

$$\mathrm{F(x)} = -\mathrm{a} + \mathrm{cx}^2$$

In the present example embodiment, a maximum distance a between the 1900 mm long cross section of the touch surface in figure 11c and the x-axis is 2.0 mm. Therefore, an ideal parabolic curve for touch surface 20 may be:

$$\mathrm{F(x)} = 5.5 * 10^{-6} * \mathrm{x}^2 - 2.0$$

where $\mathrm{F(x)}$ is the distance between the x-axis and the touch surface at position x wherein $\mathrm{F(x)}$ is zero at the mid points of the edges. i.e. where the x-axis intersects the perimeter.

Figures 12a and 12b illustrates an embodiment of touch plate 10 similar to that shown in figure 11a but wherein the touch plate 10 is curved in two axes. Figure 12a shows a top plan view and figure 12b shows an isometric view of touch plate 10. In this embodiment, the plate is curved in a concave direction relative to the x-axis and is also curved in a concave direction relative to the y-axis. As with the embodiment shown in figure 11a, the x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle and passing over the center point 0 on the touch surface. Therefore, the curvature of the plate can be measured from the distance of the touch surface from the x-axis. Similarly, the y-axis is defined as the axis running parallel to and equidistant from the pair of short edges of the rectangle and passing over the center point 0 on the touch surface. Therefore, the curvature of the plate along this axis can be measured from the distance of the touch surface from the y-axis.

Figure 12c and 12d shows respective section views along the x-axis and y-axis of the touch plate 10 of figure 12a and 12b. In an example embodiment of a curved touch plate 10. The touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. In this example embodiment, the glass is shaped such that the touch surface follows a parabolic curve relative to the x-axis. The center point O of touch surface 10 is the center of the touch surface and parallel with midpoint of the x-axis. Where the curvature of the touch surface 10 is parabolic, the maximum distance a between the touch surface and the x-axis is at the center point O. The maximum distance a is a positive number for a concave glass in the present examples. The curvature of the touch surface may therefore be modelled as:

$$z(x,y) = -a + b * x^2 + c * x^2y^2 + d * y^2$$

where z is the distance between the plane defined by the x-axis and y-axis and the touch surface, and x and y are co-ordinates in the plane of the glass.

In an example embodiment having a flat perimeter around the plate with a max distance of 2.0 mm measured along the x-direction for y = 0 (i.e. middle of plate):

$$z(x,y) = -2 + 5.56e-06 * x^2 - 4.74e-11 * x^2y2 + 1.7e-05 * y^2$$

In another example embodiment having a concave perimeter around the plate with a max distance of 2.0 mm measured along the x-direction for y = 0 (mid short to short of screen) and with a max distance of 1.5 mm measured along the y-direction for x = 0 (mid

long to long of screen). Where the top and bottom edges have 1.0 mm max distance and the left and right edges have 0.5 mm max distance:

$$z(x,y) = -2.5 + 5.56e-06 * x^2 - 2.37e-11 * x^2 * y^2 + 1.28e-05 * y^2$$

Figure 13a shows a section view along the x-axis of light propagating across an example embodiment of a curved touch plate 10 touch surface having a curved profile in the x-axis. In the section view, the propagation paths of light from a point light source 1310 are shown. Dotted lines 1320 show propagation paths of light emitted from point light source 1310a that are not received by detector surface 1340. Solid lines 1330 show propagation paths of light emitted form point light source 1310 that are received by detector surface 1340. As shown in the figure, a portion of the light is lost above the detector, a portion is lost below the detector, and a portion of the light is received at the detector surface. A person looking from the emitter point towards the mirror image of the detector (mirrored in the touch surface) will perceive the detector size as 2.2 times larger than the real detector. This magnification effect is an effect of using an off axis parabolic mirror. In the specific case of touch systems, this results in a detection signal boost of a factor of 2.2, when comparing to a flat touch surface. This boost applies only to the signal and not significantly to the ambient light otherwise received by the detectors. In a preferred embodiment, the detectors and emitters of the touch system are 3 mm or less above the touch surface (either directly or indirectly) and the length of the detection lines being in the range from 100 to 2500 mm, the angle of incidence is extremely close to 90 degrees. With this, gracing incidence, dirt or anti-glare coatings on the touch surface have no practical impact of the reflection, so it is practically a mirror.

Figure 13b provides a graph of the angle of the emitted light from the point light source 1310 with respect to the z-coordinate of the light path at the edge of the model of figure 13a. The detector surface z-coordinate range is shown by the vertical axis. Light emitted by point light source 1310 received at a z-coordinate within that range is received by the detector.

Figure 14a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a second point light source 1410 are shown. In this example, the detection signal boost is approximately 3.3. Figure 14b shows the corresponding graph of figure 13b for the second point light source 1410.

Figure 15a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a third point light source 1510 are shown. Figure

15b shows the corresponding graph of figure 13b for the third point light source 1510. In this example, the detection signal boost is approximately 3.03.

Figure 16a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a fourth point light source 1610 are shown. Figure 16b shows the corresponding graph of figure 13b for the fourth point light source 1610. In this example, the detection signal boost is approximately 2.71.

Figure 17a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a fifth point light source 1710 are shown. Figure 17b shows the corresponding graph of figure 13b for the fifth point light source 1710. In this example, the detection signal boost is approximately 2.19.

Figures 13a-17b demonstrate that different emitter positions utilize different parts of the touch surface. The parts of the touch surface that work as reflectors will depend on the actual shape of the glass and the placement and sizes of the emitter and detector apertures surface 1340.

However, the touch plate 10 cannot be manufactured, positioned, or held in shape perfectly. Consequently, a certain amount of deviation can be expected between the curve followed by the touch surface and an ideal parabolic curve.

Figure 18a shows a graph of a mathematically defined parabolic curve and a real-world parabolic touch surface. In the example embodiment of figure 18a, a curved touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070mm along the y-axis (wherein the x-axis and y-axis are defined as in the embodiment shown in figure 12a,4b). In this example embodiment, the glass is shaped such that the touch surface follows parabolic curve 1810 relative to the x-axis. The maximum distance a between the touch surface and the x-axis is 10mm. The mathematically defined parabolic curve is defined as 1820. The graph shows the deviation between the mathematically defined parabolic curve represented by dotted line 1820 and real touch surface 1810. Here, the real touch surface is asymmetrically warped. Fig 10b shows the short to short mid cross section of a 2180 mm diagonal, 16:9 ratio, thermally tempered glass that is just within or at the maximum limit of concave distance < 6 mm as well as |parabolic deviation| < 0.5 mm.

The parabolic fit of the touch surface 1810 has an s-shaped residual. Such asymmetrical warping may be the result of problems with transport rollers or an uneven temperature distribution during the rapid cooling phase of tempering process during manufacture.

Figure 18b shows a graph of the deviation between the mathematically defined parabolic curve and a real-world parabolic touch surface of figure 18a.

The following table defines a preferred set of restrictions on the shape of the touch surface in order to achieve an optimal touch surface shape. The term 'warp' defines the distance of the touch surface from the respective axis intersecting the center point O in the direction of the z-axis.

Glass size	Min x-axis warp (mm)	Max x-axis warp (mm)	Min y-axis warp (mm)	Max y-axis warp (mm)	Max convexity* (mm)	Max parabolic deviation (mm)
55"	1.0	3.50	0.0	1.35	0.1	0.5
65"	1.0	4.50	0.0	1.65	0.1	0.5
70"	1.0	5.10	0.0	1.85	0.1	0.5
75"	1.0	5.70	0.0	2.00	0.1	0.5
84"-86"	1.0	6.00	0.0	2.00	0.1	0.5

Convexity b is shown in figure 18a. Parabolic deviation is shown in figure 18b.

Figure 19a shows another graph of a mathematically defined parabolic curve and a similar glass to that of figure 18a but wherein the glass of figure 19a is out of range and not recommended for touch system production. One reason for the large concavity shown in figure 19a may be that the tempering process has been run with too large differences between bottom and top cooling parameters in a quenching process during manufacturing. The mathematically defined parabolic curve is defined as 1920. The graph shows the deviation between the mathematically defined parabolic curve and real touch surface 1910.

Figure 19b shows a graph of the deviation between the mathematically defined parabolic curve and a real-world parabolic touch surface of figure 19a. The real-world parabolic touch surface of figure 19a is an example of a symmetrical but higher order warping (e.g. W shaped). Such warping may significantly reduce signal boost and may be caused by symmetrical temperature problems (e.g. too hot in center or edge of glass) during the manufacturing tempering process.

Figure 20a shows an embodiment in which the touch surface forms a paraboloid. In figure 20a, a top plan view of the touch surface is shown with contour lines showing the depth of the touch surface relative to a flat plane intersecting the four corners of the touch surface. The numbers shown on each contour represents the depth of the contour. The x-axis, y-axis, and diagonal-axis d are all shown. The x-axis is defined as an axis running parallel to and equidistant from the pair of long edges of the rectangle. The y-axis is defined as an axis running parallel to and equidistant from the pair of short edges of the rectangle. Diagonal-axis d is defined as an axis running diagonally from one corner to a

diagonally opposite corner. In this embodiment, the x-axis, y-axis, and diagonal axis d of touch surface 10 each describe a parabola with respect to the depth of the touch surface. In figure 20b, diagonal-axis d is shown running from the bottom left corner to the top right corner. In the example embodiment of figure 20a, the curved touch plate 10 has a width of 1900mm along the x-axis and a height of 1070 mm along the y-axis.

Figures 20b-20d show optional parabola configurations for the embodiment shown in figure 20a. Figure 20b shows a graph of the desired parabola of the touch surface underneath the x-axis and relative to the x-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the x-axis. Figure 20c shows a graph of the desired parabola of the touch surface underneath the y-axis and relative to the y-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the y-axis. Figure 20d shows a graph of the desired parabola of the touch surface underneath the diagonal-axis and relative to the diagonal-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the diagonal-axis.

The embodiments shown in figure 20a-20d describe a touch surface providing substantial signal boost for signals travelling between most emitters and detectors. However, the non-flat perimeter of the touch surface makes manufacture and assembly of such a system more complex.

Figure 21a shows an embodiment in which the touch surface forms an alternative paraboloid to that of the embodiment shown in figure 20a. As with figure 20a, figure 21a provides a top plan view of the touch surface is shown with contour lines showing the depth of the touch surface relative to a flat plane intersecting the four edges of the touch surface 10. The numbers shown on each contour represents the depth of the contour. X-axis, y-axis, and diagonal-axis d are all shown. The x-axis is defined as an axis running parallel to and equidistant from the pair of long edges of the rectangle. In this embodiment, the x-axis of touch surface 10 describes a parabola with respect to the depth of the touch surface. The y-axis is defined as an axis running parallel to and equidistant from the pair of short edges of the rectangle. In this embodiment, the y-axis of touch surface 10 also describes a parabola with respect to the depth of the touch surface. Diagonal-axis d is defined as an axis running diagonally from one corner to a diagonally opposite corner. In figure 21b, diagonal-axis d is shown running from the bottom left corner to the top right corner. In the example embodiment of figure 21a, the curved touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. The perimeter of the touch surface of this embodiment is flat or close to flat. In embodiments where the perimeter of the touch surface is flat or close to flat, the surface beneath some detection lines will not be perfect parabolas. Even for an almost perfect

integrated glass shape with a warp in the range of 1-2.5 mm some detection lines (a very small portion) will actually have less signal than for a flat glass. This small drawback is counter balanced by the significant overall signal improvements. Furthermore, touch systems where the perimeter of the touch surface is flat or close to flat can be easier to manufacture and assemble.

Figure 21b shows a graph of the desired parabola of the touch surface underneath the x-axis and relative to the x-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the x-axis. Figure 21c shows a graph of the desired parabola of the touch surface underneath the y-axis and relative to the y-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the y-axis. Figure 21d shows a graph of the desired parabola of the touch surface underneath the diagonal-axis and relative to the diagonal-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the diagonal-axis.

As will be apparent, the features and attributes of the specific embodiments disclosed above may be combined in different ways to form additional embodiments, all of which fall within the scope of the present disclosure.

Conditional language used herein, such as, among others, “can,” “could,” “might,” “may,” “e.g.,” and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

The present invention has been described above with reference to specific embodiments. However, other embodiments than the above described are equally possible within the scope of the invention. Different method steps than those described above may be provided within the scope of the invention. The different features and steps of the invention may be combined in other combinations than those described. The scope of the invention is only limited by the appended patent claims.

CLAIMS

1. An assembly for holding and controlling curvature of a plate (2) for an optical touch sensitive system, comprising

a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

at least one second frame element (103a, 103b; 203) extending in a second plane and forming a support portion (101a, 101b; 201b) for the plate (2), and

at least one spacing element positioned at least partially between the support portion (101a, 101b; 201b) and the first frame element (102; 202), the spacing element being configured to control a curvature of the first frame element (102; 202), and

wherein the at least one second frame element (103a, 103b; 203) is configured to engage the plate at the support portion (101a, 101b; 201b), is attached to the first frame element (102; 202), and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element (102, 202) with said spacing element, to control a curvature of the plate.

2. The assembly of claim 1, wherein the second frame element (103a, 103b; 203) is deflectable from a relaxed state to a deflected state, in which the second plane forms a parabolic concave curve along at least a portion of the length of the support portion (101a, 101b; 201b), and wherein a screw arrangement (112a, 112b, 112c, 113a, 113b; 219a, 219b, 219c) of the assembly holds the second frame element (103a, 103b; 203) in the deflected state when assembled with the first frame element (102; 202).

3. The assembly of any of claims 1 or 2, wherein a frame (109) of the first frame element (102) comprises a plurality of spacing elements arranged spaced apart from corners of the frame (209) of the first frame element (102), wherein the spacing elements are configured to generate a force to the frame (109) away from the support portion (101a, 101b).

4. The assembly of claim 3, wherein each spacing element comprises a screw (116, 116a, 116b) arranged in a hole of the frame (109).

5. The assembly of claim 4, wherein each spacing element (112, 112a, 112b) comprises a screw with a predefined length, and a spacer arranged between a head of the screw and the frame (109).

6. The assembly of any of the previous claims, wherein assembly comprises a plurality of attachment elements (112) arranged around the frame (109) for attaching the first frame element (102) to said panel (1).

7. The assembly of claim 6, wherein each attachment element (112) comprises a plurality of screws (112a, 112b, 112c, 113a, 113b) arranged in holes of the frame (109), wherein at least one of said screws (112a, 113b) is arranged to apply a first force to the frame (109) towards the support portion (101a, 101b), and at least one other of said screws (112b, 112c, 113b) is arranged to apply a second force to the frame (109) away from the support portion (101a, 101b).

8. The assembly of claim 7, wherein each attachment element (112) comprises at least two screws (113a, 113b), wherein a first screw (113a) of said two screws is arranged opposing the support portion (101a, 101b) and to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (113b) of said two screws is arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b) and to apply said second force to the frame (109) away from the support portion (101a, 101b).

9. The assembly of claim 7, wherein each attachment element (112) comprises at least three screws (112a, 112b, 112c), wherein all three screws are arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b), and wherein a first screw (112a) of said three screws is arranged to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (112b) and a third screw (112c) of said three screws are arranged to apply said second force to the frame (109) away from the support portion (101a, 101b), the first screw (112a) being arranged between the second screw (112b) and the third screw (112c).

10. The assembly of any of the previous claims, wherein a gasket (205) is arranged on another support portion (201a) of the second frame element (202), wherein the gasket (205) has a varying thickness along its length.

11. The assembly of claim 10, wherein the gasket (205) has opposing ends, and is thinner between the opposing ends than at said ends.

12. The assembly of claim 11, wherein a first section (205a) of the gasket (205) at one of said ends and a second section (205b) of the gasket (205) at the other of said ends has a first thickness, and at least a third section (205c) of the gasket between the first section (205a) and the second section (205b) has a second thickness, wherein the first thickness is thicker than the second thickness.

13. The frame assembly of any of claims 10-12, wherein the second frame element (203) comprises a frame side and the third frame element comprises an edge cover, and wherein the edge cover comprises another support portion for said panel (1), wherein a distance between the support portion of the frame side and the support portion of the edge cover is discontinuous in an assembled state.

14. The frame assembly of claim 13, wherein the frame side comprises a first hole (217a) and a second hole (217b) arranged at opposing ends of the frame side and in a first plane, and a third hole (217c) arranged between the first hole (217a) and the second hole (217c) and in a plane that is different from the first plane, and

the edge cover comprises a first hole (218a) and a second hole (218b) arranged at opposing ends of the edge cover, and a third hole (218c) arranged between the first hole (218a) and the second hole (218c) of the edge cover, wherein the first hole (218a), the second hole (218b), and the third hole (218c) of the edge cover are generally arranged in the same plane when the edge cover is disconnected from the frame side, and

wherein the edge cover is less stiff than the frame side and deflectable such that the holes (218a, 218b, 218c) of the edge cover are aligned with the holes (217a, 217b, 217c) of the frame side and such that the support portion of the edge cover extends in a plane, which is curved.

15. A method for assembling a panel and a plate for an optical touch sensitive system, comprising:

providing a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

providing at least one second frame element (103a, 103b; 203) forming a support portion (101a, 101b; 201b) for the plate (2);

supporting the plate (2) by the support portion (101a, 101b, 201b);

attaching the second frame element to the first frame element (102; 202) such that

the support portion (101a, 101b; 201b) extends at least partially in a second plane generally opposite at least a portion of the first frame element (102; 202) and is spaced apart from the first plane; and

controlling a curvature of the first frame element (102; 102) with a spacing element attached to the first frame element (102; 202) and thereby tilting the support portion (101a, 101b, 201b) to control a curvature of the plate (2).

16. A touch sensing apparatus, comprising:

a touch surface;

a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface,

a set of light detectors arranged around the touch surface to receive light from the first set of emitters,

wherein each light detector is arranged to receive light from more than one emitter;

a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface,

wherein the touch surface is curved in a first axis according to a first parabola.

17. The touch sensing apparatus of claim 16, wherein the touch surface is curved in a second axis according to a second parabola.

18. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

19. The touch sensing apparatus of claim 18, wherein the first parabolic curve paraboloid is an elliptical paraboloid.

20. The touch sensing apparatus of claim 16, wherein each point of the first axis of the touch surface is within 0.5mm of a mathematical parabola.

21. The touch sensing apparatus of claim 16, wherein the mathematical parabola is defined according to $z(x, y)=a+bx^2+cx^2y^2+dy^2$, where z is depth, and x and y are co-ordinates in the plane of the glass.

22. The touch sensing apparatus of claim 16, wherein the touch surface comprises a portion of a surface of a plate.

23. The touch sensing apparatus of claim 22, wherein the plate comprises a glass or plastic sheet.

24. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

AMENDED CLAIMS
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[Claim 1] An assembly (100) for holding and controlling curvature of a plate (2) for an optical touch sensitive system, comprising
a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);
at least one second frame element (103a, 103b; 203) extending in a second plane and forming a support portion (101a, 101b; 201b) for the plate (2), and
at least one spacing element (116) positioned at least partially between the support portion (101a, 101b; 201b) and the first frame element (102; 202), the spacing element (116) being configured to control a curvature of the first frame element (102; 202), and
wherein the at least one second frame element (103a, 103b; 203) is configured to engage the plate at the support portion (101a, 101b; 201b), is attached to the first frame element (102; 202), and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element (102, 202) with said spacing element (116), to control a curvature of the plate.

[Claim 2] The assembly (100) of claim 1, wherein the second frame element (103a, 103b; 203) is deflectable from a relaxed state to a deflected state, in which the second plane forms a parabolic concave curve along at least a portion of the length of the support portion (101a, 101b; 201b), and wherein a screw arrangement (112a, 112b, 112c, 113a, 113b; 219a, 219b, 219c) of the assembly (100) holds the second frame element (103a, 103b; 203) in the deflected state when assembled with the first frame element (102; 202).

[Claim 3] 3. The assembly (100) of any of claims 1 or 2, wherein a frame (109) of the first frame element (102) comprises a plurality of spacing elements (116) arranged spaced apart from corners of the frame (209) of the first frame element (102), wherein the spacing elements are configured to generate a force to the frame (109) away from the support portion (101a, 101b).

[Claim 4] The assembly (100) of claim 3, wherein each spacing element (116) comprises a screw (116, 116a, 116b) arranged in a hole of the frame (109).

[Claim 5] The assembly (100) of claim 4, wherein each spacing element (116) comprises a screw with a predefined length, and a spacer arranged

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between a head of the screw and the frame (109).

[Claim 6] 6. The assembly (100) of any of the previous claims, wherein assembly (100) comprises a plurality of attachment elements (112) arranged around the frame (109) for attaching the first frame element (102) to said panel (1).

[Claim 7] The assembly (100) of claim 6, wherein each attachment element (112) comprises a plurality of screws (112a, 112b, 112c, 113a, 113b) arranged in holes of the frame (109), wherein at least one of said screws (112a, 113b) is arranged to apply a first force to the frame (109) towards the support portion (101a, 101b), and at least one other of said screws (112b, 112c, 113b) is arranged to apply a second force to the frame (109) away from the support portion (101a, 101b).

[Claim 8] 8. The assembly (100) of claim 7, wherein each attachment element (112) comprises at least two screws (113a, 113b), wherein a first screw (113a) of said two screws is arranged opposing the support portion (101a, 101b) and to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (113b) of said two screws is arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b) and to apply said second force to the frame (109) away from the support portion (101a, 101b).

[Claim 9] The assembly (100) of claim 7, wherein each attachment element (112) comprises at least three screws (112a, 112b, 112c), wherein all three screws are arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b), and wherein a first screw (112a) of said three screws is arranged to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (112b) and a third screw (112c) of said three screws are arranged to apply said second force to the frame (109) away from the support portion (101a, 101b), the first screw (112a) being arranged between the second screw (112b) and the third screw (112c).

[Claim 10] 10. The assembly (100) of any of the previous claims, wherein a gasket (205) is arranged on another support portion (201a) of the second frame element (202), wherein the gasket (205) has a varying thickness along its length.

[Claim 11] The assembly (100) of claim 10, wherein the gasket (205) has opposing ends, and is thinner between the opposing ends than at said ends.

[Claim 12] The assembly (100) of claim 11, wherein a first section (205a) of the

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gasket (205) at one of said ends and a second section (205b) of the gasket (205) at the other of said ends has a first thickness, and at least a third section (205c) of the gasket between the first section (205a) and the second section (205b) has a second thickness, wherein the first thickness is thicker than the second thickness.

[Claim 13] 13. The assembly (100) of any of claims 10-12, wherein the second frame element (203) comprises a frame side and the third frame element comprises an edge cover, and wherein the edge cover comprises another support portion for said panel (1), wherein a distance between the support portion of the frame side and the support portion of the edge cover is discontinuous in an assembled state.

[Claim 14] The assembly (100) of claim 13, wherein the frame side comprises a first hole (217a) and a second hole (217b) arranged at opposing ends of the frame side and in a first plane, and a third hole (217c) arranged between the first hole (217a) and the second hole (217c) and in a plane that is different from the first plane, and

the edge cover comprises a first hole (218a) and a second hole (218b) arranged at opposing ends of the edge cover, and a third hole (218c) arranged between the first hole (218a) and the second hole (218c) of the edge cover, wherein the first hole (218a), the second hole (218b), and the third hole (218c) of the edge cover are generally arranged in the same plane when the edge cover is disconnected from the frame side, and

wherein the edge cover is less stiff than the frame side and deflectable such that the holes (218a, 218b, 218c) of the edge cover are aligned with the holes (217a, 217b, 217c) of the frame side and such that the support portion of the edge cover extends in a plane, which is curved.

[Claim 15] 15. A method for assembling a panel and a plate for an optical touch sensitive system, comprising:

providing a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

providing at least one second frame element (103a, 103b; 203) forming a support portion (101a, 101b; 201b) for the plate (2);

supporting the plate (2) by the support portion (101a, 101b, 201b);

attaching the second frame element to the first frame element (102; 202) such that

the support portion (101a, 101b; 201b) extends at least partially in a second plane generally opposite at least a portion of the first frame

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element (102; 202) and is spaced apart from the first plane; and controlling a curvature of the first frame element (102; 102) with a spacing element (116) attached to the first frame element (102; 202) and thereby tilting the support portion (101a, 101b, 201b) to control a curvature of the plate (2).

[Claim 16] 16. A touch sensing apparatus, comprising:
a touch surface;
a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface,
a set of light detectors arranged around the touch surface to receive light from the first set of emitters,
wherein each light detector is arranged to receive light from more than one emitter;
a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface,
wherein the touch surface is curved in a first axis according to a first parabola.

[Claim 17] 17. The touch sensing apparatus of claim 16, wherein the touch surface is curved in a second axis according to a second parabola.

[Claim 18] 18. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

[Claim 19] 19. The touch sensing apparatus of claim 18, wherein the first parabolic curve paraboloid is an elliptical paraboloid.

[Claim 20] 20. The touch sensing apparatus of claim 16, wherein each point of the first axis of the touch surface is within 0.5mm of a mathematical parabola.

[Claim 21] 21. The touch sensing apparatus of claim 20, wherein the mathematical parabola is defined according to $z(x, y)=a+bx^2+cx^2y^2+dy^2$, where z is depth, and x and y are co-ordinates in the plane of the glass.

[Claim 22] 22. The touch sensing apparatus of claim 16, wherein the touch surface comprises a portion of a surface of a plate.

[Claim 23] 23. The touch sensing apparatus of claim 22, wherein the plate comprises a glass or plastic sheet.

[Claim 24] 24. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

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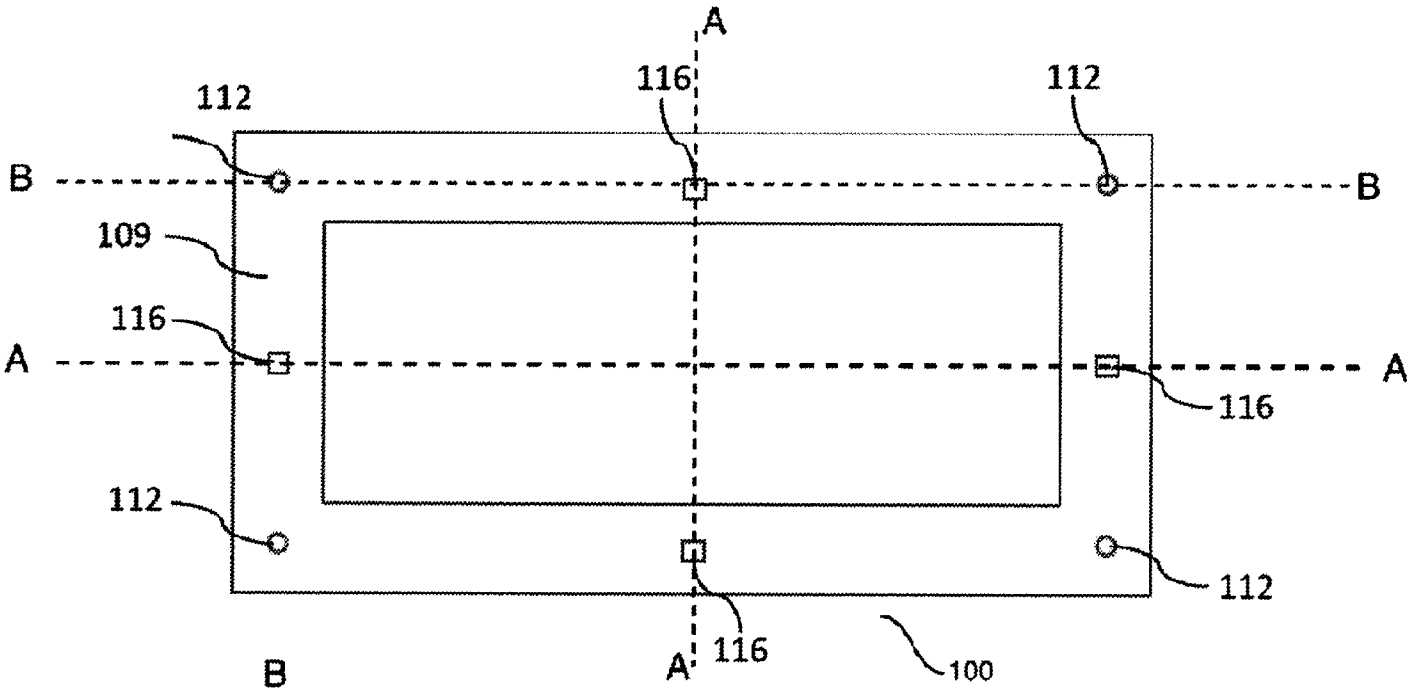


Figure 1

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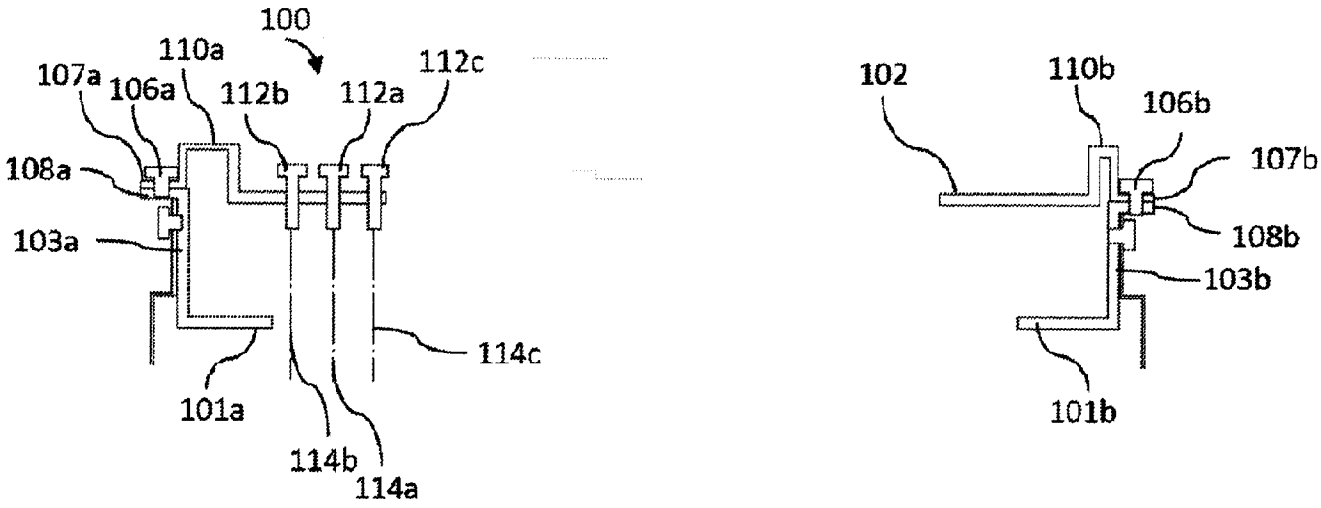

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110a
107a
106a
112b
112a
112c
108a
103a
114c
101a
114b
114a
102
110b
106b
107b
108b
103b
101b

Figure 2a

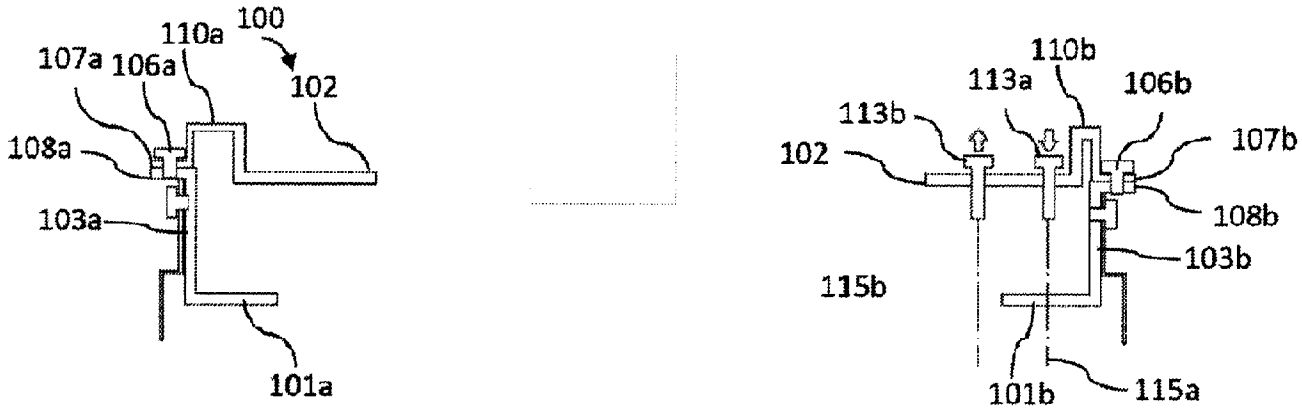

100
110a
107a
106a
102
108a
103a
101a
110b
113a
106b
113b
107b
102
108b
103b
115b
101b
115a

Figure 2b

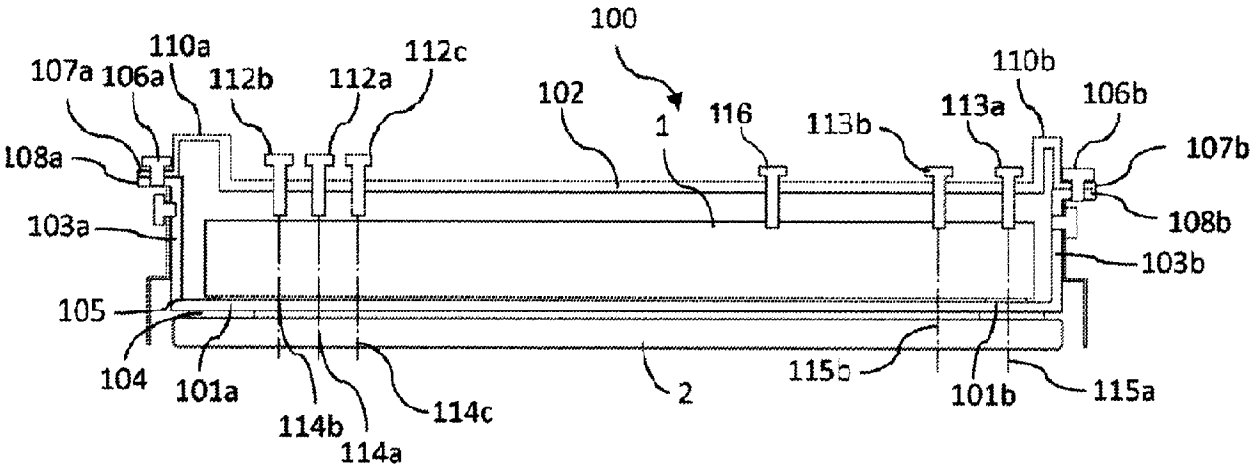


Figure 2c

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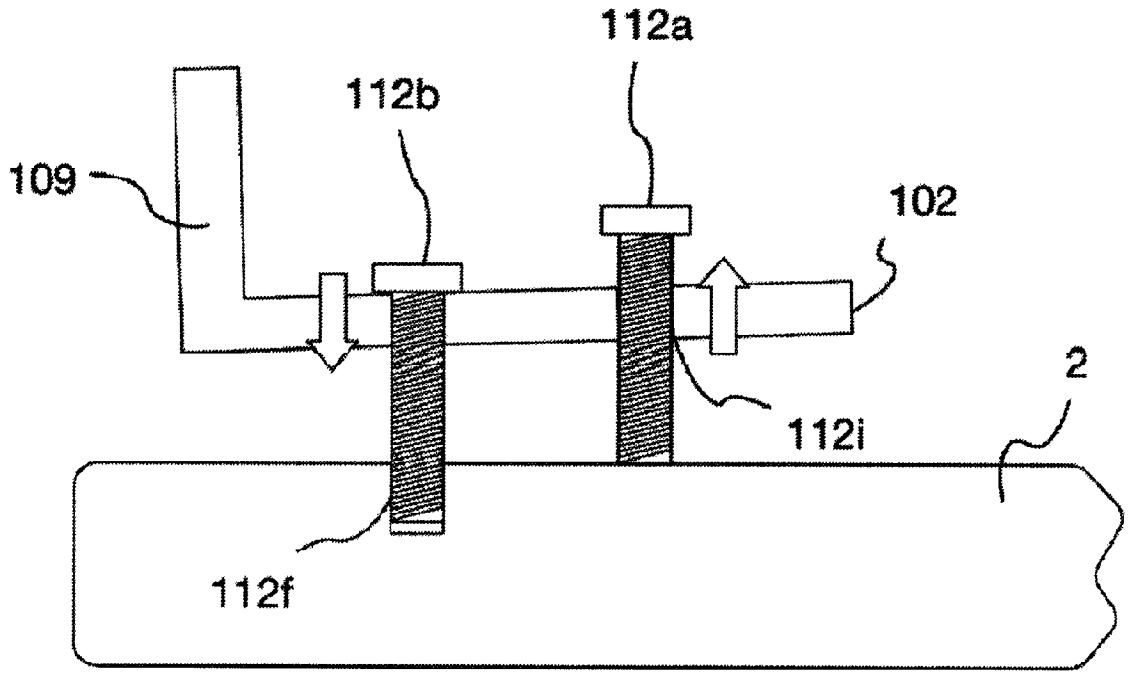


Figure 2d

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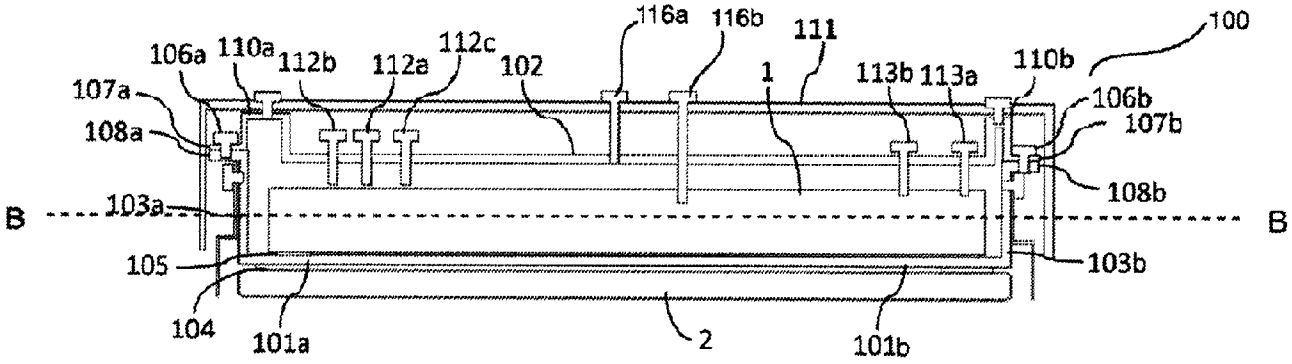


Figure 3a

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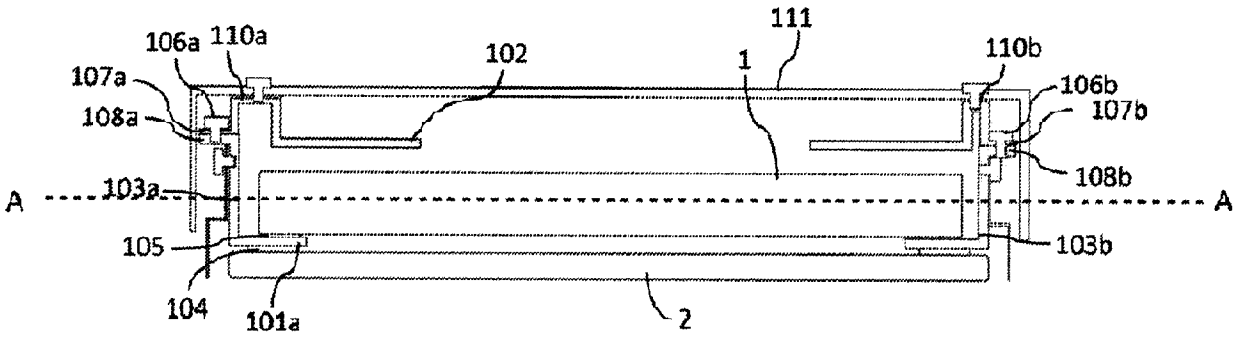

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106a
110a
102
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110b
107a
106b
107b
108a
108b
A
103a
A
105
103b
104
101a
2

Figure 3b

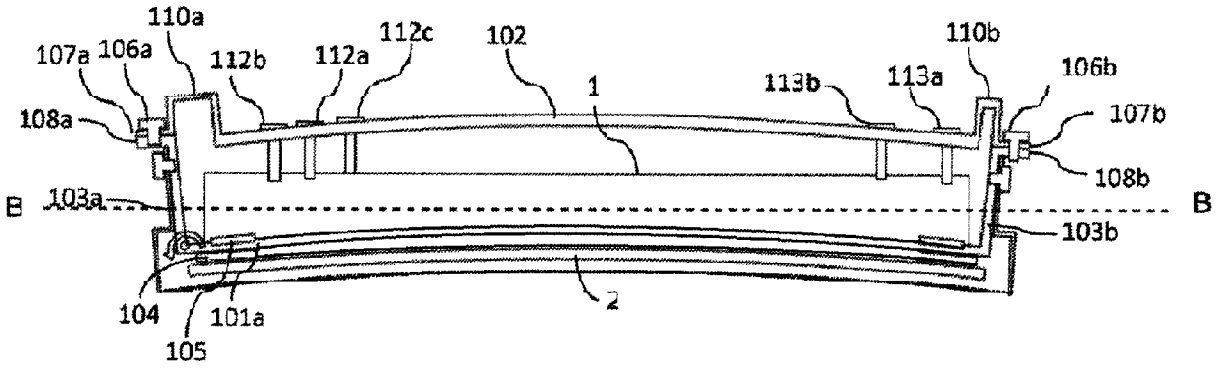

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107a
106a
112b
112a
112c
102
1
110b
113b
113a
106b
107b
108a
108b
B
103a
B
103b
104
101a
105
2

Figure 3c

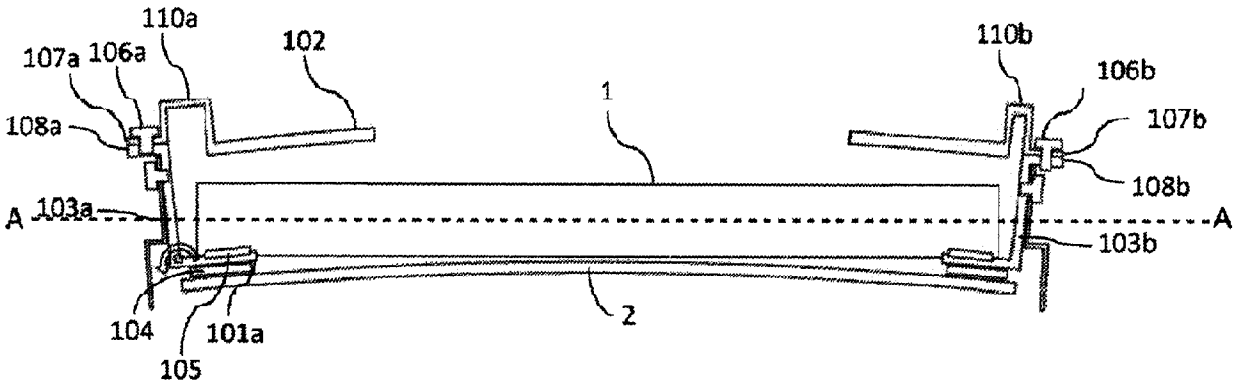

110a
102
107a
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1
2
110b
106b
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103b
A

Figure 3d

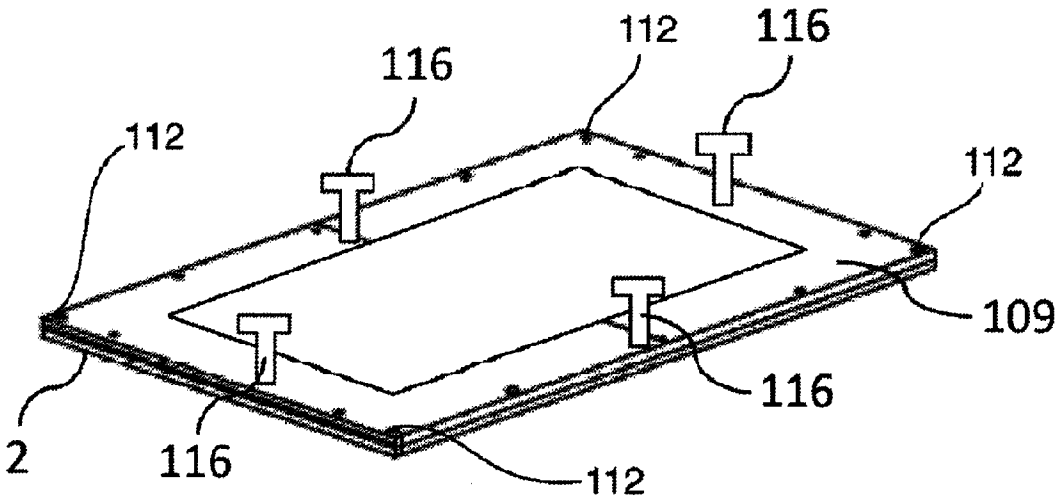


Figure 4a

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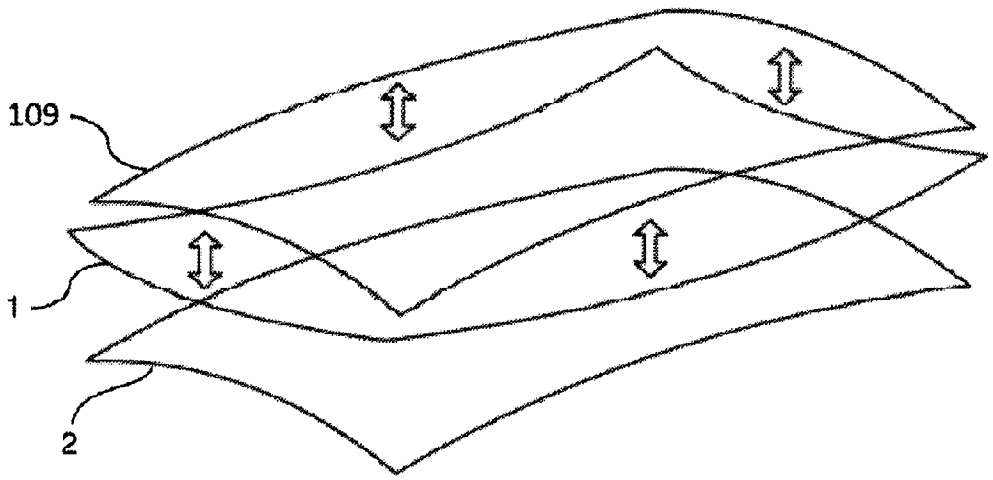


Figure 4b

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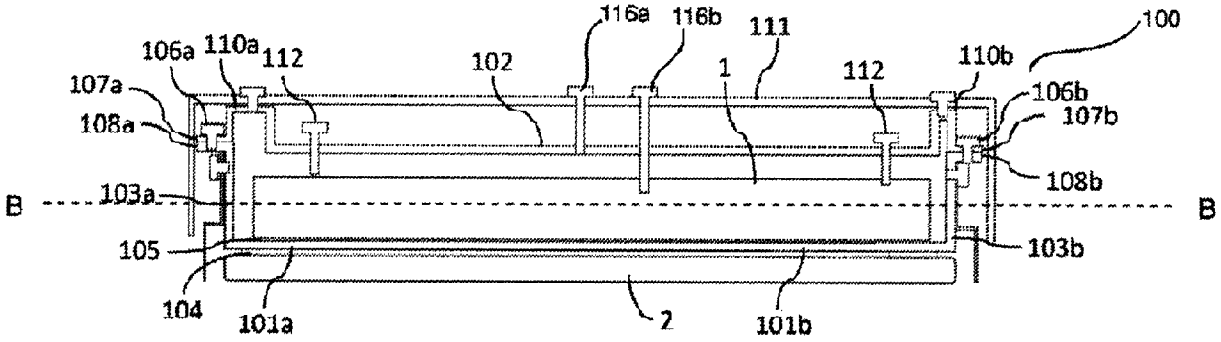

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116b
111
100
106a
110a
112
102
1
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110b
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106b
108a
107b
B
103a
108b
B
105
103b
104
101a
2
101b

Figure 4c

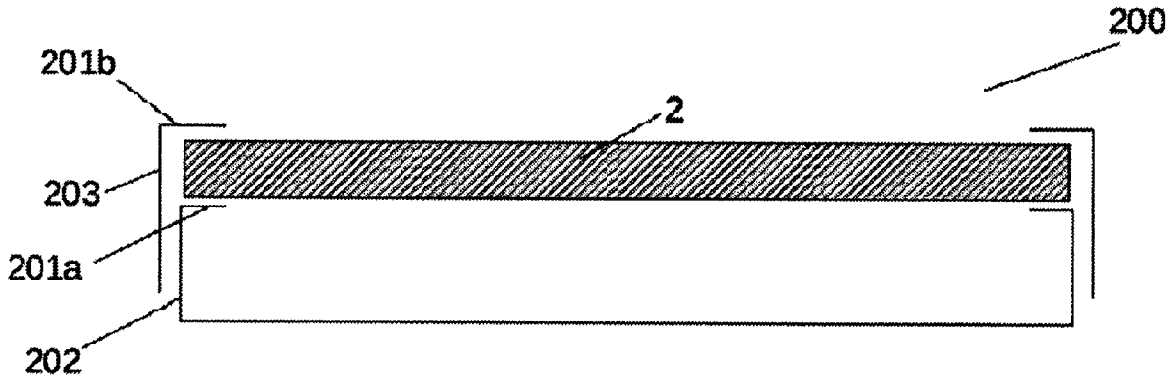


Figure 5a

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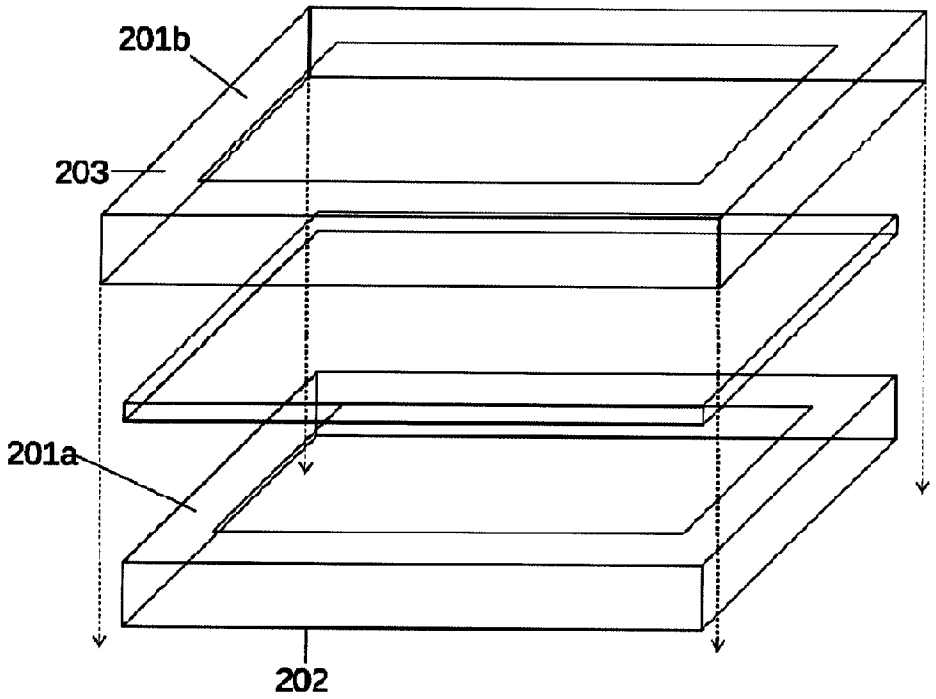


Figure 5b

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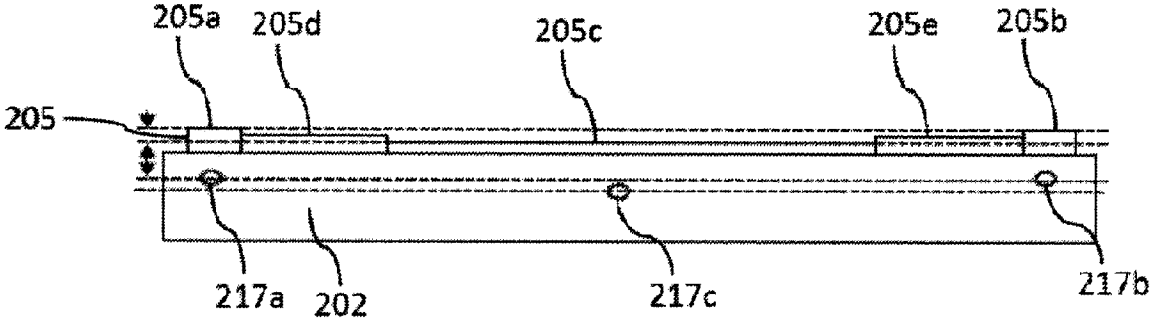


Figure 5c

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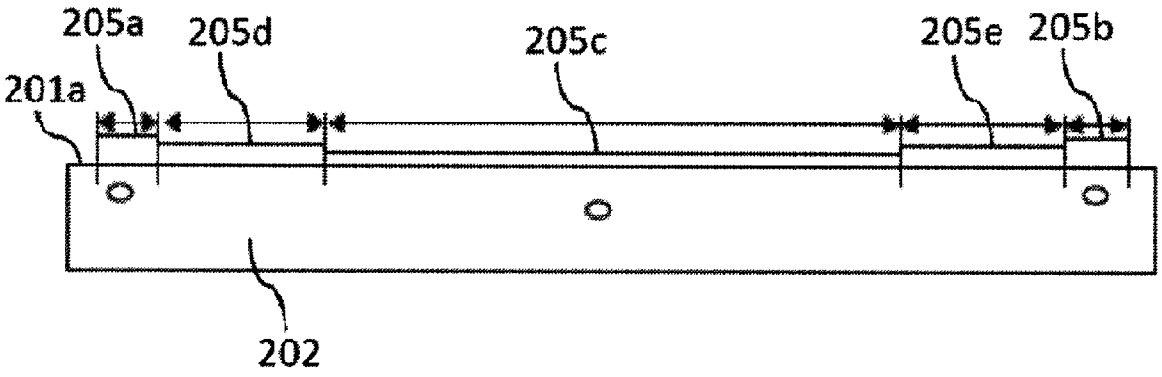


Figure 5d

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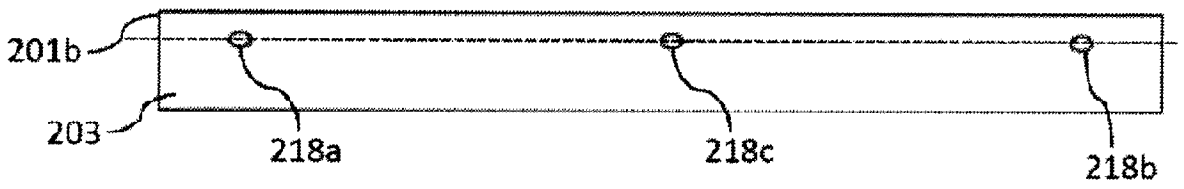


Figure 5e

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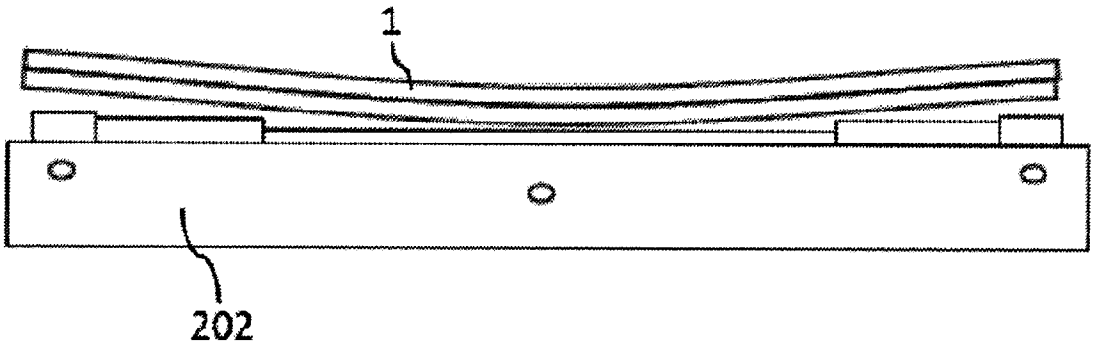


Figure 5f

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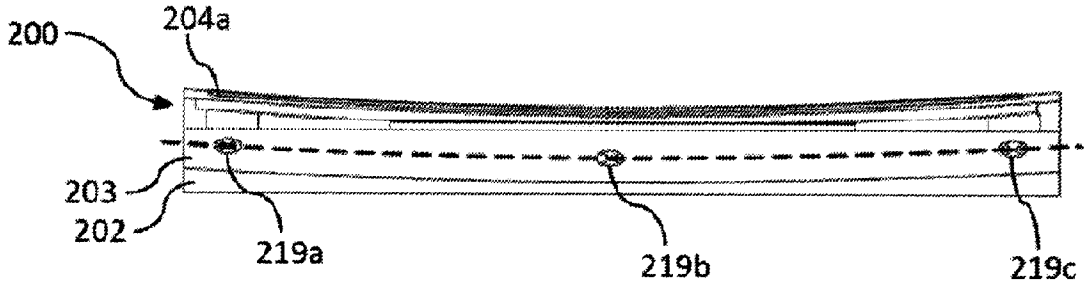


Figure 5g

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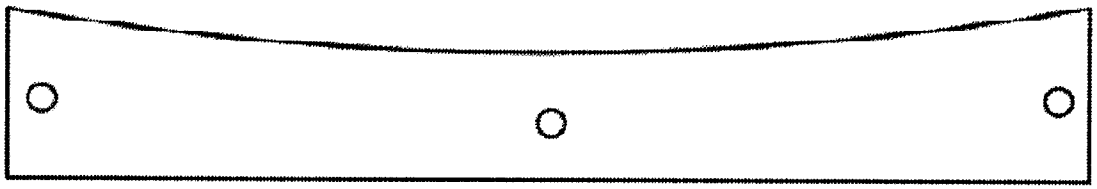


Figure 5h

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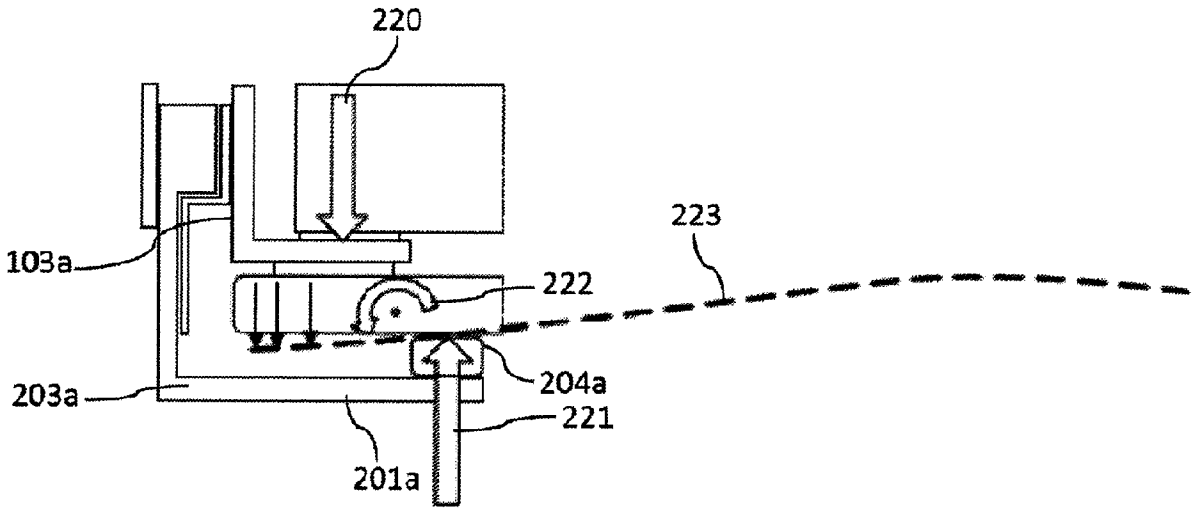


Figure 6

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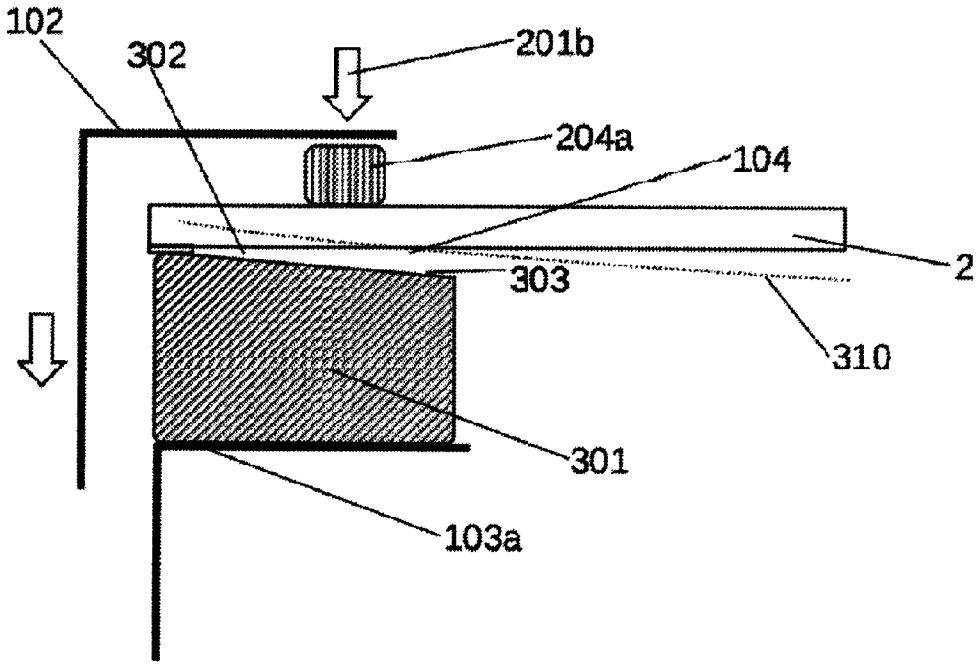


Figure 7

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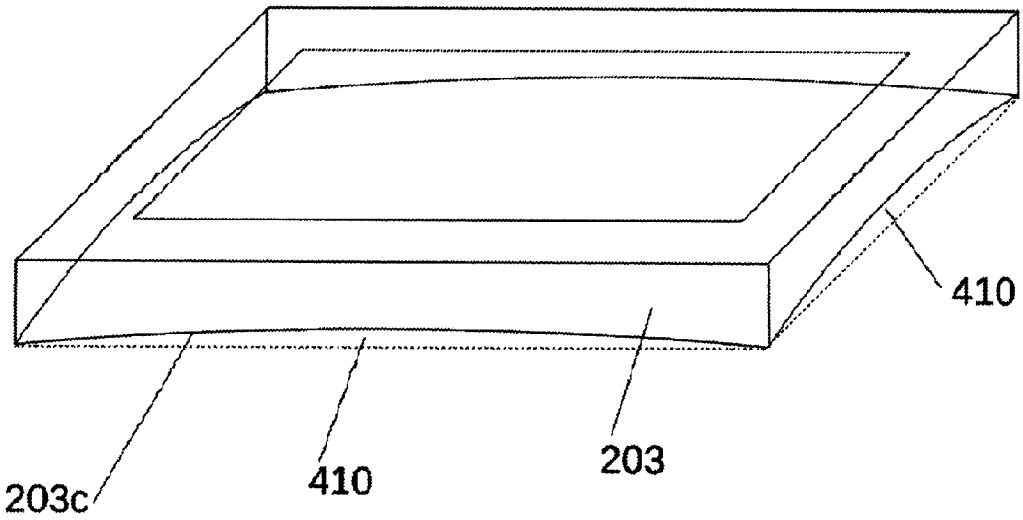


Figure 8

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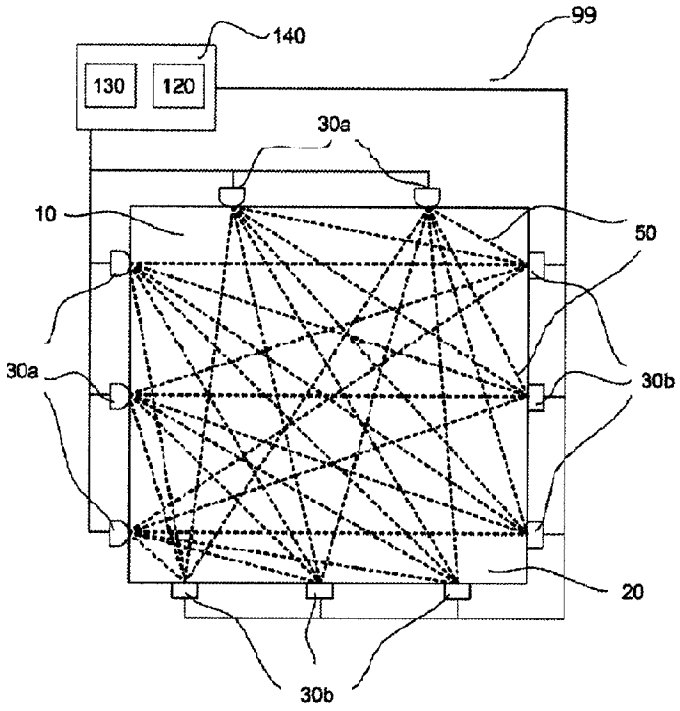


Figure 9

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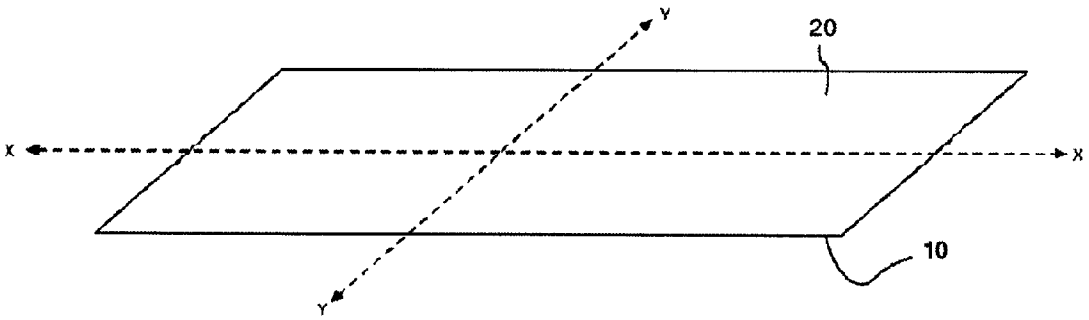


Figure 10a

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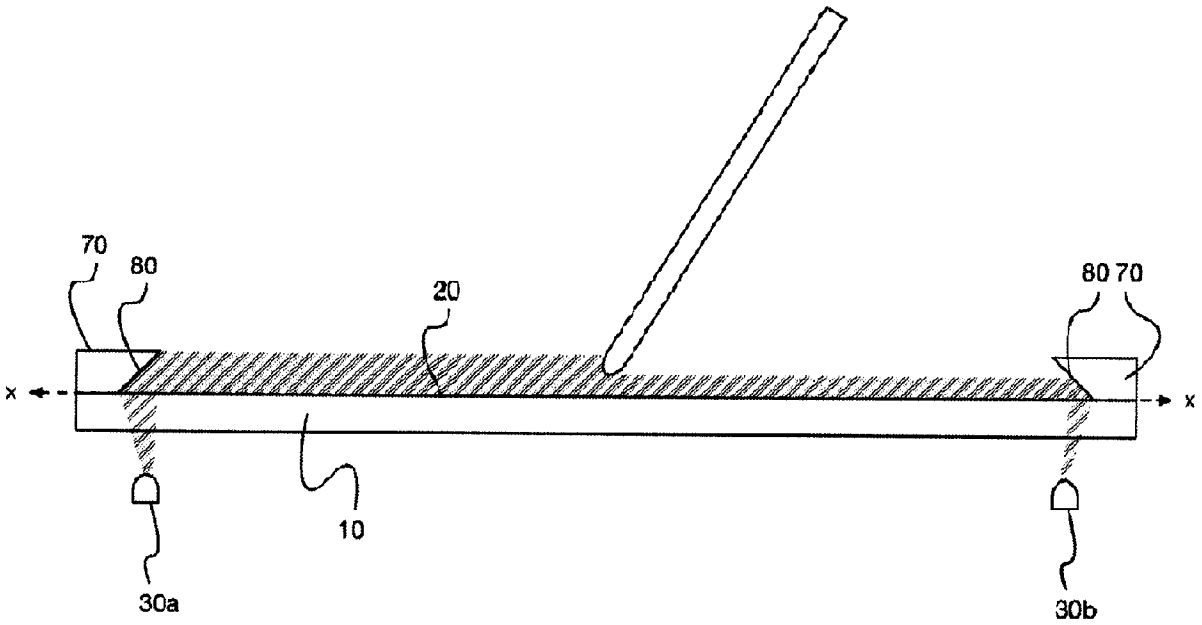


Figure 10b

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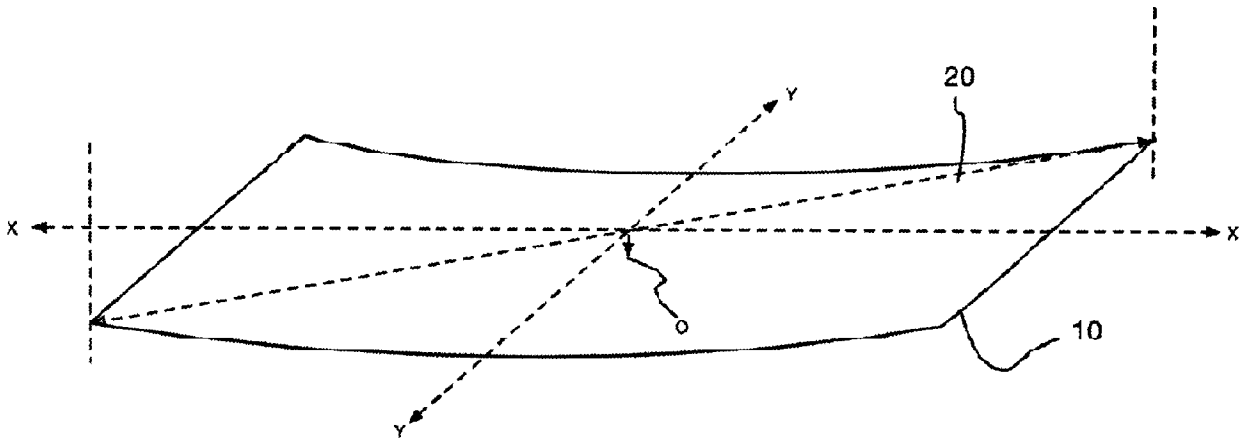


Figure 11a

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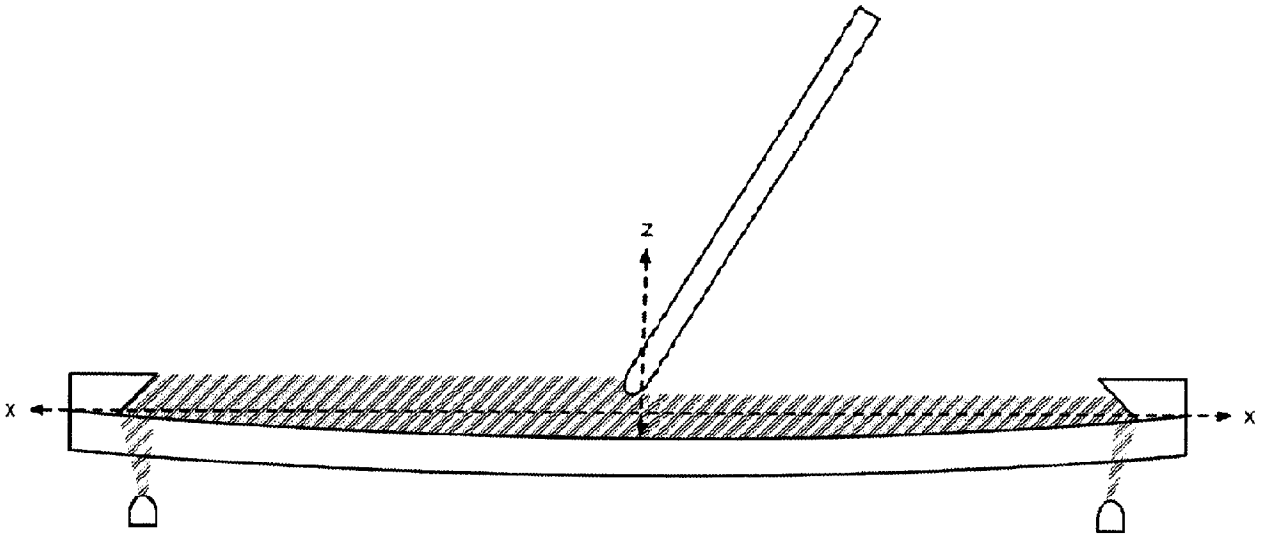


Figure 11b

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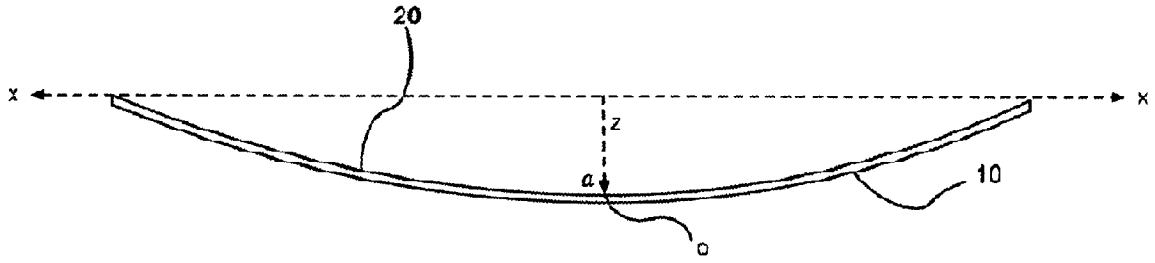


Figure 11c

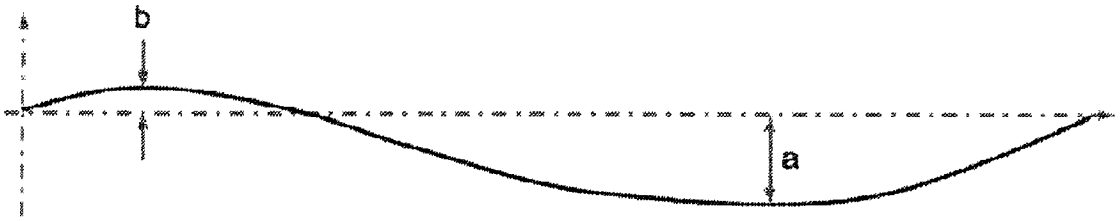


Figure 11d

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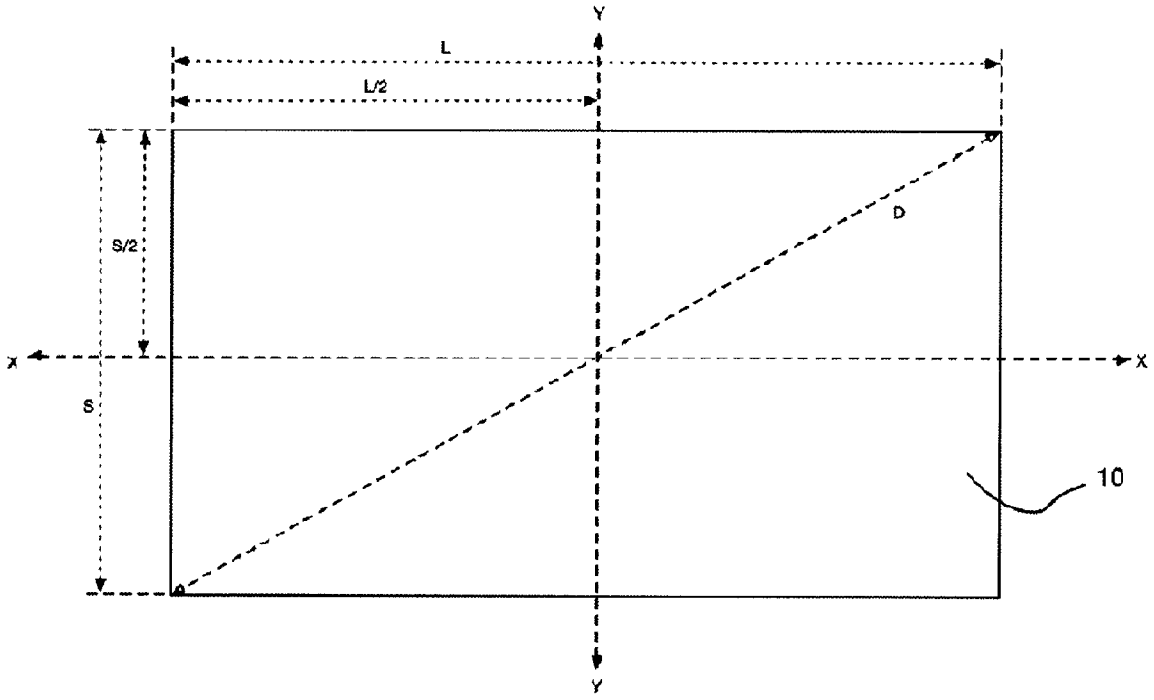


Figure 12a

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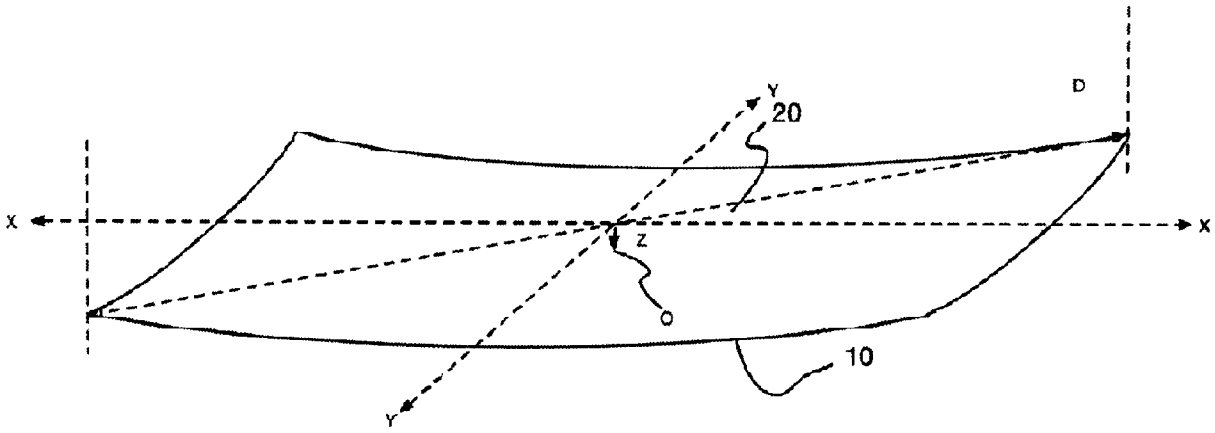


Figure 12b

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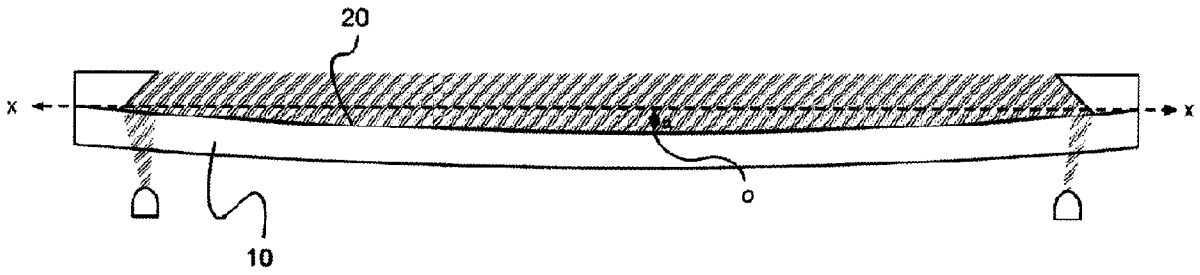


Figure 12c

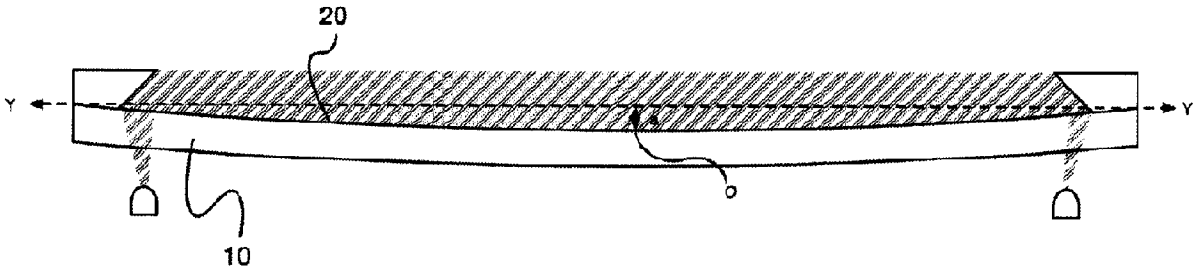


Figure 12d

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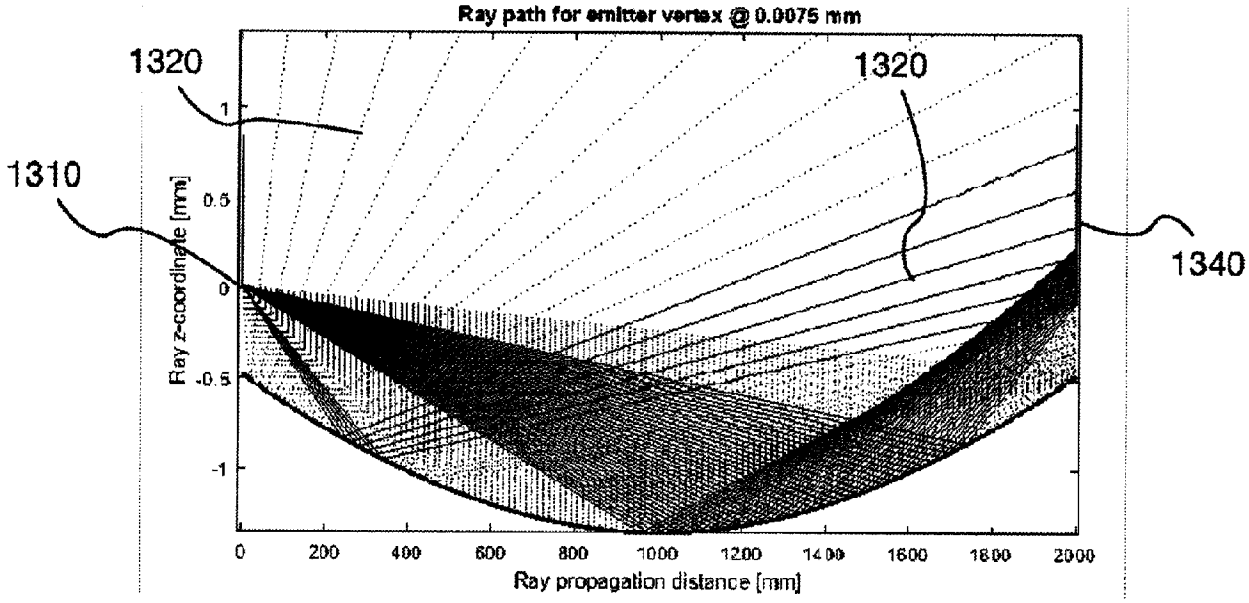


Figure 13a

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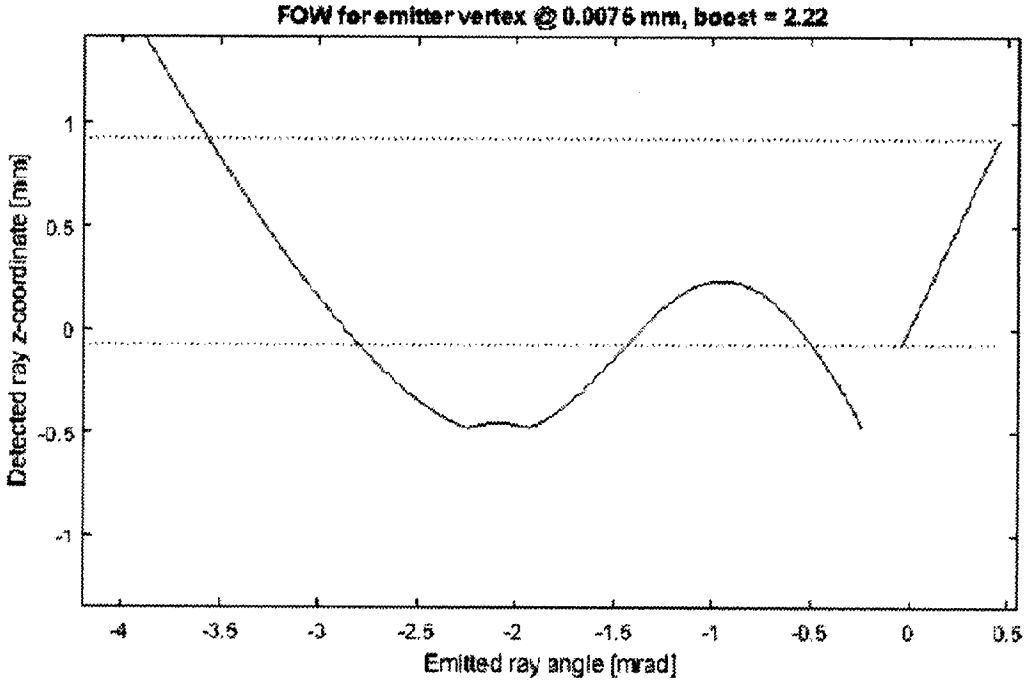


Figure 13b

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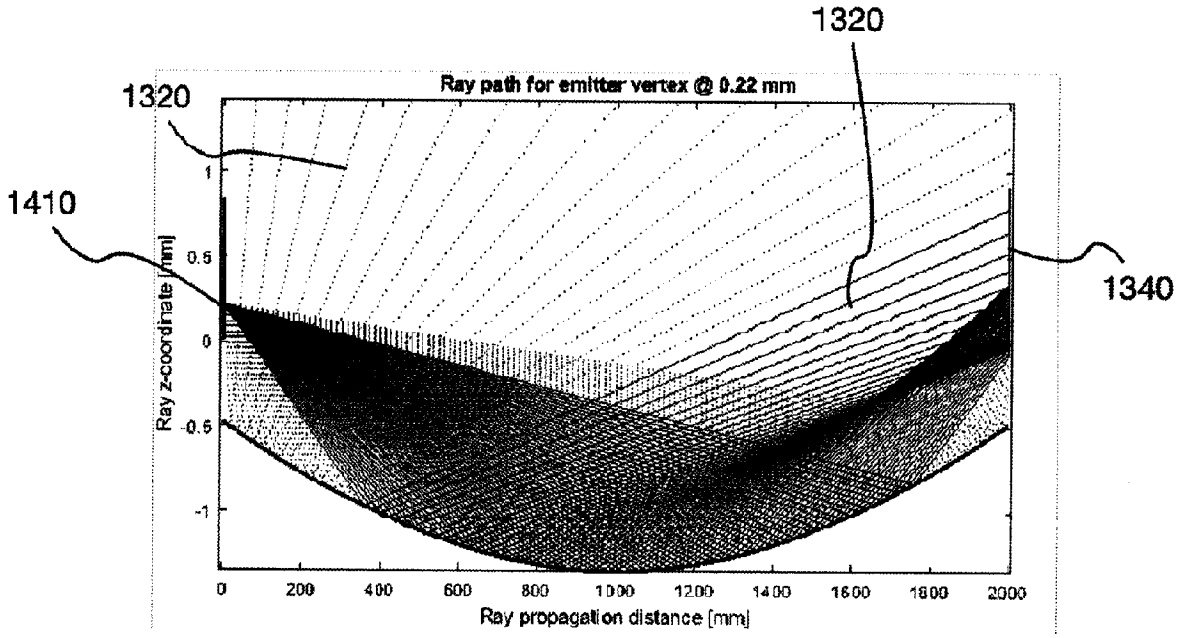


Figure 14a

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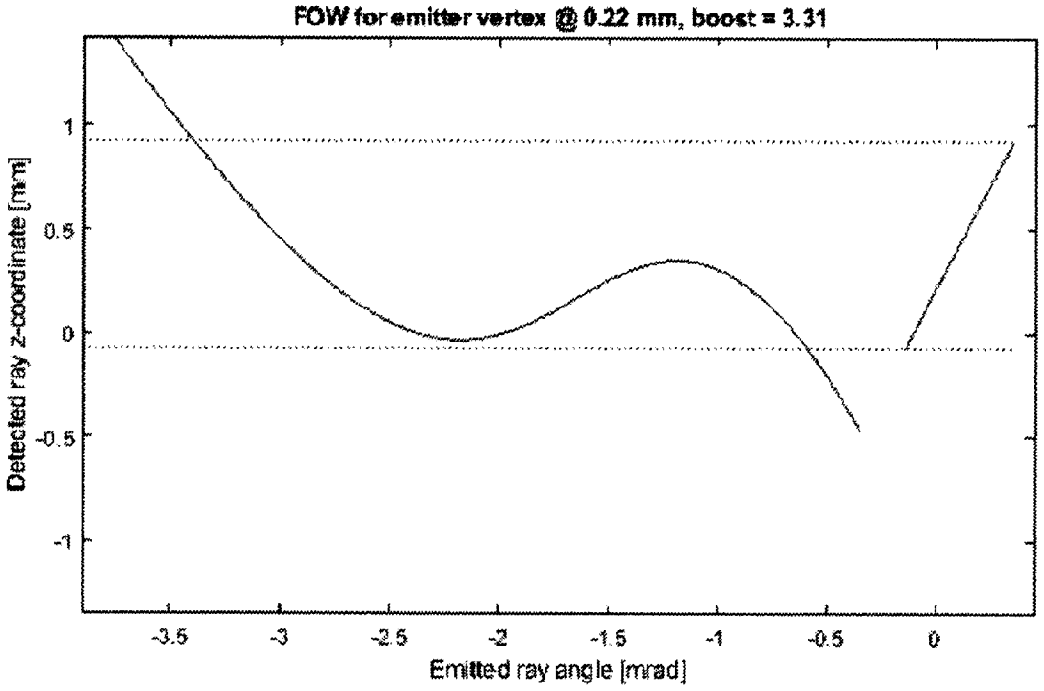


Figure 14b

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
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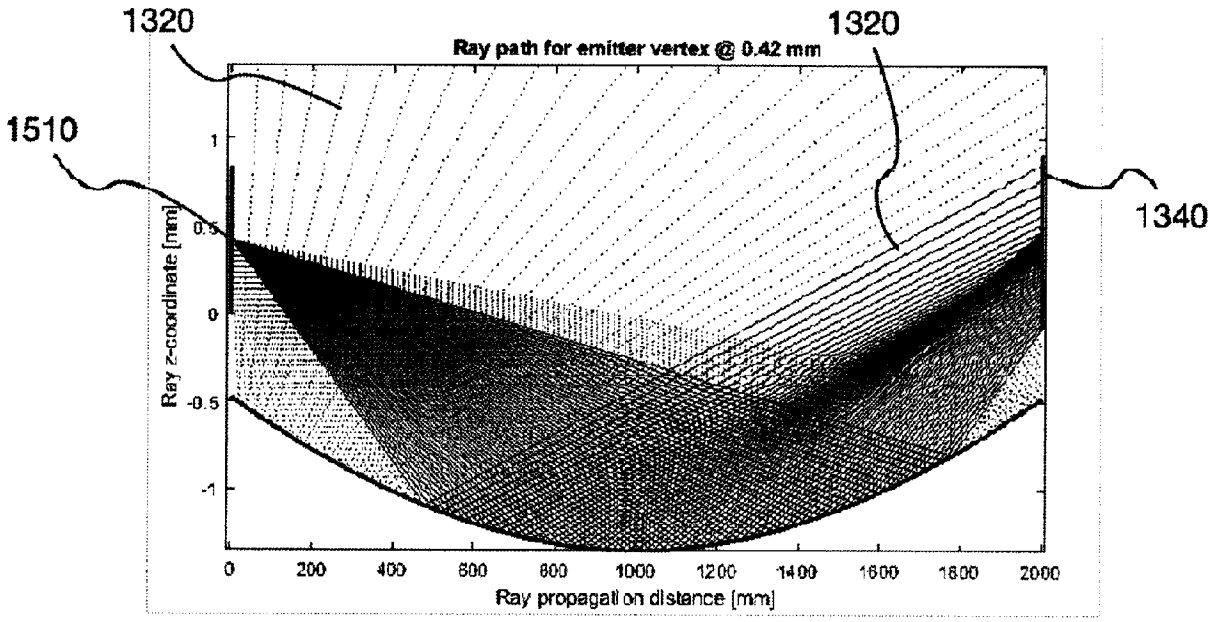


Figure 15a

IPR2024-00013
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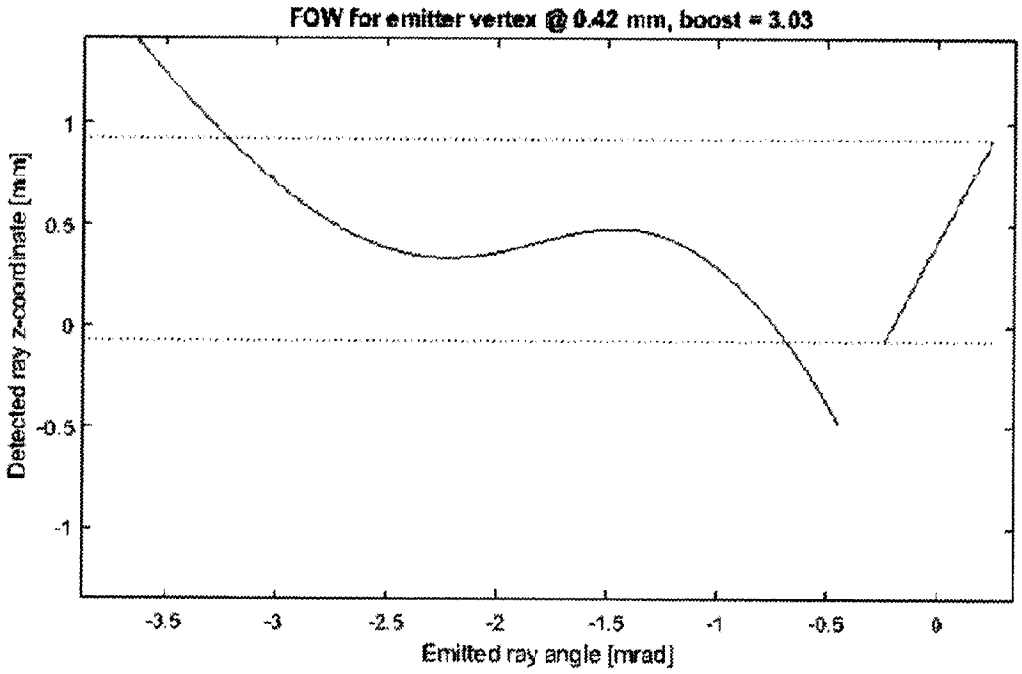


Figure 15b

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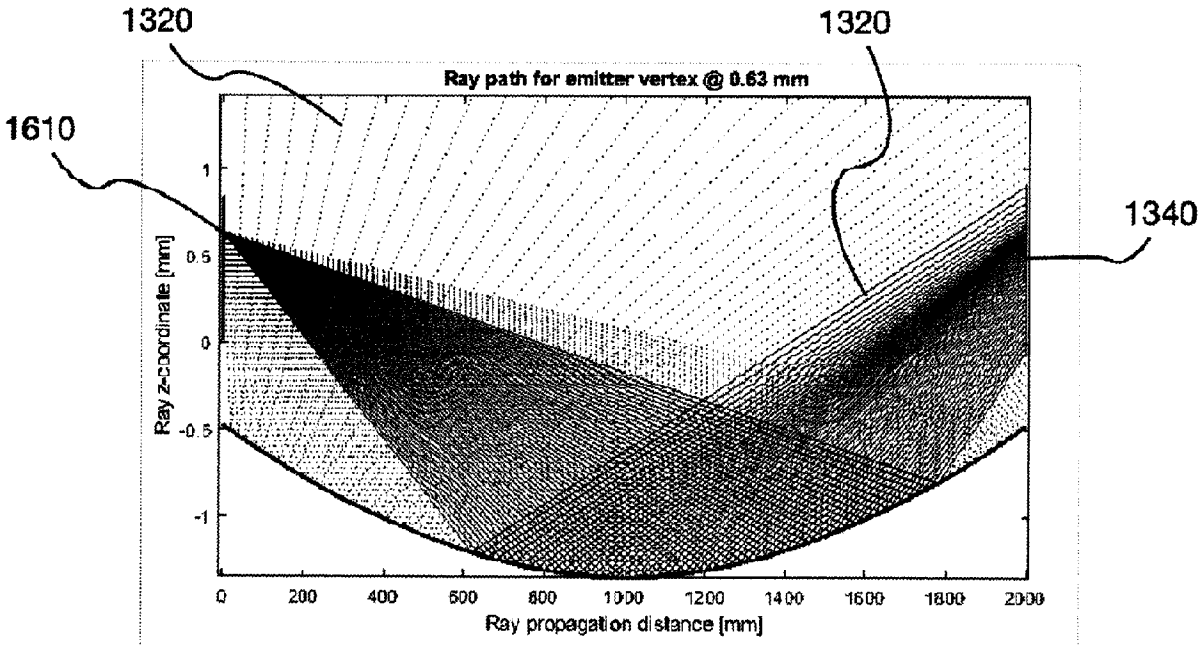


Figure 16a

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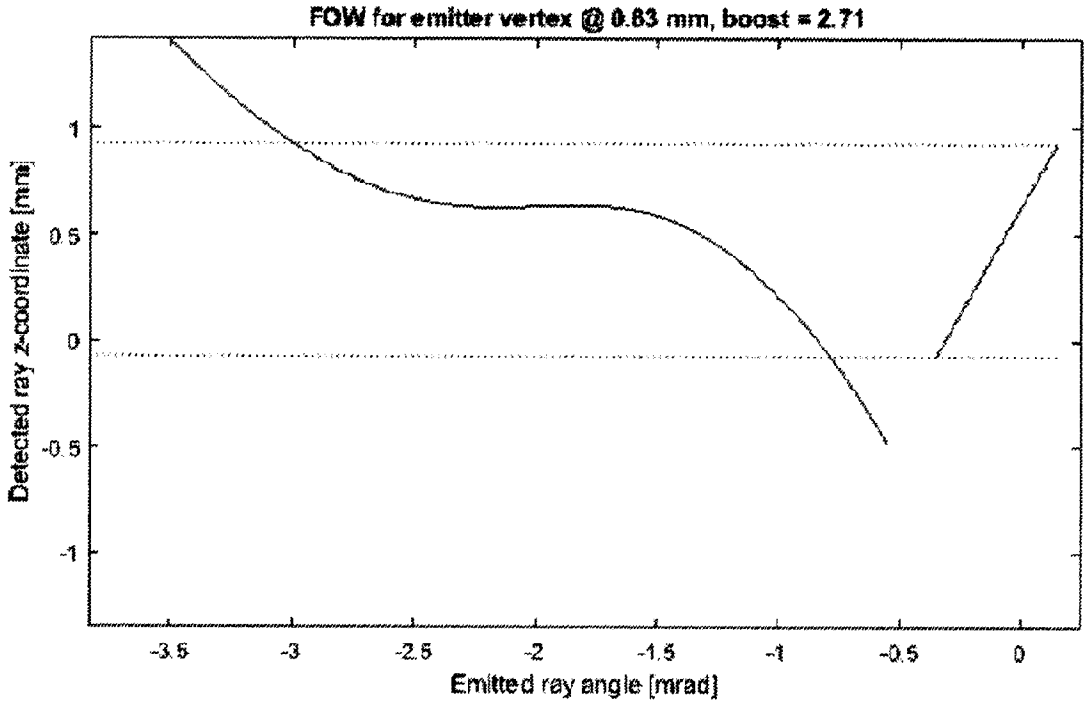


Figure 16b

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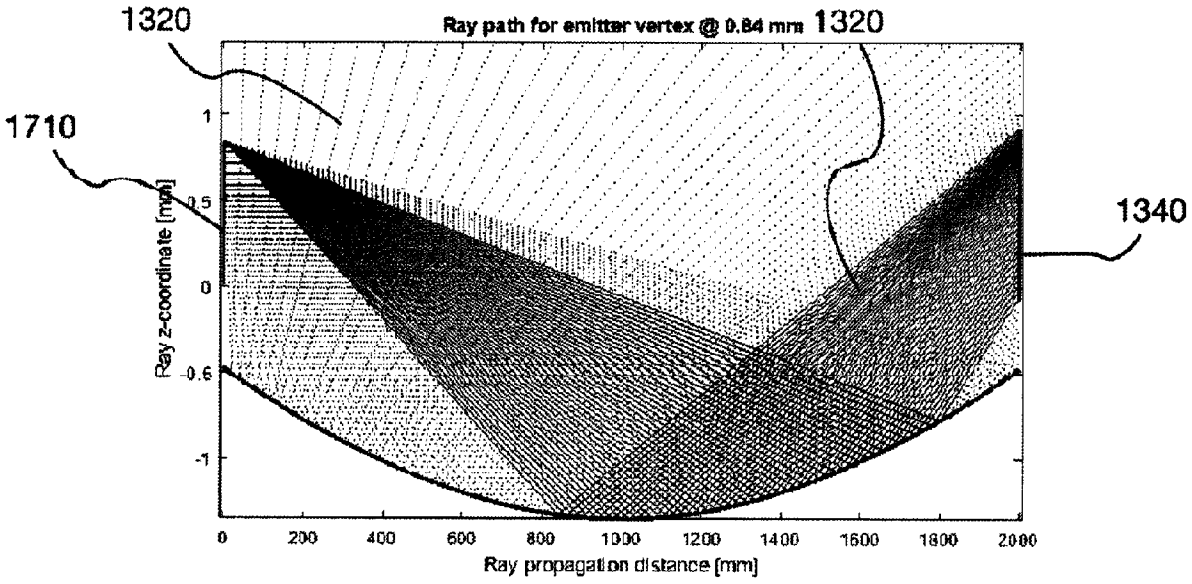


Figure 17a

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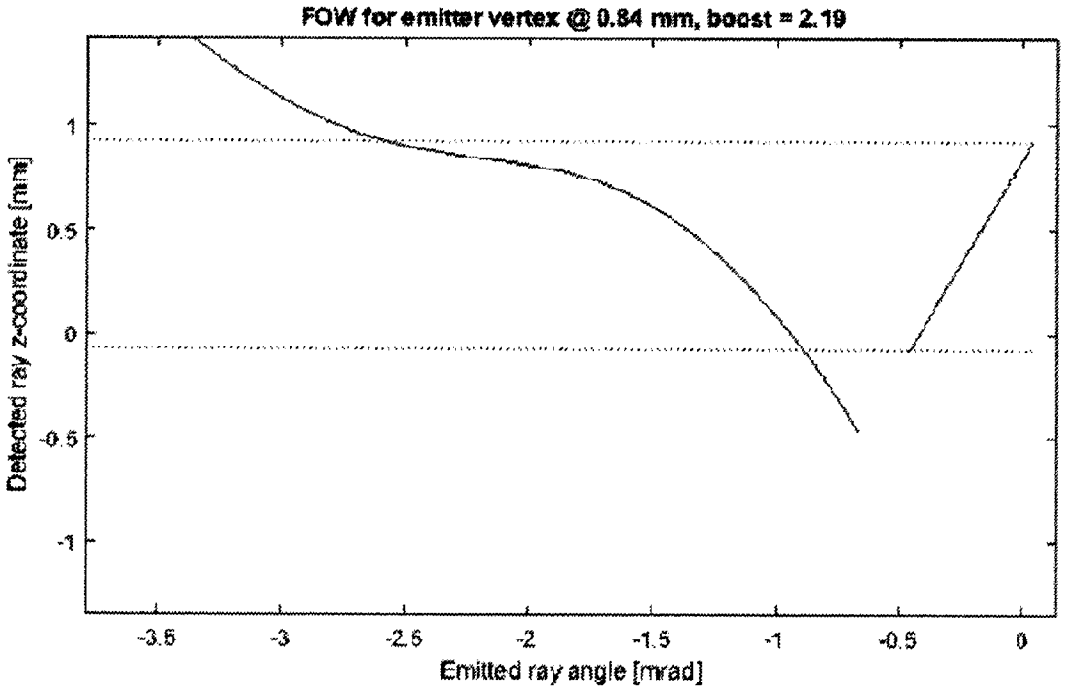


Figure 17b

IPR2024-00013
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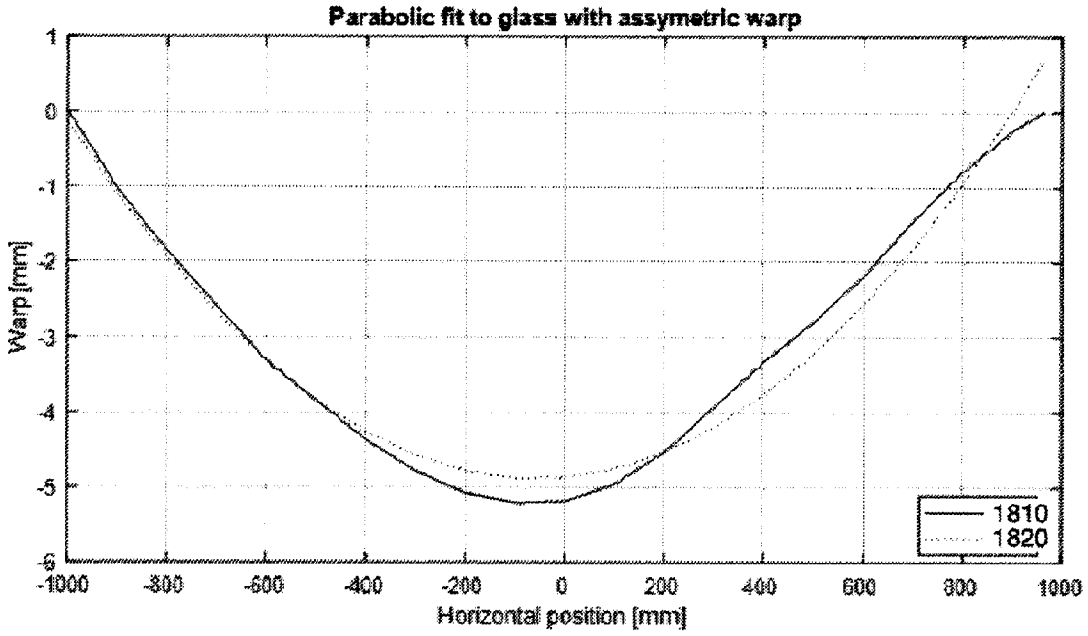

Parabolic fit to glass with assymetric warp
Warp [mm]
Horizontal position [mm]
1810
1820
1
0
-1
-2
-3
-4
-5
-6
-1000
-800
-600
-400
-200
0
200
400
600
800
1000

Figure 18a

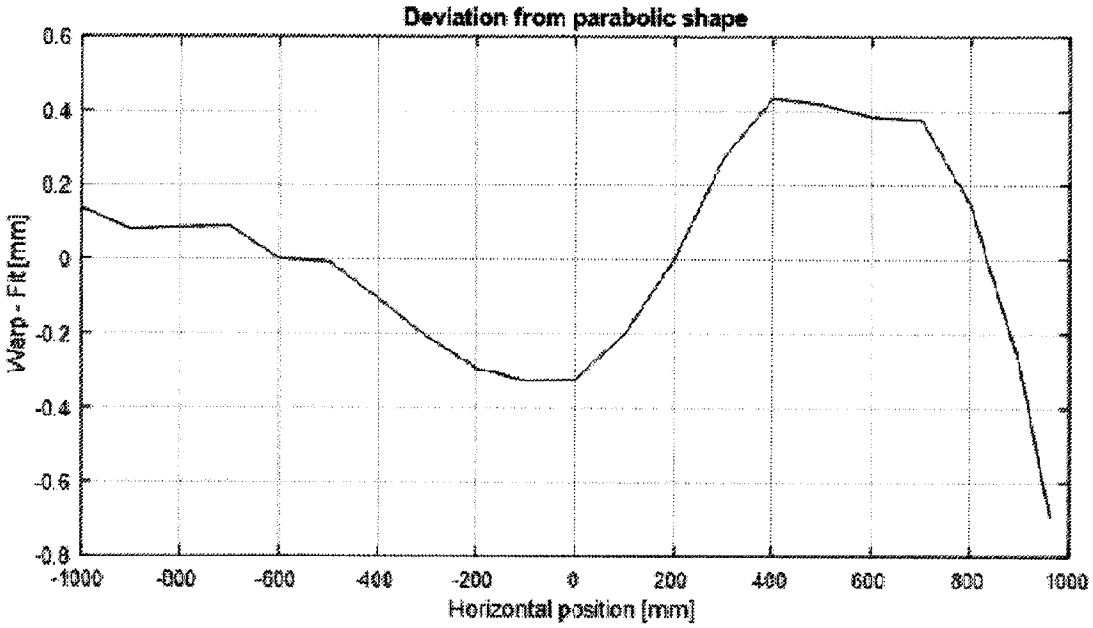


Figure 18b

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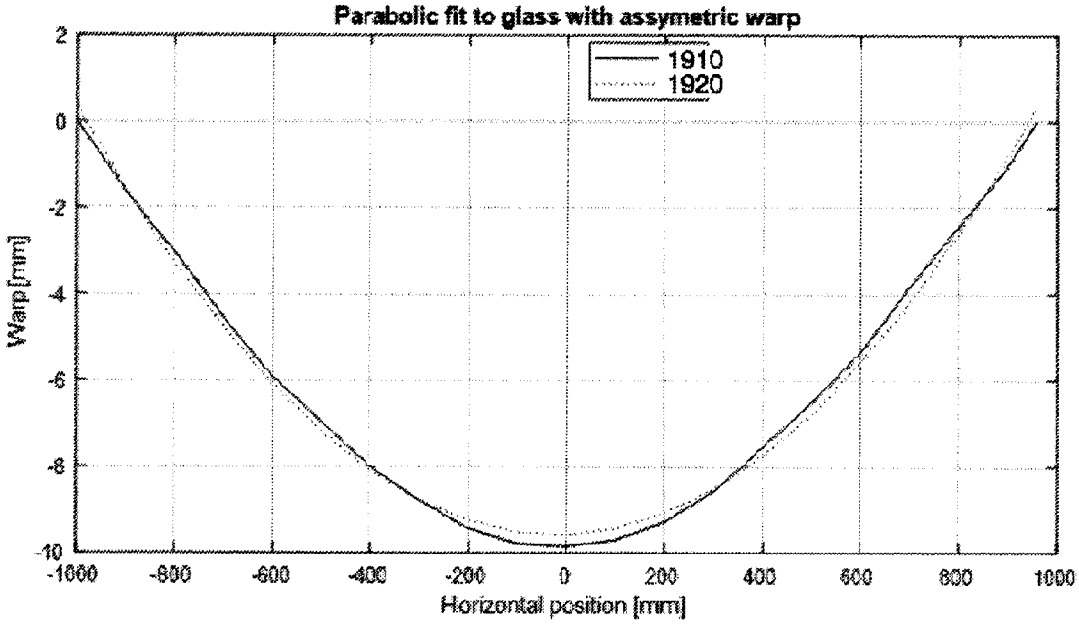


Figure 19a

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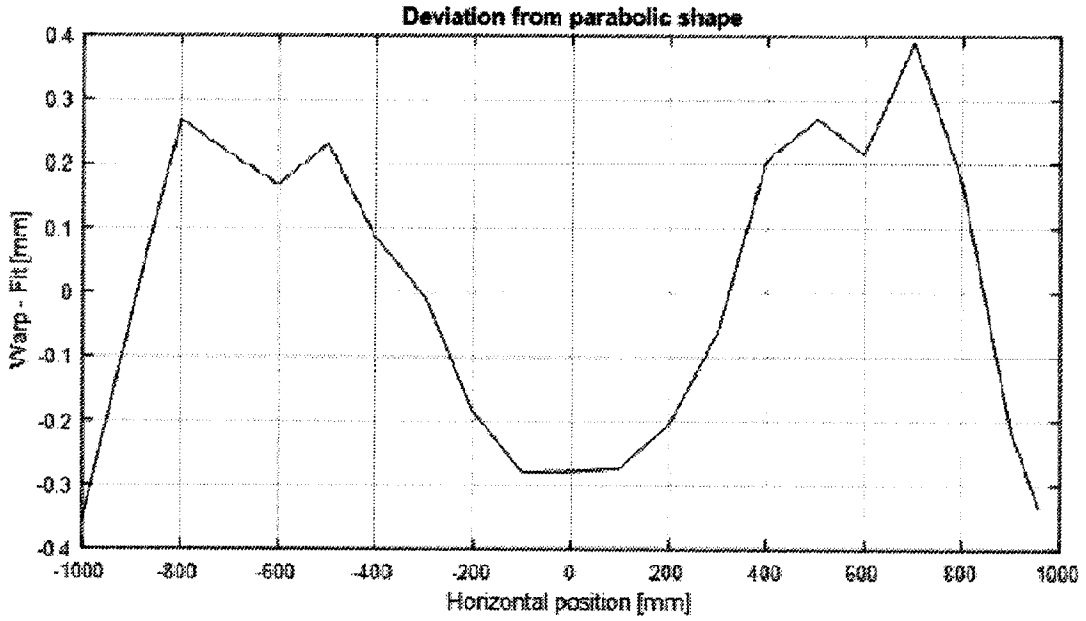


Figure 19b

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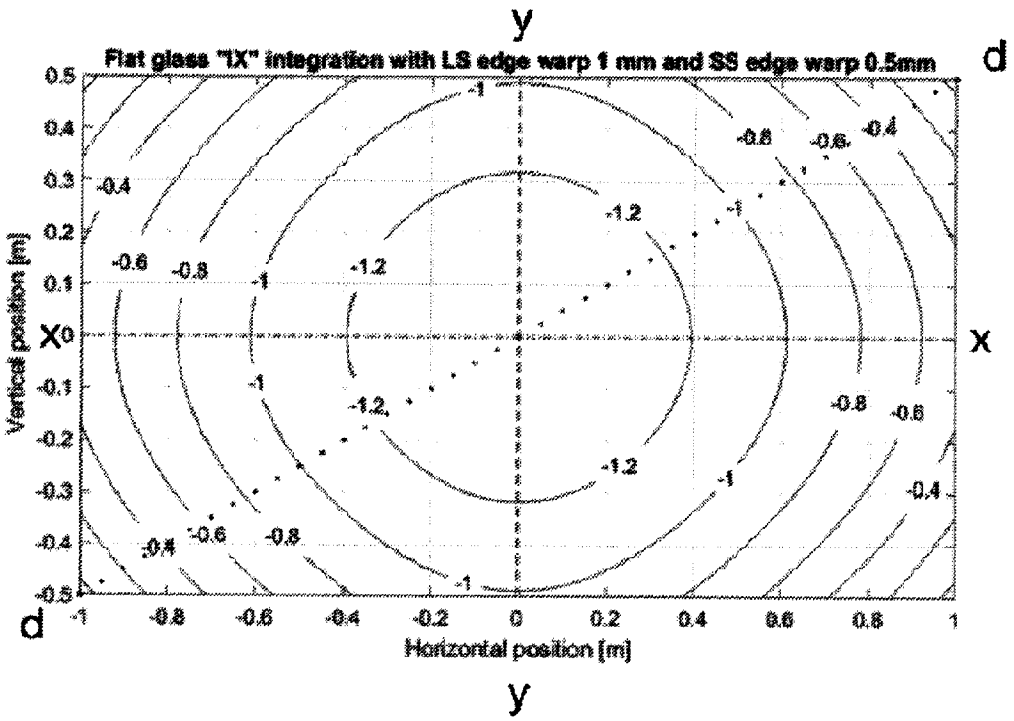

y
Flat glass "1X" integration with LS edge warp 1 mm and SS edge warp 0.5mm
d
Vertical position [m]
Horizontal position [m]
x
d
y

Figure 20a

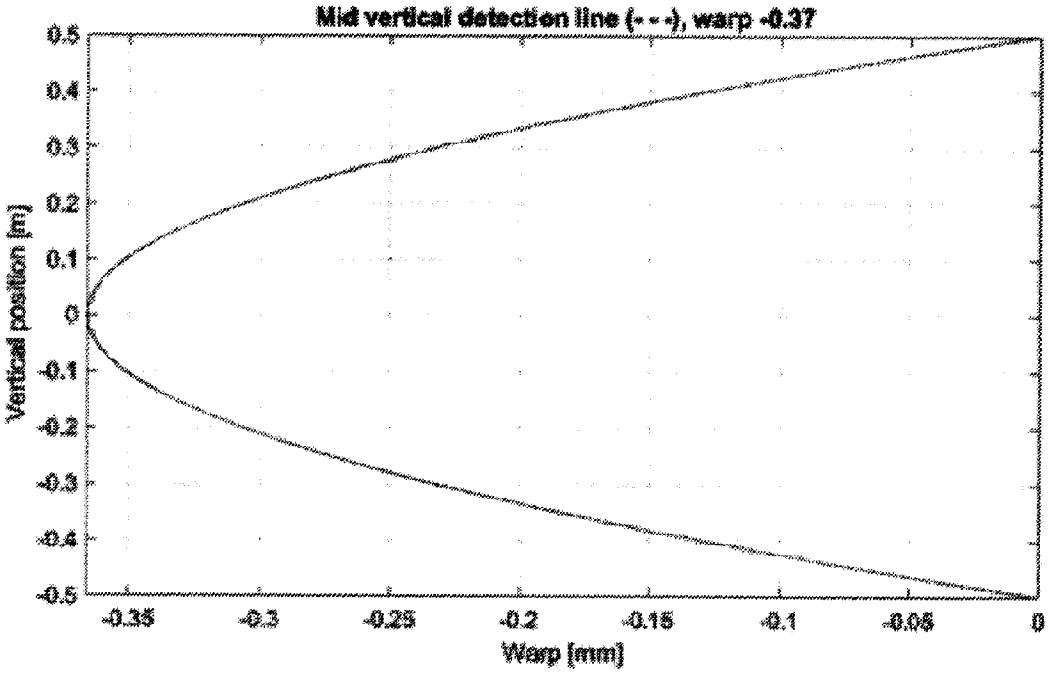


Figure 20b

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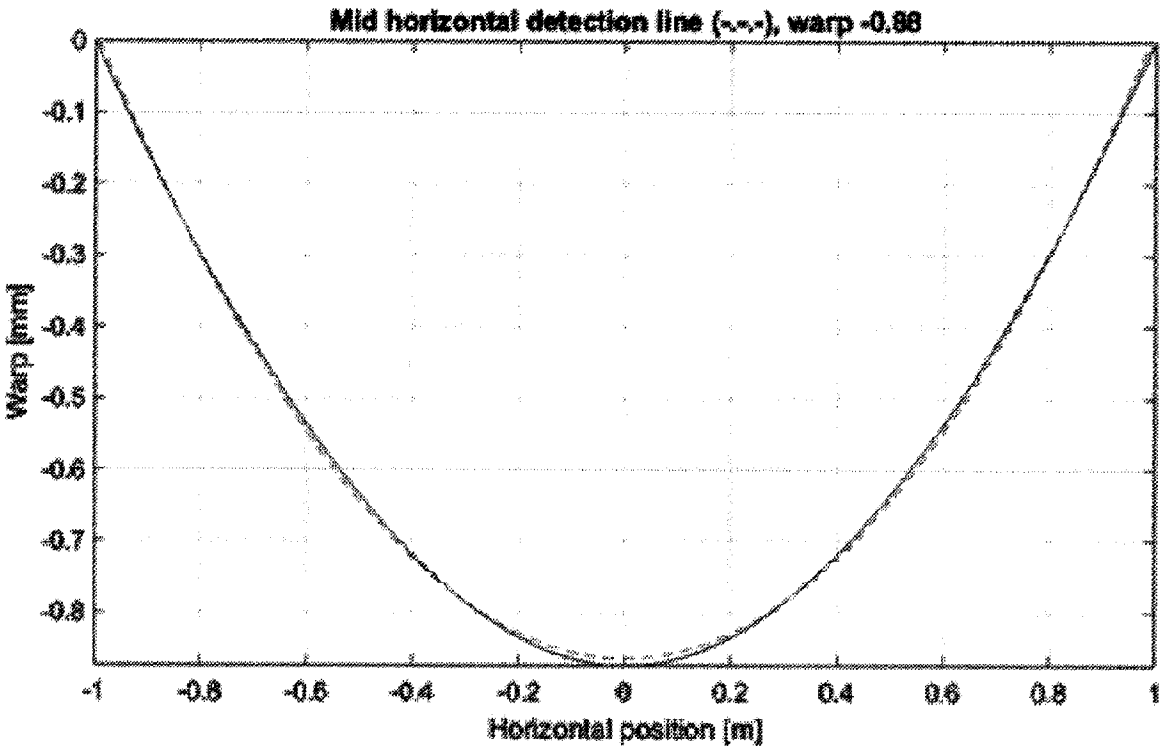


Figure 20c

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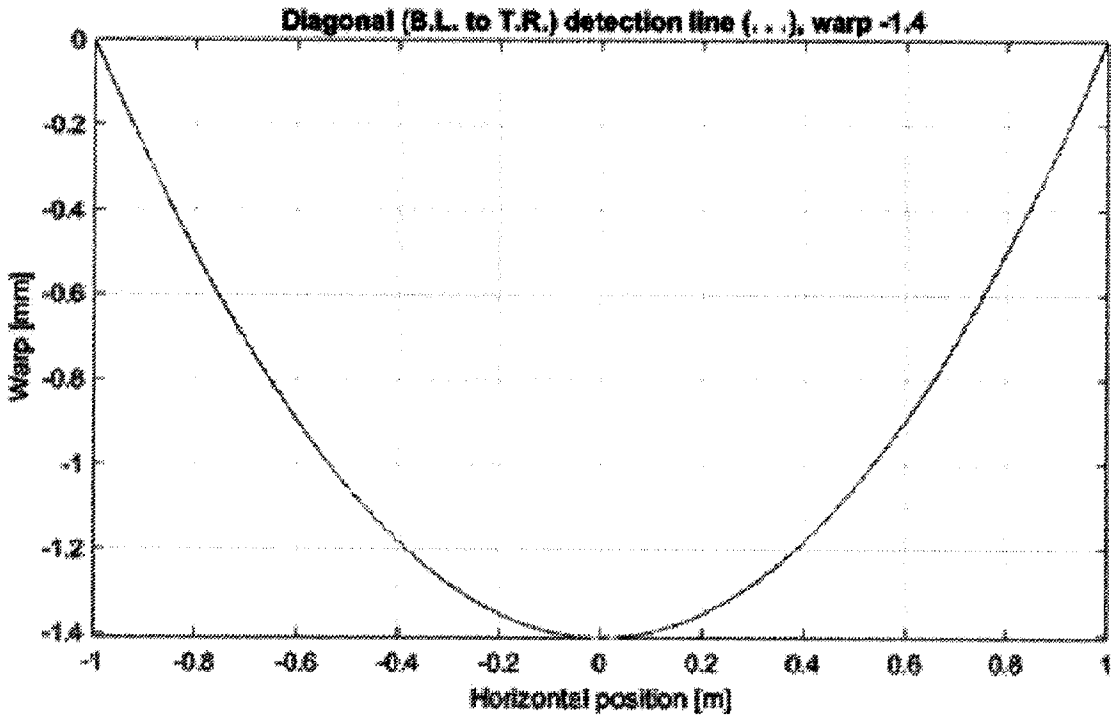


Figure 20d

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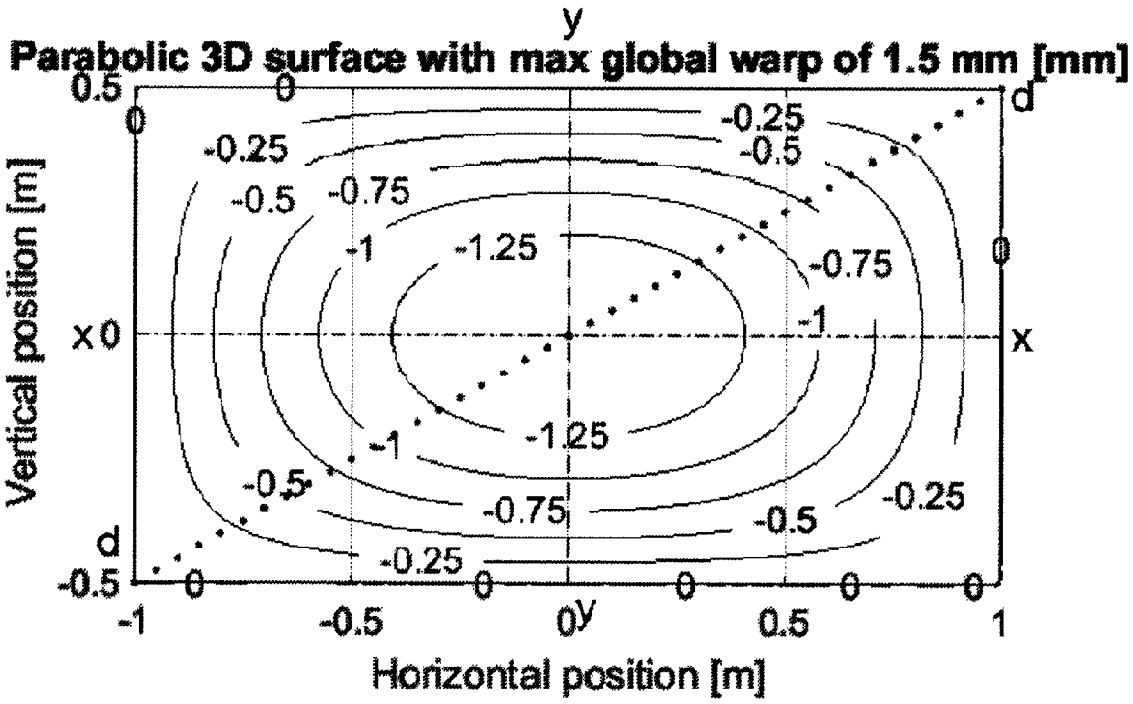


Figure 21a

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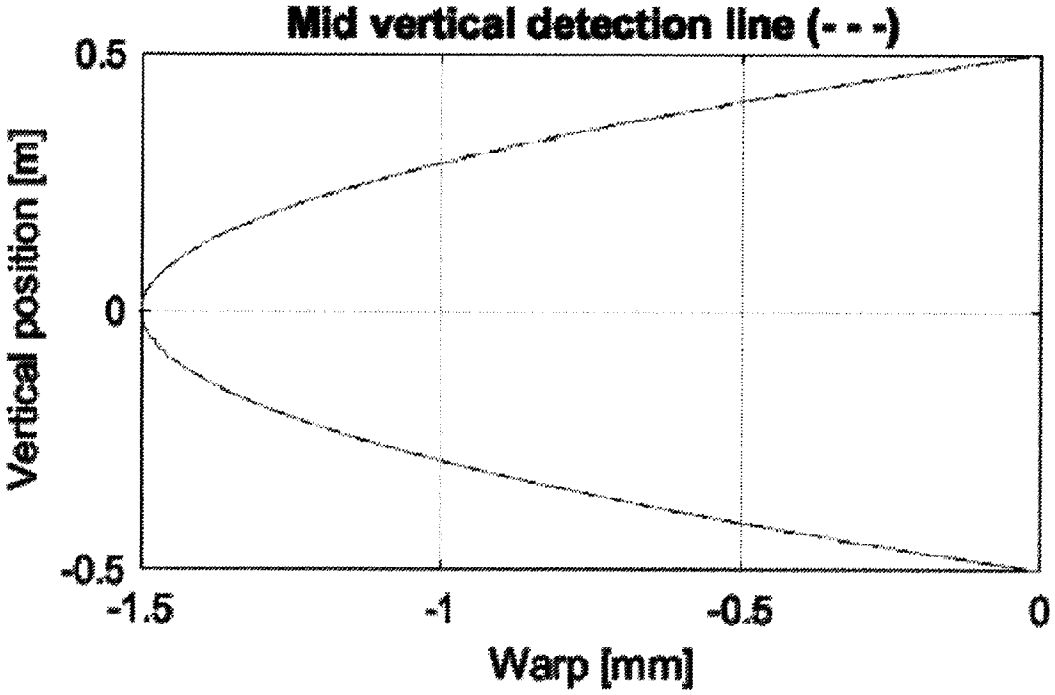


Figure 21b

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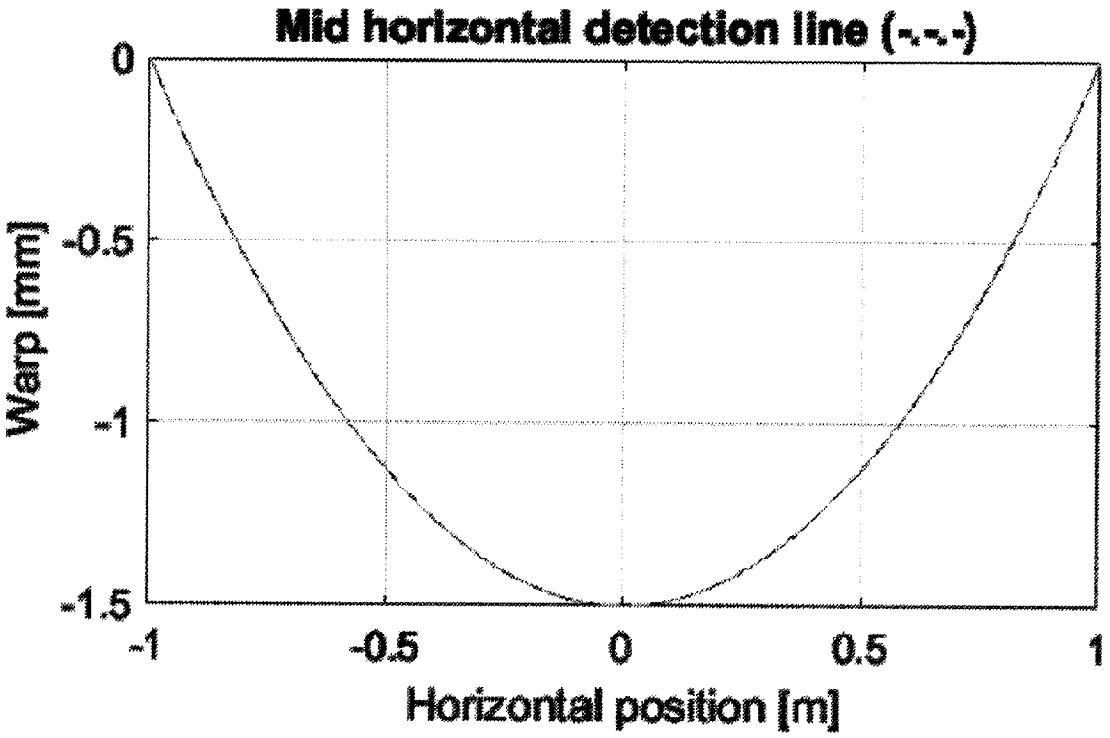

Mid horizontal detection line (-.-.-)
Warp [mm]
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
Horizontal position [m]

Figure 21c

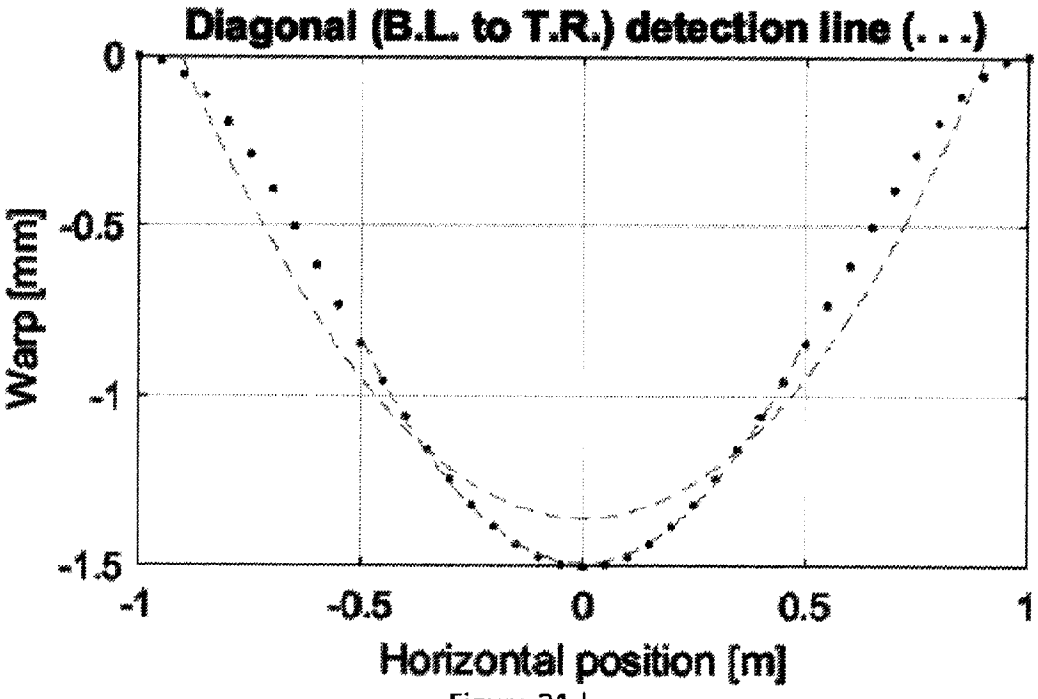


Figure 21d

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/051233

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6031524 A1 (INTERMEC IP CORP), 29 February 2000 (2000-02-29); column 1, line 60 - column 2, line 20 --	1-24
A	US 20160295711 A1 (RYU HYUNJONG ET AL), 6 October 2016 (2016-10-06); whole document --	1-24
A	EP 3043242 A1 (DEXERIALS CORP), 13 July 2016 (2016-07-13); whole document --	1-24
A	WO 2016177592 A1 (AGC GLASS EUROPE), 10 November 2016 (2016-11-10); whole document --	1-24

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
12-03-2018	12-03-2018

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Emil Bäcklund Telephone No. + 46 8 782 28 00

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Page 367 of 1254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20120062492 A1 (KATOH SATOSHI), 15 March 2012 (2012-03-15); paragraphs [0006]-[0010] --	1-24
A	US 20120045170 A1 (SHIBATA NAOKI ET AL), 23 February 2012 (2012-02-23); whole document -- --------	1-24

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Continuation of: second sheet

International Patent Classification (IPC)

G06F 1/16 (2006.01)
G06F 3/01 (2006.01)
G06F 3/03 (2006.01)
G06F 3/041 (2006.01)

US	6031524	A1	29/02/2000	NONE			
US	20160295711	A1	06/10/2016	US	9839145	B2	05/12/2017
				WO	2015111890	A1	30/07/2015
EP	3043242	A1	13/07/2016	CN	105518592	A	20/04/2016
				JP	2015052916	A	19/03/2015
				JP	5848736	B2	27/01/2016
				KR	20160053923	A	13/05/2016
				TW	201523377	A	16/06/2015
				US	20160202801	A1	14/07/2016
				WO	2015033569	A1	12/03/2015
WO	2016177592	A1	10/11/2016	CN	107531547	A	02/01/2018
				KR	20180004141	A	10/01/2018
				TW	201704169	A	01/02/2017
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				WO	2010119882	A1	21/10/2010
US	20120045170	A1	23/02/2012	CN	102375179	A	14/03/2012
				JP	2012043136	A	01/03/2012
				KR	20120017403	A	28/02/2012
				TW	201219866	A	16/05/2012

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
2013 年 10 月 31 日 (31.10.2013)

WIPO | PCT

(10) 国际公布号
WO 2013/159472 A1

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G06F 3/042 (2006.01)

(21) 国际申请号： PCT/CN20 12/080 153

(22) 国际申请日： 2012 年 8 月 15 日 (15.08.2012)

(25) 申飾 言： 中文

(26) 公布语言： 中文

(30) 优先权：
2012 101274207 2012 年 4 月 27 日 (27.04.2012) CN

(71) 申请人 (对除美国外的所有指定国)：深圳市天时通科技有限公司 (SHENZHEN TIMELINK TECHNO - LOGY CO., LTD.) [CN/CN]; 中国广东省深圳市福田保税区红棉道路 8 号英达利科技数码园 C301 (D 号)，Guangdong 5 18000 (CN)。

(72) 发明人 及
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(74) 代理人：深圳市启明专利代理事务所 (SHENZHEN QIMING PATENT AGENCY); 中国广东省深圳市福田区深南中路北方大厦 1119 室陈三九，Guangdong 518000 (CN)。

(81) 指定国 (除另有指明，要求每一种可提供的国家保护)：AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明，要求每一种可提供的地区保护)：ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)。

本国际公布：
- 包括国际检索报告(条约第 21 条(3))。

(54) Title: TOUCH CONTROL DISPLAY DEVICE

(54) 发明名称 :一种触控显示设备

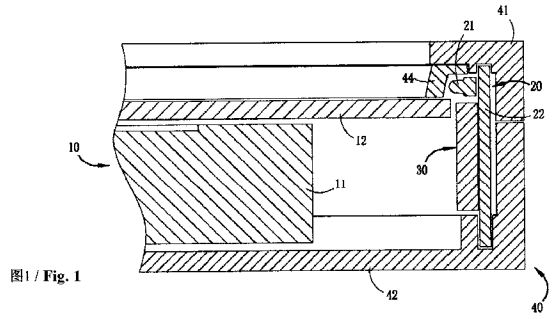


图1 / Fig. 1

(57) Abstract: A touch control display device, comprising a panel display unit, an induction signal receiving and transmitting mod - ule, a control module, and a housing; the induction signal receiving and transmitting module is annularly disposed around the panel display unit; the panel display unit, the induction signal receiving and transmitting module, and the control module are all encapsu - lated in the housing; the panel display unit comprises a liquid crystal display; the induction signal receiving and transmitting module comprises a plurality of induction signal receiving and transmitting geminate transistors and a printed circuit board; the plurality of induction signal receiving and transmitting geminate transistors are all electrically connected to the printed circuit board; each indue - tion signal receiving and transmitting geminate transistor comprises an induction signal transmitting transistor and an induction sig - nal receiving transistor; the printed circuit board is annularly disposed around the liquid crystal display, and is perpendicular to the panel of the liquid crystal display; and the induction signal receiving and transmitting geminate transistors electrically connected to the printed circuit board are disposed on the front side of the display surface of the liquid crystal display.

(57) 摘要：

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[见续页]

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一种触控显示设备，其包括平板显示部件、感应信号收发模块、控制模组以及外壳体，所述感应信号收发模块环设在所述平板显示部件的四周，所述平板显示部件、感应信号收发模块以及控制模组均封装在所述外壳体中，所述平板显示部件包括液晶显示器，所述感应信号收发模块包括若干感应信号收发对管以及印刷电路板，若干所述感应信号收发对管均电连接在所述印刷电路板上，感应信号收发对管包括感应信号发射管以及感应信号接收管，所述印刷电路板环设在所述液晶显示器的四周，且所述印刷电路板与所述液晶显示器面板垂直，电连接在所述印刷电路板上的感应信号收发对管设置在所述液晶显示器的显示面前侧。

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Hamrog Laboratories, AB, Ex. 2002

一种触控显示设备

技术领域

[0001] 本发明涉及显示触控领域，特别是指一种采用触控式的显示设备。

背景技术

[0002] 为了操作上的方便，人们用触摸屏来代替鼠标或键盘工作时，我们必须首先用手指或其它物体触摸安装在显示器前端的触摸屏，然后系统根据手指触摸的图标或菜单位置来定位选择信息输入触摸屏由触摸检测部件和触摸屏控制器组成；触摸检测部件安装在显示器屏幕前面，用于检测¾户触摸位置，接受后送触摸屏控制器；而触摸屏控制器的主要作¾是从触摸点检测装置上接收触摸信息，并将它转换成触点坐标，再送给 CPU, 它同时能接收 CPU 发来的命令并加以执行。

[0003] 对于上述应用触摸屏技术的数码产品而言其优点主要是将控制键盘与显示屏的功能进行集合使显示屏同时具有键盘的功能，这种触摸屏的技术不但可以在有效的面积内尽可能的增大显示屏的面积，同时对于整体数码产品的外观效果也有比较大的提升。通过上述的触摸屏的技术可以在不增大数码产品整体体积的前提下尽可能的增大显示屏的尺寸，从而使通过装置有触摸屏的数码产品播放电视、动画类视频成为可能。而就目前市面上出现的触摸屏而言，红外式触摸屏占据一定的份额，如专利号 200720052423.3 以及专利号 200720051069.2 所公开的两种专利产品即为常见的红外触控显示装置，其主要包括平板显示部件 (包括液晶显示屏)、围绕在平板显示部件四周的四块焊接有红外线发射管以及红外线接收管的印刷电路板、外框，其中，所述红夕线发射管以及红外线接收管均设置在所述平板显示部件的显示面前侧，且所述红外线发射管与红外线接收管分别相对应的设置在平板显示部件四周的左右两侧以及上下两侧，从而使得平板显示部件的显示面前侧形成一个红外线光栅探测网。当使用者用手指或其它物体点触平板状显示部件的显示面上某一点时，便会挡住经过该位置的两条红外线，使红外线接收管不能收到与其相对应的红外线发射管所发射的红外线，该红外触控显示装置的控制系统便能即时计算出触点的位置，再根据触点位置对应的命令运行相应的程序，从而实现平板显示部件上的触控操作。

[0004] 如上所述的这种结构的红外触控显示装置中的印刷电路板按照与平板状显示部件相互平行的方式设置，其结构上存在着一系列的缺陷，具体叙述如下：

第一，由于用于连接红外线发射管以及红外线接收管的印刷电路板嵌设在所述平板显示部件的四周，且所述印刷电路板与平板显示部件成同一平面设置，在封装所述平板显式部件的夕卜

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框时，所述外框需要将所述印刷电路板封装起来，因此造成所述平板显示部件的外框尺寸也相应的更大，从而使红外触控显示装置显得非常厚重；

第二，为使红外线发射管以及红外线接收管所发射以及接收的红外光线与平板显示部件平行，红外线发射管以及红外线接收管需要进行弯胸工序后再焊接安装到印刷线路板上，或者是先焊接安装到印刷电路板上，再进行弯胸，如此不仅工序复杂，增加了制造成本，而且红外线发射管以及红外线接收管在弯脚后可能对其寿命及稳定性产生影响。

[0005] 随着社会的不断发展，目前液晶显示器都向超薄，超窄方向发展，按照传统的红外触摸屏采用边框，一般都需要二十几毫米宽，这主要受限于用于连接上述红外线发射管以及红外线接收管的印刷电路板的排列宽度。因而造成很多超薄、超窄的显示器上难以使¾红外触控的技术。以上为传统红外触控显示装置在具体实施时所存在的主要技术缺陷，即为本发明所要研究解决的主要问题。

发明内容

[0006] 本发明的目的在于提供一种触控显示设备，其是一种与传统的触控显示装置同一性质的产品，其所要解决的主要技术问题在于：传统的触控显示装置受限于用于连接感应信号发射管以及感应信号接收管的印刷电路板的宽度，需要制作相应宽度的外框，从而使得外框一般都需要二十几毫米宽，因此造成很多超薄、超窄的显示器上难以通过采用感应信号收发方式实现触控的技术。以上为本发明所要解决的主要技术问题。

[0007] 为解决上述技术问题，本发明采用的技术方案是：本发明提供一种触控显示设备，其包括平板显示部件、感应信号收发模块、控制模组以及外壳体，其中，所述感应信号收发模块环设在所述平板显示部件的四周，所述平板显示部件、感应信号收发模块以及控制模组均封装在所述外壳体中，所述平板显示部件包括液晶显示器，所述感应信号收发模块包括若干感应信号收发对管以及印刷电路板，若干所述感应信号收发对管均电连接在所述印刷电路板上，感应信号收发对管包括感应信号发射管以及感应信号接收管，所述印刷电路板环设在所述液晶显示器的四周，且所述印刷电路板与所述液晶显示器面板垂直，其特征在于：电连接在所述印剧电路板上的感应信号收发对管设置在所述液晶显示器的显示面前働，且所述感应信号发射管与所述感应信号接收管分别相对应的设置在所述液晶显示器的左右两侧以及上下两侧，若千所述感应信号射管所发射的感应信号在所述液晶显示器的显示面前侧形成一个感应信号探测网。

[0008] 优选方式：所述印刷电路板包括四块或四块以上环设在所述液晶显示器四周的小电路板，各个小电路板之间首尾固定的电连接在一起，所述印刷电路板为硬性 PCB 或柔性

PCB 板。

[0009] 优选方式：所述控制模组与所述印刷电路板电连接，且所述控制模组固定在所述小电路板上对应所述液晶显示器的一侧或另一侧。

[0010] 优选方式：所述控制模组设置在所述底壳上，所述控制模组与所述印刷电路板之间连接有用于传输电源、数据的软排线。

[0011] 优选方式：所述印刷电路板包括四块或四块以上环设在所述液晶显示器四周的小电路板，各个小电路板之间首尾固定连接在一起，所述印刷电路板为硬性 PCB 或柔性 PCB 板，所述控制模组设置在所述底壳上，所述控制模组与构成所述印刷电路板的各个小电路板之间连接有用于传输电源、数据的软排线。

[0012] 优选方式：所述外壳体包括面壳以及底壳，所述平板显示部件以及感应信号收发模块均设置在所述底壳中，所述面壳为一与所述底壳大小匹配的四方形的框律，四方框形的所述面壳盖设在所述底壳上，所述液晶显示器的显示面对应在四方形框体围绕成的方框内，所述感应信号收发模块收设在所述面壳与所述底壳之间，所述面壳与所述底壳上相对应的设置有卡槽，与所述液晶显示器垂直的所述印剧电路板卡设在所述卡槽中，借助所述卡槽对所述印刷电路板进行固定。

[0013] 优选方式：所述感应信号收发对管为红外收发对管，且所述红外收发对管包括红外线发射管以及红外线接收管，所述红外线发射管为贴片红外 LED 。

[0014] 优选方式：所述面壳与所述液晶显示器的显示面之间预留有出光间隙，所述红外收发对管的红外线发射管以及红外线接收管相对应设置在所述出光间隙中。

[0015] 优选方式：所述面壳与所述液晶显示器之间的出光间隙中设置有滤光条，所述滤光条位于所述红外收发对管的红外线发射管以及红外线接收管前侧。

[0016] 优选方式：所述平板显示部件还包括触摸面板，所述触摸面板盖设在所述液晶显示器的显示面一侧，所述触摸面板采用透明的钢化玻璃板制成。

[0017] 与现有技术相比，本专利申请的技术效果是：本发明提供一种触控显示设备，其将所述平板显示部件以及感应信号收发模块封装在所述外壳体中时，由于所述印刷电路板与所述液晶显示器垂直，因此四方框形的所述面壳边框只需能够封盖所述感应信号收发对管以及板面与所述边框垂直的印刷电路板即可，从而能够很大程度的缩减所述面壳的宽度，进一步实现触控显示设备的边框超窄化，采用本发明的方案所述边框宽度可缩减至 3,6 毫米；而且由于所述印剧电路板与所述液晶显示器垂直，而所述感应信号收发对管与所述液晶显示器平行，因此，当所述感应信号收发对管的引胸焊接在所述印刷电路板上时，无须进行弯脚，

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序，减少了制造工序，同样节约了制造成本，且所述感应信号收发对管的引脚未作折弯加工，其使用寿命更长，稳定性更好。

附图说明

[0018] 图 1 为本发明的一种较佳实施例的局部剖视示意图。

[0019] 图 2 为本发明的一种较佳实施例的局部剖视分解示意图。

[0020] 图 3 为本发明的另一种实施例的局部剖视示意图。

[0021] 图 4 为本发明的第二种较佳实施例的局部剖视示意图。

具体实施方式

[0022] 以下将结合附图 1 至 4 以及较佳实施例对本发明提出的一种触控显示设备作更为详细说明。

[0023] 如图 1 所示，本发明提供一种触控显示设备，其包括平板显示部件 10、感应信号收发模块 20、控制模组 30 以及夕卜壳体 40, 其中，所述感应信号收发模块 20 环设在所述平板显示部件 10 的四周，所述平板显示部件 10、感应信号收发模块 20 以及控制模组 30 均封装在所述外壳体 40 中；

所述平板显示部件 10 包括液晶显示器 11;

所述感应信号收发模块 20 包括若干感应信号收发对管 21 以及印剧电路板 22, 若干所述感应信号收发对管 21 均电连接在所述印剧电路板 22 上，感应信号收发对管 21 包括感应信号发射管以及感应信号接收管；

所述印刷电路板 22 环设在所述液晶显示器 11 的四周，且所述印刷电路板 22 与所述液晶显示器 11 面板垂直；

电连接在所述印刷电路板 22 上的感应信号收发对管 21 设置在所述液晶显示器 11 的显示面前侧，且所述感应信号发射管与所述感应信号接收管分别相对应的设置在所述液晶显示器 II 的左右两侧以及上下两侧，若干所述感应信号射管所发射的感应信号在所述液晶显示器 1l 的显示面前侧形成一个感应信号探测网；

所述控制模组 30 与所述印刷电路板 22 电连接，所述控制模组 30 控制所述液晶显示器 11 以及所述感应信号收发对管 21 的工作；

所述外壳体 40 包括面壳 41 以及底壳 42, 所述平板显示部件 10 以及感应信号收发模块 20 均设置在所述底壳 42 中，所述面壳 41 为一与所述底壳 42 大小匹配的四方形的框体，四方框形的所述面壳 4】盖设在所述底壳 42 上，所述液晶显示器 11 的显示面对应在四方形框体围绕成的方框内，所述感应信号收发模块 20 收设在所述面壳 41 与所述底壳 42 之间。

[0024] 本发明在具体实施时，将所述平板显示部件 10 以及感应信号收发模块 20 封装在所述外壳体 40 中时，由于所述印刷电路板 22 与所述液晶显示器 11 垂直，四方框形的所述面壳 41 边框只需能够收纳所述感应信号收发对管 21 的长度以及与其垂直的印刷电路板 22 即可，从而能够很大程度的缩减所述面壳 41 的宽度，进一步实现触控显示设备的边框超窄化，采用本发明的方案所述边框宽度可缩减至 3.6 毫米，较小地占有现有显示设备表面边框的空间，较小地改变工艺结构，使触控与显示的整体性更强；而且由于所述印刷电路板 22 与所述液晶显示器 11 垂直，而所述感应信号收发对管 21 与所述液晶显示器 11 平行，因此，当所述感应信号收发对管 21 的引脚焊接在所述印刷电路板 22 上时，无须进行弯胸工序，减少了制造工序，同样节约了制造成本，且所述感应信号收发对管 21 的引脚未作折弯加工，其使用寿命更长，稳定性更好。

[0025] 较佳实施例：如图 1、2、3 所示，所述印剧电路板 22 为硬性 PCB 或柔性 PCB 板，所述印刷电路板 22 包括四块或四块以上环设在所述液晶显示器 11 四周的小电路板，各个小电路板之间首尾固定的电连接在一起，所述控制模组 30 固定连接在小电路板上，通过将所述控制模组 30 固定在小电路板上使本发明的内部结构更加的紧凑，所述控制模组 30 固定在所述小电路板上对应所述液晶显示器 11 的一侧或另一侧。

[0026] 较佳实施例：如图 4 所示，所述印刷电路板 22 包括四块或四块以上环设在所述液晶显示器 11 四周的小电路板，各个小电路板之间首尾固定的电连接在一起，所述控制模组 30 设置在所述底壳 42 上，所述控制模组 30 与所述印刷电路板 22 之间连接有用于传输电源、数据的软排线，通过使用软排线将所述控制模组 30 与所述感应信号收发模块 20 相连接，通过所述控制模组 30 控制所述感应信号收发模块 20 的正常工作，且通过软排线的连接方式可以方便所述控制模组 30 的拆装、换修。

[0027] 较佳实施例：如图 4 所示，所述印刷电路板 22 为硬性 PCB 或柔性 PCB 板，所述印刷电路板 22 包括四块或四块以上环设在所述液晶显示器 11 四周的小电路板，各个小电路板之间首尾固定连接在一起，所述控制模组 30 设置在所述底壳 42 上，所述控制模组 30 与构成所述印刷电路板 22 的各个小电路板之间连接有用于传输电源、数据的软排线，通过使用软排线将所述控制模组 30 与各个小电路板之间电连接，从而可以方便所述控制模组 30 以及各个小电路板的拆换、修理，防止因为极个别的感应信号收发对管 21 损坏而影响整个感应信号收发模块 20。

[0028] 较佳实施例：如图 2 所示，所述面壳 4] 与所述底壳 42 上相对应的设置有卡槽 411，与所述液晶显示器 11 垂直的所述印刷电路板 22 卡设在所述卡槽 411 中，借助所述卡槽 411

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对所述印剧电路板 22 进行固定。

[0029] 较佳实施例：所述感应信号收发对管 21 为红外收发对管，且所述红夕卜收发对管包括红外线发射管以及红外线接收管，所述红外线发射管为贴片红外 LED 。

[0030] 较佳实施例：如图 2 所示，所述面壳 41 与所述液晶显示器 11 的显示面之间预留有出光间隙 43，所述红外收发对管的红外线发射管以及红外线接收管相对应设置在所述出光间隙 43 中。

[003 1】较佳实施例：如图 1、2、3、4 所示，所述面壳 41 与所述液晶显示器 11 之间的出光间隙 43 中设置有滤光条 44, 所述滤光条 44 位于所述红外收发对管的红外线发射管以及红外线接收管前侧，利用所述滤光条 44 来滤掉外界光线，使所述红外线发射管以及红外线接收管能够选择性的对外发出、接收光。

[0032] 较佳实施例：如图 1、2、3、4 所示，所述平板显示部件 10 还包括触摸面板 12，所述触摸面板 12 盖设在所述液晶显示器 11 的显示面一侧，所述触摸面板 12 采用透明的钢化玻璃板制成，借助采用透明钢化玻璃板制成的触摸面板 】2 为位于所述显示窗口 411 处的所述液晶显示器 11 提供抗外力保护。

[0033] 综合上所述，本发明的技术方案可以充分有效的完成上述发明目的，且本发明的结构原理及功能原理都已经在实施例中得到充分的验证，而能达到预期的功效及目的，且本发明的实施例也可以根据这些原理进行变换，因此，本发明包括一切在申请专利范围中所提到范围内的所有替换内容。任何在本发明申请专利范围内所作的等效变化，皆属本案申请的专利范围之内。

1. 一种触控显示设备，其包括平板显示部件、感应信号收发模块、控制模组以及外壳体，其中，所述感应信号收发模块环设在所述平板显示部件的四周，所述平板显示部件、感应信号收发模块以及控制模组均封装在所述外壳体中，所述平板显示部件包括液晶显示器，所述感应信号收发模块包括若干感应信号收发对管以及印刷电路板，若干所述感应信号收发对管均电连接在所述印刷电路板上，感应信号收发对管包括感应信号发射管以及感应信号接收管，其特征在于：所述印刷电路板环设在所述液晶显示器的四周，且所述印刷电路板与所述液晶显示器面板垂直，电连接在所述印刷电路板上的感应信号收发对管设置在所述液晶显示器的显示面前侧，且所述感应信号发射管与所述感应信号接收管分别相对应的设置在所述液晶显示器的左右两侧以及上下两侧，若干所述感应信号射管所发射的感应信号在所述液晶显示器的显示面前侧形成一个感应信号探测网。

2. 如权利要求 1 所述的一种触控显示设备，其特征在于：所述印刷电路板包括四块或四块以上环设在所述液晶显示器四周的小电路板，各个小电路板之间首尾固定的电连接在一起，所述印刷电路板为硬性 PCB 或柔性 PCB 板。

3. 如权利要求 2 所述的一种触控显示设备，其特征在于：所述控制模组与所述印刷电路板电连接，且所述控制模组固定在所述小电路板上对应所述液晶显示器的一侧或另一侧。

4. 如权利要求 2 所述的一种触控显示设备，其特征在于：所述控制模组设置在所述底壳上，所述控制模组与所述印剧电路板之间连接有¾于传输电源、数据的软排线。

5. 如权利要求 1 所述的一种触控显示设备，其特征在于：所述印刷电路板包括四块或四块以上环设在所述液晶显示器四周的小电路板，各个小电路板之间首尾固定连接在一起，所述印刷电路板为硬性 PCB 或柔性 PCB 板，所述控制模组设置在所述底壳上，所述控制模组与构成所述印刷电路板的各个小电路板之间连接有用于传输电源、数据的软排线。

6. 如权利要求 2 或 3、4、5 中任意一项所述的一种触控显示设备，其特征在于：所述外壳体包括面壳以及底壳，所述平板显示部件以及感应信号收发模块均设置在所述底壳中，所述面壳为一与所述底壳大小匹配的四方形的框体，四方框形的所述面壳盖设在所述底壳上，所述液晶显示器的显示面对应在四方形框体围绕成的方框内，所述感应信号收发模块收设在所述面壳与所述底壳之间，所述面壳与所述底壳上相对应的设置有卡槽，与所述液晶显示器垂直的所述印刷电路板卡设在所述卡槽中，借助所述卡槽对所述印剧电路板进行固定。

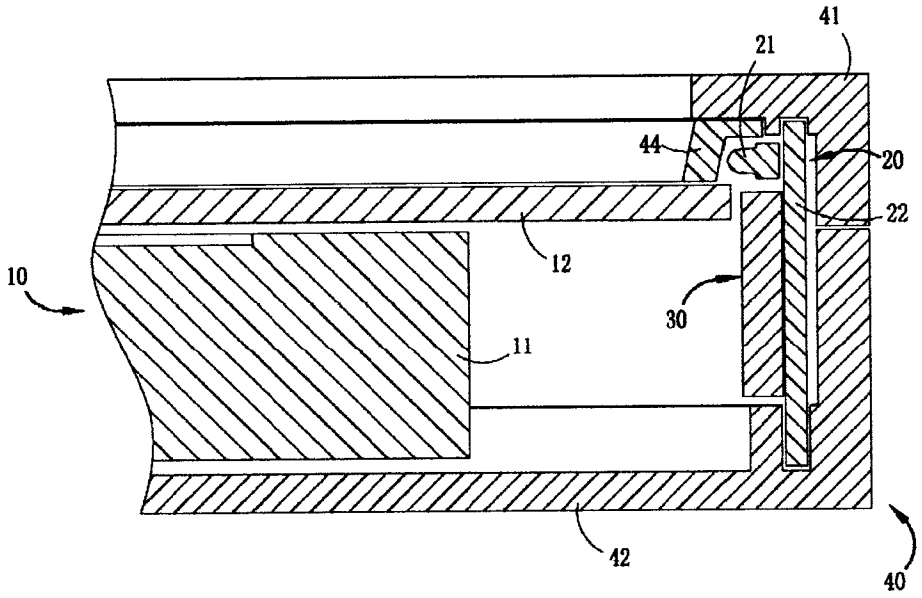
7. 如权利要求 1 所述的一种触控显示设备，其特征在于：所述感应信号收发对管为红外收发对管，且所述红外收发对管包括红外线发射管以及红外线接收管，所述红外线发射管为贴片红外 LED 。

8，如权利要求 1 所述的一种触控显示设备，其特征在于：所述面壳与所述液晶显示器的显示面之间预留有出光间隙，所述红外收发对管的红外线发射管以及红外线接收管相对应设置在所述出光间隙中。

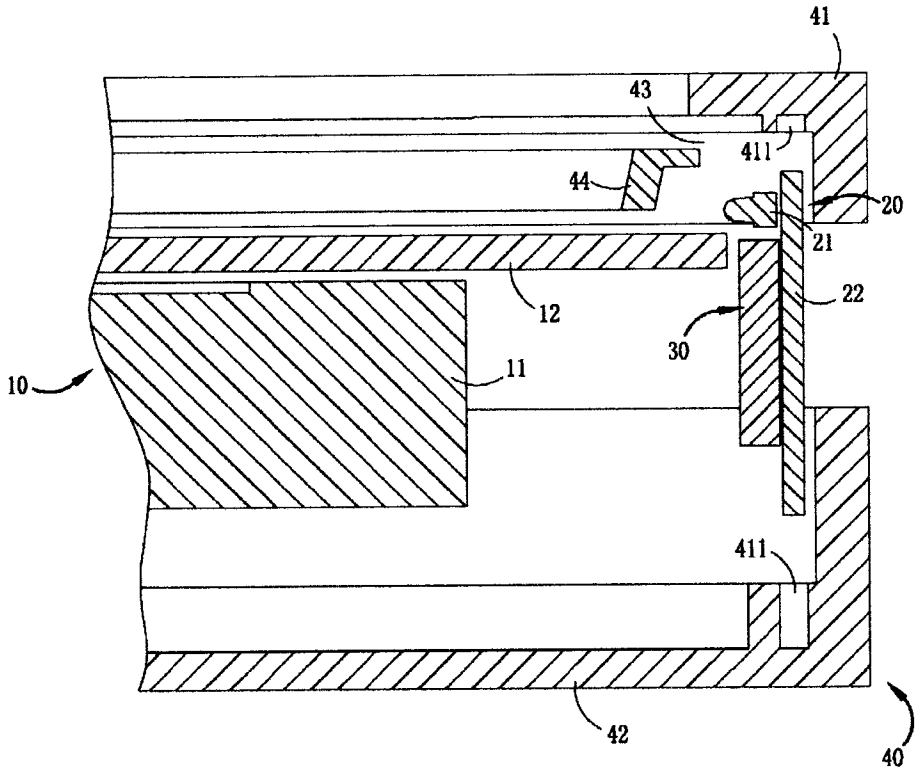
9，如权利要求 8 所述的一种触控显示设备，其特征在于：所述面壳与所述液晶显示器之间的出光间隙中设置有滤光条，所述滤光条位于所述红外收发对管的红外线发射管以及红外线接收管前侧。

10，如权利要求 9 所述的一种触控显示设备，其特征在于：所述平板显示部件还包括触摸面板，所述触摸面板盖设在所述液晶显示器的显示面一侧，所述触摸面板采用透明的钢化玻璃板制成。

说 明 书 附 图

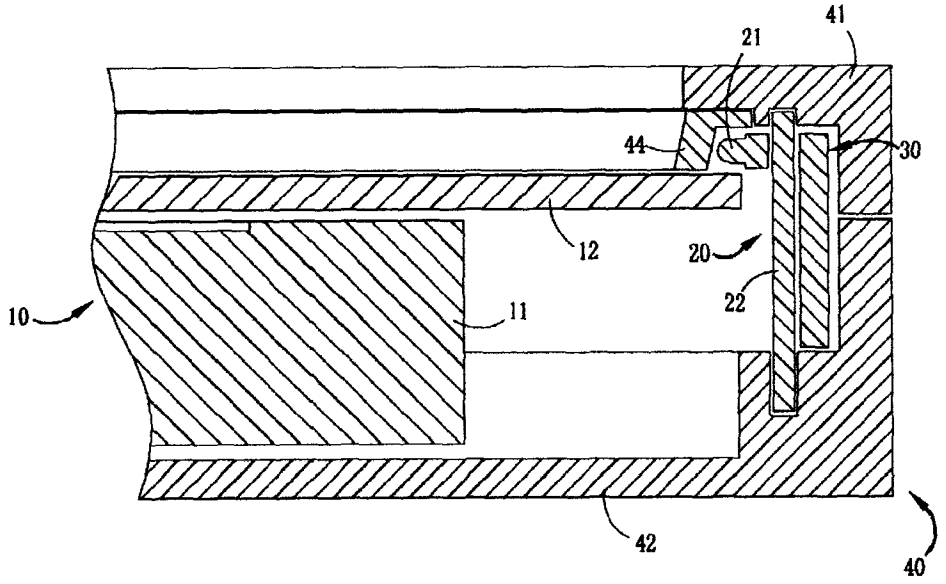


【图号】图1

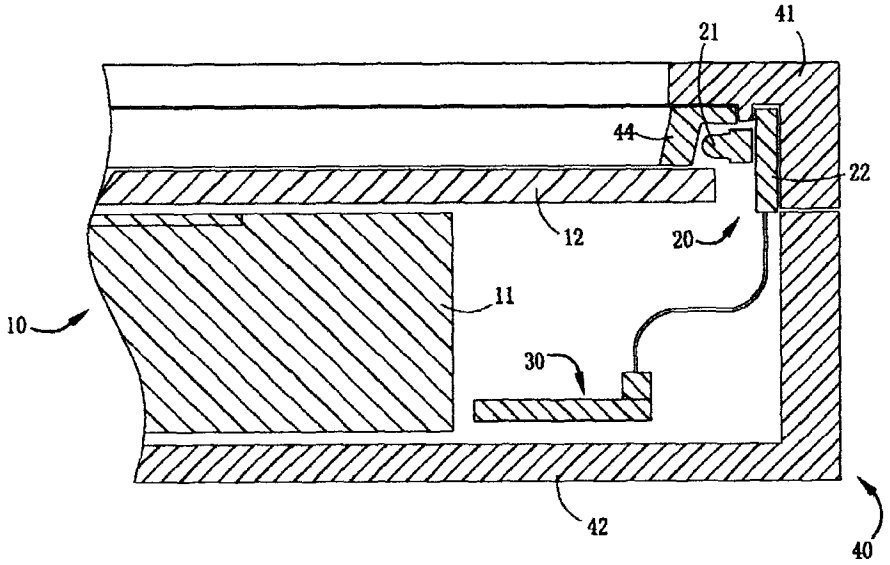


【图号】图2

说 明 书 附 图



【图号】图3



【图号】图4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/080153

A. CLASSIFICATION OF SUBJECT MATTER

G06F 3/042 (2006.01) i

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 3/-

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

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

CPRS, CNKI, WPI, EPODOC: up and down, left and right, display, shell, infrared, touch, receive, transmit, up, down, left, right, front, back, PCB, circuit board, right angle, perpendicular, vertical+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 201917889 U (ZHEJIANG RUNZHI ELECTRONIC TECHNOLOGY CO., LTD.), 03 August 201 1 (03.08.2011), abstract, description, paragraphs 0029 and 0071-0073, and figure 1	1-10
A	CN 2731587 Y (IRTOUCH SYSTEMS CO., LTD.), 05 October 2005 (05.10.2005), the whole document	1-10
A	CN 2731588 Y (IRTOUCH SYSTEMS CO., LTD.), 05 October 2005 (05.10.2005), the whole document	1-10

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
25 January 2013 (25.01.2013)	07 February 2013 (07.02.2013)
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer LIU, Qingquan Telephone No.: (86-10) 62411700

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 383 of 1254

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/080153

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 201917889 U	03.08.2011	None	
CN 2731587 Y	05.10.2005	None	
CN 2731588 Y	05.10.2005	None	

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 384 of 1254

国 际 检 索 报 告

国际申请号
PCT/CN2012/080153

A．主题的分类

G06F3/042 （2006.01 ） i

按照国际专利分类(IPC) 或者同时按照国家分类和 IPC 两种分类

B．检索领域

检索的最低限度文献(标明分类系统和分类号）

IPC: G06F3/-

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词 (如使用））

CPRS,CNKI,WPI,EPODOC: 红外,触,收,发,上下,左右,显示,壳,电路板,垂直,infrared, touch, receive, transmit, up, down, left, right, front, back, PCB, circuit board, right angle, perpendicular, vertical+

C．相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN201917889U (浙江润智电子科技有限公司)03.8 月 2011 (03.08.201 1) 摘要，说明书 0029 、00714)073 段，附图 1	1-10
A	CN273 1587Y (北京汇冠新技术有限公司)05. 10 月 2005(05. 10.2005) 全文	1-10
A	CN273 1588Y (北京汇冠新技术有限公司)05. 10 月 2005(05. 10.2005) 全文	1-10

☐ 其余文件在 C 栏的续页中列出。

☒ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的¾ ¾或¾后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件 (如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"τ" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
25. 1 月 2013(25.01.2013)	07.2 月 2013 (07.02.2013)
ISA/CN 的名称和邮寄地址： 中华人民共和国国家知识产权局 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号： (86-10)62019451	受权官员 刘清泉 电话号码：(86-10) 62411700

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 385 of 1254

国际检索报告

关于同族专利的信息

国际申请号
PCT/CN2012/080153

检索报告中引用的专利文件	公布日期	同族专利	公布日期
CN201917889U	03.08.201 1	无	
CN273 1587Y	05. 10.2005	无	
CN273 1588Y	05. 10.2005	无	

Patents WO2013/159472

Touch control display device

Abstract

A touch control display device, comprising a panel display unit, an induction signal receiving and transmitting module, a control module, and a housing; the induction signal receiving and transmitting module is annularly disposed around the panel display unit; the panel display unit, the induction signal receiving and transmitting module, and the control module are all encapsulated in the housing; the panel display unit comprises a liquid crystal display; the induction signal receiving and transmitting module comprises a plurality of induction signal receiving and transmitting geminate transistors and a printed circuit board; the plurality of induction signal receiving and transmitting geminate transistors are all electrically connected to the printed circuit board; each induction signal receiving and transmitting geminate transistor comprises an induction signal transmitting transistor and an induction signal receiving transistor; the printed circuit board is annularly disposed around the liquid crystal display, and is perpendicular to the panel of the liquid crystal display, and the induction signal receiving and transmitting geminate transistors electrically connected to the printed circuit board are disposed on the front side of the display surface of the liquid crystal display.

Classifications

- G06F3/045 Digitisers, e.g. for touch screens or touch pads, characterised by the transducing means by electromagnetic means

WO2013159472A1
WIPO (PCT)

Download PDF Find Prior Art Similar

Other languages: French, Chinese

Inventor: 陈伟山

Worldwide applications

2012 CN WO

Application PCT/CN2012/080153 events

2012-04-27 Priority to CN201210127420?A

2012-04-27 Priority to CN201210127420?

2012-08-15 Application filed by 深圳市天时通科技有限公司

2013-10-31 Publication of WO2013159472A1

Info: Patent citations (4), Cited by (6), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, PatentScope, Discuss

Claims

Hide Dependent

Claims

A touch display device includes a flat panel display component, a sensing signal transceiver module, a control module, and an outer casing, wherein the sensing signal transceiver module is disposed around the flat panel display component, and the flat panel display component The sensing signal transceiver module and the control module are all packaged in the outer casing, the flat panel display component comprises a liquid crystal display, and the sensing signal transceiver module comprises a plurality of sensing signal transceiver tubes and a printed circuit board, and the plurality of sensing signals The transceiver pair is electrically connected to the printed circuit board, and the sensing signal transceiver tube comprises an inductive signal transmitting tube and an inductive signal receiving tube, wherein: the printed circuit board ring is disposed around the liquid crystal display, Ji The printed circuit board is perpendicular to the liquid crystal display panel, and a sensing signal transceiver tube electrically connected to the printed circuit board is disposed on a front side of the display of the liquid crystal display, and the sensing signal transmitting tube and the sensing The signal receiving tubes are respectively disposed corresponding to the left and right sides of the liquid crystal display And upper and lower sides, one thousand if the sensing signal transmitted ray tube is formed in front side of the detection signal displaying the liquid crystal display of a sensing signal detection network.

2. The touch display device according to claim 1, wherein: the printed circuit board comprises four or more small circuit boards disposed around the liquid crystal display, and each small circuit board The first and last fixed electrical connections are made together, and the printed circuit board is a rigid PCB or a flexible PCB board.

3. The touch display device according to claim 2, wherein: the control module is electrically connected to the printed circuit board, and the control module is fixed on the small circuit board. One side or the other side of the liquid crystal display.

4. The touch display device according to claim 2, wherein: the control module is disposed on the bottom case, and the control module is connected to the printed circuit board ¾ in the transmission of power, data soft # line.

5. The touch display device according to claim 1, wherein: the printed circuit board comprises four or more small circuit boards disposed around the liquid crystal display, and each small circuit board The first and last ends are fixedly connected together, the printed circuit board is a rigid PCB or a flexible PCB board, the control module is disposed on the bottom case, and the control module and each small circuit board constituting the printed circuit board A soft cable for transmitting power and data is connected between them.

The touch display device according to any one of claims 2 to 3, wherein the outer casing comprises a surface shell and a bottom shell, and the flat panel display component and the sensing signal are transmitted and received. The module is disposed in the bottom case, wherein the face shell is a square frame matching the size of the bottom case, and the face plate of the four-box shape is disposed on the bottom case, the liquid crystal The display surface of the display corresponds to a square surrounded by a square frame, and the sensing signal transceiver module is disposed between the face shell and the bottom case, and the face shell and the bottom case are opposite Correspondingly, a card slot is disposed, and the printed circuit board perpendicular to the liquid crystal display is locked in the card slot, and the printed circuit board is fixed by the card slot.

7. The touch display device as claimed in claim 1, wherein: the sensing signal transceiver tube is an infrared transceiver tube, and the infrared transceiver tube comprises an infrared transmitting tube and an infrared receiving tube. The infrared emitting tube is a patch infrared LED.

Claims

8. The touch display device according to claim „ wherein: a light gap is reserved between the face shell and a display surface of the liquid crystal display, and the infrared light is sent to and received from the tube. The launch tube and the red line receiving tube are correspondingly disposed in the light exit gap.

The touch display device of claim 8 , wherein: a light filter strip is disposed in the light exit gap between the face shell and the liquid crystal display, and the filter strip is located in the infrared The infrared transmitting tube of the transmitting and receiving tube and the front side of the infrared receiving tube are provided.

The touch display device of claim 9, wherein the flat panel display component further comprises a touch panel, the touch panel is disposed on a side of the display surface of the liquid crystal display, and the touch The panels are made of transparent tempered glass panels.

Description

Touch display device

[0001] The present invention relates to the field of display touch, and more particularly to a touch display device.

Background technique

[0002] For the convenience of operation, when people use a touch screen instead of a mouse or a keyboard to work, we must first touch the touch screen mounted on the front end of the display with a finger or other object, and then the system locates the selection information according to the icon or menu position touched by the finger. The input touch screen is composed of a touch detection component and a touch screen controller, the touch detection component is installed in front of the display screen for detecting the touch position of the ¾ households, and accepting the touch screen controller, and the main function of the touch screen controller is ¾ is from the touch point The detecting device receives the touch information, converts it into contact coordinates, and sends it to the CPU, which can simultaneously receive and execute the command sent by the CPU.

[0003] For the digital products using the touch screen technology described above, the main advantage is that the functions of the control keyboard and the display screen are combined to make the display screen have the function of the keyboard at the same time. The technology of the touch screen can not only be as effective as possible within an effective area. The area of the display is increased, and the appearance effect of the overall digital product is greatly improved. Through the above-mentioned touch screen technology, it is possible to increase the size of the display screen as much as possible without increasing the overall volume of the digital product, and it is possible to play television and animated video through the digital product having the touch screen. In the current touch screens on the market, the infrared touch screen occupies a certain share. The two patent products disclosed in Patent No. 200720052423.3 and Patent No. 200720051069.2 are common infrared touch display devices, which mainly include a flat panel display. a component (including a liquid crystal display), four printed circuit boards and an outer frame around which the infrared emitting tube and the infrared receiving tube are welded around the flat display member, wherein the red and white emitting tubes and the infrared receiving tube are disposed On the front side of the display of the flat display unit, and the infrared emitting tube and the infrared receiving tube are respectively disposed on the left and right sides and the upper and lower sides of the flat display member, so that the front side of the display of the flat display member is formed. An infrared grating detection network. When the user touches a point on the display surface of the flat display member with a finger or other object, the two infrared rays passing through the position are blocked, so that the infrared receiving tube cannot receive the infrared emitting tube corresponding thereto. Infrared, the control system of the infrared touch display device can instantly calculate the position of the contact, and then run the corresponding program according to the command corresponding to the contact position, thereby realizing the touch operation on the flat display part.

[0004] The printed circuit board in the infrared touch display device of such a structure as described above is disposed in parallel with the flat display member, and has a series of defects in its structure, and is specifically described as T.

First, since a printed circuit board for connecting the infrared emitting tube and the infrared receiving tube is embedded around the flat display member, and the printed circuit board is disposed in the same plane as the flat display member, the flat panel is packaged Part of the When the frame is used, the outer frame needs to package the printed circuit board, so that the outer frame size of the flat display component is correspondingly larger, and the infrared touch display device is very thick;

Secondly, in order to make the infrared light emitted and received by the infrared emitting tube and the infrared receiving tube parallel to the flat display unit, the infrared emitting tube and the infrared receiving tube need to be bent and then soldered to the printed circuit board, or first Soldering is mounted on the printed circuit board and then bending the chest. This not only complicates the process, but also increases the manufacturing cost. The infrared emission tube and the infrared receiving tube may affect the life and stability of the infrared receiving tube after bending.

[0005] With the continuous development of the society, liquid crystal displays are currently developing in an ultra-thin and ultra-narrow direction. According to the conventional infrared touch screen, a frame is generally required to be twenty millimeters wide, which is mainly limited to the connection of the above infrared rays. The arrangement width of the printed circuit board of the transmitting tube and the infrared receiving tube. As a result, many ultra-thin, ultra-narrow displays make it difficult to make ¾ infrared touch technology. The above is the main technical defect of the conventional infrared touch display device in the specific implementation, which is the main problem to be solved by the present invention.

Summary of the invention

[0006] An object of the present invention is to provide a touch display device, which is a product of the same nature as a conventional touch display device, and the main technical problem to be solved is that the conventional touch display device is limited to The width of the printed circuit board used to connect the inductive signal transmitting tube and the inductive signal receiving tube requires the outer frame of the corresponding width, so that the outer frame generally needs to be twenty millimeters wide, thus causing many ultra-thin, ultra-narrow displays. It is difficult to implement touch technology by using an inductive signal transceiving method. The above is the main technical problem to be solved by the present invention.

[0007] In order to solve the above technical problem, the technical solution adopted by the present invention is: The present invention provides a touch display device, which includes a flat panel display component, a sensing signal transceiver module, a control module, and an outer casing, wherein the sensing The signal transceiver module is disposed around the flat panel display component, and the flat panel display component, the sensing signal transceiver module, and the control module are all encapsulated in the outer casing. The flat panel display component includes a liquid crystal display, and the sensing signal is The transceiver module includes a plurality of sensing signal transceiver tubes and a printed circuit board, and the plurality of sensing signal transceiver tubes are electrically connected to the printed circuit board, and the sensing signal transceiver tube includes an inductive signal transmitting tube and an inductive signal receiving tube. The printed circuit board is disposed around the liquid crystal display, and the printed circuit board is perpendicular to the liquid crystal display panel, wherein: the sensing signal transceiver tube electrically connected to the printed circuit board is disposed at Displaying the front side of the liquid crystal display, ü the sensing signal transmitting tube and The sensing signal receiving tubes are respectively disposed on the left and right sides and the upper and lower sides of the liquid crystal display, and if the sensing signal emitted by the sensing signal tube is formed on the front side of the liquid crystal display, an induction is formed. Signal detection network.

[0008] Preferably, the printed circuit board includes four or more small circuit boards disposed around the liquid crystal display, and each of the small circuit boards is electrically connected end to end, and the printed circuit board is electrically connected. Hard PCB or flexible PCB board.

[0009] Preferably, the control module is electrically connected to the printed circuit board, and the control module is fixed on one side or the other side of the small circuit board corresponding to the liquid crystal display.

[0010] Preferably, the control module is disposed on the bottom casing, and a soft cable for transmitting power and data is connected between the control module and the printed circuit board.

[0011] Preferably, the printed circuit board comprises four or more small circuit boards disposed around the liquid crystal display, and the small circuit boards are fixedly connected end to end, and the printed circuit board is rigid. The PCB or the flexible PCB board is disposed on the bottom case, and the control module and the small circuit boards constituting the printed circuit board are connected with a flexible cable for transmitting power and data.

[0012] Preferably, the outer casing includes a surface shell and a bottom shell, and the flat panel display component and the sensing signal transceiver module are disposed in the bottom casing, and the face shell is matched with the size of the bottom casing. a four-square frame, the four-square-shaped cover is disposed on the bottom case, and the display surface of the liquid crystal display corresponds to a square surrounded by a square frame, the sensing signal transceiver module Between the face shell and the bottom case, the face shell is provided with a card slot corresponding to the bottom case, and the printed circuit board perpendicular to the liquid crystal display is clamped in the in the card slot, the printed circuit board is fixed by the card slot.

[0013] Preferably, the sensing signal transceiver tube is an infrared transceiver tube, and the infrared transceiver tube includes an infrared line tube and an infrared receiving tube, and the infrared emitting tube is a patch infrared LED.

[0014] Preferably, a light exit gap is reserved between the face shell and the display surface of the liquid crystal display, and the infrared emitting tube and the infrared receiving tube of the infrared receiving tube are disposed in the light exiting gap.

[0015] Preferably, a light filter strip is disposed in the light exit gap between the surface shell and the liquid crystal display, and the filter strip is located on the front side of the infrared light emitting tube and the infrared receiving tube of the infrared transceiver tube.

[0016] Preferably, the flat panel display component further includes a touch panel, the touch panel is disposed on a display surface side of the liquid crystal display, and the touch panel is made of a transparent tempered glass panel.

[0017] Compared with the prior art, the technical effect of the application of the present invention is: The present invention provides a touch display device, which encapsulates the flat display component and the sensing signal transceiver module in the outer casing Because the printed circuit board is perpendicular to the liquid crystal display, the frame-shaped frame of the square frame only needs to be able to cover the sensing signal transceiver tube and the printed circuit board whose board surface is perpendicular to the frame. Therefore, the width of the face shell can be greatly reduced, and the frame of the touch display device can be further narrowed. The width of the frame can be reduced to 3,6 mm by using the solution of the invention; The circuit board is perpendicular to the liquid crystal display, and the sensing signal transceiver tube is parallel to the liquid crystal display. Therefore, when the sensing signal transceiver tube is soldered to the printed circuit board ff1, there is no need to bend Footwork In order to reduce the manufacturing process, the manufacturing cost is also saved, and the pins of the sensing signal transceiver are not bent, and the service life is longer and the stability is better.

DRAWINGS

1 is a partial cross-sectional view showing a preferred embodiment of the present invention.

2 is a partial cross-sectional exploded view of a preferred embodiment of the present invention.

3 is a partial cross-sectional view showing another embodiment of the present invention.

4 is a partial cross-sectional view showing a first preferred embodiment of the present invention.

detailed description

[0022] A touch display device according to the present invention will be described in more detail below with reference to FIGS. 1 to 4 and preferred embodiments.

As shown in FIG. 1 , the present invention provides a touch display device, which includes a flat panel display component 10, a sensing signal transceiver module 20, a control module 30, and a housing 40, wherein the sensing signal is transmitted and received. The module 20 is disposed around the flat panel display unit 10, and the flat panel display component 10, the sensing signal transceiver module 20, and the control module 30 are all packaged in the outer casing 40;

The flat panel display unit 10 includes a liquid crystal display 11;

The sensing signal transceiver module 20 includes a plurality of sensing signal transceiver tubes 21 and a printed circuit board 22, and a plurality of the sensing signal transceiver tubes 21 are electrically connected to the printed circuit board 22, and the sensing signal transceiver tube 21 is including an inductive signal transmitting tube and an inductive signal receiving tube;

The printed circuit board 22 is disposed around the liquid crystal display 11, and the printed circuit board 22 is perpendicular to the panel of the liquid crystal display 11;

An inductive signal transceiving pair 21 electrically connected to the printed circuit board 22 is disposed on a front side of the display of the liquid crystal display 11, and the sensing signal transmitting tube and the sensing signal receiving tube respectively are disposed at a position The sensing signals emitted by the plurality of sensing signal tubes form an inductive signal detecting network on the display side of the liquid crystal display 11 on the left and right sides and the upper and lower sides of the liquid crystal display II;

The control module 30 is electrically connected to the printed circuit board 22, and the control module 30 controls the operation of the liquid crystal display 11 and the sensing signal transceiver pair 21;

The outer casing 40 includes a face shell 41 and a bottom case 42. The flat panel display unit 10 and the inductive signal transceiver module 20 are disposed in the bottom case 42. The face shell 41 is a size of the bottom case 42. a matching square frame, the square frame 4 is covered on the bottom case 42, and the display surface of the liquid crystal display 11 corresponds to a square surrounded by a square frame. The sensing signal transceiver module 20 is disposed between the face shell 41 and the bottom case 42. [0024] In the specific implementation, when the flat panel display component 10 and the sensing signal transceiver module 20 are packaged in the outer casing 40, since the printed circuit board 22 is perpendicular to the liquid crystal display 11, four squares The frame 41 of the shape of the face can only accommodate the length of the sensing signal transmitting and receiving tube 21 and the printed circuit board 22 perpendicular thereto, and the width of the face 41 can be greatly reduced, further realizing The frame of the touch display device is ultra-narrow, and the width of the frame can be reduced to 3.6 mm by using the solution

of the invention, which occupies less space of the surface frame of the existing display device, and changes the process structure to make the touch and display smaller. The overall integrity is stronger; and Ji is perpendicular to the liquid crystal display 11 because the printed circuit board 22 is perpendicular to the liquid crystal display 11, and the sensing signal transceiver tube 21 is parallel to the liquid crystal display 11, so that when the sensing signal is transmitted and received to the tube When the lead of 21 is soldered on the printed circuit board 22, the bending process is not required, the manufacturing process is reduced, and the manufacturing cost is also saved, and the sensing letter is saved. Transceiver 21 of pin header is not any bending that causes] % longer life, better stability.

[0025] Preferred embodiment: As shown in FIG. 1, 2, and 3, the printed circuit board 22 is a rigid PCB or a flexible PCB board, and the printed circuit board 22 includes four or more rings. A small circuit board around the liquid crystal display 11, each of the small circuit boards is electrically connected together end to end, and the control module 30 is fixedly connected to the small circuit board by fixing the control module 30 to the small circuit. The internal structure of the present invention is made more compact on the board, and the control module 30 is fixed on one side or the other side of the small circuit board corresponding to the liquid crystal display 11.

[0026] Preferred embodiment: As shown in FIG. 4, the printed circuit board 22 includes four or more small circuit boards disposed around the liquid crystal display 1, and each of the small circuit boards is fixed between the first and the last. The control module 30 is disposed on the bottom case 42. The control module 30 and the printed circuit board 22 are connected with a flexible cable for transmitting power and data. The control module 30 is connected to the sensing signal transceiver module 20, and the control module 30 controls the normal operation of the sensing signal transceiver module 20, and the connection mode of the flexible cable can be conveniently used. The disassembly and replacement of the control module 30 will be described.

[0027] Preferred embodiment: As shown in FIG. 4, the printed circuit board 22 is a rigid PCB or a flexible PCB board, and the printed circuit board 22 includes four or more rings disposed around the liquid crystal display 11. a small circuit board, each small circuit board is fixedly connected end to end, the control module 30 is disposed on the bottom case 42, and the control module 30 and each small circuit constituting the printed circuit board 22 A flexible cable for transmitting power and data is connected between the boards, and the control module 30 is electrically connected to the small circuit boards by means of a flexible cable, so that the control module 30 can be facilitated. The replacement and repair of each small circuit board prevents the entire sensing signal transceiver module 20 from being affected by the damage of the tube 21 due to the transmission of a very small number of sensing signals.

[0028] Preferred embodiment: As shown in FIG. 2, the face shell 4] is provided with a card slot 411 corresponding to the bottom case 42, and the printed circuit board 22 perpendicular to the liquid crystal display 11 a card is disposed in the card slot 411 by means of the card slot 411 The print circuit board 22 is fixed.

[0029] The preferred embodiment: the sensing signal transceiver tube 21 is an infrared transceiver tube, and the red transceiver tube includes an infrared emitting tube and an infrared receiving tube, and the infrared emitting tube is a patch infrared LED .

[0030] Preferred embodiment: as shown in FIG. 2, a light-emitting gap 43 is reserved between the face shell 41 and the display surface of the liquid crystal display 11, and the infrared transmitting and receiving tube of the infrared transmitting and receiving tube and the infrared receiving The tube is correspondingly disposed in the light exit gap 43.

[0031] Preferred embodiment: As shown in FIG. 1, 2, 3, and 4, a filter strip 44 is disposed in the light exit gap 43 between the face shell 41 and the liquid crystal display 11, and the filter strip is disposed. 44 is located on the front side of the infrared transmitting tube and the infrared receiving tube of the infrared transceiver tube, and uses the filter strip 44 to filter out external light, so that the infrared emitting tube and the infrared receiving tube can selectively send and receive externally Light.

[0032] Preferred embodiment: As shown in FIG. 1, 2, 3, and 4, the flat panel display unit 10 further includes a touch panel 12, and the touch panel 12 is disposed on a display surface side of the liquid crystal display 11. The touch panel 12 is made of a transparent tempered glass plate, and the touch panel 2 made of a transparent tempered glass plate provides protection against external force to the liquid crystal display 11 located at the display window 411.

[0033] In summary, the technical solution of the present invention can fully and effectively accomplish the above object, and the structural principle and functional principle of the present invention have been fully verified in the embodiment, and the expected effect and purpose can be achieved. The embodiments of the present invention can also be modified according to these principles, and therefore, the present invention includes all alternatives within the scope of the claims. Any equivalent changes made within the scope of the patent application of the present invention are within the scope of the patent application of the present application.

Patent Citations (4)

Publication number	Priority date	Publication date	Assignee	Title
CN2731587Y *	2004-06-25	2005-10-05	北京汇冠新技术有限公司	Novel infrared touch panel
CN2731588Y *	2004-06-25	2005-10-05	北京汇冠新技术有限公司	Novel infrared touch panel
CN201917889U *	2010-12-26	2011-08-03	浙江润智电子科技有限公司	Side frame structure member of infrared touch display device
Family To Family Citations				
CN202661975U *	2012-04-27	2013-01-09	深圳市天时通科技有限公司	Touch control displaying device

* Cited by examiner, † Cited by third party

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CN203012682U *	2012-11-30	2013-06-19	北京汇冠新技术股份有限公司	Infrared touch screen

CN103123556A *	2013-03-01	2013-05-29	深圳市天时通科技有限公司	Projection type touch-control electronic whiteboard and frame structure thereof
CN104699326A *	2013-12-06	2015-06-10	深圳市天时通科技有限公司	Novel infrared touch control screen and touch control display device
CN104657005A *	2015-03-24	2015-05-27	北京溯云科技有限公司	Infrared touch frame and infrared touch display screen
CN104867415A *	2015-05-30	2015-08-26	中山市晶艺光电科技有限公司	Shell with touch induction structure and LED digital displayer
CN108259676A *	2018-02-08	2018-07-06	上海摩软通讯技术有限公司	Terminal device and photosensitive control method

* Cited by examiner, † Cited by third party, ‡ Family to family citation

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US10025411B2	2018-07-17	Touch screen and pressure touch detection method thereof
CN105278788B	2019-03-19	Touch input device
JP2017010542A	2017-01-12	Electrode sheet for detecting pressure and pressure detection module having the same
JP5864741B2	2016-02-17	Touch sensitive display
US20160018922A1	2016-01-21	in-cell touch panel and display device
US9578148B2	2017-02-21	Smartphone capable of detecting touch position and pressure
JP5370944B2	2013-12-18	Touch panel and manufacturing method thereof
JP2018067323A	2018-04-26	Touch input device
CN102103442B	2014-10-22	Display device including optical sensing frame and method of sensing touch
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CN102053766B	2013-09-11	Electrostatic capacitance-type input device, method of manufacturing electrostatic capacitance-type input device, and electro-optical apparatus provided with input function
JP6510638B2	2019-05-08	Mobile device display module and mobile device
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JP2006155616A	2006-06-15	Touch input system using light guide
US20200065551A1	2020-02-27	Optical fingerprint recognition assembly, display device, and terminal
TWI494819B	2015-08-01	Touch panel assembly and electronic device

Priority And Related Applications

Priority Applications (2)

Application	Priority date	Filing date	Title
CN201210127420.7A	2012-04-27	2012-04-27	Touch display device
CN2012101274207		2012-04-27	

Legal Events

Date	Code	Title	Description
2013-12-25	121	Ep: the epo has been informed by wipo that ep was designated in this application	**Ref document number:** 12875319 **Country of ref document:** EP **Kind code of ref document:** A1
2014-10-27	NENP	Non-entry into the national phase in:	**Ref country code:** DE
2015-05-27	122	Ep: pct app. not ent. europ. phase	**Ref document number:** 12875319 **Country of ref document:** EP **Kind code of ref document:** A1
2015-10-21	32PN	Ep: public notification in the ep bulletin as address of the adressee cannot be established	**Free format text:** NOTING OF LOSS OF RIGHTS PURSUANT TO RULE 112(1) EPC (EPO FORM 1205N DATED 11/06/2015)
2015-10-28	122	Ep: pct app. not ent. europ. phase	**Ref document number:** 12875319 **Country of ref document:** EP **Kind code of ref document:** A1

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
liquid crystal related substances		claims,abstract,description	58	0
inductive effects		claims,abstract,description	23	0
shell materials		claims,description	21	0
corresponding		claims,description	9	0
toughened glasses		claims,description	4	0

Show all concepts from the description section

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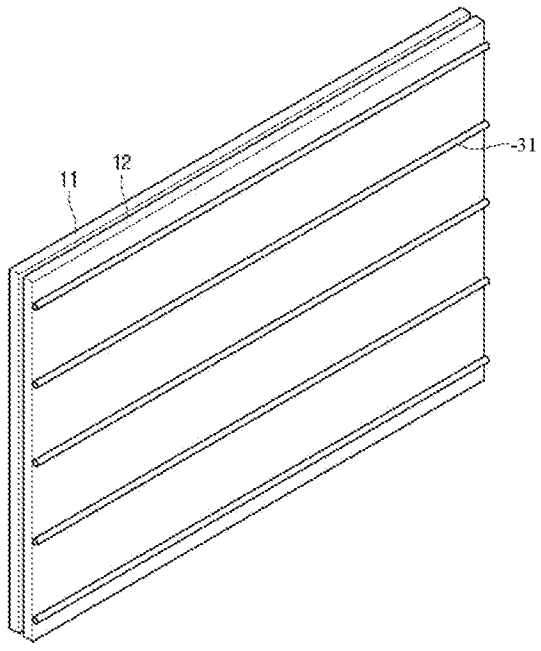
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[Continued on nextpage]

(54) **Title:** DISPLAY DEVICE



(57) **Abstract:** A display device is provided. The display device may include a display panel for displaying an image and a back cover provided behind the display panel and coupled to the display panel. A bending assembly may be coupled to the back cover to bend the display panel. A controller may be provided that is configured to control the bending assembly to apply a physical force to the back cover to bend the display panel a prescribed amount.

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Description

Title of Invention: DISPLAY DEVICE

Technical Field

[I] Provided is a display device and a bending assembly configured to bend the display device.

Background Art

[2] The present disclosure relates to a display device and method of changing a curvature of the display screen to improve user's immersion while viewing the display screen.

[3] A display device may be a Liquid Crystal Display Device (LCD), a Plasma Display Panel (PDP), an Electro Luminescent Display (ELD), and a Vacuum Fluorescent Display (VFD). Display devices may also include 3-D imaging technology. With proliferation and advancement in digital technology, improvements in display technology to provide content to users is needed.

[4]

Disclosure of Invention

Technical Problem

[5] Development of the display device to improve user's immersion while viewing the display screen is required.

Solution to Problem

[6] Embodiments provide a display device having a structure capable of improving user's immersion.

[7] In one embodiment, a display device includes: a display unit displaying an image; and a bending assembly bending the display unit.

[8] The bending assembly may include a bending actuator applying force to the display unit and a bending control unit controlling an operation of the bending actuator.

Advantageous Effects of Invention

[9] According to and embodiment of the present disclosure, user's immersion while viewing the display screen can be improved. In addition, bending amount of the display screen can be easily controlled.

[10]

Brief Description of Drawings

[II] The embodiments will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

[12] Figure 1 is a view illustrating a shape of a display module according to an embodiment of the present disclosure;

[13] Figure 2 is a view illustrating a shape of a display module and a back cover

according to an embodiment of the present disclosure;

[14] Figures 3A and 3B are views illustrating a portion of a display device according to an embodiment of the present disclosure;

[15] Figures 4 to 6 are cross-sectional views illustrating a portion of a display device according to an embodiment of the present disclosure;

[16] Fig 7 is a plan view illustrating a coupling structure of a back cover and a printed circuit board;

[17] Figures 8A and 8B are sectional views of a second fastener;

[18] Fig 9 is a sectional view of a third fastener;

[19] Fig 10 is a separate perspective view of a third fastener;

[20] Figures 11A and 1IB are views illustrating a partial configuration of a display device according to another embodiment of the present disclosure;

[21] Figure 12 is a cross-sectional view illustrating a partial configuration of a display device according to another embodiment of the present disclosure;

[22] Figures 13 to 15B are views illustrating a partial configuration of a display device according to another embodiment of the present disclosure;

[23] Figures 16 to 17 are views illustrating a partial configuration of a display device according to another embodiment of the present disclosure;

[24] Figure 18 is a view when a sliding member is applied and Figure 19 is a view of an individual sliding member;

[25] Figures 20A and 20B are views illustrating a partial configuration of a display device according to another embodiment of the present disclosure;

[26] Figure 2 1A is a view illustrating a display module, a back cover, and a bending actuator according to an embodiment of the present disclosure;

[27] Figure 21B is a view when Figure 21A is bent;

[28] Figure 22 is a view illustrating a direction of force applied between parallel straight currents;

[29] Figure 23 is a view illustrating a display module, a back cover, and a bending actuator according to another embodiment of the present disclosure;

[30] Figure 24A is a view illustrating a flat cross section of Figure 23;

[31] Figure 24B is a view when Figure 24A is bent;

[32] Figure 25 is a view illustrating a display module, a back cover, and a bending actuator according to another embodiment of the present disclosure;

[33] Figure 26 is a view illustrating a flat cross section of Figure 25;

[34] Figure 27 is a view illustrating a display module, a back cover, and a bending actuator according to another embodiment of the present disclosure;

[35] Figure 28 is a sectional view of a bi-metal;

[36] Figure 29 is a plan view illustrating a back cover and a display module of Figure 27;

[37] Figure 30 is a view illustrating a bending actuator according to another embodiment of the present disclosure;

[38] Figure 31 is a view illustrating a bending actuator according to another embodiment of the present disclosure;

[39] Figure 32 is a view illustrating a bending actuator according to another embodiment of the present disclosure;

[40] Figure 33 is a view illustrating a plan view of Figure 32;

[41] Figures 34 to 36 are views illustrating a bending actuator according to another embodiment of the present disclosure; and

[42] Figure 37 is a sectional view illustrating a coupling structure of a first shaft and a second shaft.

[43]

Best Mode for Carrying out the Invention

[44] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

[45] Hereinafter a display device according to embodiments of the present disclosure will be described in more detail with reference to the drawings. Hereinafter, each of embodiments described herein may be modified in various forms, and the technical range of the present disclosure is not limited thereto. Moreover, the form and size of each of components shown in the drawings may be exaggerated for clarity of illustration.

[46] Figure 1 is a view illustrating a bending shape of a display module according to the present disclosure. The display module 11 (also display panel) equipped in a display device may bend in a curved shape with a constant curvature R. For example, in relation to the curved shape of the display module 11, the curvature R may be set to allow the distances dl, d2, and d3 between a user's viewing position P and the front side of a panel to have the same or similar value, and the display module 11 may have a shape that is bent depending on the set curvature R.

[47] Accordingly, while viewing an image displayed on a display device, user's immersion in the displayed content may be improved, and especially, when viewing a 3D image, user's immersion may be drastically improved by the curved shape of the display module 11. Moreover, the display module 11 displaying an image may include a self light emitting panel such as an OLED panel, or may include a panel that is not a self light emitting panel such as an LCD panel or a PDP panel and a backlight unit emitting light to the panel.

[48] Hereinafter, merely for ease in description, the display module 11 is depicted as a self light emitting Organic Light Emitting Device (OLED) panel that uses an OLED as

an example. The OLED has a structure in which an organic light emitting layer of a functional thin film form is inserted between an anode electrode and a cathode electrode. Holes are injected from the cathode electrode and electrons are injected from the anode electrode so that the electrons and holes are combined to form excitons in the organic light emitting layer and then, the excitons are recombined to emit light

[49] As a method of realizing a full color organic light emitting display, there are an independent light emitting method, a color filter method, and a color conversion method. The independent light emitting method realizes R, G, and B by thermally depositing a light emitting material of each of R, G, and B with a metal shadow mask having a detailed pattern. The color filter method realizes R, G, and B by forming a white light emitting layer and patterning an R, G, and B color filter. The color conversion method forms a blue light emitting layer and realizing R, G, and B by using a color conversion layer changing blue into green and red. However, it should be appreciated that a display module of the present disclosure is not limited to an OLED panel, and as mentioned above, various flat panel display modules such as an LCD module, a PDP module, an FED module, or another appropriate type of display may be applied to the present disclosure.

[50] The display module 11 may be a flat panel display module 11 having a curvature close to 0°, and the flat panel display module 11 may be bent by a back cover 12. Thus, the display module 11 may have a curved shape having the constant curvature R as shown in Figure 1.

[51] Figure 2 is a sectional view illustrating a configuration of a display device according to the present disclosure. As shown in Figure 2(a), the display module 11 may be the flat panel display module 11. As shown in Figure 2(b), the back cover 12 disposed at the rear of the display module 11 may be bent by applying a force to the display module 11. Therefore, as shown in Figure 2(c), the display module 11 and the back cover 12 may be bent together. While Figure 2 illustrates only the display module 11 and the back cover 12 among components of the display device according to an embodiment of the present disclosure, the display device may further include various components not illustrated.

[52] Here, the back cover 12 may be a single plate-shaped member coupled to the rear of the display module 11 and may be formed of a material having elasticity to be bent forward. For example, the back cover 12 may be formed of Carbon Fiber-reinforced Plastic (CFRP). The back cover 12 may be disposed at the rear of the display module 11 and may serve to protect the display module 11. The back cover 12 may also be used to bend the display module 11 by applying physical force to the display module 11. However, the back cover 12 is not necessarily formed of a single plate-shaped member, and thus, may be formed of a plurality of plate-shaped members or an

assembly in which another configuration is coupled to a plurality of plate-shaped members.

[53] Additionally, in the present disclosure, although the back cover 12 having the approximately same area as the display module 11 is shown in the drawing, this illustrates just a conceptual shape to describe the bending shape of the back cover 12 and the display module 11. The actual back cover 12 may have a vertical or horizontal width that is shorter or longer than that of the display module 11. That is, the shape and size of the back cover 12 is not limited to the drawing.

[54] Moreover, the center of the back cover 12 in the lateral direction and the display module 11 may be fixed, and other parts other than the center may be installed not to restrain movement forward or backward. Therefore, when the back cover 12 and the display module 11 are bent, the left and right edges may move front to back.

[55] However, the back cover 12 and the display module 11 may be installed so that the front to back movements of both lateral ends are restrained and the center of the display in the lateral direction may move front to back. In this case, the back cover 12 and the display module 11 may be bent.

[56] Moreover, a display device according to an embodiment of the present disclosure may include a bending assembly that bends a display unit 10 by applying physical force to the display unit 10. The bending assembly may include a bending actuator and a bending control unit that controls the bending actuator. Here, the display unit 10 may include the above-mentioned display module 11 and back cover 12. Moreover, the display unit 10 may further include a middle cover 13 between the display module 11 and the back cover 12.

[57] In addition, the bending actuator as used herein may also refer to a device that produces mechanical force through use of various types of energy sources such as electricity or hydraulic pressure. The bending actuator may be provided in various shapes as described with various embodiments below.

[58] The bending control unit may control operations of the bending actuator. For example, when the bending actuator is an elastic member, for example being formed of a shape memory alloy, the bending control unit adjusts the amount of current applied to the shape memory alloy to adjust a temperature change of the shape memory alloy, so that a length change of the shape memory alloy may be controlled. Moreover, when the bending actuator is a sensitive heat tube surrounded by conductive wire, electromagnet, bimetal, piezoelectric element, or heat wire, operations of the bending actuator may be controlled. This will be described later in each embodiment.

[59] Hereinafter, with reference to Figures 3A to 37, specific embodiments of a display device including the combined above-mentioned configurations according to the present disclosure will be described in more detail.

[60] Hereinafter, a configuration of a display device according to one embodiment of the present disclosure will be described with reference to Figures 3A to 10. Figures 3A to 10 schematically illustrate only a configuration relating to the bending of the display module 11 merely for ease of description of a structure and principle for bending a display device. However, it should be appreciated that the display device may include various other configurations besides the shown configuration.

[61] First, referring to Figures 3A, 3B, and 4, the display device may include the display module 11, the back cover 12 coupled to the rear of the display module 11, and the bending assembly bending the back cover 12. Here, the bending assembly includes a elastic members. The elastic member may be formed of, for example, a shape memory alloy (SMA).

[62] SMA is an alloy using shape memory and superplastic properties appearing in a metal transformed from austenite to martensite. When a specific shape is memorized in austenite of a high temperature state and then cooled to low temperature, martensite transformation occurs, and residual stress is formed in the tissue. Therefore, the specific shape is transformed. Then, when being heated again at an austenite temperature, the transformed specific shape is restored to its original shape.

[63] Accordingly, when current flows in an SMA set to be restored to an original shape at a predetermined temperature, the SMA serves as resistance and temperature increases. Therefore, the SMA returns to its original shape and size according to temperature increase. At this point, the SMA may be set to increase or decrease its length at an increased predetermined temperature.

[64] Moreover, the bending assembly may include a bending actuator that applies physical force to the back cover 12 and a bending controller (also bending control unit) that controls operations of the bending actuator. Here, the bending actuator may include an SMA 31 and the bending control unit may control a length change of the SMA 31.

[65] The SMA 31 may be provided in a rod shape extending in the left and right directions, and may be attached to the backside of the back cover 12. For reference, the front side of the back cover 12 is a side facing the display module 11 and its backside is the opposite side. The rod shape may have various cross-sections, such as a round or rectangular cross-section. For example, the SMA 31 may have a cylindrical or wire shape.

[66] The SMA 31 may be provided in plurality, horizontally in parallel to each other. The SMA 31 may be provided to maintain a predetermined length at a room temperature and when the temperature rises more than a set temperature, its length extends.

[67] At this point, the rise in the temperature may be achieved by power supply that is controlled by the bending control unit. Accordingly, once power is supplied by the

bending control unit, a resistance of the SMA 31 causes the temperature to rise. As the temperature rises, the length of the SMA 31 extends laterally, in the left and right directions.

[68] When the length of the SMA 31 increases, the back cover 12 may bend and both the left and right ends of the display module 11 may protrude toward the front relative to the center of the display module 11, and its center may have a concave shape. At this point, an angle at which the back cover 12 bends may be adjusted by controlling an amount of current through the SMA 31.

[69] When the back cover 12 is bent, the both left and right ends of the back cover 12 applies pressures to the left and right edge of the backside of the display module 11, and the display module 11 is concavely bent toward the front. Therefore, user's immersion in the viewed image or perception may be enhanced.

[70] Moreover, as shown in Figure 5, a recess may be formed to receive the SMA 31. For example, a groove-shaped receiving unit for receiving the SMA 31 may be formed concave from the backside toward the front at the rear of the back cover 12 and the SMA 31 may be received therein.

[71] Additionally, as shown in Figure 6, the SMA 31 may be buried in or encapsulated in the back cover 12. The depth of the SMA 31 in the back cover 12 may be provided such that it is positioned toward the rear side of the back cover 12 relative to a center depth of the back cover 12, as illustrated. In this case, the SMA receiving unit may be a space where the SMA 31 in the back cover 12 is disposed. The SMA may be insert-molded together with the back cover 31.

[72] A printed circuit board (PCB) may be coupled to the rear of the display module 11 and the back cover 12 having the above configuration. Referring to Figure 7, the back cover 12 may be coupled to the PCB 15 by using a bracket 17.

[73] The plate-shaped bracket 17 may be disposed at the rear of the back cover 12 and the PCB 15 may be disposed at the rear of the bracket 17. At this point, the back cover 12 and the bracket 17 may be coupled by a first fastener 41 at the central part and the bracket 17 and the PCB 15 may be coupled by a second fastener 43 at the left and right direction edges.

[74] Accordingly, the first fastener 41 may be coupled to the backside of the back cover 12 at the center in the lateral direction and the front side of the bracket 17 at the center in the lateral direction, and the second fastener 43 may be coupled to the backside of the bracket 17 near the left and right side edge and the front of the PCB 15 near the left and right side edge.

[75] Figures 8A to 8B are sectional views illustrating a structure of the second fastener 43. The fastener 43 may include a front support part 43a of a roughly cylindrical shape coupled to the rear of the bracket 17, a spring 43c having the rear end supported by the

front support part 43a, and a head part 43b coupled to the rear end of the spring 43c.

[76] The front support unit 43a may be a pern nut whose portion protrudes toward the rear and the head part 43b may be a member of a roughly cylindrical shape. The head part 43b may be coupled to the PCB 15. Here, the spring 43c may be a coil spring. The second fastener 43 maintains a state as show in Figure 8A usually but when external force is applied to the bracket 17 or the PCB 15, as shown in Figure 8B, the spring 42c is compressed so that impact between two members is absorbed.

[77] Moreover, the left and right edges of the back cover 12 and the left and right edges of the bracket 17 may be coupled to each other by a third fastener 45. Figures 9 and 10 illustrate the third fastener 45 in more detail.

[78] The third fastener 45 provides a fastening structure that absorbs the bending of the back cover 12 between the back cover 12 and the bracket 17. The third fastener 45 may include a first member 45a coupled to the backside of the back cover 12 and a second member 45c coupled to the front side of the bracket 17. The backside of the first member 45a may have a rounded shape whose center protrudes convexly, and an opening part 45b extending in the lateral direction may be formed at the center of the rear.

[79] The second member 45c may extend from front to back relative to the display module 11 and may be insertable into the opening part 45b. A long hole 45d may be formed long in the lateral direction in the second member 45c. The long hole 45d may have a rounded shape as may progressively approach the left and right edge. Moreover, a head 45e may be coupled to the rear of the second member 45c.

[80] Accordingly, when the second member 45c is inserted into the opening part 45b of the first member 45a, a coupling protrusion may be inserted into the long hole 45d. Therefore, the second member 45c may be rotatable based on the coupling protrusion and may be movable by the length of the long hole 45d. Accordingly, the back cover 12 in a flat sate or a bending state may be continuously coupled to the back cover 12 and the bracket 17.

[81] Hereinafter, a configuration of a display device according to one embodiment of the present disclosure will be described with reference to Figures 11A and 1IB. Figures 11A and 1IB schematically illustrate only a configuration relating to the bending of the display module 11 merely for ease of description of a structure and principle for bending a display device. However, it should be appreciated that the display device may include various other configurations besides the shown configuration.

[82] The display device includes a display unit bending toward the front and a bending assembly bending the display unit. The display unit includes a display module 11 and a back cover 12 coupled to the rear of the display module 11. The bending assembly bends the back cover 12 so as to bend a display panel.

[83] Moreover, the bending assembly includes a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator.

[84] In the embodiment of Figure 3, the SMA 31 configuring the bending actuator extends from the left end part of the back cover 12 to the right end part. However, in this embodiment, a fixing unit 32 (also support bracket) is provided at the rear center of the back cover 12. Accordingly, the bending actuator according to this embodiment includes the SMA 31 and the fixing unit 32 where the SMA 31 is fixed. The bending control unit controls operations of the bending actuator.

[85] The SMA 31 has a rod shape (e.g., cylindrical or wire shape) and extends in the left and right directions. A plurality of SMAs 31 may be attached to the rear of the back cover 12 and extend horizontally, parallel to each other. There may be a group of SMAs 31 that form a left column at the left side of the fixing unit 32 and there may be a group of SMAs 31 that form a right column at the right side of the fixing unit 32. Accordingly, the right end part of the left column and the left end part of the right column may be fixed at the fixing unit 32.

[86] Due to the above configuration, when power is applied to the SMA 31, the wires extend in the left and right directions and the back cover 12 is bent toward the front with a centrally concaved shape. At this point, the control unit may supply power to the left column to allow only a portion where the left column is attached to be bent and on the contrary, may supply power to the right column to allow only a portion where the right column is attached to be bent. Moreover, by differently supplying the amount of current applied to the left column or the right column, the degree of bending may differ.

[87] When the back cover 12 is bent, the both left and right end parts of the back cover 12 forwardly applies pressures around the left and right edges of the display module 11, so that the display module 11 is bent simultaneously. Moreover, when power is cut off by the bending control unit, and thus a temperature of the SMA 31 drops, the length of the SMA 31 is reduced and the display module 11 and the back cover 12 return to their original flat states by the elastic restoring force of the material.

[88] While the SMA 31 is described herein as including only the two columns such as the left column and the right column, the SMA 31 may have other configurations, for example, to have three columns or more.

[89] Furthermore, as shown in Figures 11A and 1IB, the SMA 31 may be attached to the backside of the back cover 12, or like Figures 5 and 6, the SMA 31 may be received in the SMA receiving unit on the inner side of the back cover 12. Like the embodiment of Figures 5, the SMA receiving unit may have a groove shape concave toward the inner side (the front) at the backside of the back cover 12, and when the SMA 31 is buried

inside the back cover 12, the space in which it is buried may be the SMA receiving unit.

[90] Moreover, when the SMA 31 is buried inside the back cover 12, it may be disposed toward the rear of the back cover 12 with respect a depth of the back cover 12. The reason is that the length of the SMA 31 increases at a predetermined temperature in this embodiment. Additionally, when the SMA 31 is received in the SMA receiving unit, a portion of the fixing unit 32 may be buried at the rear of the back cover 12.

[91] Moreover, in the display device according to the present disclosure, the bracket 17, the first fastener 41, and the second fastener 43 shown in Figure 7 to 8B may be applicable for the coupling of the PCB 15. Additionally, as shown in Figures 9 and 10, the third fastener 45 may be applicable.

[92] Hereinafter, a configuration of a display device will be described with reference to Figure 12. Figure 12 schematically illustrates only a configuration relating to the bending of the display module 11 merely to facilitate description of a structure and principle for bending a display device. However, the display may include various other configurations besides the shown configuration.

[93] The SMA 31 may be disposed at position symmetric to the position of Figure 6 toward the front of the back cover 12 toward the display, as illustrated in Figure 12. The display device may include a display unit for displaying an image and a bending assembly for bending the display unit. The display unit may include a display module 11 displaying an image and a back cover 12 coupled to the rear of the display module 11.

[94] Moreover, the bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator. Here, the bending actuator may include the SMA 31 and the bending control unit that controls a length change of the SMA 31.

[95] The SMA 31 may be provided in a rod shape (e.g., cylindrical or wire shape) and extending in the left and right directions, and may be attached to the front of the back cover 12. The SMA 31 maintains a predetermined length at a room temperature and when the temperature rises more than a set temperature, its length is reduced. Here, because the SA 31 is provided toward the front surface of the back cover 12, the length of the SMA 31 is reduced to bend the display forward. At this point, the rise in the temperature may be achieved by power supply that is controlled by the bending control unit.

[96] Accordingly, once power is supplied by the bending control unit, current flows though the SMA and the resistance of the SMA 31 generates heat, thereby raising its temperature. As the temperature rises, the length of the SMA 31 is reduced laterally, i.e., in the left and right directions.

[97] When the length of the SMA 31 is reduced, the back cover 12 becomes bent and both the left and right ends may protrude toward the front relative to its center, and the center may have a concave shape. At this point, an angle at which the back cover 12 bends may be adjusted by controlling the amount of current to the SMA 31. When the back cover 12 is bent, the display module 11 at the front of the back cover 12 is concavely bent toward the front. Due to this, user's immersion or perception while viewing the display may be enhanced.

[98] Moreover, when the SMA 31 is disposed at the front of the back cover 12, like the above embodiment (refer to Figures 11A and 1IB), the SMA 31 may be grouped to form a left column and the right column, or other configurations, for example, three columns or more. Furthermore, the length of each column may be differently controlled. For example, the length of the SMA 31 in the left column may be controlled to have a first prescribed length, and the SMA 31 in the right column may be controlled to have a second prescribed length, such that the curvature of the display may be controlled more precisely.

[99] Moreover, in the display device according to this embodiment, the bracket 17, the first fastener 41, and the second fastener 43 shown in Figure 7 to 8B may be applicable for coupling the PCB 15. Additionally, as shown in Figures 9 and 10, the third fastener 45 may be applicable.

[100] Hereinafter, a configuration of a display device according to another embodiment of the present disclosure will be described with reference to Figures 13 to 15B. Figures 13 to 17 schematically illustrate only a configuration relating to the bending of the display module 11 merely to facilitate description of a structure and principle for bending a display device. However, the display device according to the present embodiment may include various other configurations besides the shown configuration.

[101] Figure 13 is a perspective view illustrating the back cover 12 and the bending assembly of the display device, and Figure 14 is a view illustrating the front side of the back cover 12. Moreover, Figures 15A and 15B are plan views of the display device. The display device may include a display unit and a bending assembly that bends the display unit. The display unit may include a display module 11, a thin plate-shaped middle cover 13 attached to the backside of the display module 11 (or display panel) through a double-sided tape 14 or another appropriate method of connection, and a back cover 12 coupled to the rear of the middle cover 13. The bending assembly may apply force to bend the back cover 12, so that the entire display unit may be bent.

[102] Here, the bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit that controls operations of the bending actuator. The bending actuator may include an SMA 31 and a fixing unit 33 (or support bracket) fixing the SMA 31 to the front of the back cover 12. Also, the bending

actuator may control a length change of the SMA 31.

[103] The fixing unit 33 may include four extension units 38a that extend front to back and protruding toward the front around each edge of the back cover 12. The fixing unit 33 may have a roughly rectangular shape and a vertical extension unit 33b that vertically connects two extension units 38a may be provided around the left and right sides of the back cover 12. The vertical extension unit 33b may be provided to be in one or more pairs. As illustrated, the vertical portions may be provided a prescribed distance from the back cover toward the display panel.

[104] The SMA 31 extends across two vertical extension units 33b. The SMA 31 may be provided to have a rod shape that extends in the left and right directions, and may be provided in plurality to extend horizontally, parallel to each other. The rod shape may have various cross-sections, such as a round shape, square shape or the like. For example, the SMA 31 may have a wire shape.

[105] Accordingly, the SMA 31 may be coupled to a position that is spaced toward the front from the front side of the back cover 12, and extends parallel to the front side of the back cover 12. That is, the left end part of the SMA 31 may be coupled to the vertical extension unit 33b at the left side and the right end part of the SMA 31 may be coupled to the vertical extension unit 33b at the right side. Moreover, the fixing unit 33 and the SMA 31 may be formed as one module. When a module including the fixing unit 33 and the SMA 31 is manufactured separately and is coupled to the front side of the back cover 12, manufacturing efficiency may be improved.

[106] In this embodiment, the SMA 31 may maintain a predetermined length at a room temperature and when the temperature rises more than a set temperature, its length is reduced. At this point, the rise in the temperature may be achieved by a power supply that is controlled by the bending control unit.

[107] Accordingly, once current is supplied to the SMA 31, the resistance of the SMA 31 may produce a prescribed amount of heat causing its temperature to increase. As the temperature increases, the length of the SMA 31 is reduced in the lateral, e.g., left and right, directions.

[108] When the length of the SMA 31 is reduced from Figure 15A to Figure 15B, the back cover 12 becomes bent and the both left and right end parts protrude toward the front relatively, and its center has a concavely retreated shape. At this point, an angle at which the back cover 12 bends may be adjusted by controlling the amount of current through the SMA 31.

[109] When the back cover 12 is bent, pressure is forwardly applied on the both left and right ends of the middle cover 13 from the front of the back cover 12, and due to this, the display module 11 is also concavely bent toward the front. Therefore, user's immersion may be increased. Moreover, when power is cut off by the bending control

unit, and thus a temperature of the SMA 31 drops, the length of the SMA 31 is increased again and the display module 11 and the back cover 12 return to their original flat states by the elastic restoring force of the material.

[110] Moreover, the bracket 17, the first fastener 41, and the second fastener 42 shown in Figures 7 to 8B may be applicable to the display device according to this embodiment. Additionally, as shown in Figures 9 and 10, the third fastener 43 may be also applicable.

[111] Hereinafter, a partial configuration of a display device will be described with reference to Figures 16 to 19. Figures 16 to 19 schematically illustrate only a partial configuration relating to the bending of the display module 11 merely to facilitate description for a structure and principle for bending a display device. However, the display device according to the present embodiment may include various other configurations besides the shown configuration.

[112] Figure 16 illustrates the middle portion of the display module 11, the back cover 12, and the middle cover 13 in the display device. Figure 17 illustrates a portion horizontally deviated from the center of the display module 11, the back cover 12, and the middle cover 13 in the display device. The display device may include a display unit and a bending assembly that bends the display unit. The display unit may include a display module 11, a middle cover 13 located at the rear of the display module 11, and a back cover 12 located at the rear of the middle cover 13. The bending assembly applies physical force to the back cover 12, so that the entire display unit may be bent.

[113] The middle cover 13 may be attached to the backside of the display module 11 by using a double-sided tape 14 or another appropriate method of connection. The back cover 12 may have a shape in which the left and right ends protrude toward the front relative to the center, and the center is curved toward the rear. Accordingly, the central part of the back cover 12 is spaced from the middle cover 13 toward the rear and the left and right end parts of the back cover 12 contact the left and right edge backside of the middle cover 13. At this point, the back cover 12 and the middle cover 13 may contact directly, or may contact through a sliding member 37 as described in more detail hereinafter. Additionally, when the sliding member 37 is provided, the left and right end parts of the back cover 12 and the middle cover 13 may not contact each other, and thus may be spaced apart from each other.

[114] Moreover, the bending assembly may include a bending actuator that applies physical force to the back cover 12 and a bending control unit that controls operations of the bending actuator. The bending actuator may include an SMA 31 (or elastic member) and fixing units 35a and 35b (or support bracket) fixing the SMA 31 to the rear of the back cover 12. The bending control unit may control a length change of the SMA 31.

[115] The fixing units 35a and 35b may include a central fixing unit 35a (or center support) protruding toward the front from the front side at the left and right direction center of the back cover 12 and a side fixing unit 35b (or lateral support) protruding from the front side toward the front around the left and right both end parts of the back cover 12.

[116] The front end of the central fixing unit 35a is coupled to the rear of the left and right direction center of the middle cover 13, and the rear end is coupled to the left and right direction center of the back cover 12. At this point, the central fixing unit 35a may function as a spacer to maintain a predetermined interval between the back cover 12 and the middle cover 13.

[117] The SMA 31 may be attached to the both left and right sides of the central fixing unit 35a, or the central fixing unit 35a may serve as a supporter to allow one SMA 31 to pass through. An end part of the SMA 31 may be fixed at the side fixing unit 35. The SMA 31 may be provided in a wire shape extending in the left and right directions, and is forwardly spaced a predetermined distance apart from the back cover 12.

[118] The SMA 31 may maintain a predetermined length at a room temperature and when the temperature rises more than a set temperature, its length may be reduced. At this point, the rise in the temperature is achieved by power supply that is controlled by the bending control unit. Accordingly, once power is supplied by the bending control unit, the resistance of the SMA 31 causes generation of heat and its temperature rises. As the temperature rises, the length of the SMA 31 is reduced in the lateral, e.g., left and right, directions.

[119] When the length of the SMA 31 is reduced, the both end parts (or lateral sides) of the back cover 12 are pulled toward the center, and as the distance between the both end parts of the back cover 12 becomes narrower, both end parts of the back cover 12 are moved toward the front relative to the center. Then, the both end parts of the back cover 12 forwardly apply pressure to a point horizontally deviated from the center of the mid cover 13, so that the display module 11 becomes bent.

[120] At this point, the back cover 12 may have a curved shape whose center in the lateral direction is curved toward the rear relatively and both lateral ends protrude toward the front relatively. In this case, when the distance between the both end parts of the back cover 12 becomes narrower, the back cover 12 becomes bent with a greater curvature than the original, which then forwardly applies pressure to a point horizontally deviated from the center of the mid cover 13 so that the display module 11 becomes bent. At this point, an angle at which the back cover 12 bends may be adjusted by controlling current flow through the SMA 31.

[121] Since the central fixing unit 35a maintains a predetermined interval laterally between the center of the back cover 12 and the center of the display module 11, when the back cover 12 is bent, forward pressure is applied by both the left and right ends of the back

cover 12 to both the left and right end parts of the display module 11 to simultaneously bend the display module 11. Therefore, user's immersion may be increased.

[122] Moreover, when power is cut off by the bending control unit and thus a temperature of the SMA 31 drops, the length of the SMA 31 is increased and the display module 11 and the back cover 12 return to their original flat states by the elastic restoring force of the material. Moreover, the sliding member 37 shown in Figures 18 and 19 may be additionally included in the above configuration.

[123] The sliding member 37 may be fixed at one of the back cover 12 or the middle cover 13 and may be slidable at the other. That is, the sliding member 37 may be coupled to the front side of the back cover 12 so that it may slide relative to the backside of the middle cover 13, or may be coupled to the rear of the middle cover 13 so that it may slide relative to the front of the back cover 12. Additionally, the sliding member 37 may be coupled to each of the back cover 12 and the middle cover 13, so that sliding may occur between a portion coupled to the back cover 12 and a portion coupled to the middle cover 13.

[124] Hereinafter, a configuration and function of the sliding member 37 according to this embodiment will be described with reference to Figures 18 and 19. The sliding member 37 slide relative to a body 37a fixed at the middle cover 13 and a moving member 37d fixed at the back cover 12 to be movable horizontally.

[125] The body 37a may have a plate-shaped member that extends horizontally, and its center slide relative to a sliding area 37b extending horizontally. Moreover, a fixing unit 37c protruding toward the front side may be provided at the front side of the body 37a. The fixing unit 37c may be fixed by directly contacting the backside of the middle cover 13, and the body 35a may be spaced by the length of the fixing unit 37c apart from the middle cover 13. The moving member 37d may be provided to allow reciprocating sliding in the sliding area 37b, and its flat backside may be coupled to the front side of the back cover 12. Since the sliding member 37 is provided, the back cover 12 and the middle cover 13 may have coherence at a portion horizontally deviated from the center in addition to the center.

[126] Moreover, when the sliding member 37 is provided between the back cover 12 and the middle cover 13, the left and right end parts of the back cover 12 protrude toward the front relatively by the bending assembly. When pressure is applied on the backside of the middle cover 13, the back cover 12 does not directly contact the middle cover 13 and contacts the middle cover 13 through the sliding member 37, allowing the display module 11 to be bent more efficiently. Additionally, when the sliding member 37 is provided, the left and right end parts of the back cover 12 may contact the middle cover 13 so that the back cover 12 applies pressure on the middle cover 13.

[127] Moreover, the bracket 17, the first fastener 41, and the second fastener 43 shown in

Figures 7 to 8B may be applicable to the display device according to this embodiment. Additionally, the third fastener 45 shown in Figures 9 and 10 may be also applicable.

[128] Hereinafter, a configuration of a display device will be described with reference to Figures 20A and 20B. Figure 20A is a view of a flat state before a display unit of the display device is bent. Figure 20B is a view when the display unit is bent. Merely for convenience and to facilitate description, a configuration shown in Figures 20A and 20B does not include all of the features of the display device, and only a partial configuration relating to the bending of the display module 11 is shown while other configurations are omitted.

[129] The display device may include a display unit, a bending assembly bending the display unit, and a lower frame 50 supporting the display unit from the lower part. The display unit may include a display module 11 (or display panel) and a back cover 12 at the rear of the display module 11. The lower frame 50 receives various parts therein such as a control module, and the display module 11 and the back cover 12 are coupled to the top of the lower frame 50. Additionally, a stopper 51 may be provided at the top of the lower frame 50 and may contact the backside of the back cover 12 at the rear of both the left and right ends of the back cover 12.

[130] The bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator. The bending actuator includes an SMA 31, a fixing unit 39 fixing the SMA 31 to the rear of the back cover 12, and a motor 52 rotating the fixing unit 39. The bending control unit controls a length change of the SMA 31 and operations of the motor 52.

[131] The fixing unit 39 (or support bracket) may be provide in a cylindrical shape extending in a vertical direction, and may be backwardly spaced apart from the center of the back cover 12. The SMA 31 (or elastic member) may be provided in a cylindrical or wire shape extending in a lateral direction. Its front end may be coupled to the center laterally at the backside of the back cover 2 and its rear end may be coupled to the fixing unit 39. A plurality of SMA 31 may be provided horizontally, parallel to each other.

[132] The motor 52 may be coupled to the lower part of the fixing unit 39, and the fixing unit 39 may rotate by rotation of the motor 52. The bending control unit may be included in the control module provided at the inner side of the lower frame 50, and may control a current applied to the SMA 31 and rotation of the motor 52.

[133] Accordingly, once current is supplied to the SMA 31 by the bending control unit, resistance of the SMA 31 may cause heat generation and its temperature rises. As the temperature rises, the length of the SMA 31 may be reduced in the lateral, e.g., left and right, directions.

[134] When the length of the SMA 31 is reduced, the both left and right end regions of the back cover 12 are restrained from moving toward the rear, and only the center part is moved toward the rear, so that the back cover 12 has a bending shape that is centrally concaved relative to the front. At this point, an angle at which the back cover 12 is bent may be adjusted by controlling a current applied to the SMA 31.

[135] Moreover, in this embodiment, auxiliary bending is possible by rotation of the motor 52. When the motor 52 rotates, the cylindrical fixing unit 37 rotates to wind the SMA 31 on its outer circumferential surface, so that the center part of the back cover 12 may be further pulled back. Accordingly, when the motor 52 is used sufficient bending effect may be achieved even when the reduced length of the SMA 31 is insufficient for the desired amount of bending.

[136] Additionally, when the length reduction of the SMA 31 is not obtained properly, the bending of the back cover 12 and the display module 11 becomes possible. Also, as the fixing unit 37 rotates, it winds the outer circumference surface with the SMA 31, so that the center part of the back cover may be further retreated.

[137] As mentioned above, when the back cover 12 is bent, the left and right direction center of the back cover 12 is retreated and thus, the left and right direction center part of the display module 11 is pulled toward the rear. Due to this, the display module 11 is bent simultaneously. Therefore, user's immersion may be increased by bending the display unit.

[138] Moreover, when power is cut off by the bending control unit, and thus a temperature of the SMA 31 drops, the length of the SMA 31 is increased and the display module 11 and the back cover 12 return to their original flat states by the elastic restoring force of the material. In this case, if the wire-shaped SMA 31 is wounded on a fixing unit by rotating a motor, the display module 121 returns to a flat state by reversely rotating the fixing unit to unwind the SMA 31.

[139] Hereinafter, a display device will be described with reference to Figures 21A to 22. Figures 21A to 22 schematically illustrate only a configuration relating to the bending of the display module 11 merely to facilitate description of a structure and principle for bending a display device. However, the display device may include various other configurations besides the shown configuration.

[140] The display device may include a display unit displaying an image and a bending assembly bending the display unit. The display unit may include a display module 11 displaying an image and a back cover 12 coupled to the rear of the display module 11.

[141] The bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator. The bending actuator may be a leading wire 34 coupled to the rear of the back cover 12 to flow current.

[142] Figure 21A is a view of a flat state when the display module 11 and the back cover 12 are not bent. Figure 21B is a view when the display unit 11 and the back cover 12 are bent. Figures 21A and 21B are views when a plurality or wires 34 coupled to the rear of the back cover 12 extend vertically. Additionally, Figure 22 is a view illustrating the direction of a current flowing in a wire and the direction of a force acting on between wires.

[143] As shown in Figure 22(a), when the direction of a current flowing in one wire is the same as that in an adjacent wire, gravitation acts on between two wires. As shown in Figure 22(b), when the direction of a current flowing in one wire is different from that in an adjacent wire, repulsion acts on between two wires.

[144] Referring to Figures 21A and 21B, the wire 34 may be provided in plurality vertically in parallel to each other. Each wire 34 extends in parallel to another adjacent wire 34. The wire 34 may be attached to the backside of the back cover 12, or may be built in the back cover 12. The wire 34 may be built in the back cover 12, it needs to be positioned at the rear on the basis of the back and forth direction center of the back cover 12.

[145] Moreover, as shown in Figures 21A and 21B, a groove part 18 formed long vertically may be provided at the front of the back cover 12. The groove part 18 may have a roughly V-shaped shape whose left and right widths become narrower gradually as they approach the rear from the front, and a plurality of groove parts 18 are horizontally arranged in parallel to each other. Each groove part 18 may be disposed parallel to an adjacent groove part 18.

[146] Moreover, the left and right direction central parts of the back cover 12 and the display module 11 may be fixed, and other parts other than the fixed central parts may be installed not to restrain the movement in the front and rear directions. Therefore, when the back cover 12 and the display module 11 are bent, the left and right direction edges may move back and forth.

[147] However, the back cover 12 and the display module 11 may be installed so that the back and forth movements of both end parts are restrained and a central part of the left and right directions may move back and forth. In this case, the back cover 12 and the display module 11 may be bent.

[148] Due to the above configuration, when current is applied to the wire 34 by the bending control unit, it generates a magnetic field. At this point, a current flowing into the wire 34 is controlled so that the direction of a current flowing in one wire 34 is opposite to that in an adjacent wire 34. Therefore, repulsion occurs between the one wire 34 and the adjacent wire 34.

[149] When repulsion acts on between each wire 34, a force in the lateral direction is applied to the rear of the back cover 12 relative to its center. Accordingly, the back

cover 12 and the display module 11 change from a flat shape shown in Figure 21A into a shape whose both left and right ends protrude toward the front and the center is pushed back, as illustrated in Figure 21B. At this point, since a plurality of groove parts 18 are formed in the front side of the back cover 12, the groove part 18 becomes smaller to aid the bending of the back cover 12, so that the back cover 12 may be bent with a smaller amount of force.

[150] Moreover, the amount of current flowing in the wire 34 may be controlled by the bending control unit and by adjusting the amount of current, the bending degree of the back cover 12 and the display module 11 may be adjusted. Furthermore, the wire 34 may be coupled to the front of the back cover 12. In this case, the wire 34 may be attached to the front side of the back cover 12, or may be built at the front inside the back cover 12 in the front to back direction relative to a thickness of the back cover 12.

[151] When the wire 34 is coupled to the front of the back cover 12, the bending control unit may allow the direction of a current flowing in each wire 34 to be identical. Due to this, gravitation may act on between each wire 34. Once gravitation occurs between each wire 34, since a force to narrow the left and right widths is applied to the front on the basis of the back and forth direction center of the back cover 12, an interval between the groove parts 18 becomes narrower. Due to this, the back cover 12 and the display module 11 may be bent toward the front. In this case, the degree of bending of the back cover 12 and the display module 11 may be controlled when the bending control unit controls current flow through the wires 34.

[152] Moreover, as mentioned above, as the wire 34 serves as a bending actuator, when a current flowing in the wire 34 is cut off the display module 11 and the back cover 12 return to their original flat states by elastic restoring force. If necessary, a current flowing in the wire 34 is applied in an opposite direction, so that this may aid to unbend the display module 11 and the back cover 12 to the original states.

[153] Moreover, a bending actuator configuring a bending assembly may be an electromagnet as shown in Figures 23 to 26. When compared with the configuration of Figures 21A and 21B, all other configurations are the same except that the wire 34 is replaced with an electromagnet 38, and thus repeated description is omitted.

[154] Figures 23 to 25B are views when the electromagnet 38 is coupled to the rear of the back cover 12, and Figures 25 and 26 are views when the electromagnet 38 is coupled to the front of the back cover 12. The electromagnet 38 may extend to have its polarities in the lateral directions. That is, the left end part is an S pole, the right end part is an N pole. When the left end part is an N pole, the right end part is an S pole.

[155] In relation to the electromagnet 38, a plurality of electromagnets which are vertically arranged in parallel to each other may form one electromagnet column 38a. A plurality of columns of electromagnets may be provided horizontally across the back cover 12

and aligned with adjacent electromagnets.

[156] The electromagnet 38 may generate different N and S poles depending on whether the electromagnet 38 is coupled to the front or rear of the back cover 12. Accordingly, as shown in Figure 23, when a plurality of electromagnet columns are coupled to the rear of the back cover 12, the bending control unit controls the current to create repulsion between one electromagnet column and another adjacent electromagnet column.

[157] Once repulsion acts between each electromagnet column, a force to expand the rear in the lateral direction is applied to the back cover 12 as illustrated in Figures 24A and 24B. Due to this, the back cover 12 and the display panel 11 are bent, so that the left and right direction end parts protrude toward the front and the central part is moved toward the rear. The bending of the back cover 12 bends the display module 11 a prescribed amount. At this point, an angle at which the display module 11 and the back cover 12 bend may be adjusted by controlling the amount of current flowing in the electromagnet.

[158] Moreover, as shown in Figures 25 and 26, when a plurality of electromagnet columns are coupled to the front of the back cover 12, the bending control unit controls current to generate gravitation to act between one electromagnet column and another adjacent electromagnet column. Figure 25 is a view when an electromagnet is coupled to the front of the back cover 12 and Figure 26 is a plan view thereof.

[159] Once gravitation is applied to between each electromagnet column, the front of the back cover 12 becomes narrower in the lateral direction. Due to this, the back cover 12 and the display module 11 may be bent. In this case, the amount of current flowing in the electromagnet 38 is controlled by the bending control unit, so that the degree of bending of the display module 11 and the back cover 12 may be adjusted.

[160] Moreover, as mentioned above, as the electromagnet 38 serves as a bending actuator, when a current flowing in the electromagnet 38 is cut off, the display module 11 and the back cover 12 return to their original flat states by elastic restoring force. If necessary, a current flowing in the electromagnet 38 is applied in an opposite direction, so that this may aid to unbend the display module 11 and the back cover 12 to the original states. Additionally, when the electromagnet 38 is used as the bending actuator, the groove part 18 may be provided at the front of the back cover 12.

[161] Moreover, a bending actuator configuring a bending assembly may be an bi-metal or piezoelectric element as shown in Figures 27 to 31. When compared with the configuration of Figures 23 to 25, all other configurations are the same except that the wire 34 is replaced with a bi-metal 36 or a piezoelectric element 36a, and thus repeated description is omitted.

[162] Figures 27 to 29 are views when the bi-metal 36 is attached to the back cover 12. Ac-

cordingly, the bending actuator becomes the bi-metal 36. The bi-metal 36 refers to an object including thin metal plates that have different thermal expansion coefficients and are joined together. When temperature rises, a metal plate having a greater thermal expansion coefficient expands longer so that it is bent toward a metal plate having a less thermal expansion coefficient.

[163] Figure 27 is a view when the bi-metal 36 is attached to the front side of the back cover 12. Figure 28 is a sectional view of the bi-metal 36. Figure 29 is a view when the back cover 12 and the display module 11 are combined. First, referring to Figure 28, the bi-metal 36 includes a first metal 36a having a relatively greater thermal expansion coefficient and a second metal 35a coupled to the front of the first metal 36a. At this point, the first metal 36a may be a piezoelectric element. A voltage applied to the piezoelectric element 36a may be controlled by the bending control unit.

[164] The piezoelectric element 36a is a device having piezoelectric effect (when mechanical pressure is applied, voltage occurs and when voltage is applied, mechanical deformation occurs). When external force is applied, electric polarization occurs to generate potential difference and on the contrary, when voltage is applied, deformation or stress occurs.

[165] The display device according to this embodiment uses the property that when voltage is applied to the piezoelectric element 36a, it expands. The piezoelectric element 36a may be formed of BaTi03, PbZr03 or another appropriate type of material. One bi-metal 36 may have a band shape and extends in the lateral direction. Also, a plurality of the bi-metal 36 may be provided vertically, in parallel to each other.

[166] Moreover, a plurality of groove parts 18 may be provided perpendicular to a direction in which the piezoelectric element 36a extends. A configuration and functions of the groove part 18 are the same as described above.

[167] Due to the above configuration, when power is supplied to the piezoelectric element 36a by the bending control unit, the length of the piezoelectric element 36a is increased and the both end parts of the bi-metal are bent toward the front. As the bi-metal 36 is bent, the back cover 12 is bent with the same curvature radius. Due to this, the display module 11 is bent simultaneously.

[168] Accordingly, the back cover 12 and the display module 11 may have a shape in which the lateral ends protrude toward the front, and the center part is moved toward the rear. That is, the display unit is bent in a shape concaved toward the front.

[169] At this point, when the bending control unit may control a voltage applied to the piezoelectric element 36a, the amount of length change in the piezoelectric element 36a is adjusted so that the bending amount of the back cover 12 may be controlled. Moreover, when the bending control unit cuts off a voltage applied to the piezoelectric device 36a, the piezoelectric device 36a returns to its original length, and also the back

cover 12 and the display module 11 return to their original flat states.

[170] Additionally, as shown in Figure 30, the bi-metal 36 may be coupled to the rear of the back cover 12. In this case, the configuration and operation principle of the bi-metal 30 are the same as those of Figures 9 to 11.

[171] Moreover, the bending actuator may include only a piezoelectric element instead of the bi-metal 36. In Figure 31, only the piezoelectric element 36a is attached to the position where the bi-metal 36 of Figure 30 was attached before. Therefore, the piezoelectric element 36a extends in the left and right directions and is provided in plurality vertically in parallel to each other.

[172] As mentioned above, since the length of the piezoelectric element 36a is increased by applying a predetermined voltage, after the piezoelectric element 36a is coupled to the rear of the back cover 12, when voltage is applied to the piezoelectric element 36a by the bending control unit, the length of the piezoelectric element 36a is increased so that the back cover 12 may be bent toward the front. When the piezoelectric element 36a is bent, the display module 11 is bent simultaneously, so that user's immersion may be improved.

[173] Moreover, when the bending control unit cuts off a voltage applied to the piezoelectric element 36a, the piezoelectric element 36a returns to its original length, and also the back cover 12 and the display module 11 return to their original flat states by the restoring force of the piezoelectric element 36a and the elastic restoring force of the display panel 11 and the back cover 12.

[174] Figures 32-33 illustrates another configuration of the bending actuator according to the present disclosure. The display device may include a display unit displaying an image and a bending assembly bending the display unit. The display unit may include a display module 11 displaying an image and a back cover 12 coupled to the rear of the display module 11. The bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator.

[175] The bending actuator 47 shown in Figure 32 and 33 includes a sensitive heat tube 47a filled with refrigerant gas, a flow path 47b serving as a path through which the refrigerant gas of the sensitive heat tube 47a flows, a cylinder 47c coupled to the end part of the flow path 47b, and a heater 47d surrounding the external of the sensitive heat tube 47a. The heater 47d may be a heating wire.

[176] The flow path 47b has a roughly T-shape as seen from the rear. The flow path 47b may extend from the sensitive heat tube 47a upward, is split into the left and right flow paths 47b at a predetermined position, and then extends at an angle toward the front left and right outer edges. Accordingly, the cylinder 47c coupled to a distal end of the flow path 47b also extends at an angle toward the front left and right outer edges.

[177] Moreover, a stopping part 48 (or stopper) that protrudes toward the rear may be provided at both the left and right edges on the backside of the back cover 12. The stopping part 48 may include a pressing side 48a (or angled surface) toward a direction in which the cylinder 47c extends and the cylinder 47c contacts the pressing side 48a.

[178] When voltage is applied to the heater 47d by the bending control unit and the heater 47d heats the refrigerant, the volume of the refrigerant gas expands and the cylinder 47c is pushed outward. The cylinder 47c applies pressure to the pressing side 48a of the stopping part 48 so that the lateral edges of the back cover 12 are pressed toward the front. Therefore, the back cover 12 is bent toward the front. When the back cover 12 is bent, the display module 11 at the front of the back cover 12 is concavely bent toward the front. Due to this, user's immersion may be increased.

[179] Moreover, when the bending control unit cuts off the power applied to the heater 47d, the display module 11 and the back cover 12 return to their original flat states by the elastic restoring force thereof. Moreover, the bending actuator may have the structure shown in Figures 16 and 19.

[180] Figures 34 to 47 illustrate another configuration of the bending actuator according to the present disclosure. The display device may include a display unit displaying an image and a bending assembly bending the display unit. The display unit may include a display module 11 displaying an image and a back cover 12 coupled to the rear of the display module 11.

[181] The bending assembly may include a bending actuator applying physical force to the back cover 12 and a bending control unit controlling operations of the bending actuator. Here, the bending actuator may include a motor 49a, shafts 49b and 49c, and a speaker 49d.

[182] Figure 34 is a plan view when the speaker 49d is hidden by the rear of the display module 11 and the back cover 12. Figure 35 is a plan view when the speaker 49d is visible at the left and right side of the display unit. Figure 36 is a view when the speaker 49d is further pressed to bend the back cover 12 and the display module 11. Additionally, Figure 47 is a sectional view illustrating a coupling structure of the first shaft 49b and the second shaft 49c.

[183] In the bending assembly applied to the display device according to this embodiment, the bending actuator 49 may include the motor 49a and the shafts 49b and 49c. The shafts 49b and 49c may include a first shaft 49b having a screw gear on the outer circumference thereof and a hollow second shaft 49c having a gear corresponding to the first shaft 49b on the inner circumference thereof. Moreover, the speaker 49 is coupled to the end part of the second shaft 49c to be slidable.

[184] The display module 11, the back cover 12, and the bending actuator 49 may all be provided on the lower frame 50. At this point, the center part of the display module 11

and the back cover 12 may be fixed at the lower frame 50, and both the left and right end parts are not fixed. Accordingly, when external force is applied from the rear to around the both left and right ends of the display module 11 and the back cover 12, the lateral ends may protrude toward the front when the display module is bent.

[185] Moreover, the guide part 53 for guiding the sliding of the speaker 49d may be provided at the lower frame 50. The guide unit 53 protrudes toward the top of the lower frame 40 and extends in a straight line shape, and thus the speaker 49d contacts the backside of the guide unit 53 and is guided. Additionally, the stopping part 48 shown in Figures 34 to 36 is provided at the left and right edges of the back cover 12.

[186] Under the above structure, when the bending control unit rotates the motor 49a, the rotation of the motor 49a rotates the first shaft 49b. At this point, a power transmitting means such as a gear, a chain, and a belt may be provided between the rotational axis of the motor 49a and the first shaft 49b.

[187] The second shaft 49c may be pushed toward the outer edge as the first shaft 49b rotates inside second shaft 49c. At this point, in order for the second shaft 49c to be pushed toward the outer edges a prescribed amount, the rotation of the second shaft 49b needs to be limited. Since the second shaft 49c is coupled to the speaker 49d and the speaker 49d contacts the guide unit 53, the second shaft 49c is pushed toward the outer edge and to the front.

[188] When the second shaft 49c is pushed, and thus the speaker 49d is pressed at an angle toward the edges, the speaker 49d which was hidden from view protrudes at the outer edges of the display module 11 as shown in Figure 35. Accordingly, a user may control a display device to hide a speaker when not in use and show the speaker when in use.

[189] Moreover, the speaker 49d is slid toward the outer edges and contacts the stopping part 48 as shown in Figure 35. During this state, when the motor 49a rotates, the speaker 49d presses against the stopping part 48. Due to this, the lateral edges of the back cover 12 may be pressed toward the front. Therefore, as shown in Figure 36, the lateral edges of the back cover 12 and the display module 11 may protrude toward the front to bend the display module 11 forward. Hence, the user's immersion may be improved. Furthermore, by reversing the rotation direction of the motor 49a, the bending control unit may return the bent display module 11 and back cover 12 to their original flat states.

[190] Moreover, the bracket 17, the first fastener 41, and the second fastener 43 shown in Figures 7 to 8B may be applicable to the display device according to this embodiment. Additionally, the third fastener 45 shown in Figures 9 and 10 may be also applicable.

[191] As broadly described and embodied herein, a display device is provided having a structure capable of improving user's immersion while viewing content. In one embodiment, a display device may include a display unit displaying an image, and a

bending assembly bending the display unit. The bending assembly may include a bending actuator applying force to the display unit and a bending control unit controlling an operation of the bending actuator. According to the present disclosure, since a display module of a display device is bent, user's immersion may be improved. Also, the bending degree of a display module may be easily adjusted.

[192] In one embodiment, a display device may include a display panel for displaying an image, a back cover provided behind the display panel and coupled to the display panel, a bending assembly coupled to the back cover to bend the display panel, and a controller configured to control the bending assembly to apply a physical force to the back cover to bend the display panel a prescribed amount.

[193] The bending assembly may include a plurality of elastic members formed of shape memory alloy that expands or contracts corresponding to a change in temperature of the shape memory alloy. The shape memory alloy may have a cylindrical shape having a prescribed length that changes based on an amount of current that flows through the shape memory alloy.

[194] The elastic members may be provided on the back cover to extend laterally across on the back cover such that the shape memory alloy expands or contracts laterally with respect to the back cover. The elastic members may be provided on a front surface or a rear surface of the back cover. A recess may be formed in the back cover to accommodate the elastic members.

[195] A support bracket may be coupled to the back cover to support the shape memory alloy. A middle cover may be attached to a rear surface of the display panel and provided between the display panel and the back cover, wherein the support bracket is provided on a front surface of the back cover between the back cover and the middle cover, the shape memory alloy extending laterally along the back cover and coupled to the support bracket. The support bracket may include a plurality of vertical portions spaced a prescribed distance from the back cover toward the display panel, the elastic members coupled to the vertical portions to extend laterally across the back cover. Moreover, the support bracket and the elastic members may be modularized for coupling to the back cover.

[196] A support bracket may be coupled to the back cover and may include a center support that extends vertically along a center of the back cover and a plurality of lateral supports provided at lateral regions of the back cover, the support bracket coupling the center and lateral regions of the back cover to the display panel, and the back cover may have a prescribed curvature in a lateral direction and when the shape memory alloy provided laterally along the back cover contracts in length, a center of the display is pulled toward the back cover to bend the display panel. When the shape memory alloy contracts, the prescribed curvature of the back cover may be increased to bend

the display panel. The plurality of lateral supports may be slidable connectors that allow the middle cover to slide laterally relative to the back cover when the display panel is bent. The slidable connectors include a body fixed at one of the back cover or the middle cover and a moving member slidably coupled to the body and fixed to the other one of the back cover or the middle cover.

[197] A support bracket may be provided a prescribed distance behind the back cover, the support bracket extending vertically and positioned to correspond to a center of the back cover, wherein the elastic members extend from the support bracket to the rear cover to pull the center of the rear cover toward the support bracket when the temperature of the shape memory alloy is increased above a prescribed level. A motor may be coupled to the support bracket to rotate the support bracket along a longitudinal axis of the support bracket, wherein the shape memory alloy is wound around an outer surface of the support bracket when the support bracket is rotated to bend the display panel.

[198] The plurality of elastic members may be provided to extend parallel to each other to form a first column corresponding to a left side of the display panel and a second column corresponding to a right side of the display panel. The controller may control a length of the shape memory alloy in the left column to be different than in the right column. The controller may control an amount of current applied to the shape memory alloy to change a length of the shape memory alloy to bend the display panel.

[199] The display device may also include a bracket coupled to a rear of the back cover, a printed circuit board coupled to a rear of the bracket, and a first fastener provided between the bracket and the back cover to couple the back cover to the bracket along a central vertical axis of the display panel. A second fastener may be provided between the bracket and the printed circuit board to couple the printed circuit board to the bracket along a lateral side of the printed circuit board. Another fastener may be provided between the bracket and the back cover to couple a lateral region of the back cover to the bracket, wherein this fastener includes a first portion coupled to the back cover and a second portion coupled to the bracket, the first portion being movably coupled to the second portion to allow lateral movement of the rear cover relative to the bracket.

[200] The bending assembly may include a plurality of wires that extend vertically on the back cover and positioned a prescribed distance from each other in a lateral direction with respect to the display panel, the plurality of wires configured to apply a prescribed amount of force with respect to an adjacent wire to bend the display panel. The plurality of wires may be provided adjacent a front surface of the back cover that faces the display panel or adjacent a rear surface of the back cover opposite the front surface. Here, when the wires are provided adjacent the front surface of the back cover, the

controller controls a direction of current through each wire to be the same to apply a force that pulls each wire toward an adjacent wire. Moreover, when the wires are provided at the rear surface of the back cover, the controller controls the current through each adjacent wire to be opposite to apply a force that pushes each wire away from an adjacent wire.

[201] The bending assembly may include a plurality of electromagnets arranged relative to each other to apply a lateral force to the back cover. The plurality of electromagnets may be provided adjacent a rear surface of the back cover that faces away from the display panel, and the controller controls a direction of current through each electromagnet such that an N pole of one electromagnet faces an N pole of an adjacent electromagnet. Moreover, the plurality electromagnets may be provided adjacent a front surface of the back cover that faces the display panel, and the controller controls a direction of current through each electromagnet such that an N pole of one electromagnet faces an S pole of an adjacent electromagnet.

[202] The bending assembly may include a bi-metal having a first metal provided at a front side that faces the display panel and a second metal provided at a rear side opposite the front side, the first metal having a thermal expansion coefficient that is relatively less than a thermal expansion coefficient of the second metal. The bending assembly may include a bi-metal having a first metal provided at a front side that faces the display panel and a second metal provided at a rear side opposite the front side, the second metal being a piezoelectric element. The bending assembly may also include a piezoelectric element that is coupled to the back cover, a length of the piezoelectric element configured to change in a lateral direction relative to the display panel.

[203] The bending assembly may include a heat sensitive tube, refrigerant provided in the heat sensitive tube, a heater to heat the heat sensitive tube, and a cylinder connected to a distal end of the sensitive heat tube, wherein, when the heater heats the refrigerant, the heat sensitive tube expands to move the cylinder laterally to apply a lateral force to a side edge of the back cover. A stopper may be provided at a rear surface of the back cover that limits a range of movement of the cylinder, the stopper including an angled surface that abuts against the cylinder when the cylinder is moved laterally. The heater may be a heating wire that surrounds an outer surface of the heat sensitive tube.

[204] The bending assembly may include a motor and a shaft provided behind the back cover and extending to a lateral region of the back cover, a length of the shaft being changed by driving the motor, wherein when the shaft is extended, a pressure is applied to a side edge of the back cover to bend the display panel. The shaft may include a first shaft that is rotated by the motor, and a second shaft coupled to the first shaft through a screw gear. Moreover, a speaker may be coupled to a distal end of the shaft. The speaker may be positioned behind the display panel when the length of the

shaft is at a first length. The speaker may be positioned adjacent the display panel when the length of the shaft is at a second length greater than the first length. Moreover, the speaker may be positioned adjacent the display panel and a rear lateral edge of the back cover to apply the pressure to the side edge of the back cover to bend the display panel when the length of the shaft is at a third length greater than the second length. In the various embodiments, the back cover may be formed of a Carbon Fiber-Reinforced Plastic.

[205] Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

[206] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

[207]

Claims

[Claim 1] A display device comprising:
a display panel for displaying an image;
a back cover provided behind the display panel and coupled to the display panel;
a bending assembly coupled to the back cover to bend the display panel; and
a controller configured to control the bending assembly to apply a physical force to the back cover to bend the display panel a prescribed amount.

[Claim 2] The display device according to claim 1, wherein the bending assembly includes a plurality of elastic members formed of shape memory alloy that expands or contracts corresponding to a change in temperature of the shape memory alloy.

[Claim 3] The display device according to claim 2, wherein the shape memory alloy has a cylindrical shape having a prescribed length that changes based on an amount of current that flows through the shape memory alloy.

[Claim 4] The display device according to claim 2, wherein the elastic members are provided on the back cover to extend laterally across on the back cover such that the shape memory alloy expands or contracts laterally with respect to the back cover.

[Claim 5] The display device according to claim 4, wherein the elastic members are provided on a front surface or a rear surface of the back cover.

[Claim 6] The display device according to claim 4, wherein a recess is formed in the back cover to accommodate the elastic members.

[Claim 7] The display device according to claim 2, wherein a support bracket is coupled to the back cover to support the shape memory alloy.

[Claim 8] The display device according to claim 7, further comprising a middle cover attached to a rear surface of the display panel and provided between the display panel and the back cover, wherein the support bracket is provided on a front surface of the back cover between the back cover and the middle cover, the shape memory alloy extending laterally along the back cover and coupled to the support bracket.

[Claim 9] The display device according to claim 8, wherein the support bracket includes a plurality of vertical portions spaced a prescribed distance from the back cover toward the display panel, the elastic members

coupled to the vertical portions to extend laterally across the back cover.

[Claim 10] The display device according to claim 9, wherein the support bracket and the elastic members are modularized for coupling to the back cover.

[Claim 11] The display device according to claim 2, wherein
a support bracket is coupled to the back cover and includes a center support that extends vertically along a center of the back cover and a plurality of lateral supports provided at lateral regions of the back cover, the support bracket coupling the center and lateral regions of the back cover to the display panel, and
the back cover has a prescribed curvature in a lateral direction and when the shape memory alloy provided laterally along the back cover contracts in length, a center of the display is pulled toward the back cover to bend the display panel.

[Claim 12] The display device according to claim 11, wherein, when the shape memory alloy contracts, the prescribed curvature of the back cover is increased to bend the display panel.

[Claim 13] The display device according to claim 12, wherein the plurality of lateral supports are slidable connectors that allow the middle cover to slide laterally relative to the back cover when the display panel is bent.

[Claim 14] The display device according to claim 13, wherein the slidable connectors include a body fixed at one of the back cover or the middle cover and a moving member slidably coupled to the body and fixed to the other one of the back cover or the middle cover.

[Claim 15] The display device according to claim 2, further comprising a support bracket provided a prescribed distance behind the back cover, the support bracket extending vertically and positioned to correspond to a center of the back cover, wherein the elastic members extend from the support bracket to the rear cover to pull the center of the rear cover toward the support bracket when the temperature of the shape memory alloy is increased above a prescribed level.

[Claim 16] The display device according to claim 15, further comprising a motor coupled to the support bracket to rotate the support bracket along a longitudinal axis of the support bracket, wherein the shape memory alloy is wound around an outer surface of the support bracket when the support bracket is rotated to bend the display panel.

[Claim 17] The display device according to claim 2, wherein the plurality of elastic

members are provided to extend parallel to each other to form a first column corresponding to a left side of the display panel and a second column corresponding to a right side of the display panel.

[Claim 18] The display device according to claim 17, wherein the controller controls a length of the shape memory alloy in the left column to be different than in the right column.

[Claim 19] The display device according to claim 2, wherein the controller controls an amount of current applied to the shape memory alloy to change a length of the shape memory alloy to bend the display panel.

[Claim 20] The display device according to claim 1, further comprising
a bracket coupled to a rear of the back cover,
a printed circuit board coupled to a rear of the bracket, and
a first fastener provided between the bracket and the back cover to couple the back cover to the bracket along a central vertical axis of the display panel.

[Claim 21] The display device according to claim 20, further comprising a second fastener provided between the bracket and the printed circuit board to couple the printed circuit board to the bracket along a lateral side of the printed circuit board.

[Claim 22] The display device according to claim 20, further comprising a second fastener provided between the bracket and the back cover to couple a lateral region of the back cover to the bracket, wherein the second fastener includes a first portion coupled to the back cover and a second portion coupled to the bracket, the first portion being movably coupled to the second portion to allow lateral movement of the rear cover relative to the bracket.

[Claim 23] The display device according to claim 1, wherein the bending assembly includes a plurality of wires that extend vertically on the back cover and positioned a prescribed distance from each other in a lateral direction with respect to the display panel, the plurality of wires configured to apply a prescribed amount of force with respect to an adjacent wire to bend the display panel.

[Claim 24] The display device according to claim 23, wherein the plurality of wires are provided adjacent a front surface of the back cover that faces the display panel or adjacent a rear surface of the back cover opposite the front surface, wherein
when the wires are provided adjacent the front surface of the back cover, the controller controls a direction of current through each wire to

be the same to apply a force that pulls each wire toward an adjacent wire, and

when the wires are provided at the rear surface of the back cover, the controller controls the current through each adjacent wire to be opposite to apply a force that pushes each wire away from an adjacent wire.

[Claim 25] The display device according to claim 1, wherein the bending assembly includes a plurality of electromagnets arranged relative to each other to apply a lateral force to the back cover.

[Claim 26] The display device according to claim 25, wherein the plurality of electromagnets are provided adjacent a rear surface of the back cover that faces away from the display panel, and the controller controls a direction of current through each electromagnet such that an N pole of one electromagnet faces an N pole of an adjacent electromagnet.

[Claim 27] The display device according to claim 25, wherein the plurality electromagnets are provided adjacent a front surface of the back cover that faces the display panel, and the controller controls a direction of current through each electromagnet such that an N pole of one electromagnet faces an S pole of an adjacent electromagnet.

[Claim 28] The display device according to claim 1, wherein the bending assembly includes a bi-metal having a first metal provided at a front side that faces the display panel and a second metal provided at a rear side opposite the front side, the first metal having a thermal expansion coefficient that is relatively less than a thermal expansion coefficient of the second metal.

[Claim 29] The display device according to claim 1, wherein the bending assembly includes a bi-metal having a first metal provided at a front side that faces the display panel and a second metal provided at a rear side opposite the front side, the second metal being a piezoelectric element.

[Claim 30] The display device according to claim 1, wherein the bending assembly includes a piezoelectric element that is coupled to the back cover, a length of the piezoelectric element configured to change in a lateral direction relative to the display panel.

[Claim 31] The display device according to claim 1, wherein the bending assembly includes

a heat sensitive tube,

refrigerant provided in the heat sensitive tube,

a heater to heat the heat sensitive tube, and

a cylinder connected to a distal end of the sensitive heat tube,
wherein, when the heater heats the refrigerant, the heat sensitive tube expands to move the cylinder laterally to apply a lateral force to a side edge of the back cover.

[Claim 32] The display device according to claim 31, where a stopper is provided at a rear surface of the back cover that limits a range of movement of the cylinder, the stopper including an angled surface that abuts against the cylinder when the cylinder is moved laterally.

[Claim 33] The display device according to claim 32, wherein the heater is a heating wire that surrounds an outer surface of the heat sensitive tube.

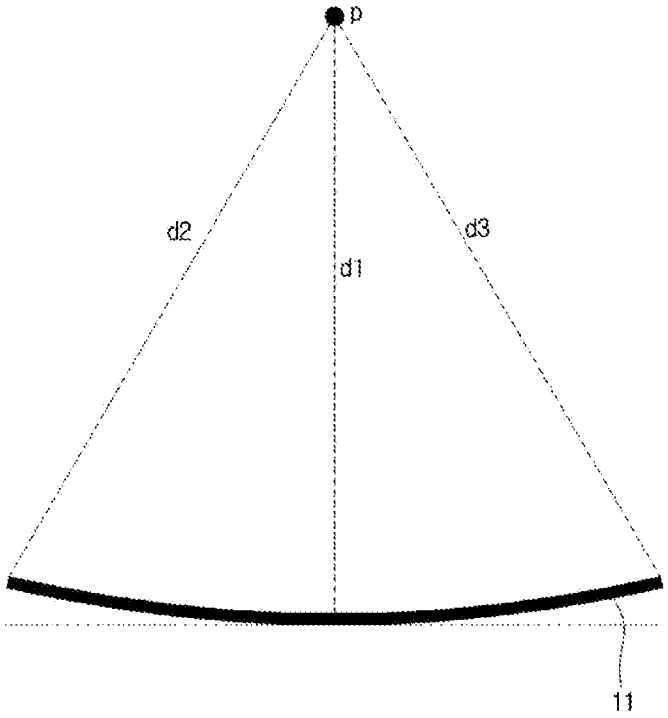
[Claim 34] The display device according to claim 1, wherein the bending assembly includes a motor and a shaft provided behind the back cover and extending to a lateral region of the back cover, a length of the shaft being changed by driving the motor, wherein when the shaft is extended, a pressure is applied to a side edge of the back cover to bend the display panel.

[Claim 35] The display device according to claim 34, wherein the shaft includes
a first shaft that is rotated by the motor, and
a second shaft coupled to the first shaft through a screw gear.

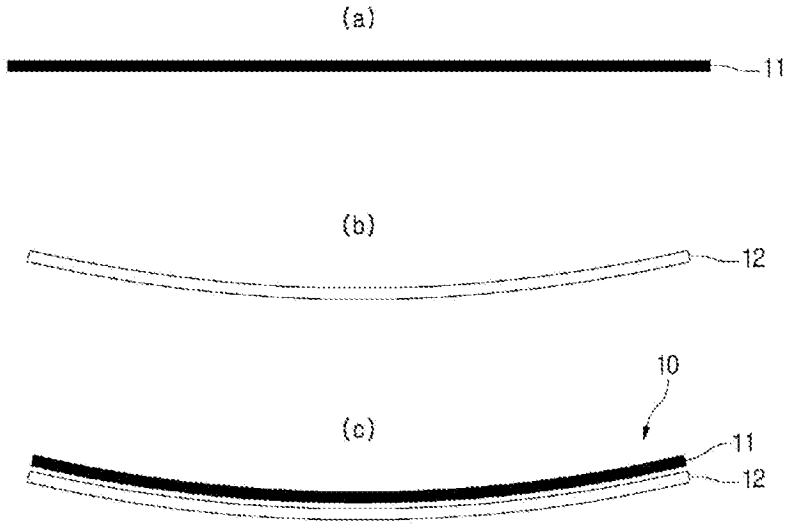
[Claim 36] The display device according to claim 34, wherein a speaker is coupled to a distal end of the shaft, wherein
the speaker is positioned behind the display panel when the length of the shaft is at a first length,
the speaker is positioned adjacent the display panel when the length of the shaft is at a second length greater than the first length, and
the speaker is positioned adjacent the display panel and a rear lateral edge of the back cover to apply the pressure to the side edge of the back cover to bend the display panel when the length of the shaft is at a third length greater than the second length.

[Claim 37] The display device according to claim 1, wherein the back cover comprises Carbon Fiber-Reinforced Plastic.

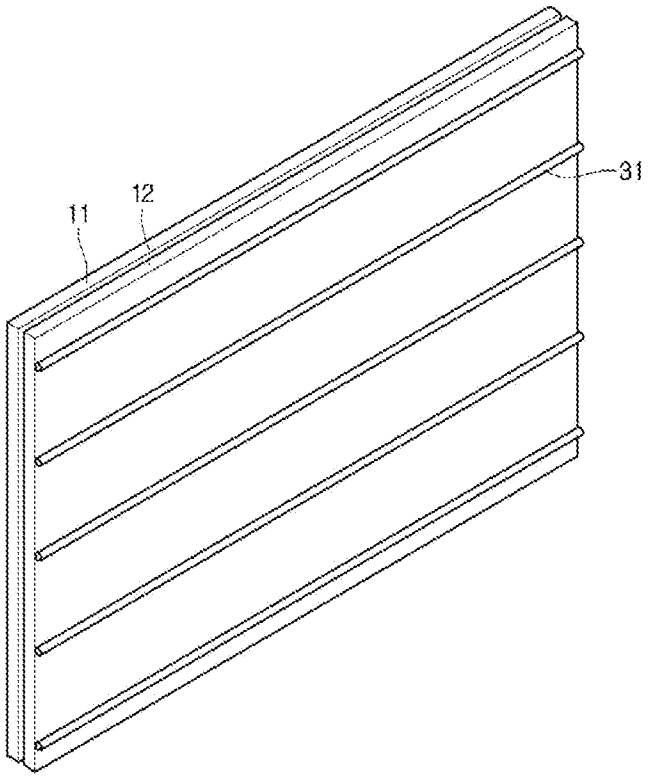
[Fig. 1]



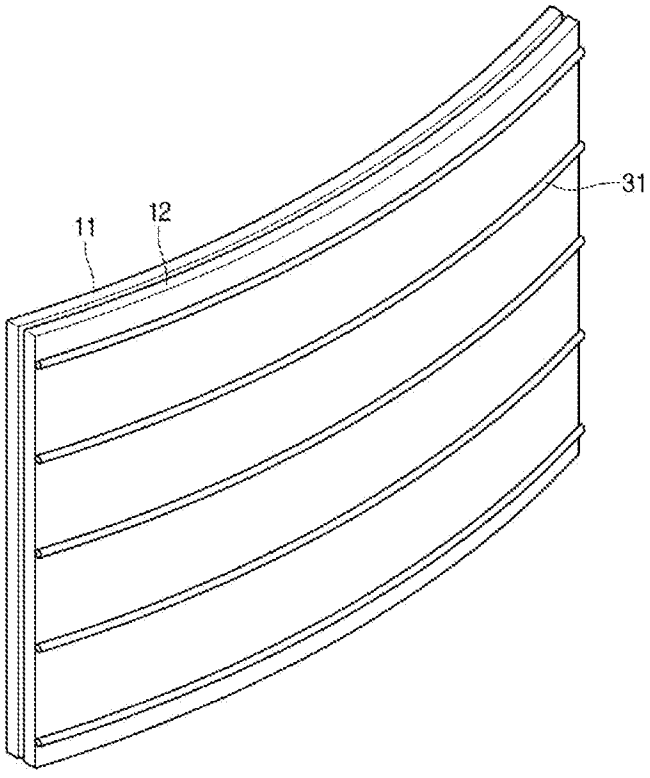
[Fig. 2]



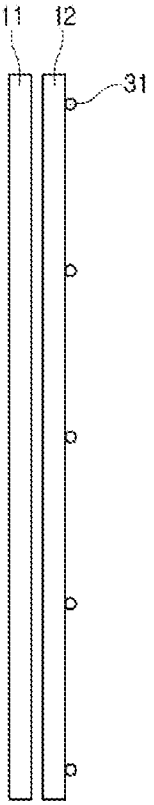
[Fig. 3A]



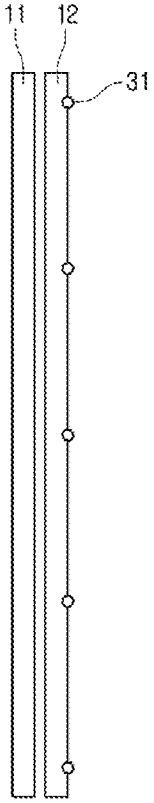
[Fig. 3B]



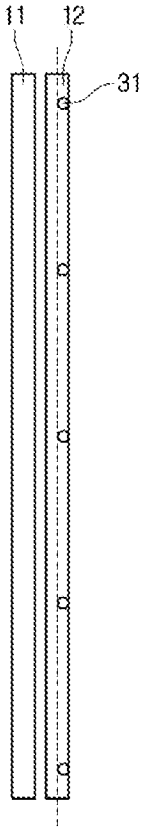
[Fig. 4]



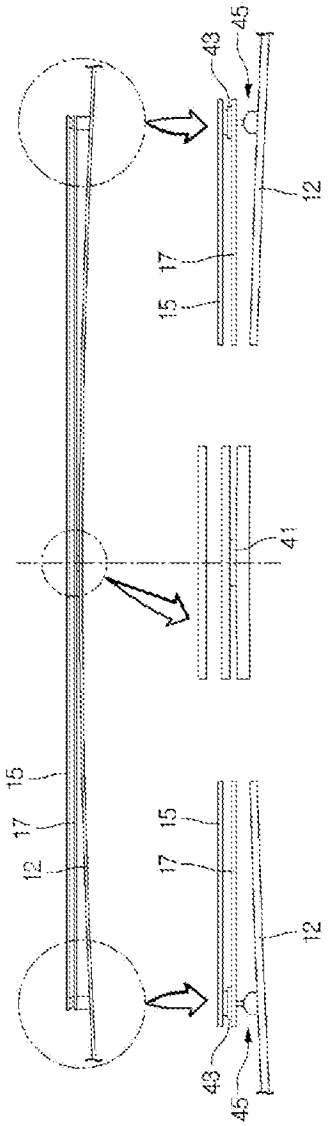
[Fig. 5]



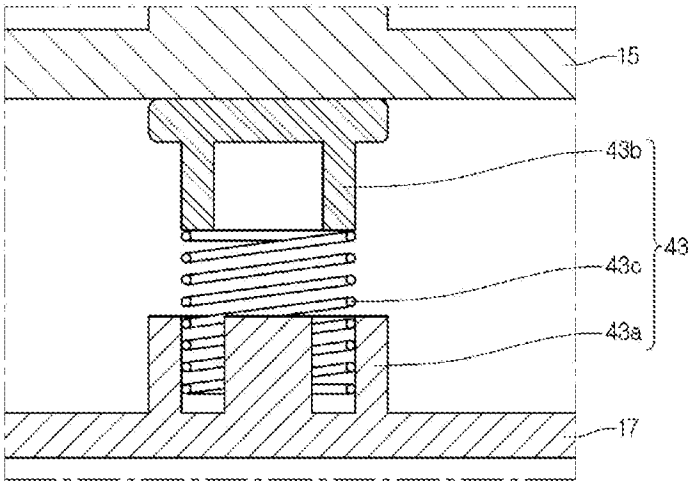
[Fig. 6]



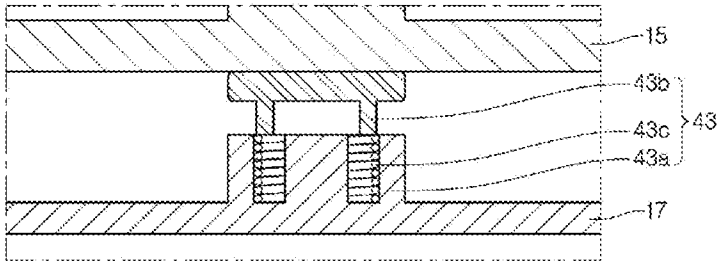
[Fig. 7]



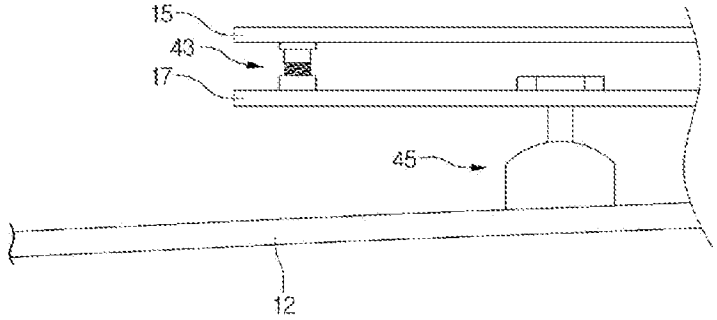
[Fig. 8A]



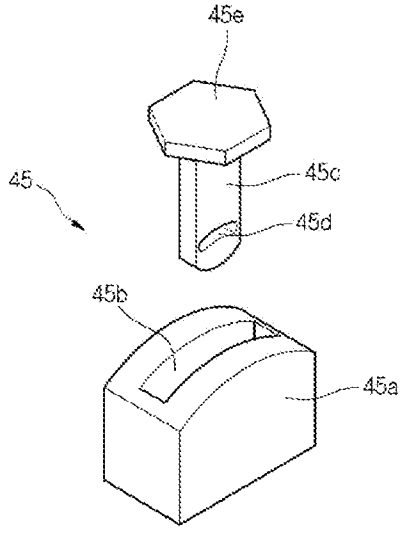
[Fig. 8B]



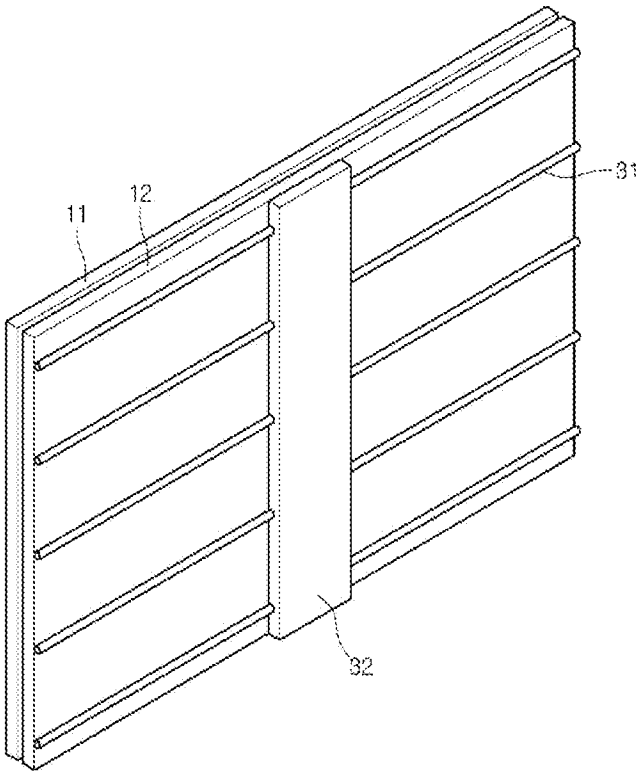
[Fig. 9]



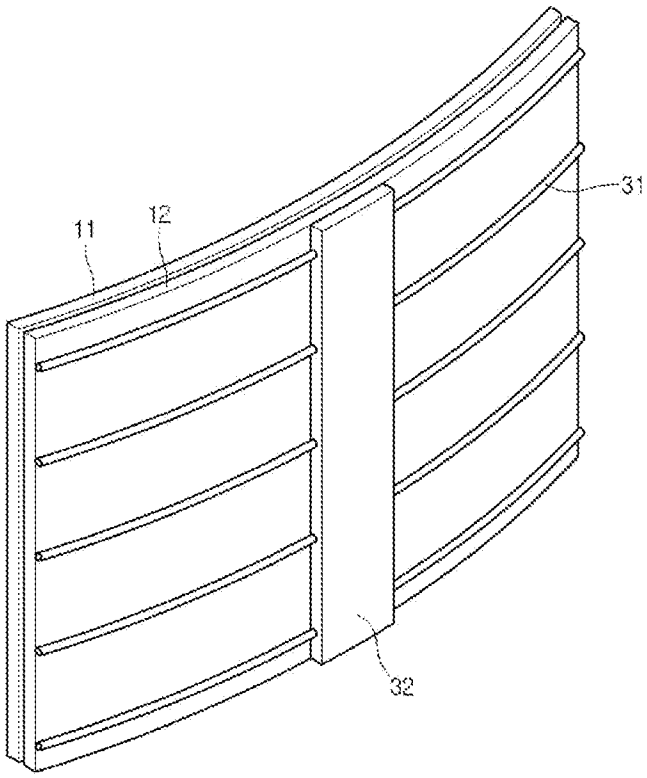
[Fig. 10]



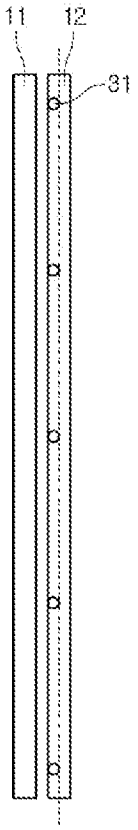
[Fig. 11A]



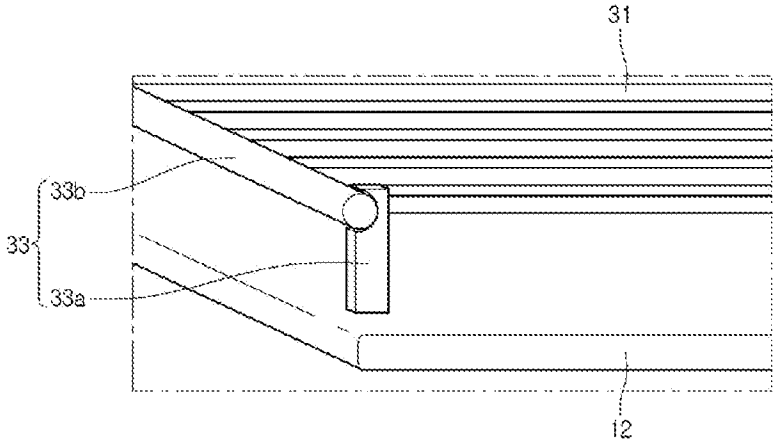
[Fig. 11B]



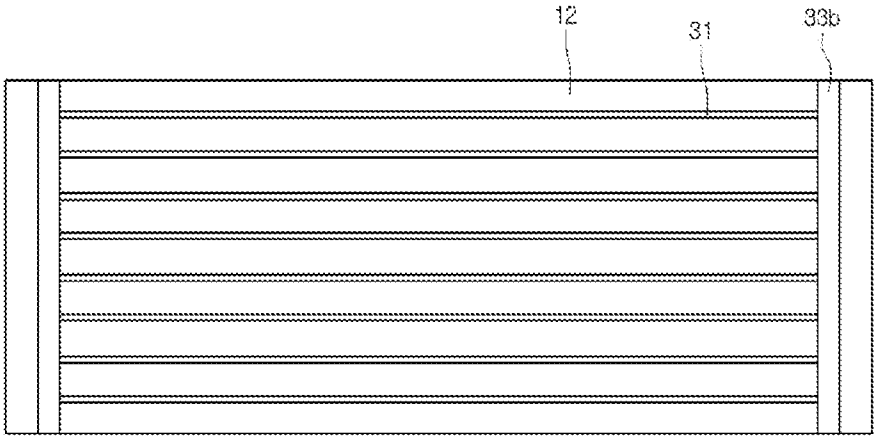
[Fig. 12]



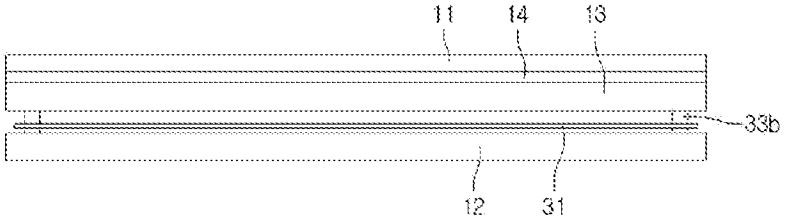
[Fig. 13]



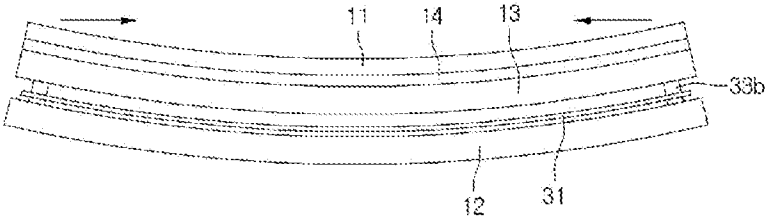
[Fig. 14]



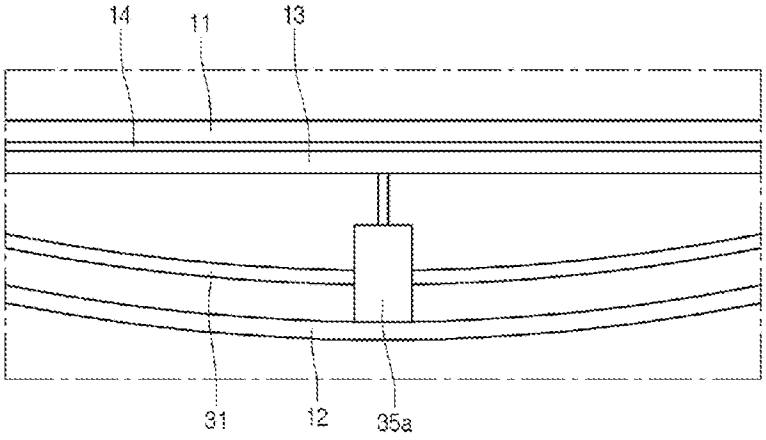
[Fig. 15A]



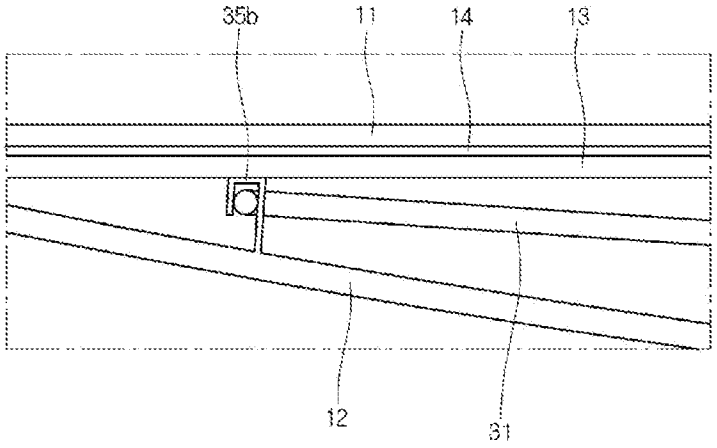
[Fig. 15B]



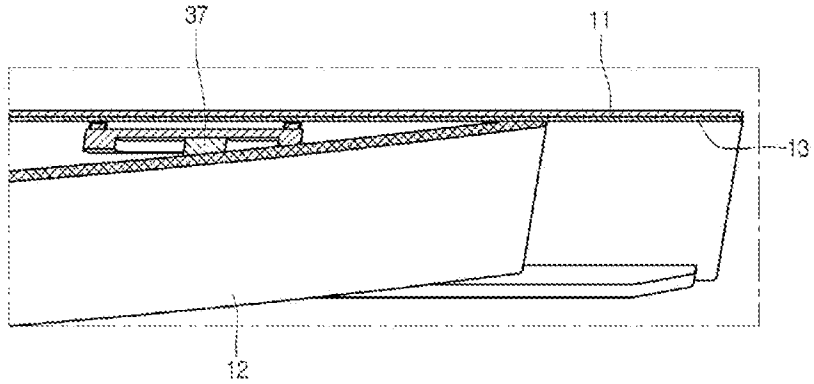
[Fig. 16]



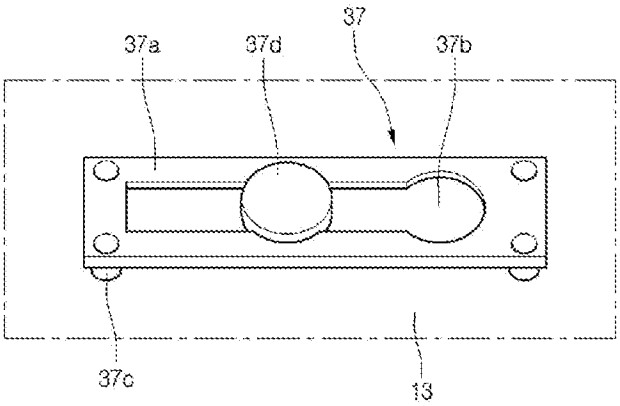
[Fig. 17]



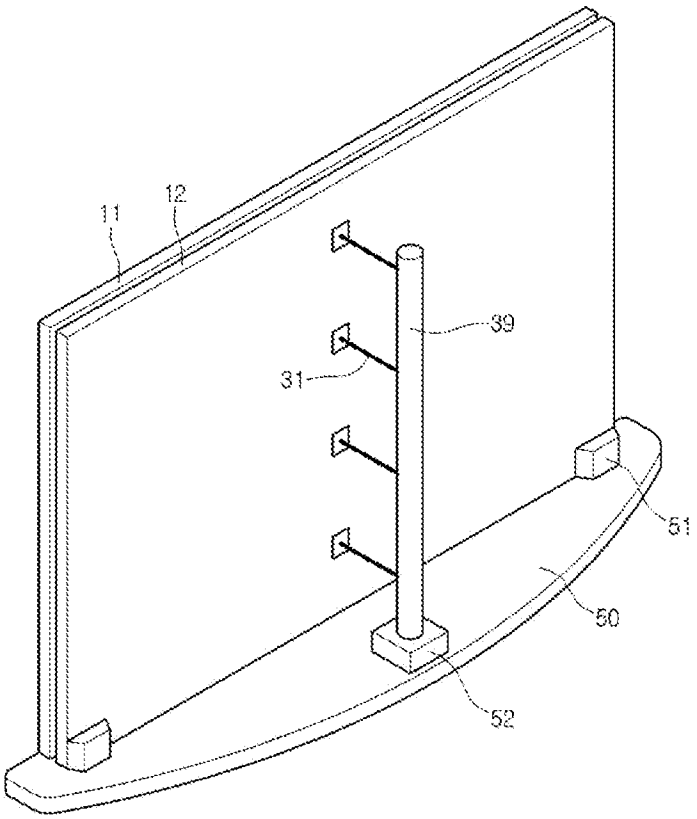
[Fig. 18]



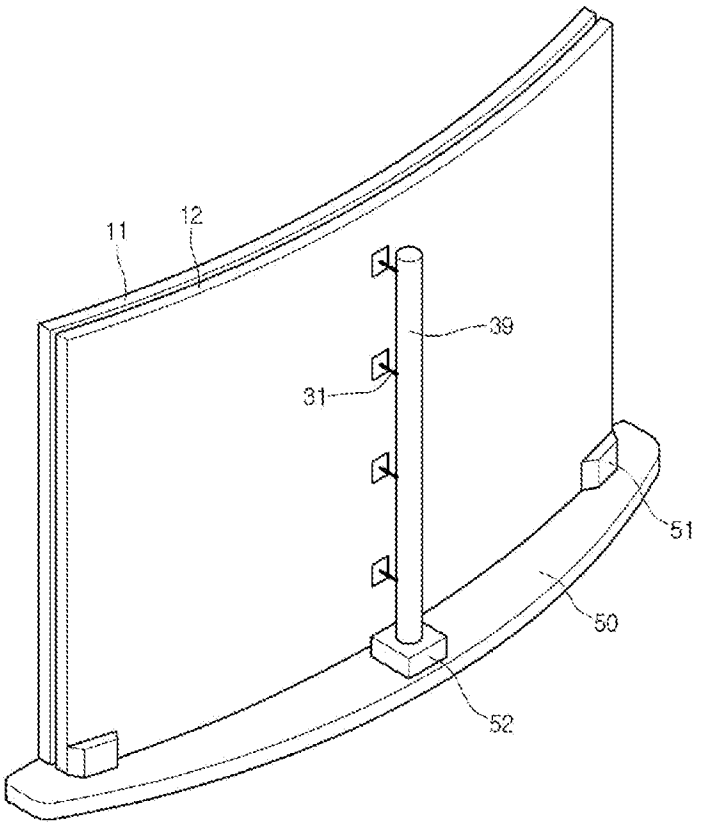
[Fig. 19]



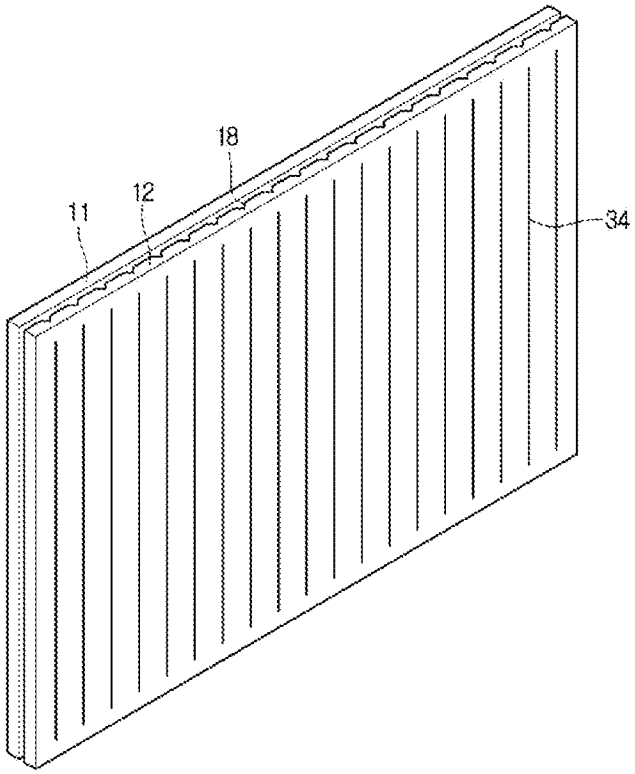
[Fig. 20A]



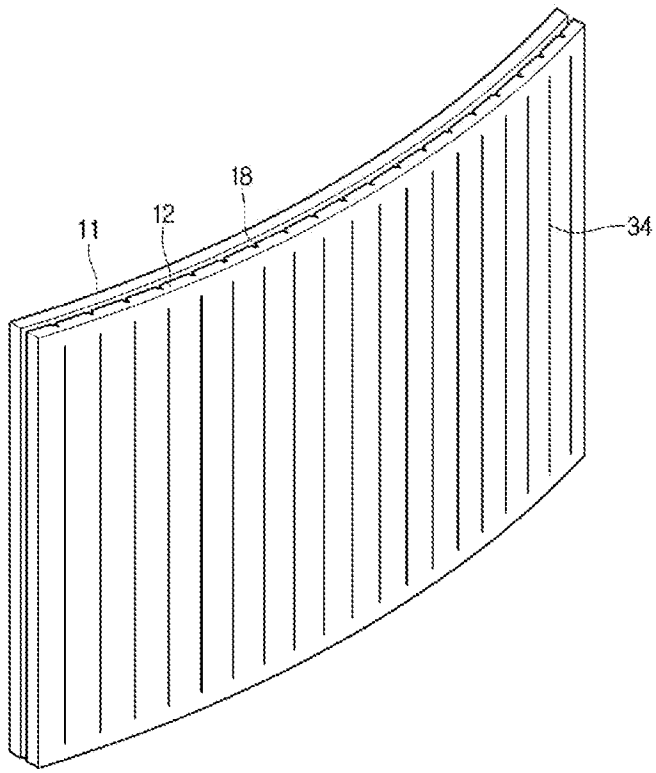
[Fig. 20B]



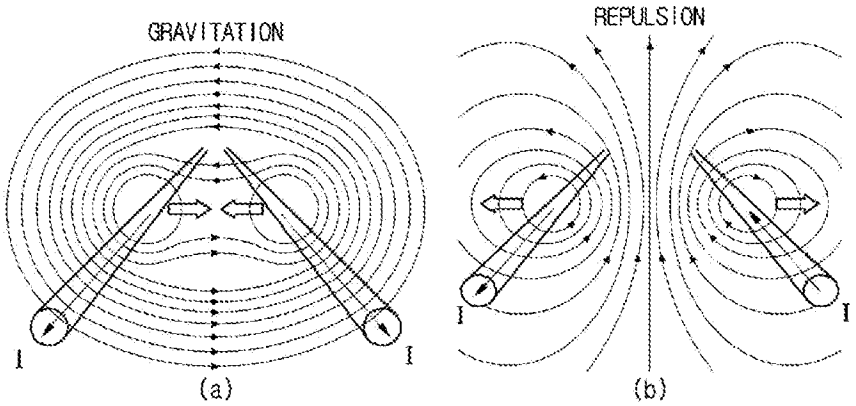
[Fig. 21A]



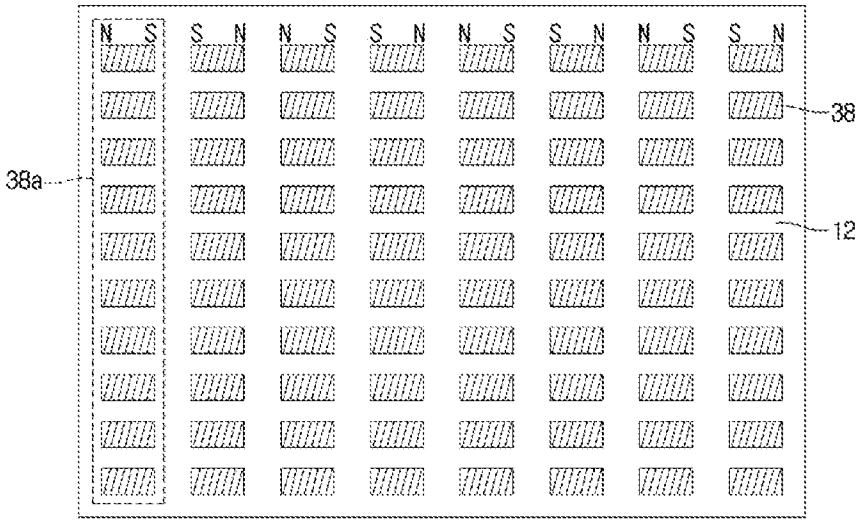
[Fig. 21B]



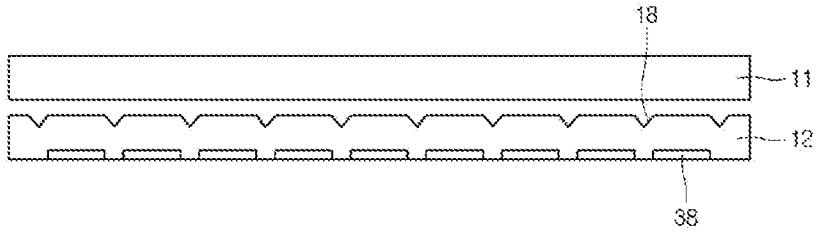
[Fig. 22]



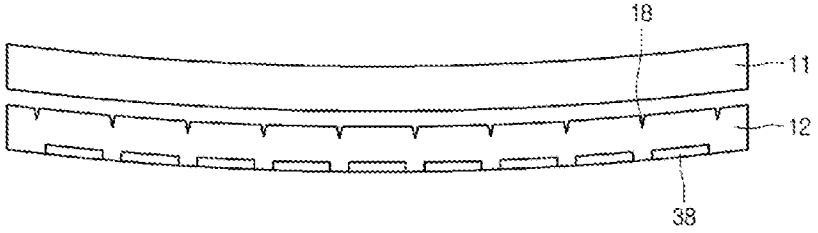
[Fig. 23]



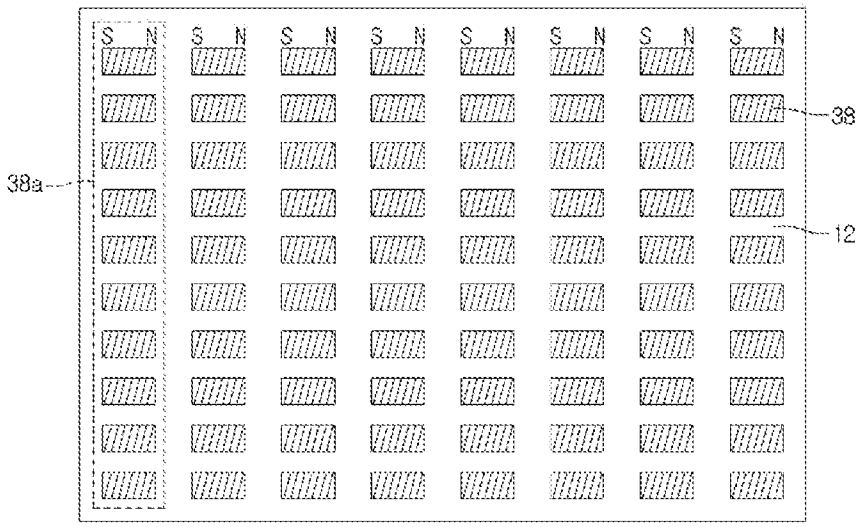
[Fig. 24A]



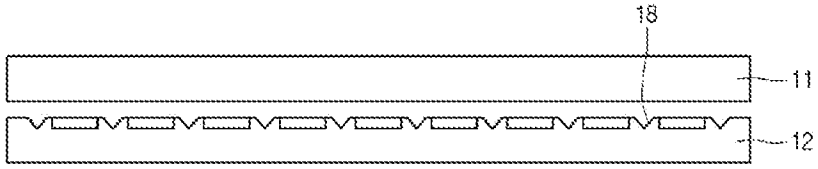
[Fig. 24B]



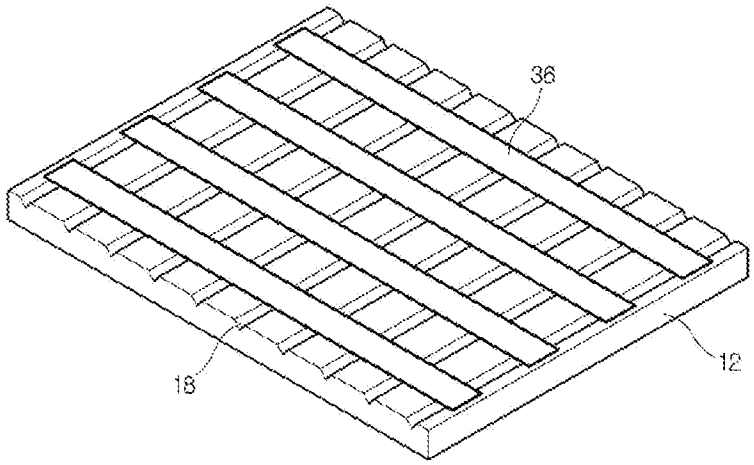
[Fig. 25]



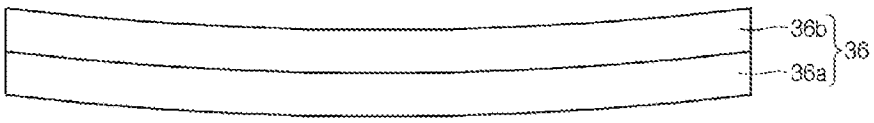
[Fig. 26]



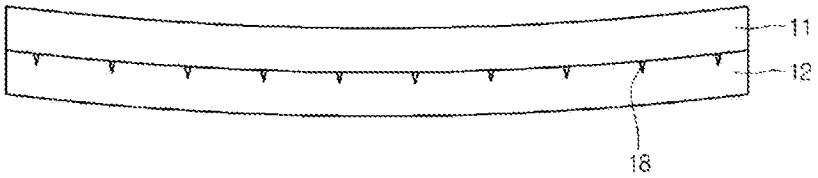
[Fig. 27]



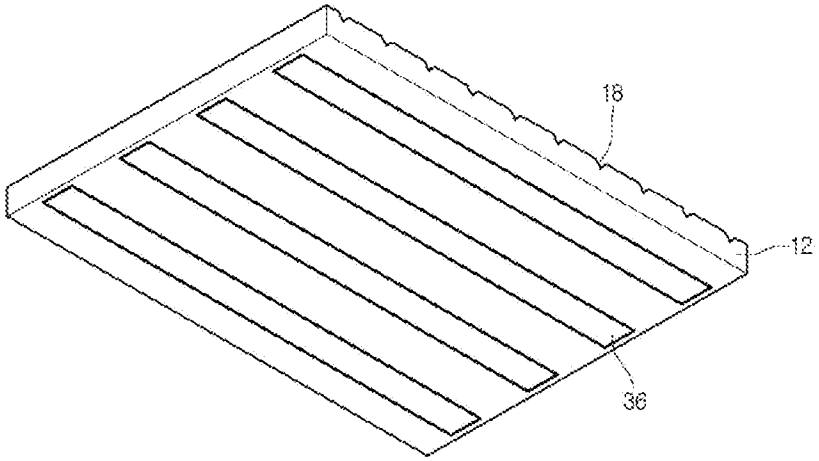
[Fig. 28]



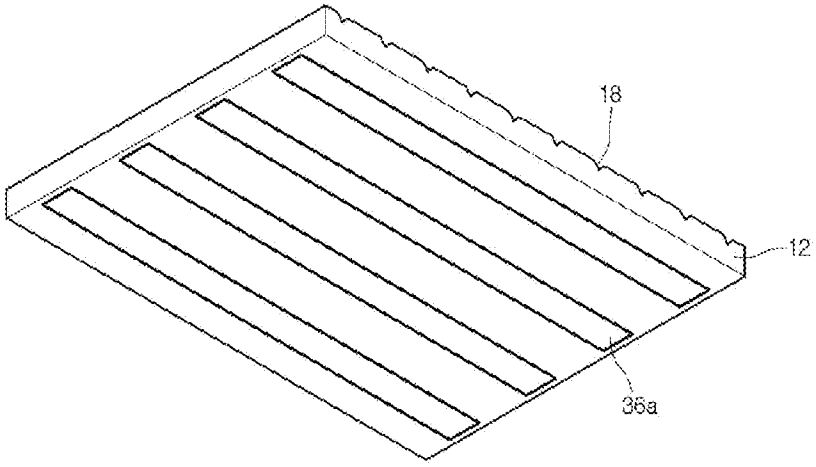
[Fig. 29]



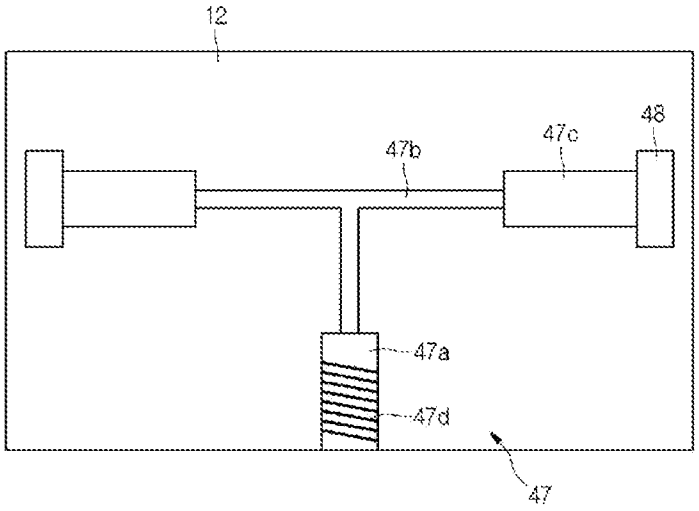
[Fig. 30]



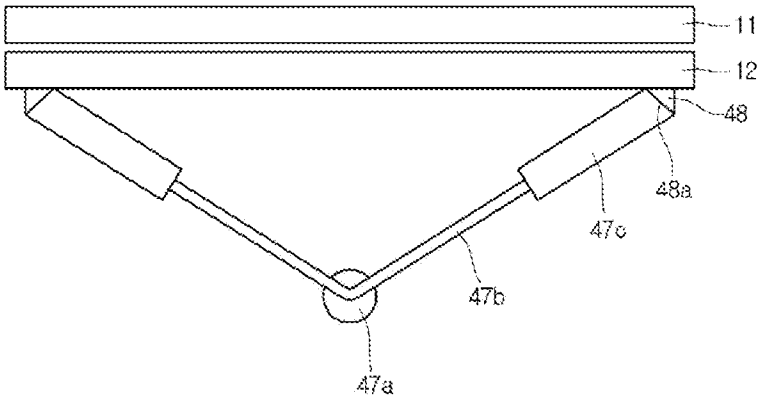
[Fig. 31]



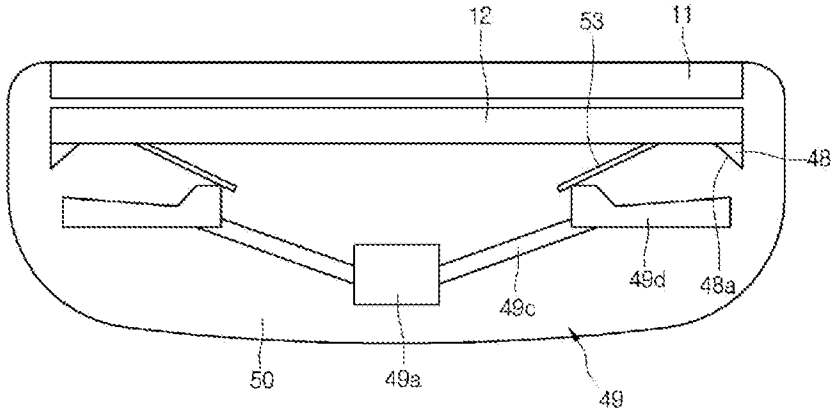
[Fig. 32]



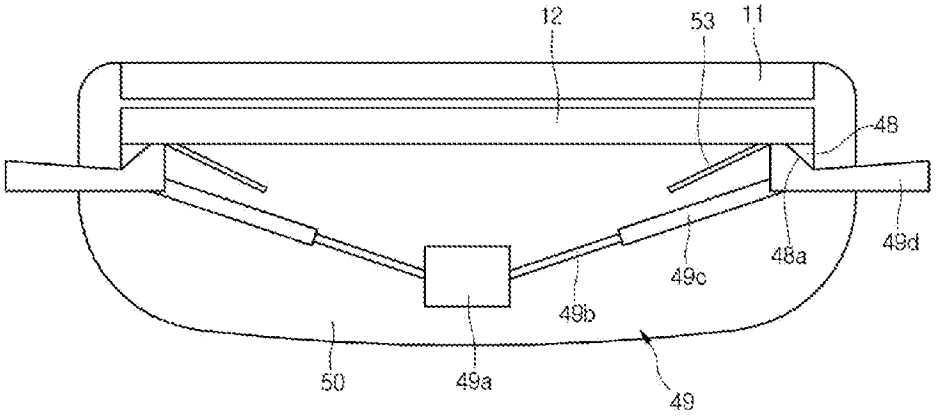
[Fig. 33]



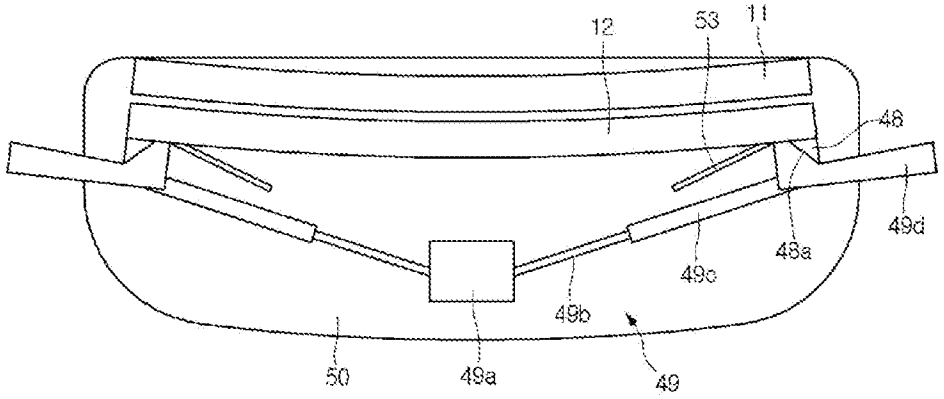
[Fig. 34]



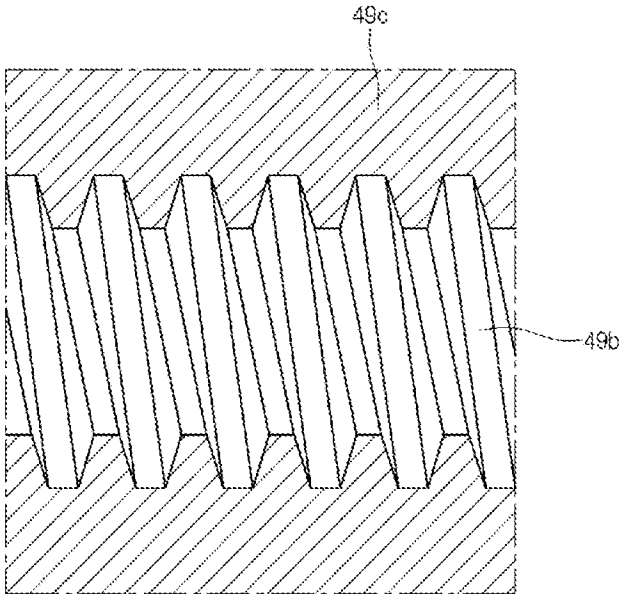
[Fig. 35]



[Fig. 36]



[Fig. 37]



INTERNATIONAL SEARCH REPORT

International application No
PCT/KR2013/009503

A. CLASSIFICATION OF SUBJECT MATTER

G09F 9/00(2006.01)i

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)
G09F 9/00; G02B 27/22; G09F 9/35; G02B 3/08; H05B 33/02; H04N 5/64; G02F 1/1333; G06F 3/041

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: display, control, bending, curvature

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2006-023676 A (PIONEER CORP.) 26 January 2006 See paragraphs [0015]- [0024] ; and figures 3.	1,23,24
Y		2-22, 25-37
Y	wo 2010-085575 Al (ARTIFICIAL MUSCLE, INC.) 29 July 2010 See paragraphs [0078] , [0141] ; and figures 1A, IB.	2-19 ,25-30 ,37
Y	JP 2009-109812 A (NEC CORP.) 21 May 2009 See paragraphs [0015]- [0022] ; and figures 1, 3.	9-16
Y	JP 2009-063640 A (SONY CORP.) 26 March 2009 See paragraphs [0022]- [0050] ; and figures 2, 4.	13,14, 20-22 ,31-33 ,36
Y	JP 10-026754 A (NIPPON DENKI IDO TSUSHIN KK.) 27 January 1998 See paragraphs [0011]- [0016] ; and figure 2.	16,34-36

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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
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(54) Title: AN IMPROVED TOUCH DEVICE

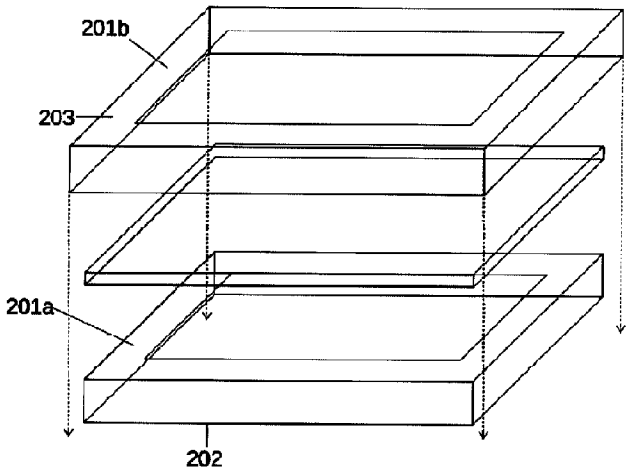


Figure 5b

(57) Abstract: An assembly for holding and controlling curvature of a glass plate for an optical touch sensitive system is described. The assembly comprising a first frame element extending in a first plane and configured to extend at least partially around a panel; at least one second frame element extending in a second plane and forming a support portion for the plate, and at least one spacing element positioned at least partially between the support portion and the first frame element. The spacing element us configured to control a curvature of the first frame element and wherein the at least one second frame element is configured to engage the plate at the support portion, is attached to the first frame element, and is tiltable, by controlling the curvature of the first frame element with said spacing element, to control a curvature of the plate.

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AN IMPROVED TOUCH DEVICE

Field of the Invention

This invention relates in general to the field of optical touch sensitive systems. More particularly, the invention relates to a curved plate and an assembly for holding a plate of the system, such as a glass plate, relative to a panel such that curvature of the plate is controlled. The invention also relates to a method for assembling a plate of an optical touch sensitive system with a panel (such as a display panel) in such a way that curvature is controlled.

Background of the Invention

In one category of touch sensitive panels known as above surface optical touch systems and known from e.g. US4459476, a plurality of optical emitters and optical receivers are arranged around the periphery of a touch surface to create a grid of intersecting light paths above the touch surface. Each light path extends between a respective emitter/receiver pair. An object that touches the touch surface will block certain ones of the light paths. Based on the identity of the receivers detecting a blocked light path, a processor can determine the location of the intercept between the blocked light paths. This type of system is only capable of reliably detecting the location of one object (single-touch detection). Further, the required number of emitters and receivers, and thus cost and complexity, increases rapidly with increasing surface area and/or spatial resolution of the touch panel.

In a variant, e.g. shown in WO2006/095320, each optical emitter emits a beam of light that diverges across the touch surface, and each beam is detected by more than one optical receiver positioned around the periphery of the touch surface.

These systems typically direct light to travel across the surface of the touch surface at a height of up to 5 mm.

Other above surface touch sensitive systems use tomographic touch imaging for sensing a touch, e.g. as described in WO2016/130074. Such systems allow for directing the light much closer to the touch surface, which in turn allows for significant improvements in accuracy and requires a lower light budget. The light is typically directed at a height of up to about 1 mm above the plate.

Typically, the touch surface is a glass plate. In systems where the light is directed closer to the touch surface, distortions in the plate have a disproportionally large effect on the light signal. Therefore, glass plates as used in previously known above surface optical touch systems are unsuitable when the light is transmitted closer to the plate, since the accuracy of the system is impaired by the distortions in the plate.

Additionally, a frame for assembly of the plate of the optical touch sensitive system and a panel, such as an LCD panel, may introduce distortion in the form of uncontrolled warpage, i.e. a twist or curve in the plate is introduced even if it is usually flat. The uncontrolled warpage may even block the light transmitted across the plate. This is due to uncontrolled twisting of the frame as such when it is attached to the panel.

Although not described in relation to touch systems, methods of minimizing glass warpage are known from the window industry and from the display panel industry. Such solutions include pre-bent glass in order to control warpage. However, such solutions are unsuitable/insufficient for touch sensitive systems since they typically require bulky frames at the border of the glass and/or pressure points closer to the center of the panel where force may be applied to control the shape of the glass. These solutions are unsuitable where a minimal/lightweight border bezel is required, and no supporting objects may touch the glass further in than at the borders. Additionally, pre-bent glass is expensive and fragile to transport.

Therefore, an improved frame assembly for holding a plate of an optical touch sensitive system relative to a panel would be advantageous and in particular allowing for improved precision, increased compactness, cost-effectiveness, and/or controlled curvature would be advantageous. Further, a touch panel having a shape conducive to transmitting as much light from the emitters as possible to the detectors is needed.

Summary of the Invention

Accordingly, embodiments of the present invention preferably seek to mitigate, alleviate or eliminate one or more deficiencies, disadvantages or issues in the art, such as the above-identified, singly or in any combination by providing an assembly, a method for assembling, and a kit of frame elements according to the appended patent claims.

A first embodiment of the invention describes an assembly for holding and controlling curvature of a plate for an optical touch sensitive system, comprising a first frame element extending in a first plane and configured to extend at least partially around a panel; at least one second frame element extending in a second plane and forming a support portion for the plate, and at least one spacing element positioned at least partially between the support portion and the first frame element, the spacing element being configured to control a curvature of the first frame element, and wherein the at least one second frame element is configured to engage the plate at the support portion, is attached to the first frame element, and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element with said spacing element, to control a curvature of the plate.

A second embodiment of the invention describes a method for assembling a panel and a plate for an optical touch sensitive system, comprising: providing a first frame element extending in a first plane and configured to extend at least partially around a panel; providing at least one second frame element forming a support portion for the plate; supporting the plate by the support portion; attaching the second frame element to the first frame element such that the support portion extends at least partially in a second plane generally opposite at least a portion of the first frame element and is spaced apart from the first plane; and controlling a curvature of the first frame element with a spacing element attached to the first frame element and thereby tilting the support portion to control a curvature of the plate.

A third embodiment of the invention describes a kit of frame elements for assembling a panel and a plate for a touch sensitive system, comprising: a first frame element extending in a first plane; at least one second frame element forming a support portion for the plate and being attachable to the first frame element, and a spacing element adjustably attachable to the first frame element; wherein at least a portion of the support portion is tiltable, by the spacing element, relative to the first frame element to extend in the second plane, which is curved.

Some embodiments of the invention provide for controlling curvature of a plate for an optical touch sensitive system such that it does not occur when the plate is assembled with a panel. This prevents distortion in the plate from affecting a light signal transmitted across the plate, which in turn allows improvements in accuracy and lower light budget of the system. Additionally, or alternatively, embodiments provide for controlling curvature such that the field of view, for a detector receiving light from a light emitter of the touch sensitive system, is increased compared to a substantially flat plate. Again, the improved field of view provides for improved accuracy of the touch sensitive system and allows for a better light budget. Furthermore, embodiments provide for an assembly that is compact at the same time as curvature may be controlled. Also, the curvature may be controlled without contacting the center of the plate.

A fourth embodiment of the invention describes a touch sensing apparatus, comprising a touch surface; a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface, a set of light detectors arranged around the touch surface to receive light from the first set of emitters, wherein each light detector is arranged to receive light from more than one emitter; a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface, wherein the touch surface is curved in a first axis according to a first parabola.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Brief Description of the Drawings

These and other aspects, features and advantages of which embodiments of the invention are capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which:

Figure 1 is a top view of the first frame element showing cross-sectional axes A-A and B-B;

Figures 2a-2d are cross-sectional views of embodiments of assemblies;

Figure 3a is a schematic illustration showing the cross-section axis B-B of figure 1 of the assembly with the second frame element relative to the first frame element and holding the plate in a flat plane;

Figure 3b is a schematic illustration showing the cross-section axis A-A of figure 1 of the assembly with the second frame element relative to the first frame element and holding the plate in a flat plane;

Figure 3c is a schematic view (cross section) showing the cross-section axis B-B of figure 1 of the assembly with the second frame element warped relative to the first frame element and holding the plate in a curved plane that is concave;

Figure 3d is a schematic view (cross section) showing the cross-section axis A-A of figure 1 of the assembly with the second frame element warped relative to the first frame element and holding the plate in a curved plane that is concave;

Figure 4a is a perspective view of the first frame element;

Figure 4b is a schematic illustration of the panel in a convex shape and the frame of the first frame element in a concave shape, including plate 2 also controlled into a concave shape;

Figure 4c is a side view showing screws 116a and 116b;

Figures 5a-5h are side views and perspective views of an embodiment of the assembly comprising a screw arrangement for configuring frame shape; and

Figures 6 is a schematic cross section from a first direction of an embodiment of the assembly;

Figure 7 is a schematic side-view of another embodiment for providing curvature of plate 2;

Figure 8 shows an isometric view of a variation of the embodiment of figures 5a-5g;

Figure 9 is a diagram showing a top down view of an optical touch system and corresponding detection lines;

Figure 10a shows an isometric view of a flat touch surface of an optical touch system;

Figure 10b shows a section view of an optical touch system with a flat touch surface;

Figure 11a shows an isometric view of a touch surface of an optical touch system having a curved profile in the x-axis;

Figure 11b shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis;

Figure 11c shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis;

Figure 11d shows an example of types of warpage that a touch panel may exhibit.

Figure 12a shows top view of a touch surface of an optical touch system;

Figure 12b shows an isometric view of a touch surface of an optical touch system having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 12c shows a section view along the x-axis of an optical touch system with a touch surface having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 12d shows a section view along the y-axis of an optical touch system with a touch surface having a curved profile in the x-axis and a curved profile in the y-axis;

Figure 13a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 13b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 14a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 14b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 15a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 15b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 16a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 16b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 17a shows a section render of light emitted from a point at an edge of a curved touch surface and propagating across the curved touch surface to be received at a detector at an opposite edge of the touch surface;

Figure 17b shows a graph of light emitted from a point at an edge of a curved touch surface and received at a detector at an opposite edge of the touch surface with respect to the angle of the emitter light;

Figure 18a shows a curvature of a real touch surface vs a parabolic curved surface along an x-axis;

Figure 18b shows a deviation between a real touch surface vs a parabolic curved surface along an x-axis;

Figure 19a shows a curvature of a real touch surface vs a parabolic curved surface along an x-axis;

Figure 19b shows a deviation between a real touch surface vs a parabolic curved surface along an x-axis;

Figure 20a shows top view of displacement contours for a touch surface according to an embodiment;

Figure 20b shows curvature of a touch surface along an x-axis according to the embodiment of figure 20a;

Figure 20c shows curvature of a touch surface along a y-axis according to the embodiment of figure 20a;

Figure 20d shows curvature of a touch surface along a diagonal line according to the embodiment of figure 20a;

Figure 21a shows top view of displacement contours for a touch surface according to another embodiment;

Figure 21b shows curvature of a touch surface along an x-axis line according to the embodiment of figure 21a;

Figure 21c shows curvature of a touch surface along a y-axis line according to the embodiment of figure 21a;

Figure 21d shows curvature of a touch surface along a diagonal line according to the embodiment of figure 21a.

Description of Embodiments

Specific embodiments of the invention will now be described with reference to the accompanying drawings. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

In optical touch sensitive systems, a plate 2 of the system, such as a glass plate may be arranged opposite a panel 1, such as an LCD panel or additional frame. The plate 2 is normally substantially flat. The perimeter of the plate 2 after integration is a concern: the four sides/edges of the plate 2 must all be plane or slightly concave as seen from the touch surface, i.e. the side of the plate 2 above which light is transmitted. An aspect of this is to ensure that the mechanical parts that hold or support the perimeter of the plate 2 are free from convexity. Sometimes, there are several components that are involved in holding the plate 2 (back cover, carriers, edge cover, screw bosses etc.) The stiffer component of the assembly, the more it will govern the final shape of the plate 2.

In prior art solutions, the frame that holds the plate 2 at the edge/perimeter may introduce some twist (the corners will not lay perfectly on a flat plane) to the plate. Twist may induce convexity along the plate diagonals and should thus be minimized or avoided. The twist tolerance depends, e.g., on glass specification, product, size, shape of integrated glass perimeter, and on how a VESA mount is attached.

Figure 1 shows an embodiment of a frame assembly 100, 200 that prevents inducement of convexity along the plate, such as along the plate edges and/or diagonals. Some embodiments avoid convexity and may even induce concavity to further improve the touch system. Frame 109 is formed from first frame element 102. Attachment element 112 and spacing element 116 are described in the embodiments below.

According to some embodiments of the invention, an assembly 100, 200, which is configured to hold or support the plate 2 and the panel 1, applies a controlled force to the plate 2 such that curvature of the plate 2 is controlled. In the embodiments illustrated in figures 2a-2c and 3a-3d, the force applies a torque to a support portion 101a, 101b for the plate 2. In the embodiments of figures 4a-4c, the force is substantially straight and perpendicular to the plate 2. In the following, the embodiments of figures 2a-2c, 3a-3d, 4a-4c, and 5a-5g will be described separately. However, these embodiments may be combined to provide further embodiments, such as the combination illustrated in figures 6a-6c.

Figures 2a-2d illustrate embodiments wherein the frame assembly 100 comprises a first frame element 102 and at least one second frame element 103a, 103b. The first frame element 102 may form a rear bracket frame that extends at least partially over the backside of the panel 1. The second frame element 103a, 103b may form a holder or support bracket. Furthermore, second frame element 103a, 103b may extend along at least a portion of a perimeter of the plate 2 and/or the panel 1. Separate second frame elements 103a, 103b may extend at least partially along the perimeter of different sides of the plate 2 and/or panel 1. For example, two second frame elements 103a, 103b may extend along opposing perimeters of the plate 2 and/or panel 1. Alternatively, four second frame elements 103a, 103b may extend along the perimeter of the plate 2 and/or panel 1, i.e. one along each side of a rectangular plate 2 and/or panel 1.

As is illustrated in figures 4a-4c, the panel 1 may be held between the first frame element 102 and the second frame element 103a, 103b. The plate 2 may be supported or held at a first side of a portion of the second frame element 103a, 103b forming the support portion 101a, 101b. The panel 1 may be held or supported by a second side of the support portion 101a, 101b, which forms a support portion for the panel 1. An adhesive 104, such as an adhesive tape, may be arranged between the support portion 101a, 101b and the plate 2. A gasket 105 may be arranged between the support portion 101a, 101b and the panel 1.

In one embodiment, elements 102, 103 (shown in the figure as comprising elements 103a and 103b) are formed from a single piece.

The second frame element 103a, 103b may be attached to the first frame element 102.

In the embodiments of figures 2a-2c and 3a-3d, the second frame element 103a, 103b, is attached to the first frame element 102 by at least one attachment member 106a, 106b, such as a screw, a weld, a rivet etc. Therefore, the second frame element 103a, 103b may be rigidly attached to the first frame element 102.

The first frame element 102 may comprise a flange 107a, 107b that extends at the perimeter of the first frame element 102. Similarly, the second frame element 103a, 103b may comprise a flange 108a, 108b. When assembled, the flange 107a, 107b of the first frame element 102 may be arranged in abutment with the flange 108a, 108b of the second frame element 103a, 103b. The flange 107a, 107b of the first frame element 102 may be held together with the flange 108a, 108b of the second frame element 103a, 103b by the attachment member 106a, 106b.

The first frame element 102 may form a frame 109 (shown in figure 1) that extends in a first plane. The frame 109 is configured to extend at least partially around a first side of a panel 1. The first side of the panel 1 may be the backside of the panel 1. In some embodiments, the frame 109 has a width, such as 3-10 cm. The frame 109 may extend from the edges of the first side towards the center of the first side of the panel 1. Therefore, the frame 109 may be rectangular, and made from a single piece of material.

As is illustrated in figures 3a and 3b, the assembly 100 may comprise at least one support area 110a, 110b for supporting a back cover 111. The support area 110a, 110b may extend in a plane that is substantially parallel to the first plane, in which the frame 109 extends. The support area 110a, 110b may be located further away from the support portion 101a, 101b of the second frame element 103a, 103b than the frame 109, such that the frame 109 and the back cover 111 are spaced apart. In the illustrated embodiment, the support area 110a, 110b is provided between the flange 107a, 107b and the frame 109 of the first frame element 102. The back cover 111 may be attached to the support area 110a, 110b, e.g. by attachment elements, such as screws.

In other embodiments, the support area 110a, 110b is provided by the flange 108a, 108b of the second frame element 103a, 103b. The flange 107a, 107b of the first frame element 102 may be connected to the second frame element 103a, 103b between the flange 108a, 108b and the support portion 101a, 101b of the second frame element 103a, 103b.

The second frame element 103a, 103b may form the support portion 101a, 101b. For example, the second frame element 103a, 103b may form an elongated member that is at least partly L-shaped in cross-section. When assembled, the second frame element 103a, 103b may extend along the perimeter of the panel 1, and wrap around the perimeter of the panel such that the support portion 101a, 101b extends at least partially in a second plane generally opposite the frame 109 and spaced apart from the first plane. Thereby the second frame element 103a, 103b is configured to extend at least partially at a second side of the panel 1, e.g. at a front side of the panel 1.

In some embodiments, the second frame element 103a, 103b has a first portion and a second portion. The first portion may be provided at an angle relative to the second portion. The second portion may form the support portion 101a, 101b and be configured to extend in the second plane opposite the frame 109. The first portion may extend between the second portion and the first frame element 102. Also, the first portion may extend along the edge or side surface of the plate 2 when assembled. The first frame element 102 may be connected to the first portion of the second frame element 103a, 103b. The first portion may be substantially perpendicular to the second portion.

As is illustrated in figures 3a-3d, the first frame element 102 may be attached to the first portion of the second frame element 103a, 103b such they are fixed relative to each other. Furthermore, the second frame element 103 is tiltable relative to the first frame element 102. A force applied to the first frame element 102 is transferred to the second frame element 103 such that the support portion 101a, 101b is tilted towards the first frame element 102. Thus, a torque may control tilt of the second portion of the second frame element 103a, 103b, i.e. the support portion 101a, 101b that supports the plate 2, relative to the first frame element 102, which is illustrated with a curved arrow in figure 3c and 3d. In some embodiments, the angle of tilt of the support portion 101a, 101b is controlled to be neutral, i.e. the angle of tilt of the support portion 101a, 101b is controlled such that it is substantially parallel with the panel 1 and/or controls the plate 2 to be in a flat plane, as is illustrated in figures 3a and 3b. In other embodiments, the angle of tilt of the support portion 101a, 101b is controlled to be negative relative to the touch surface, i.e. the angle of tilt of the support portion 101a, 101b is controlled such that the free end of the support portion 101a, 101b is tilted towards the frame 109, as is illustrated in figure 3c and 3d. In the latter case, the plate 2 is given a slightly concave shape, i.e. in the direction from the touch surface of the plate 2 towards the panel 1. In each of these cases curvature is controlled such that the field of view, for a detector receiving light from a light emitter of the touch sensitive system, is improved since convexity in the plate is avoided. Again, improved field of view provides for improved accuracy of the touch sensitive system and allows for lower light budget. Furthermore, since the support portion 101a, 101b only needs to extend a short distance over the plate 2 at the perimeter the assembly is compact at the same time as curvature may be controlled. Also, curvature may be controlled without contacting the center of the plate. When the concavity is applied, the sensitivity of the system may be even further improved.

Figures 2a-2d and 3a-3d illustrate embodiments of an attachment element 112 for attaching the first frame element 102 to the panel. A plurality of attachment elements 112 (e.g. as shown in triplicate as elements 112a, 112b, and 112c) may be arranged around

the frame 109, such as at each corner of the frame 109, which is illustrated as circles in figure 4a. Each attachment element may comprise a group of screws 112a, 112b, 112c, 113a, 113b. Each screw may be arranged in a hole of the frame 109, which may be threaded. Each attachment element may comprise at least two screws 112a, 112b, 112c, 113a, 113b. At least one of the screws 112a, 113a may be arranged to displace the frame 109 away from panel 1, which is indicated with an arrow in figure 2d e.g. by having a thread in the frame 109 and pushing on the panel 1. At least one other of the screws 112b, 112c, 113b may be arranged to displace the frame 109 towards the panel 1, which is also indicated with an arrow in figure 2d. e.g. by having a thread in the panel and a hole in frame 109.

Figure 2a illustrates an embodiment wherein each attachment element comprises at least three screws 112a, 112b, 112c. All three screws 112a, 112b, 112c are arranged closer to a center of the first frame element 102 than a perimeter of the support portion 101a, 101b, i.e. an imaginary extension 114a, 114b, 114c of the longitudinal axis of each screw 112a, 112b, 112c passes outside the support portion 101a, 101b when viewed in cross-section, as is illustrated in figure 2a. In the illustrated embodiment, a first screw 112a is arranged between a second screw 112b and a third screw 112c. Figure 2a only illustrates one group of screws. However, a group of screws may be arranged at any location around the frame 109 to attach the first frame element 102 to the panel 1.

Figure 2b illustrates an embodiment wherein each group of screws consists of only two screws 113a, 113b. A first screw 113a is arranged opposing the support portion 101a, 101b, i.e. an imaginary extension 115a of the longitudinal axis of the first screw 113a passes through the support portion 101b when viewed in cross-section, such as through the center thereof, as is illustrated in figure 2b. A second screw 113b of the two screws is arranged closer to a center of the first frame element 102 than a perimeter of the support portion 101b, i.e. an imaginary extension 115b of the longitudinal axis of the first screw 113b passes outside the support portion 101b when viewed in cross-section, as is illustrated in figure 2b.

As shown in figure 2d, the first screw 112a is arranged to displace the frame 109 away from panel 1. This may be enabled by a threaded hole 112i in the frame 102 which the first screw engages while a head of the screw abuts the panel 1. The second screw 112b is arranged to displace the frame 109 towards the panel. This may be enabled by a threaded hole 112f in the panel 1, which the second screw 112b engages while the head of the second screw 112b abuts the surface of the frame. By using screw 112a and/or 112b, forces may be applied to frame 102 and/or panel 2 to control bending or rotation of the frame/panel.

Since the first screw 113b is aligned over the support portion 101a, 101b in the embodiment of figure 2b, only two screws are required to control bending or rotation of the frame.

In figures 2a-2b, only one group of screws is illustrated. However, a group of screws may be arranged at any location around the frame 109 to support the plate 2 and the panel 1.

figure 2c illustrates that a combination the embodiment of figures 2a and 2b, i.e. groups of screws with two as well as three screws may be arranged around the frame 109. Therefore, flexibility is provided for.

As is illustrated in figures 2a-2c and 3c and 3d, each group of screws 112a, 112b, 112c, 113a, 113b may apply a force to the frame 109. Therefore, a torque may be applied at the second frame element 103a, 103b via controlling the curvature of the frame 109 such that tilt of the support portion 101a, 101b, and thereby curvature of the plate, is controlled. In the assembly illustrated in figure 3a, a net force is applied such that the frame is substantially flat and parallel with the panel 1. In the assembly illustrated in figure 3c and 3d, a net force away from the support portion 101a, 101b is provided to the frame 109, which will be slightly concave when viewed from the touch surface of the plate 2. As a consequence, a torque will be provided at to the second frame element 103a, 103b, which will tilt the support portion 101a, 101b along the edge or perimeter of the plate 2. Therefore, controlling the curvature of the first frame element 109 may control curvature of the plate. The plate 2 may become concave as viewed from the touch surface of the plate 2.

Figures 4a-4c, 5a-5g and 6a-6c illustrate embodiments wherein an alternative or additional control of the shape of the frame 109 may be introduced. As shown in figure 4a, attachment elements 112 may be arranged at the corners of the frame 109. The attachment elements 112 may comprise the group of screws 112a, 112b, 112c, 113a, 113b as described above with regard to figures 2a-2c and 3a-3d. The attachment elements 112 may be arranged to pull the panel 1 towards the frame 109. This may be done with or without tilting the support portion 101a, 101b as described above. At least one spacing element 116 (where spacing element 116 may comprise screw 112 and a separate spacing component) may be arranged along the perimeter of the frame 109 between two attachment elements 112. The spacing element 116 is arranged in the assembly to apply a force to the frame 109 directed away from the panel 1. Thereby, a force applied by the spacing element 112 may be transferred to the second frame element 103a, 103b such that the support 101a, 101b is tilted as described above, whereby curvature of the plate 2 is controlled.

As is illustrated in figure 4b, the general shape of the frame 109 will be concave, whereas the general shape of the panel 1 may be convex. The panel may also remain substantially plane depending on its rigidity. The resulting shape of the plate 2 will be concave. Therefore, each side of the frame 109 may be controlled to follow a curved path. The curvature may be controlled by adjusting the force applied by each spacing element 116 and/or via the number of spacing elements 116 along each side of the frame 109. As a result, the support portion 101a, 101b, at least at the free end of the support portion 101a, 101b, may also follow a curved path. Therefore, at least a portion of the support portion 101a, 101b may extend in a plane that is curved.

When the second frame element 103a, 103b is disassembled or only attached to the first frame element 102, it may have a relaxed state. In the relaxed state, the support portion 101a, 101b extends in a plane that is substantially flat. The second frame element 103a, 103b may be deflectable from the relaxed state to a deflected state or stressed state, such as by the attachment elements 112 and spacing elements 116. The level of tilt at the opposing ends of the support 101a, 101b where the attachment elements 112 are provided may be less than the level of tilt between the ends where spacing element(s) 116 is/are provided. As consequence, the second frame element 103a, 103b may be deflected to the deflected or stressed state. In the deflected or stressed state, the support portion 101a, 101b extends, along its length, in a plane that is curved. A cross section of this plane taken along the support portion 101a, 101b, such as at the free end or tip of the support portion 101a, 101b may form a parabolic concave curve along at least a portion of the length of the support portion 101a, 101b. A combination of the attachment element 112 and the spacing element 116, that together may form a screw arrangement, may hold the second frame element 103a, 103b in the deflected or stressed state when assembled with the first frame element 102.

The spacing element 116 may be provided by a single screw that engages a thread in the frame 109 while its tip engages or abuts a surface on panel 1. Alternatively, panel 1 comprises a threaded hole into which spacing element 116 is threaded so that spacing element 116 can be used to displace the frame 109 towards panel 11. Additionally, element 116 may comprise a spacer component such as a washer, spacer, etc. In figure 3a and 3b and figure 6a, two spacing elements 116a, 116b are shown for illustrative purposes and may form separate embodiments. A single-spacing element 116a, 116b may be used in other embodiments. The head of the spacing element 116a, 116b may abut the back cover 111 while the spacing element 116a, 116b may engage the frame 109, wherein the frame 109 may be pulled towards the back cover 111. As a result, the frame 109 becomes concave. In some embodiments, the spacing element 116a does not abut or engage the

panel 1, wherein the panel 1 may be unaffected by the force applied to the frame 109. In other embodiments, the spacing element 116b is sufficiently long such that a tip of the spacing element 116b abuts a surface of the panel 1. This adds further control of the shape of the plate 2.

In some of the embodiments, the frame assembly 100 comprises a plurality of spacing elements 116 arranged spaced apart from corners of the frame 109. One or several spacing elements 116 may be arranged along each perimeter or side of the frame 109. If a single spacing element 116 is arranged along each side, it is preferably centered between the corners of the frame 109.

Each spacing element 116 may comprise a screw with a predefined length. This means that the screw can be fully seated such that the head and tip abut respective surfaces, whereby a predefined curvature of the plate 2 is obtained. The level of curvature may be adjusted by one or several spacers arranged between the head and the surface which the head engages. This is particularly useful if multiple spacing elements 116 are arranged along a single side, or if different sides have different lengths. The more spacers provided, the less force will be applied to the frame 109. Alternatively, as shown in figure 5h, predefined height differences may be generated via other methods, e.g. by milling the frame to the predefined heights, allowing a more continuous support structure.

Figures 5a-5h illustrate embodiments of an assembly 200, which may be combined with the first frame element 102 described above. The embodiments shown in figures 5a-5h are shown inverted relative to the embodiments shown previously, with the plate 2 at the top.

As shown in figures 5a and 5b, the frame assembly 200 may comprise a first frame element 202, and a second frame element 203. The first frame element 202 and the second frame element 203 may be elongated members, each having a support portion 201a, 201b. The first frame element 202 and the second frame element 203 may e.g. be L-shaped in cross section. A first portion of each of the first frame element 202 and the second frame element 203 may be configured to extend along the edge of the panel 1. A second portion of each of the first frame element 202 and the second element 203 forms the support portion 201a, 201b, and may be configured to extend from the perimeter of the plate 2 a short distance, such as a 1-3 cm, over the surface of the plate 2 when assembled. Furthermore, the second frame element 203 may be arranged on top of the first frame element 202 and such that the perimeter of the plate 2 is arranged between the second portion of each of the frame elements 202, 203 when assembled. Therefore, each support portion 201a, 201b may support or engage opposing surfaces of the plate 2, such as is illustrated in figure 5g.

In some embodiments, such as illustrated in figures 5c-5d, a gasket 205 (e.g. gaskets 205a, 205b, 205c, 205d, 205e) is arranged between the first frame element 202 and the second frame element 203. The gasket may e.g. be arranged on the support portion 201a of the first frame element 202. Also, a sealing 204a may be arranged on the support portion 201b of the second frame element 203.

The gasket 205 may have a varying thickness along its length, i.e. also along the length of the first frame element 202. This provides for obtaining a desired curved shape of the perimeter of the plate 2 when captured between the first frame element 202 and the second frame element 203, as is illustrated in figures 5f-5g. For example, the gasket 205 has opposing ends and may be thinner between the opposing ends than at said ends. This provides for obtaining a predefined concavity of the perimeter of the plate 2. The gasket is sufficiently stiff that it is thicker at the ends even when compressed. The gasket 205 may be about 1.5-2.0mm at the ends and about 1 mm thinner at the center.

In some embodiments, the gasket 205 has a plurality of sections along its length. The thickness of each section may vary. For example, a first section 205a of the gasket is provided at one of its ends and a second section 205b of the gasket at the other of its ends. The first section 205a and the second section 205b may have a first thickness that may be equal at each section. At least a third section 205c of the gasket is arranged between the first section 205a and the second section 205b. The third section 205c has a second thickness. The first thickness is thicker than the second thickness. For example, difference in thickness is about 0.5-2mm, preferably about 1.0mm. The difference in thickness may vary depending on the length of the gasket 205 and the edge of the plate 2 at which the concavity is to be introduced. In some embodiments, fourth and fifth sections 205d, 205e may be provided between the first and second sections 205a, 205b and the third section 205c, respectively. The fourth and fifth sections 205d, 205e may add further control of the shape of the concave curve provided by the arrangement 200. The length of each the first and second sections 205a, 205b may be about 2-20% of the total length of the gasket 205. The length of the third section may be about 60-96% of the total length of the gasket 205. The length of each of the fourth and fifth sections 205d, 205e may be about 10-20% of the total length of the gasket 205. In some embodiments the total length of the fourth and fifth sections 205d, 205e is shorter than the length of the third section 205c, and the total length of the first and second sections 205a, 205a is shorter than total length of the fourth and fifth sections 205d, 205e. This provides for a parabolic concave curve along the length of the frame assembly 200.

A distance between the support portion 201a of the first frame element 202 and the support portion 201b of the second frame element 203 may be discontinuous in an assembled state, as can be seen in figure 5e.

In order to maintain the concavity of the plate 2, the first frame element 202 and the second frame element 203 may be held together such that the distance between the support portions 201a, 201b is maintained in the assembled state. The first frame element 202 has a first hole 217a and a second hole 217b arranged at opposing ends of the first frame element 202, such as at the second portion of the first frame element 202. The first and the second hole 217a, 217b are arranged in a first plane. A third hole 217c is arranged between the first hole 217a and the second hole, such as centered between the first hole 217a and the second hole 217b. The third hole 217c is provided in a plane that is different from the first plane. The distance or offset between the plane in which the first and second holes 217a, 217b are arranged and the plane in which the third hole 217c is arranged may be substantially the same as the difference in thickness between the first and second sections 205a, 205b and the third section 205c, i.e. about 0.5-2mm. In some embodiments the first and second holes 217a, 217b are centered in each of the first and second sections 205a, 205b of the gasket 205 along the length of the first frame element 202.

Similarly, the second frame element 203 may comprise a first hole 218a and a second hole 218b arranged at opposing ends of the second frame element 203. A third hole 218c may be arranged between the first hole 218a and the second hole 218b of the second frame element 203. The first hole 218a, the second hole 218b, and the third hole 218c of the second frame element 203 is generally arranged in the same plane when the second frame element 203 is disconnected from the first frame element 202. The second frame element 203 may be less stiff or weaker than the first frame element 202 and be deflectable such that each hole 218a, 218b, 218c of the second frame element 203 is aligned with the holes 217a, 217b, 217c of first frame element 202. Therefore, the support portion 201b of the second frame element 203 may be deflected such that it extends in plane, which is curved in the assembled state of the frame assembly 200. Screws 219a, 219b, 219c may be inserted through the aligned holes 217a, 217b, 217c; 218a, 218b, 218c and may directly engage the panel or engage a threaded hole in the panel 1, which will hold the frame elements 202, 203 in the assembled state. Other relative arrangements of the holes 217a, 217b, 217c; 218a, 218b, 218c are foreseen, wherein the center holes 217c, 218c of each frame element 202, 203 are misaligned in the relaxed state of the second frame element 203 but aligned in the deflected or stressed state of the second frame element 203.

In some embodiments, the first frame element 202 forms a frame side, and the second frame element 203 forms an edge cover. If used together with the frame 109 discussed with regard to figures 4a-4c, the frame side may replace the second frame element of the embodiments of figures 4a-4c. Therefore, the frame side comprises the support portion 201a with a support surface generally opposing the frame 109 and is configured to support the gasket 205.

As illustrated in figure 6, a component (e.g. a sealing component 204a) may be provided between the support portion 201a and the plate 2. Figure 6 illustrates the resulting forces and torque generated when a force 220 is applied to second frame element 203a. A second force 221 is applied to support portion 201. Therefore, a net torque 222 is generated, i.e. counter-clockwise in the illustrated arrangement. The plate 2 will assume a curved path, as is illustrated with dotted line 223.

In an embodiment shown in figure 7, an alternative arrangement is provided for providing curvature of plate 2. In this embodiment, support block 301 is arranged to support glass plate 2. Support block 301 has a surface portion comprising a tapered edge 303 at an angle from second frame element 103A. Plate 2 is pressed against the top surface of support block 301 from pressure 201b from first frame element 102 and sealing 204a. Pressure 201b causes plate 2 to follow the contour of the top surface of block 301 and plate 2 is forced into a curving plane at an angle to the plane of second frame element 103A. The resulting path of plate 2 is shown by curvature path 310. Tapered surface portion 303 is angled between 0.5 degrees and 3 degrees from second frame element 103A.

In an embodiment shown in figure 8, a variation of the embodiment shown in figures 5a-5g is provided. In this embodiment, second frame element 203 has been modified, such that a portion 410 has been removed from the edge portion 203c of second frame element 203. This reduces the force required to bend second frame element 203 in a manner that results in a curvature of plate 2. Portion 410 may be removed by a milling process, by a carving or cutting process, or second frame element 203 may be formed without portion 410 via a molding process or similar. Portion 410 preferably reduces the depth of second frame element 203 at the narrowest point by between 5-20%.

The frame elements of the embodiments of the assembly may be made from sheet metal and given a desired design, thickness, and/or be made from different materials such that the forces, shapes, torques, etc. discussed above are obtained.

Embodiments comprise a method for assembling the panel 1 and the plate 2 for the optical touch sensitive system. The method may comprise providing the frame elements according to the embodiments presented herein. The method further comprises

attaching the first frame element to the second frame element, supporting the plate at a support portion of the assembly, and attaching at least one of the first frame assembly and the second frame assembly to the panel such that the support portion extends in flat or curved plane. Also, the method comprises attaching the second frame element to the first frame element such that the support portion extends at least partially in a second plane generally opposite at least a portion of the first frame element and is spaced apart from the first plane. A curvature of the first frame element may be controlled with a spacing element attached to the first frame element and may thereby tilt the support portion to control a curvature of the plate.

Figure 9 illustrates a top plan view of an example of a touch-sensitive apparatus 99. Emitters 30a are distributed around the periphery of touch plate 10, to propagating light across touch surface 20. Detectors 30b are distributed around the periphery of touch surface 20, to receive part of the propagating light. The light from each of emitters 30a will propagate to a number of different detectors 30b on a plurality of light paths 50.

The embodiments above describe methods of achieving control of plate shape and curvature. The following embodiments describe desirable shapes of the plate for achieving improved performance of a touch sensor system. Light paths 50 may conceptually be represented as "detection lines" that extend across the touch surface 20 between pairs of emitters 30a and detectors 30b. The emitters 30a and detectors 30b collectively define a grid of detection lines 50 ("detection grid") on the touch surface 20, as seen in a top plan view. The spacing of intersections in the detection grid define the spatial resolution of the touch-sensitive apparatus 99, i.e. the smallest object that can be detected on the touch surface 20. The width of the detection line is a function of the width of the emitters and corresponding detectors. A wide detector detecting light from a wide emitter provides a wide detection line with a broader surface coverage, minimizing the space in between detection lines which provide no touch coverage. A disadvantage of broad detection lines may be a reduced ability to differentiate between separate objects and a lower signal to noise ratio.

As used herein, the emitters 30a may be any type of device capable of emitting radiation in a desired wavelength range, for example a diode laser, a VCSEL (vertical-cavity surface-emitting laser), an LED (light-emitting diode), an incandescent lamp, a halogen lamp, etc. The emitters 30a may also be formed by the end of an optical fiber. The emitters 30a may generate light in any wavelength range. The following examples presume that the light is generated in the infrared (IR), i.e. at wavelengths above about 750 nm. Analogously, the detectors 30b may be any device capable of converting light (in the same wavelength range) into an electrical signal, such as a photo-detector, a CCD device, a CMOS device, etc.

The detectors 30b collectively provide an output signal, which is received and sampled by a signal processor 130. The output signal contains a number of sub-signals, also denoted "projection signals", each representing the energy of light received by one of light detectors 30b from one of light emitters 30a. Depending on implementation, the signal processor 130 may need to process the output signal for separation of the individual projection signals. The projection signals represent the received energy, intensity or power of light received by the detectors 30b on the individual detection lines 50. Whenever an object partially or completely occludes detection line 50, the received energy on this detection line is decreased or "attenuated".

The signal processor 130 may be configured to process the projection signals so as to determine a property of the touching objects, such as a position (e.g. in a x, y coordinate system), a shape, or an area. This determination may involve a straight-forward triangulation based on the attenuated detection lines, e.g. as disclosed in US7432893 and WO2010/015408, or a more advanced processing to recreate a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 20, where each attenuation value represents a local degree of light attenuation. The attenuation pattern may be further processed by the signal processor 130 or by a separate device (not shown) for determination of a position, shape or area of touching objects. The attenuation pattern may be generated e.g. by any available algorithm for image reconstruction based on projection signal values, including tomographic reconstruction methods such as Filtered Back Projection, FFT-based algorithms, ART (Algebraic Reconstruction Technique), SART (Simultaneous Algebraic Reconstruction Technique), etc. Alternatively, the attenuation pattern may be generated by adapting one or more basis functions and/or by statistical methods such as Bayesian inversion. Examples of such reconstruction functions designed for use in touch determination are found in WO2009/077962, WO2011/049511, WO2011/139213, WO2012/050510, and WO2013/062471, all of which are incorporated herein by reference.

In the illustrated example, the apparatus 99 also includes a controller 120 which is connected to selectively control the activation of the emitters 30a and, possibly, the readout of data from the detectors 30b. Depending on implementation, the emitters 30a and/or detectors 30b may be activated in sequence or concurrently, e.g. as disclosed in US8581884. The signal processor 130 and the controller 120 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 130 and the controller 120 may be at least partially implemented by software executed by a processing unit 140.

Figure 10a illustrates a substantially flat rectangular touch plate 10 according to the prior art. In this example, the touch plate is made of glass, plastic, or any other materials such as PMMA (Poly(methyl methacrylate)). Two axes are defined in figure 10a. The x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle and along the flat surface of the touch surface. The y-axis is defined as the axis running parallel to and equidistant from the pair of short edges of the rectangle and along the flat surface of the touch surface. At least a portion of the top surface of touch plate 10 comprises touch surface 20.

Figure 10b illustrates an example of a touch apparatus according to the prior art. Figure 10b shows the touch apparatus in cross section wherein the cross section runs along the x-axis of the plate 10. Light is emitted by emitter 30a, passes through transmissive plate 10 through touch surface 20 and is reflected by reflector surface 80 of edge reflector 70 to travel in a plane substantially parallel with touch surface 20. The light will then continue until deflected by reflector surface 80 of the edge reflector 70 at an opposing edge of the transmissive plate 10, wherein the light will be deflected back down through transmissive plate 10 and onto detectors 30b. Where an object is applied to touch surface 20, some of the light above the touch surface 20 is occluded. This occlusion is detected by the touch apparatus and used to determine the presence, size, and/or shape of the object. The emitters and detectors may be arranged in a number of other configurations such that the light from the emitters is delivered to the touch surface and delivered from the touch surface to the detectors. Other known arrangements are that of arranging the emitters and detectors above the touch surface and transmitting and receiving the light directly without the use of reflecting surfaces. The light may also be delivered to the touch surface by means of a wave guide, fiber optic cable, or other optical component.

Figure 11a illustrates an embodiment of touch plate 10 similar to that shown in figure 10a but wherein the touch plate 10 is curved. In this embodiment, the plate remains substantially flat in the direction of the y-axis but is curved in a concave direction relative to the x-axis. In this embodiment, the x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle. The vertex of the parabola or paraboloid of the touch surface is where the touch surface is deepest relative to the edges of the touch plate. Where the x-axis is positioned at the height of the edge of the touch plate, the curvature of the plate can be measured using the distance of the touch surface from the x-axis. Figure 11b shows a cross-section view along the x-axis of the touch plate 10 of figure 11a.

Figure 11c shows an example embodiment of a curved touch plate 10. The touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. In this example embodiment, the glass is shaped such that the touch surface follows a parabolic curve relative to the x-axis. The midpoint O of touch surface 20 is the center of the touch surface and the midpoint of the x-axis. Where the curvature of the touch surface 20 is parabolic, the maximum distance a between the touch surface and the x-axis is at the center point O of the touch surface.

Figure 11d shows the maximum allowed concave distance a and maximum allowed convexity b. The maximum allowed convexity b may be a significant consideration as a portion of the touch surface that is substantially convex may result in occlusion of the light between the emitters and detectors and significant loss of touch signal. The maximum allowed convexity b is a negative number in the present examples.

In one embodiment, the range of the distance a for vertically orientated touch plate is limited in order to improve the yield and performance of touch systems. The range is set dependent on the size of the touch system. A smallest value is needed to assure that non-parabolic deviations in the glass shape and convexity in the integration doesn't result in a convex integrated touch surface. A largest value is needed in order to assure that the height of the light field for the final touch system is kept reasonably low in order to enable better contact detection and lift-off detection for touch objects. Preferably, range of the distance a is 0-2.5 mm.

The maximum distance a is a positive number for a concave glass in the present examples. The curvature of the touch surface may therefore be modelled as:

$$\mathrm{F(x)} = -\mathrm{a} + \mathrm{cx}^2$$

In the present example embodiment, a maximum distance a between the 1900 mm long cross section of the touch surface in figure 11c and the x-axis is 2.0 mm. Therefore, an ideal parabolic curve for touch surface 20 may be:

$$\mathrm{F(x)} = 5.5 * 10^{-6} * \mathrm{x}^2 - 2.0$$

where $\mathrm{F(x)}$ is the distance between the x-axis and the touch surface at position x wherein $\mathrm{F(x)}$ is zero at the mid points of the edges. i.e. where the x-axis intersects the perimeter.

Figures 12a and 12b illustrates an embodiment of touch plate 10 similar to that shown in figure 11a but wherein the touch plate 10 is curved in two axes. Figure 12a shows a top plan view and figure 12b shows an isometric view of touch plate 10. In this embodiment, the plate is curved in a concave direction relative to the x-axis and is also curved in a concave direction relative to the y-axis. As with the embodiment shown in figure 11a, the x-axis is defined as the axis running parallel to and equidistant from the pair of long edges of the rectangle and passing over the center point 0 on the touch surface. Therefore, the curvature of the plate can be measured from the distance of the touch surface from the x-axis. Similarly, the y-axis is defined as the axis running parallel to and equidistant from the pair of short edges of the rectangle and passing over the center point 0 on the touch surface. Therefore, the curvature of the plate along this axis can be measured from the distance of the touch surface from the y-axis.

Figure 12c and 12d shows respective section views along the x-axis and y-axis of the touch plate 10 of figure 12a and 12b. In an example embodiment of a curved touch plate 10. The touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. In this example embodiment, the glass is shaped such that the touch surface follows a parabolic curve relative to the x-axis. The center point O of touch surface 10 is the center of the touch surface and parallel with midpoint of the x-axis. Where the curvature of the touch surface 10 is parabolic, the maximum distance a between the touch surface and the x-axis is at the center point O. The maximum distance a is a positive number for a concave glass in the present examples. The curvature of the touch surface may therefore be modelled as:

$$z(x,y) = -a + b * x^2 + c * x^2y^2 + d * y^2$$

where z is the distance between the plane defined by the x-axis and y-axis and the touch surface, and x and y are co-ordinates in the plane of the glass.

In an example embodiment having a flat perimeter around the plate with a max distance of 2.0 mm measured along the x-direction for y = 0 (i.e. middle of plate):

$$z(x,y) = -2 + 5.56e-06 * x^2 - 4.74e-11 * x^2y2 + 1.7e-05 * y^2$$

In another example embodiment having a concave perimeter around the plate with a max distance of 2.0 mm measured along the x-direction for y = 0 (mid short to short of screen) and with a max distance of 1.5 mm measured along the y-direction for x = 0 (mid

long to long of screen). Where the top and bottom edges have 1.0 mm max distance and the left and right edges have 0.5 mm max distance:

$$z(x,y) = -2.5 + 5.56e-06 * x^2 - 2.37e-11 * x^2 * y^2 + 1.28e-05 * y^2$$

Figure 13a shows a section view along the x-axis of light propagating across an example embodiment of a curved touch plate 10 touch surface having a curved profile in the x-axis. In the section view, the propagation paths of light from a point light source 1310 are shown. Dotted lines 1320 show propagation paths of light emitted from point light source 1310a that are not received by detector surface 1340. Solid lines 1330 show propagation paths of light emitted form point light source 1310 that are received by detector surface 1340. As shown in the figure, a portion of the light is lost above the detector, a portion is lost below the detector, and a portion of the light is received at the detector surface. A person looking from the emitter point towards the mirror image of the detector (mirrored in the touch surface) will perceive the detector size as 2.2 times larger than the real detector. This magnification effect is an effect of using an off axis parabolic mirror. In the specific case of touch systems, this results in a detection signal boost of a factor of 2.2, when comparing to a flat touch surface. This boost applies only to the signal and not significantly to the ambient light otherwise received by the detectors. In a preferred embodiment, the detectors and emitters of the touch system are 3 mm or less above the touch surface (either directly or indirectly) and the length of the detection lines being in the range from 100 to 2500 mm, the angle of incidence is extremely close to 90 degrees. With this, gracing incidence, dirt or anti-glare coatings on the touch surface have no practical impact of the reflection, so it is practically a mirror.

Figure 13b provides a graph of the angle of the emitted light from the point light source 1310 with respect to the z-coordinate of the light path at the edge of the model of figure 13a. The detector surface z-coordinate range is shown by the vertical axis. Light emitted by point light source 1310 received at a z-coordinate within that range is received by the detector.

Figure 14a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a second point light source 1410 are shown. In this example, the detection signal boost is approximately 3.3. Figure 14b shows the corresponding graph of figure 13b for the second point light source 1410.

Figure 15a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a third point light source 1510 are shown. Figure

15b shows the corresponding graph of figure 13b for the third point light source 1510. In this example, the detection signal boost is approximately 3.03.

Figure 16a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a fourth point light source 1610 are shown. Figure 16b shows the corresponding graph of figure 13b for the fourth point light source 1610. In this example, the detection signal boost is approximately 2.71.

Figure 17a shows a section view of the embodiment of figure 13a. In the section view, the propagation paths of light from a fifth point light source 1710 are shown. Figure 17b shows the corresponding graph of figure 13b for the fifth point light source 1710. In this example, the detection signal boost is approximately 2.19.

Figures 13a-17b demonstrate that different emitter positions utilize different parts of the touch surface. The parts of the touch surface that work as reflectors will depend on the actual shape of the glass and the placement and sizes of the emitter and detector apertures surface 1340.

However, the touch plate 10 cannot be manufactured, positioned, or held in shape perfectly. Consequently, a certain amount of deviation can be expected between the curve followed by the touch surface and an ideal parabolic curve.

Figure 18a shows a graph of a mathematically defined parabolic curve and a real-world parabolic touch surface. In the example embodiment of figure 18a, a curved touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070mm along the y-axis (wherein the x-axis and y-axis are defined as in the embodiment shown in figure 12a,4b). In this example embodiment, the glass is shaped such that the touch surface follows parabolic curve 1810 relative to the x-axis. The maximum distance a between the touch surface and the x-axis is 10mm. The mathematically defined parabolic curve is defined as 1820. The graph shows the deviation between the mathematically defined parabolic curve represented by dotted line 1820 and real touch surface 1810. Here, the real touch surface is asymmetrically warped. Fig 10b shows the short to short mid cross section of a 2180 mm diagonal, 16:9 ratio, thermally tempered glass that is just within or at the maximum limit of concave distance < 6 mm as well as |parabolic deviation| < 0.5 mm.

The parabolic fit of the touch surface 1810 has an s-shaped residual. Such asymmetrical warping may be the result of problems with transport rollers or an uneven temperature distribution during the rapid cooling phase of tempering process during manufacture.

Figure 18b shows a graph of the deviation between the mathematically defined parabolic curve and a real-world parabolic touch surface of figure 18a.

The following table defines a preferred set of restrictions on the shape of the touch surface in order to achieve an optimal touch surface shape. The term 'warp' defines the distance of the touch surface from the respective axis intersecting the center point O in the direction of the z-axis.

Glass size	Min x-axis warp (mm)	Max x-axis warp (mm)	Min y-axis warp (mm)	Max y-axis warp (mm)	Max convexity* (mm)	Max parabolic deviation (mm)
55"	1.0	3.50	0.0	1.35	0.1	0.5
65"	1.0	4.50	0.0	1.65	0.1	0.5
70"	1.0	5.10	0.0	1.85	0.1	0.5
75"	1.0	5.70	0.0	2.00	0.1	0.5
84"-86"	1.0	6.00	0.0	2.00	0.1	0.5

Convexity b is shown in figure 18a. Parabolic deviation is shown in figure 18b.

Figure 19a shows another graph of a mathematically defined parabolic curve and a similar glass to that of figure 18a but wherein the glass of figure 19a is out of range and not recommended for touch system production. One reason for the large concavity shown in figure 19a may be that the tempering process has been run with too large differences between bottom and top cooling parameters in a quenching process during manufacturing. The mathematically defined parabolic curve is defined as 1920. The graph shows the deviation between the mathematically defined parabolic curve and real touch surface 1910.

Figure 19b shows a graph of the deviation between the mathematically defined parabolic curve and a real-world parabolic touch surface of figure 19a. The real-world parabolic touch surface of figure 19a is an example of a symmetrical but higher order warping (e.g. W shaped). Such warping may significantly reduce signal boost and may be caused by symmetrical temperature problems (e.g. too hot in center or edge of glass) during the manufacturing tempering process.

Figure 20a shows an embodiment in which the touch surface forms a paraboloid. In figure 20a, a top plan view of the touch surface is shown with contour lines showing the depth of the touch surface relative to a flat plane intersecting the four corners of the touch surface. The numbers shown on each contour represents the depth of the contour. The x-axis, y-axis, and diagonal-axis d are all shown. The x-axis is defined as an axis running parallel to and equidistant from the pair of long edges of the rectangle. The y-axis is defined as an axis running parallel to and equidistant from the pair of short edges of the rectangle. Diagonal-axis d is defined as an axis running diagonally from one corner to a

diagonally opposite corner. In this embodiment, the x-axis, y-axis, and diagonal axis d of touch surface 10 each describe a parabola with respect to the depth of the touch surface. In figure 20b, diagonal-axis d is shown running from the bottom left corner to the top right corner. In the example embodiment of figure 20a, the curved touch plate 10 has a width of 1900mm along the x-axis and a height of 1070 mm along the y-axis.

Figures 20b-20d show optional parabola configurations for the embodiment shown in figure 20a. Figure 20b shows a graph of the desired parabola of the touch surface underneath the x-axis and relative to the x-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the x-axis. Figure 20c shows a graph of the desired parabola of the touch surface underneath the y-axis and relative to the y-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the y-axis. Figure 20d shows a graph of the desired parabola of the touch surface underneath the diagonal-axis and relative to the diagonal-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the diagonal-axis.

The embodiments shown in figure 20a-20d describe a touch surface providing substantial signal boost for signals travelling between most emitters and detectors. However, the non-flat perimeter of the touch surface makes manufacture and assembly of such a system more complex.

Figure 21a shows an embodiment in which the touch surface forms an alternative paraboloid to that of the embodiment shown in figure 20a. As with figure 20a, figure 21a provides a top plan view of the touch surface is shown with contour lines showing the depth of the touch surface relative to a flat plane intersecting the four edges of the touch surface 10. The numbers shown on each contour represents the depth of the contour. X-axis, y-axis, and diagonal-axis d are all shown. The x-axis is defined as an axis running parallel to and equidistant from the pair of long edges of the rectangle. In this embodiment, the x-axis of touch surface 10 describes a parabola with respect to the depth of the touch surface. The y-axis is defined as an axis running parallel to and equidistant from the pair of short edges of the rectangle. In this embodiment, the y-axis of touch surface 10 also describes a parabola with respect to the depth of the touch surface. Diagonal-axis d is defined as an axis running diagonally from one corner to a diagonally opposite corner. In figure 21b, diagonal-axis d is shown running from the bottom left corner to the top right corner. In the example embodiment of figure 21a, the curved touch plate 10 has a width of 1900 mm along the x-axis and a height of 1070 mm along the y-axis. The perimeter of the touch surface of this embodiment is flat or close to flat. In embodiments where the perimeter of the touch surface is flat or close to flat, the surface beneath some detection lines will not be perfect parabolas. Even for an almost perfect

integrated glass shape with a warp in the range of 1-2.5 mm some detection lines (a very small portion) will actually have less signal than for a flat glass. This small drawback is counter balanced by the significant overall signal improvements. Furthermore, touch systems where the perimeter of the touch surface is flat or close to flat can be easier to manufacture and assemble.

Figure 21b shows a graph of the desired parabola of the touch surface underneath the x-axis and relative to the x-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the x-axis. Figure 21c shows a graph of the desired parabola of the touch surface underneath the y-axis and relative to the y-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the y-axis. Figure 21d shows a graph of the desired parabola of the touch surface underneath the diagonal-axis and relative to the diagonal-axis. The deviation (bottom axis) from the x-axis is shown relative to the position (left axis) along the diagonal-axis.

As will be apparent, the features and attributes of the specific embodiments disclosed above may be combined in different ways to form additional embodiments, all of which fall within the scope of the present disclosure.

Conditional language used herein, such as, among others, “can,” “could,” “might,” “may,” “e.g.,” and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

The present invention has been described above with reference to specific embodiments. However, other embodiments than the above described are equally possible within the scope of the invention. Different method steps than those described above may be provided within the scope of the invention. The different features and steps of the invention may be combined in other combinations than those described. The scope of the invention is only limited by the appended patent claims.

CLAIMS

1. An assembly for holding and controlling curvature of a plate (2) for an optical touch sensitive system, comprising

a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

at least one second frame element (103a, 103b; 203) extending in a second plane and forming a support portion (101a, 101b; 201b) for the plate (2), and

at least one spacing element positioned at least partially between the support portion (101a, 101b; 201b) and the first frame element (102; 202), the spacing element being configured to control a curvature of the first frame element (102; 202), and

wherein the at least one second frame element (103a, 103b; 203) is configured to engage the plate at the support portion (101a, 101b; 201b), is attached to the first frame element (102; 202), and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element (102, 202) with said spacing element, to control a curvature of the plate.

2. The assembly of claim 1, wherein the second frame element (103a, 103b; 203) is deflectable from a relaxed state to a deflected state, in which the second plane forms a parabolic concave curve along at least a portion of the length of the support portion (101a, 101b; 201b), and wherein a screw arrangement (112a, 112b, 112c, 113a, 113b; 219a, 219b, 219c) of the assembly holds the second frame element (103a, 103b; 203) in the deflected state when assembled with the first frame element (102; 202).

3. The assembly of any of claims 1 or 2, wherein a frame (109) of the first frame element (102) comprises a plurality of spacing elements arranged spaced apart from corners of the frame (209) of the first frame element (102), wherein the spacing elements are configured to generate a force to the frame (109) away from the support portion (101a, 101b).

4. The assembly of claim 3, wherein each spacing element comprises a screw (116, 116a, 116b) arranged in a hole of the frame (109).

5. The assembly of claim 4, wherein each spacing element (112, 112a, 112b) comprises a screw with a predefined length, and a spacer arranged between a head of the screw and the frame (109).

6. The assembly of any of the previous claims, wherein assembly comprises a plurality of attachment elements (112) arranged around the frame (109) for attaching the first frame element (102) to said panel (1).

7. The assembly of claim 6, wherein each attachment element (112) comprises a plurality of screws (112a, 112b, 112c, 113a, 113b) arranged in holes of the frame (109), wherein at least one of said screws (112a, 113b) is arranged to apply a first force to the frame (109) towards the support portion (101a, 101b), and at least one other of said screws (112b, 112c, 113b) is arranged to apply a second force to the frame (109) away from the support portion (101a, 101b).

8. The assembly of claim 7, wherein each attachment element (112) comprises at least two screws (113a, 113b), wherein a first screw (113a) of said two screws is arranged opposing the support portion (101a, 101b) and to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (113b) of said two screws is arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b) and to apply said second force to the frame (109) away from the support portion (101a, 101b).

9. The assembly of claim 7, wherein each attachment element (112) comprises at least three screws (112a, 112b, 112c), wherein all three screws are arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b), and wherein a first screw (112a) of said three screws is arranged to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (112b) and a third screw (112c) of said three screws are arranged to apply said second force to the frame (109) away from the support portion (101a, 101b), the first screw (112a) being arranged between the second screw (112b) and the third screw (112c).

10. The assembly of any of the previous claims, wherein a gasket (205) is arranged on another support portion (201a) of the second frame element (202), wherein the gasket (205) has a varying thickness along its length.

11. The assembly of claim 10, wherein the gasket (205) has opposing ends, and is thinner between the opposing ends than at said ends.

12. The assembly of claim 11, wherein a first section (205a) of the gasket (205) at one of said ends and a second section (205b) of the gasket (205) at the other of said ends has a first thickness, and at least a third section (205c) of the gasket between the first section (205a) and the second section (205b) has a second thickness, wherein the first thickness is thicker than the second thickness.

13. The frame assembly of any of claims 10-12, wherein the second frame element (203) comprises a frame side and the third frame element comprises an edge cover, and wherein the edge cover comprises another support portion for said panel (1), wherein a distance between the support portion of the frame side and the support portion of the edge cover is discontinuous in an assembled state.

14. The frame assembly of claim 13, wherein the frame side comprises a first hole (217a) and a second hole (217b) arranged at opposing ends of the frame side and in a first plane, and a third hole (217c) arranged between the first hole (217a) and the second hole (217c) and in a plane that is different from the first plane, and

the edge cover comprises a first hole (218a) and a second hole (218b) arranged at opposing ends of the edge cover, and a third hole (218c) arranged between the first hole (218a) and the second hole (218c) of the edge cover, wherein the first hole (218a), the second hole (218b), and the third hole (218c) of the edge cover are generally arranged in the same plane when the edge cover is disconnected from the frame side, and

wherein the edge cover is less stiff than the frame side and deflectable such that the holes (218a, 218b, 218c) of the edge cover are aligned with the holes (217a, 217b, 217c) of the frame side and such that the support portion of the edge cover extends in a plane, which is curved.

15. A method for assembling a panel and a plate for an optical touch sensitive system, comprising:

providing a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

providing at least one second frame element (103a, 103b; 203) forming a support portion (101a, 101b; 201b) for the plate (2);

supporting the plate (2) by the support portion (101a, 101b, 201b);

attaching the second frame element to the first frame element (102; 202) such that

the support portion (101a, 101b; 201b) extends at least partially in a second plane generally opposite at least a portion of the first frame element (102; 202) and is spaced apart from the first plane; and

controlling a curvature of the first frame element (102; 102) with a spacing element attached to the first frame element (102; 202) and thereby tilting the support portion (101a, 101b, 201b) to control a curvature of the plate (2).

16. A touch sensing apparatus, comprising:

a touch surface;

a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface,

a set of light detectors arranged around the touch surface to receive light from the first set of emitters,

wherein each light detector is arranged to receive light from more than one emitter;

a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface,

wherein the touch surface is curved in a first axis according to a first parabola.

17. The touch sensing apparatus of claim 16, wherein the touch surface is curved in a second axis according to a second parabola.

18. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

19. The touch sensing apparatus of claim 18, wherein the first parabolic curve paraboloid is an elliptical paraboloid.

20. The touch sensing apparatus of claim 16, wherein each point of the first axis of the touch surface is within 0.5mm of a mathematical parabola.

21. The touch sensing apparatus of claim 16, wherein the mathematical parabola is defined according to $z(x, y)=a+bx^2+cx^2y^2+dy^2$, where z is depth, and x and y are co-ordinates in the plane of the glass.

22. The touch sensing apparatus of claim 16, wherein the touch surface comprises a portion of a surface of a plate.

23. The touch sensing apparatus of claim 22, wherein the plate comprises a glass or plastic sheet.

24. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

AMENDED CLAIMS
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[Claim 1] An assembly (100) for holding and controlling curvature of a plate (2) for an optical touch sensitive system, comprising
a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);
at least one second frame element (103a, 103b; 203) extending in a second plane and forming a support portion (101a, 101b; 201b) for the plate (2), and
at least one spacing element (116) positioned at least partially between the support portion (101a, 101b; 201b) and the first frame element (102; 202), the spacing element (116) being configured to control a curvature of the first frame element (102; 202), and
wherein the at least one second frame element (103a, 103b; 203) is configured to engage the plate at the support portion (101a, 101b; 201b), is attached to the first frame element (102; 202), and wherein the shape and/or position of the second frame element is controlled by the curvature of the first frame element (102, 202) with said spacing element (116), to control a curvature of the plate.

[Claim 2] The assembly (100) of claim 1, wherein the second frame element (103a, 103b; 203) is deflectable from a relaxed state to a deflected state, in which the second plane forms a parabolic concave curve along at least a portion of the length of the support portion (101a, 101b; 201b), and wherein a screw arrangement (112a, 112b, 112c, 113a, 113b; 219a, 219b, 219c) of the assembly (100) holds the second frame element (103a, 103b; 203) in the deflected state when assembled with the first frame element (102; 202).

[Claim 3] 3. The assembly (100) of any of claims 1 or 2, wherein a frame (109) of the first frame element (102) comprises a plurality of spacing elements (116) arranged spaced apart from corners of the frame (209) of the first frame element (102), wherein the spacing elements are configured to generate a force to the frame (109) away from the support portion (101a, 101b).

[Claim 4] The assembly (100) of claim 3, wherein each spacing element (116) comprises a screw (116, 116a, 116b) arranged in a hole of the frame (109).

[Claim 5] The assembly (100) of claim 4, wherein each spacing element (116) comprises a screw with a predefined length, and a spacer arranged

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between a head of the screw and the frame (109).

[Claim 6] 6. The assembly (100) of any of the previous claims, wherein assembly (100) comprises a plurality of attachment elements (112) arranged around the frame (109) for attaching the first frame element (102) to said panel (1).

[Claim 7] The assembly (100) of claim 6, wherein each attachment element (112) comprises a plurality of screws (112a, 112b, 112c, 113a, 113b) arranged in holes of the frame (109), wherein at least one of said screws (112a, 113b) is arranged to apply a first force to the frame (109) towards the support portion (101a, 101b), and at least one other of said screws (112b, 112c, 113b) is arranged to apply a second force to the frame (109) away from the support portion (101a, 101b).

[Claim 8] 8. The assembly (100) of claim 7, wherein each attachment element (112) comprises at least two screws (113a, 113b), wherein a first screw (113a) of said two screws is arranged opposing the support portion (101a, 101b) and to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (113b) of said two screws is arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b) and to apply said second force to the frame (109) away from the support portion (101a, 101b).

[Claim 9] The assembly (100) of claim 7, wherein each attachment element (112) comprises at least three screws (112a, 112b, 112c), wherein all three screws are arranged closer to a center of the first frame element (102) than a perimeter of the support portion (101a, 101b), and wherein a first screw (112a) of said three screws is arranged to apply said first force to the frame (109) towards the support portion (101a, 101b), and a second screw (112b) and a third screw (112c) of said three screws are arranged to apply said second force to the frame (109) away from the support portion (101a, 101b), the first screw (112a) being arranged between the second screw (112b) and the third screw (112c).

[Claim 10] 10. The assembly (100) of any of the previous claims, wherein a gasket (205) is arranged on another support portion (201a) of the second frame element (202), wherein the gasket (205) has a varying thickness along its length.

[Claim 11] The assembly (100) of claim 10, wherein the gasket (205) has opposing ends, and is thinner between the opposing ends than at said ends.

[Claim 12] The assembly (100) of claim 11, wherein a first section (205a) of the

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gasket (205) at one of said ends and a second section (205b) of the gasket (205) at the other of said ends has a first thickness, and at least a third section (205c) of the gasket between the first section (205a) and the second section (205b) has a second thickness, wherein the first thickness is thicker than the second thickness.

[Claim 13] 13. The assembly (100) of any of claims 10-12, wherein the second frame element (203) comprises a frame side and the third frame element comprises an edge cover, and wherein the edge cover comprises another support portion for said panel (1), wherein a distance between the support portion of the frame side and the support portion of the edge cover is discontinuous in an assembled state.

[Claim 14] The assembly (100) of claim 13, wherein the frame side comprises a first hole (217a) and a second hole (217b) arranged at opposing ends of the frame side and in a first plane, and a third hole (217c) arranged between the first hole (217a) and the second hole (217c) and in a plane that is different from the first plane, and

the edge cover comprises a first hole (218a) and a second hole (218b) arranged at opposing ends of the edge cover, and a third hole (218c) arranged between the first hole (218a) and the second hole (218c) of the edge cover, wherein the first hole (218a), the second hole (218b), and the third hole (218c) of the edge cover are generally arranged in the same plane when the edge cover is disconnected from the frame side, and

wherein the edge cover is less stiff than the frame side and deflectable such that the holes (218a, 218b, 218c) of the edge cover are aligned with the holes (217a, 217b, 217c) of the frame side and such that the support portion of the edge cover extends in a plane, which is curved.

[Claim 15] 15. A method for assembling a panel and a plate for an optical touch sensitive system, comprising:

providing a first frame element (102; 202) extending in a first plane and configured to extend at least partially around a panel (1);

providing at least one second frame element (103a, 103b; 203) forming a support portion (101a, 101b; 201b) for the plate (2);

supporting the plate (2) by the support portion (101a, 101b, 201b);

attaching the second frame element to the first frame element (102; 202) such that

the support portion (101a, 101b; 201b) extends at least partially in a second plane generally opposite at least a portion of the first frame

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element (102; 202) and is spaced apart from the first plane; and controlling a curvature of the first frame element (102; 102) with a spacing element (116) attached to the first frame element (102; 202) and thereby tilting the support portion (101a, 101b, 201b) to control a curvature of the plate (2).

[Claim 16] 16. A touch sensing apparatus, comprising:
a touch surface;
a set of emitters arranged around the touch surface to emit first beams of light to propagate across the touch surface,
a set of light detectors arranged around the touch surface to receive light from the first set of emitters,
wherein each light detector is arranged to receive light from more than one emitter;
a processing element configured to determine, based on output signals of the set of light detectors, the position of an object on the touch surface,
wherein the touch surface is curved in a first axis according to a first parabola.

[Claim 17] 17. The touch sensing apparatus of claim 16, wherein the touch surface is curved in a second axis according to a second parabola.

[Claim 18] 18. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

[Claim 19] 19. The touch sensing apparatus of claim 18, wherein the first parabolic curve paraboloid is an elliptical paraboloid.

[Claim 20] 20. The touch sensing apparatus of claim 16, wherein each point of the first axis of the touch surface is within 0.5mm of a mathematical parabola.

[Claim 21] 21. The touch sensing apparatus of claim 20, wherein the mathematical parabola is defined according to $z(x, y)=a+bx^2+cx^2y^2+dy^2$, where z is depth, and x and y are co-ordinates in the plane of the glass.

[Claim 22] 22. The touch sensing apparatus of claim 16, wherein the touch surface comprises a portion of a surface of a plate.

[Claim 23] 23. The touch sensing apparatus of claim 22, wherein the plate comprises a glass or plastic sheet.

[Claim 24] 24. The touch sensing apparatus of claim 16, wherein the touch surface forms a paraboloid.

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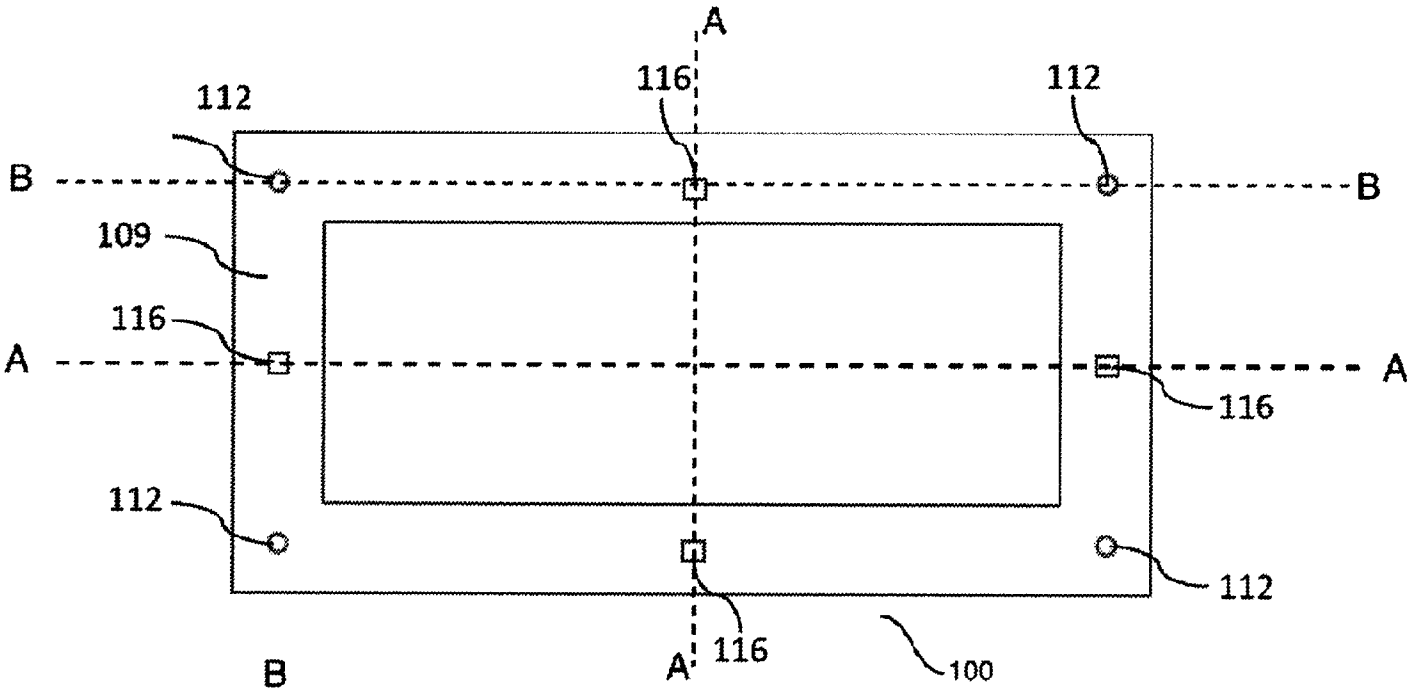


Figure 1

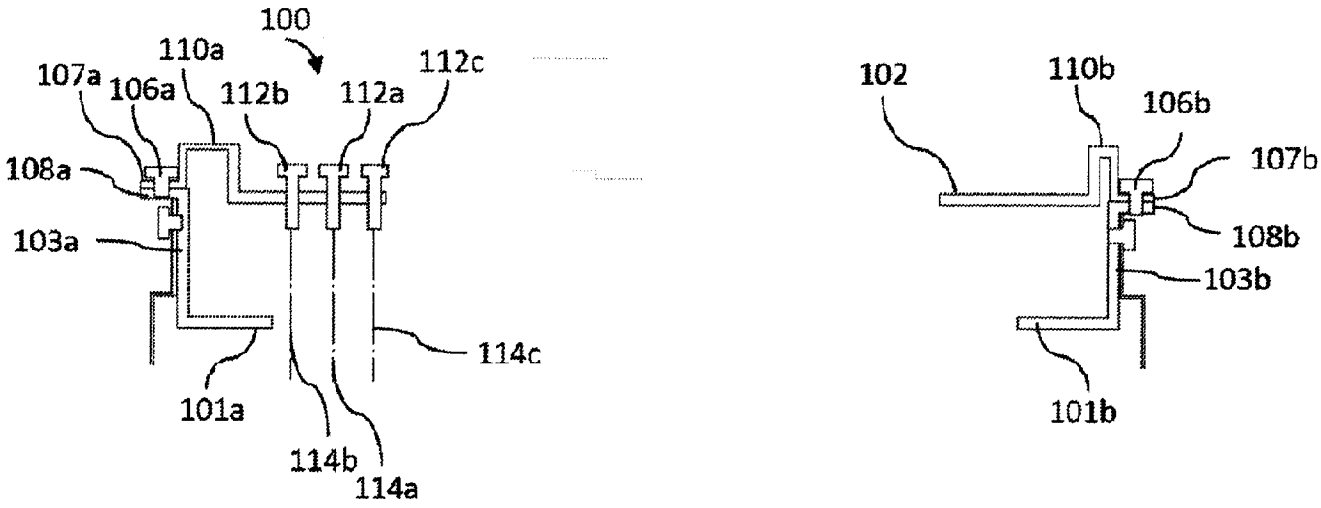

100
110a
107a
106a
112b
112a
112c
108a
103a
114c
101a
114b
114a
102
110b
106b
107b
108b
103b
101b

Figure 2a

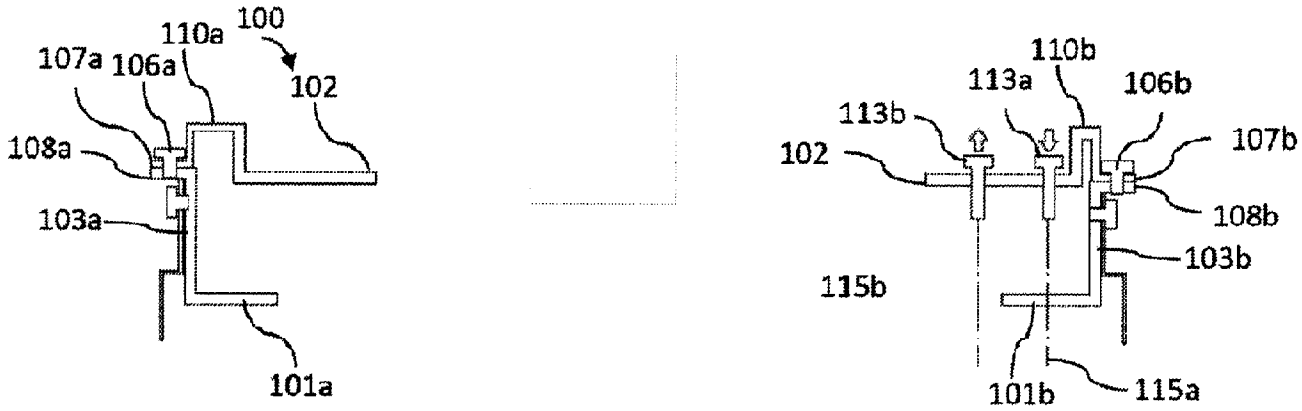

100
110a
107a
106a
102
108a
103a
101a
110b
113a
106b
113b
107b
102
108b
103b
115b
101b
115a

Figure 2b

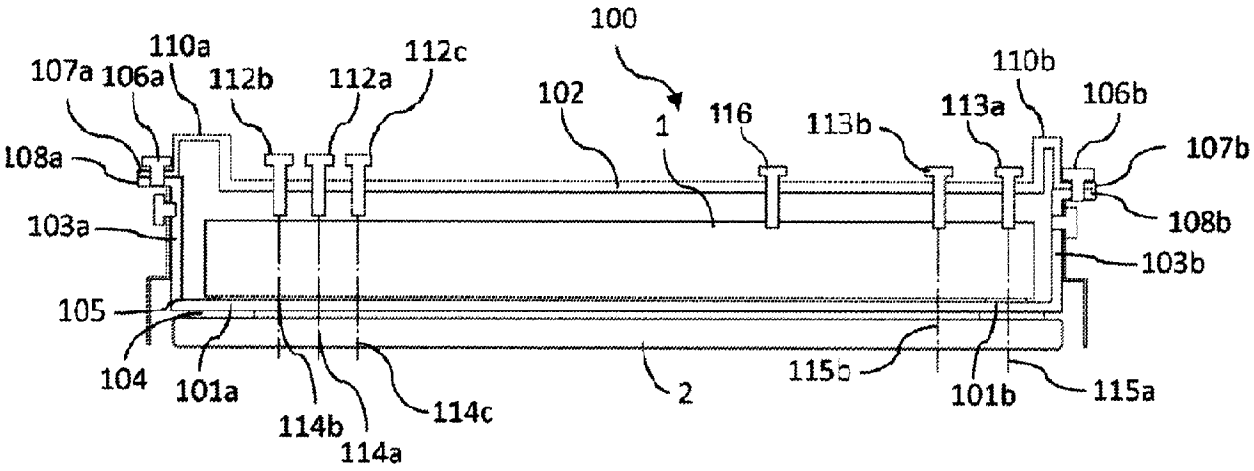


Figure 2c

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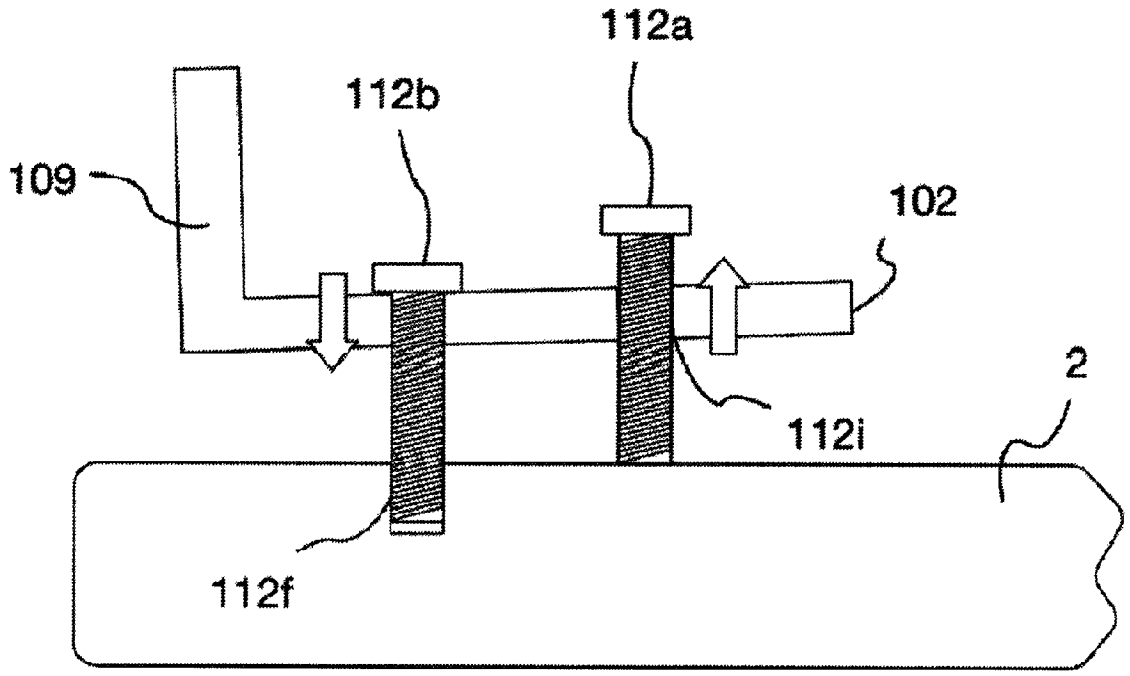


Figure 2d

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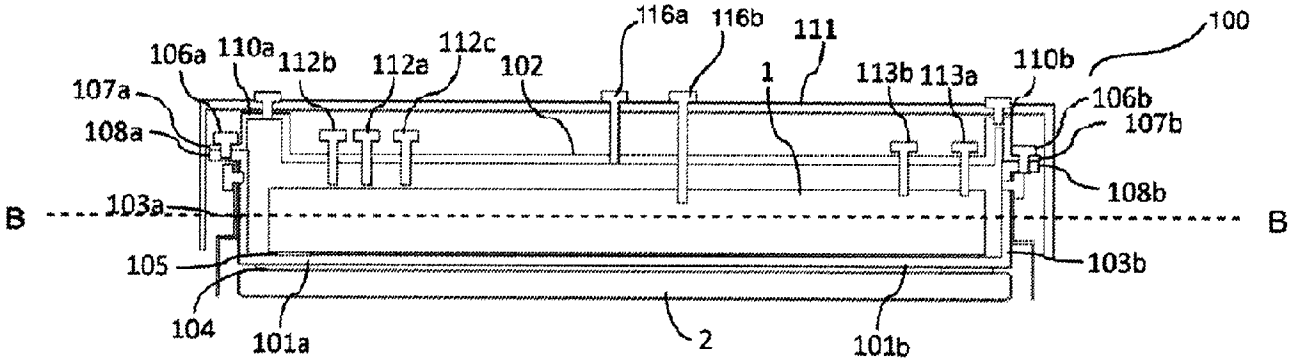


Figure 3a

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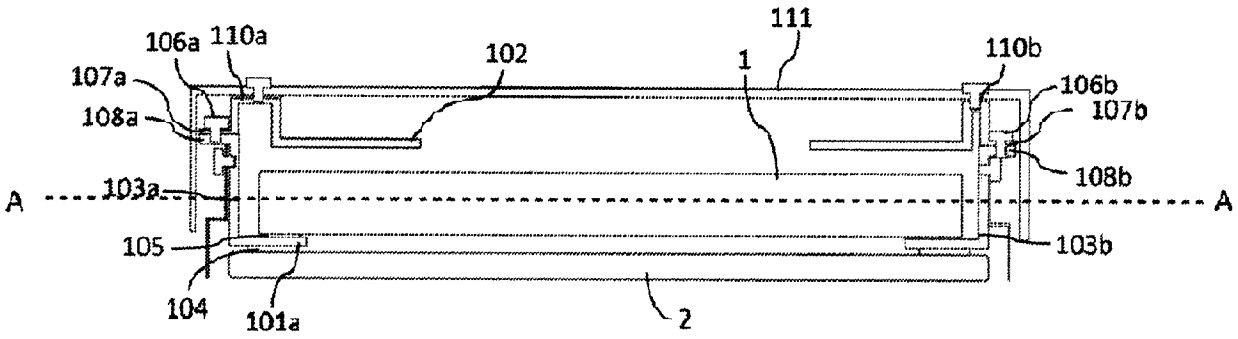

111
106a
110a
102
1
110b
107a
106b
107b
108a
108b
A
103a
A
105
103b
104
101a
2

Figure 3b

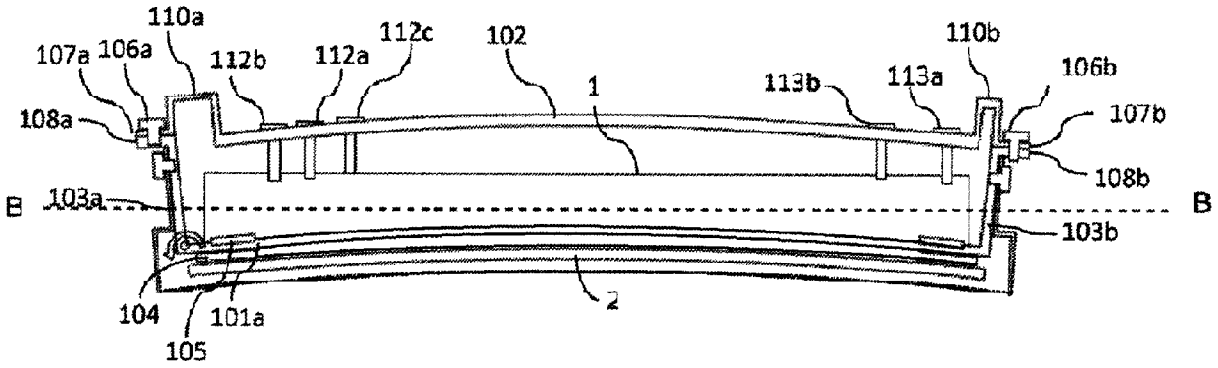

110a
107a
106a
112b
112a
112c
102
1
110b
113b
113a
106b
107b
108a
108b
B
103a
B
103b
104
101a
105
2

Figure 3c

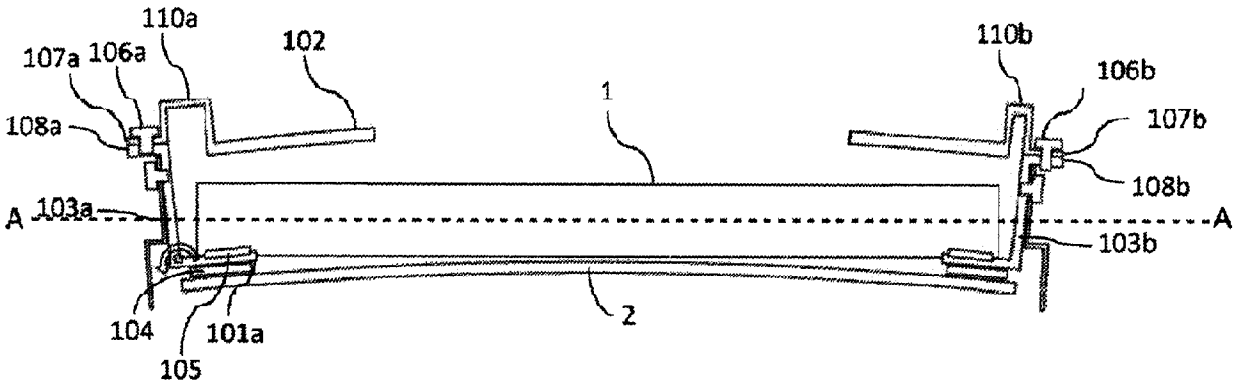

110a
102
107a
106a
108a
A
103a
104
105
101a
1
2
110b
106b
107b
108b
103b
A

Figure 3d

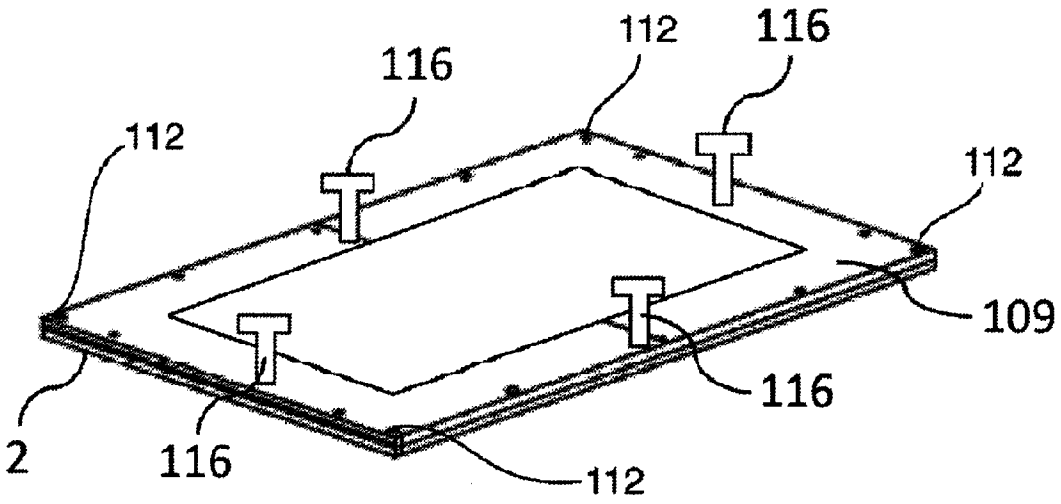


Figure 4a

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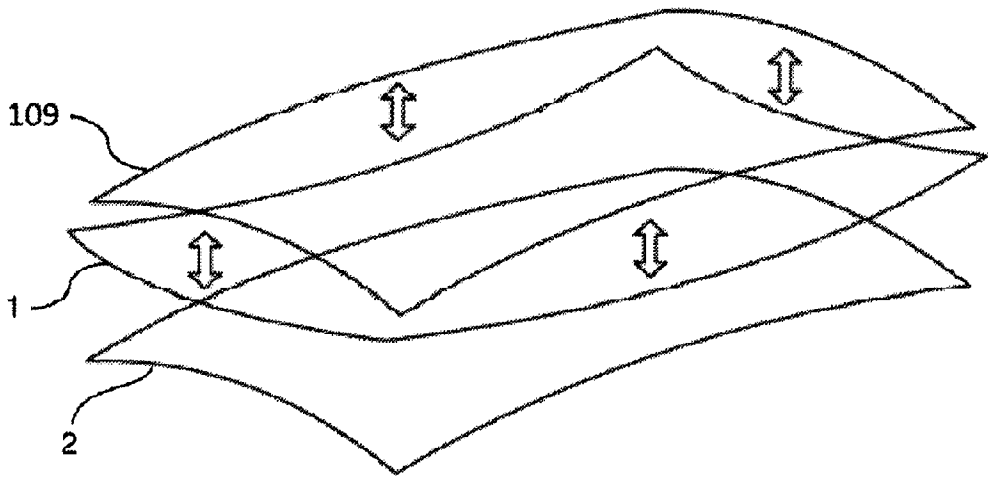


Figure 4b

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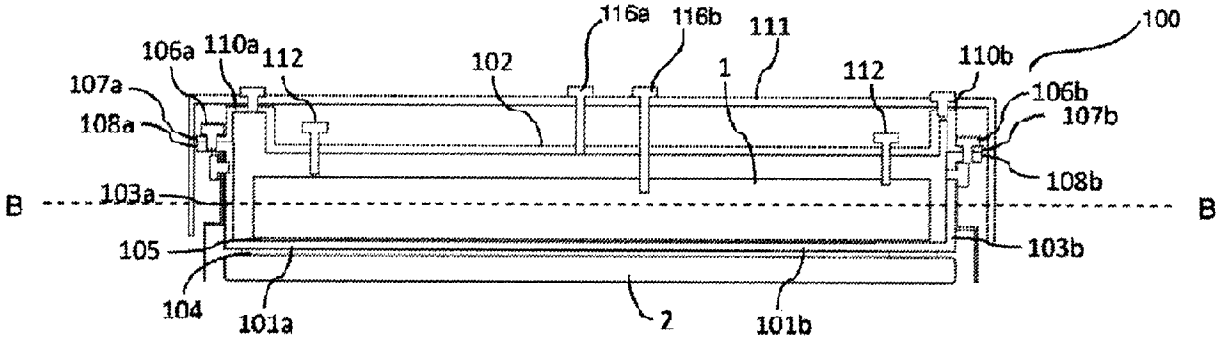

116a
116b
111
100
106a
110a
112
102
1
112
110b
107a
106b
108a
107b
B
103a
108b
B
105
103b
104
101a
2
101b

Figure 4c

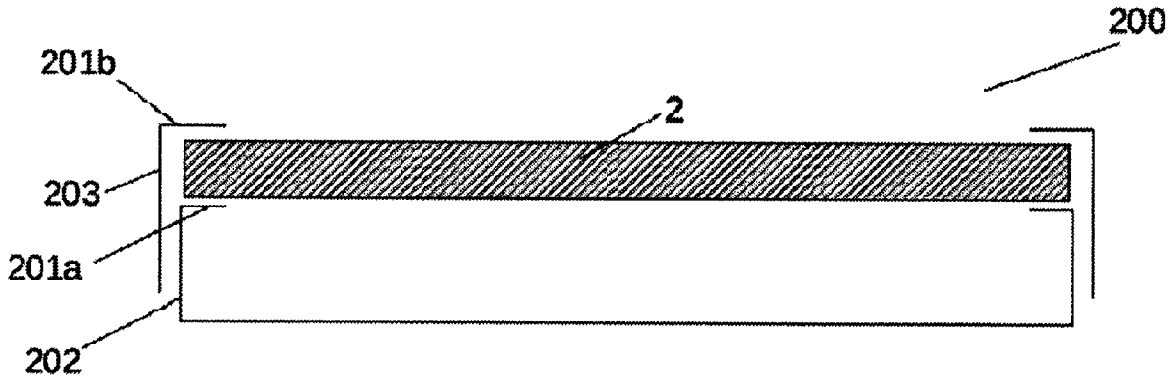


Figure 5a

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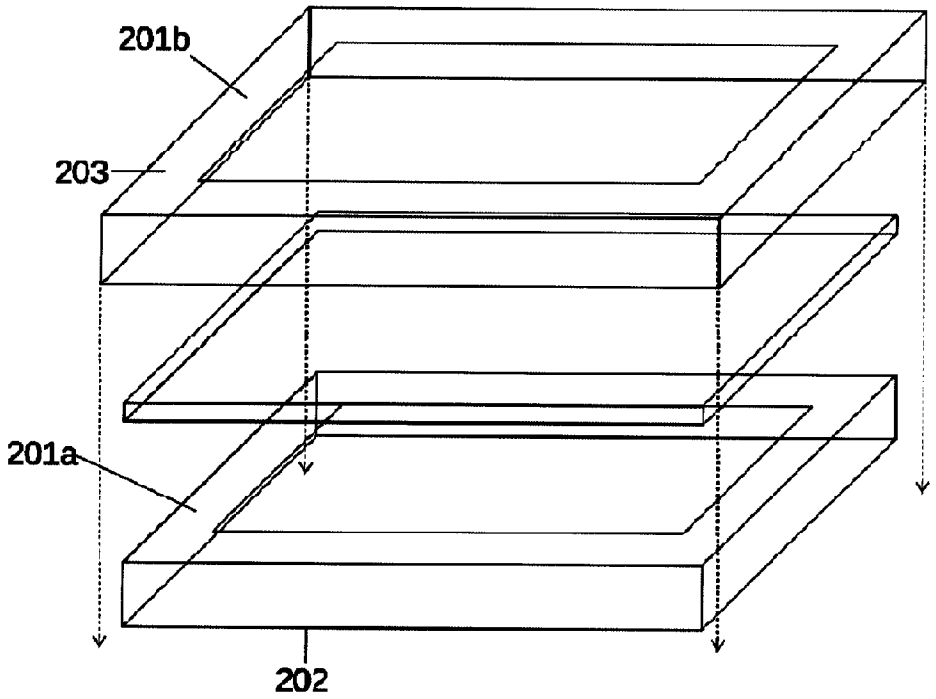


Figure 5b

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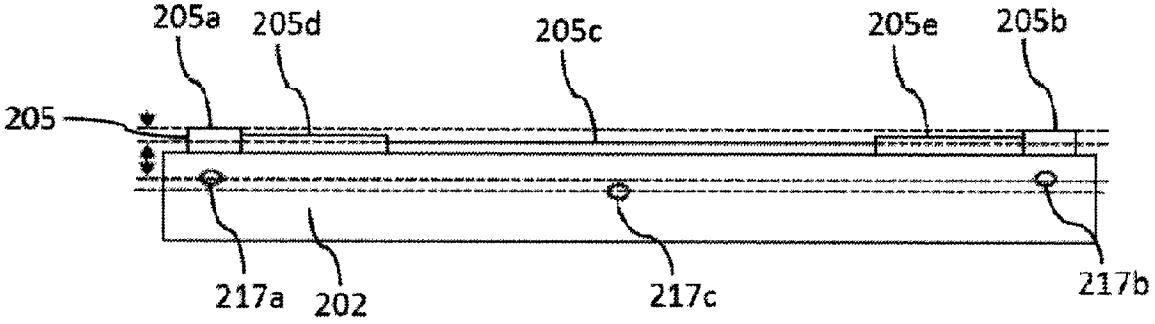


Figure 5c

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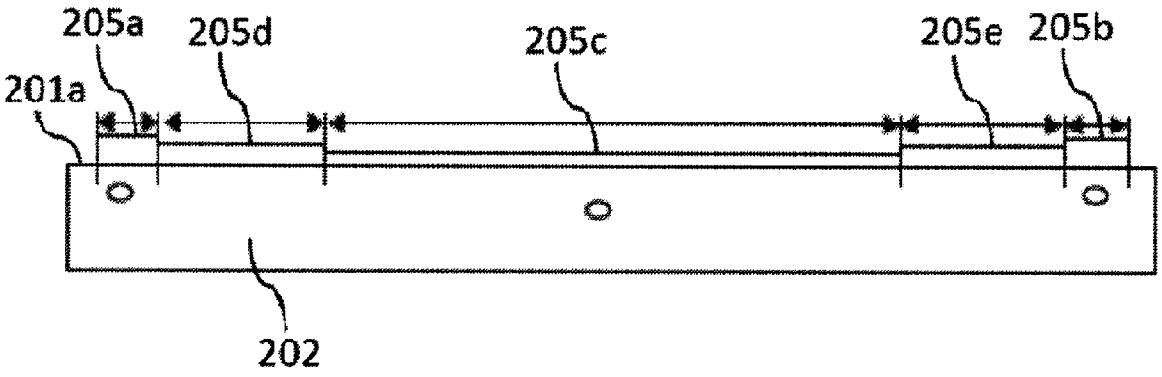


Figure 5d

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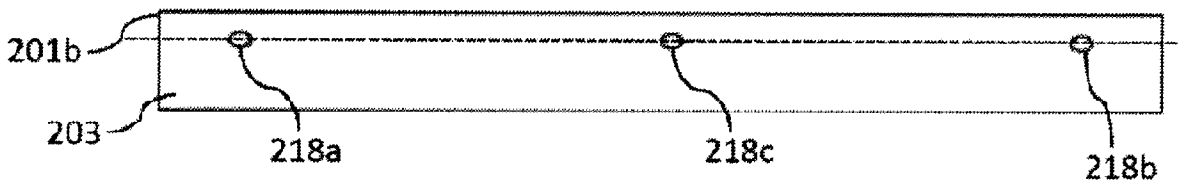


Figure 5e

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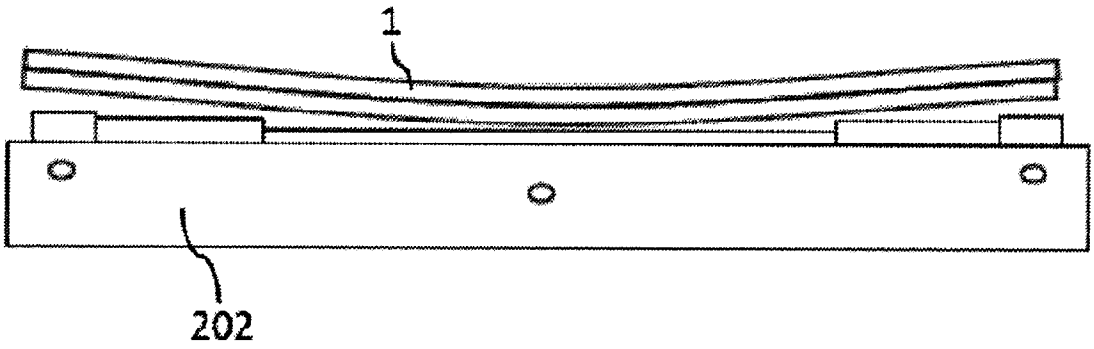


Figure 5f

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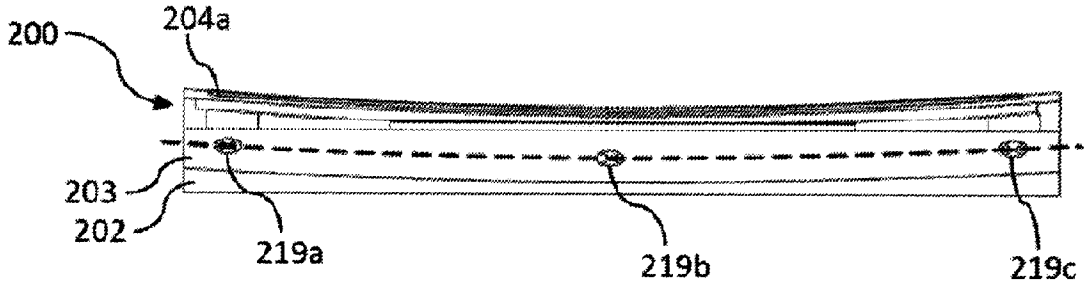


Figure 5g

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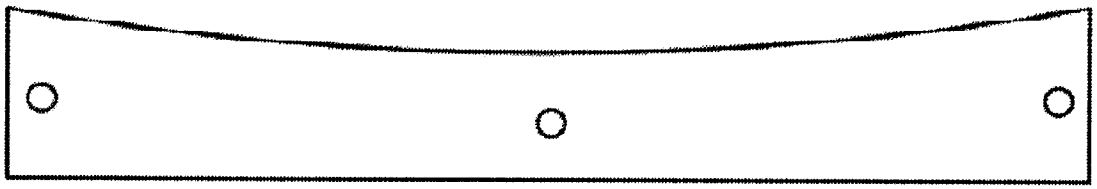


Figure 5h

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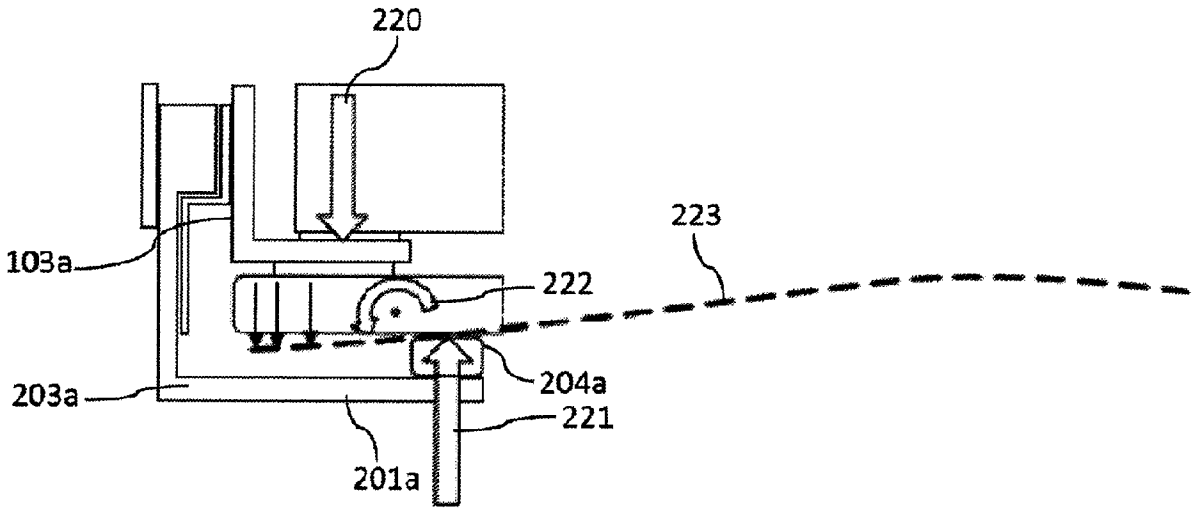


Figure 6

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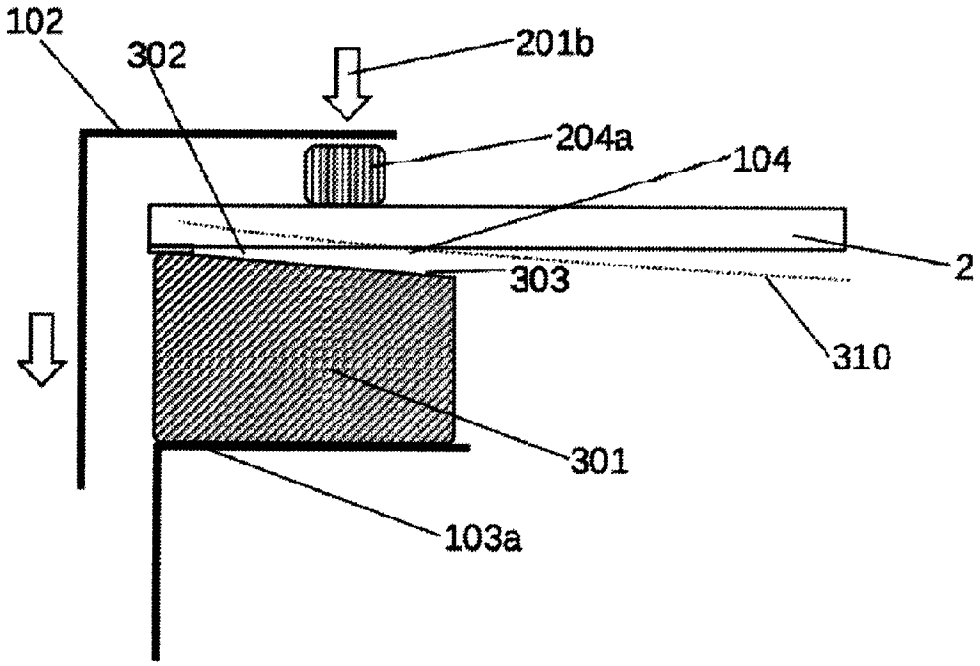


Figure 7

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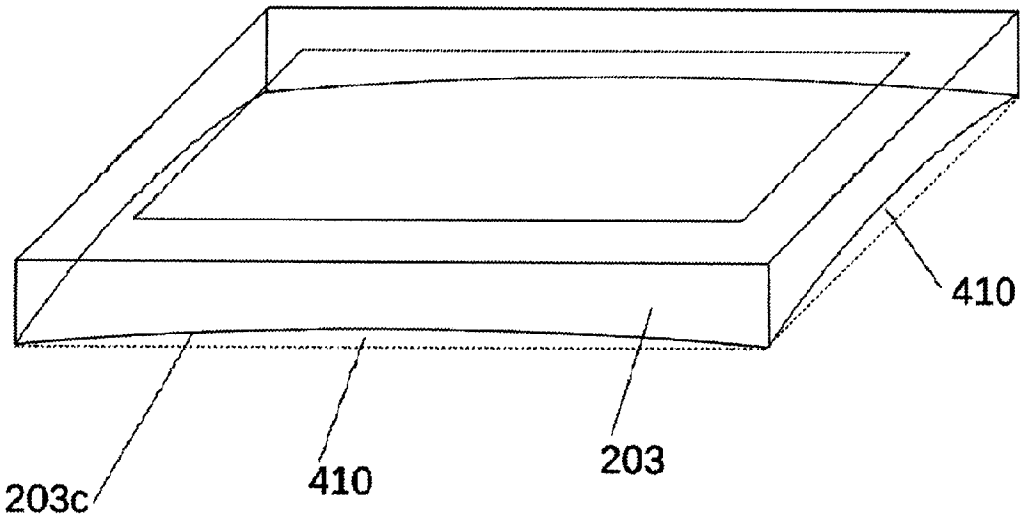


Figure 8

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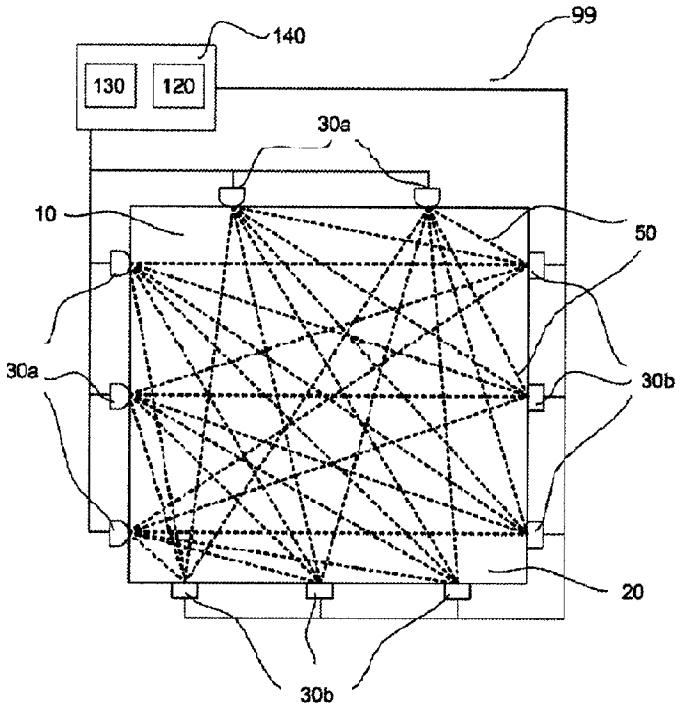


Figure 9

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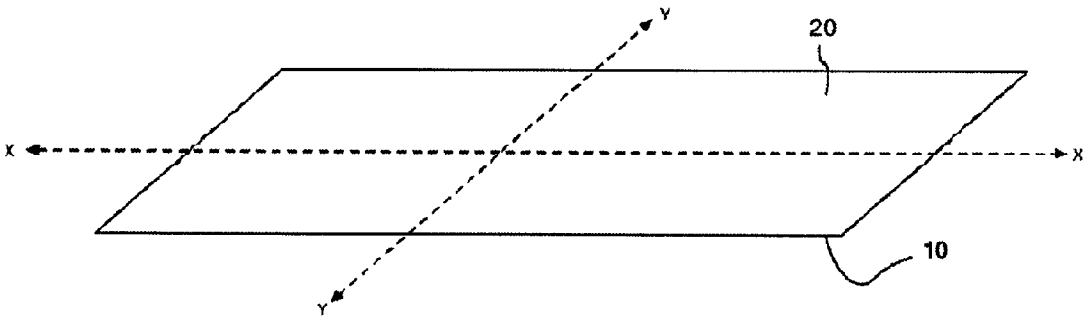


Figure 10a

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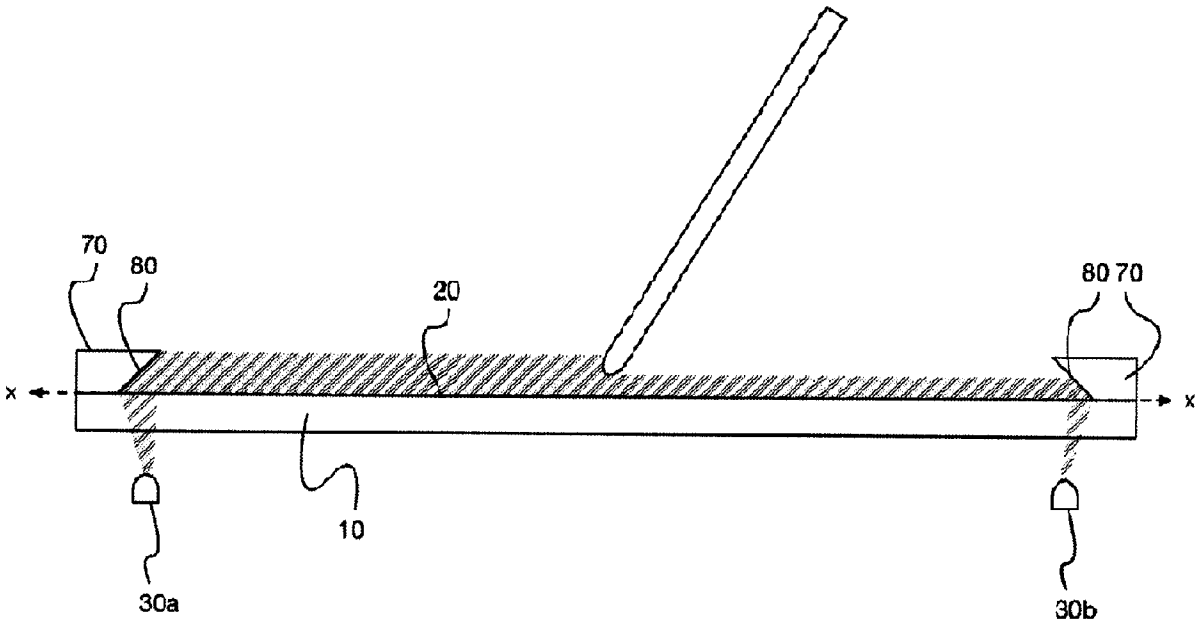


Figure 10b

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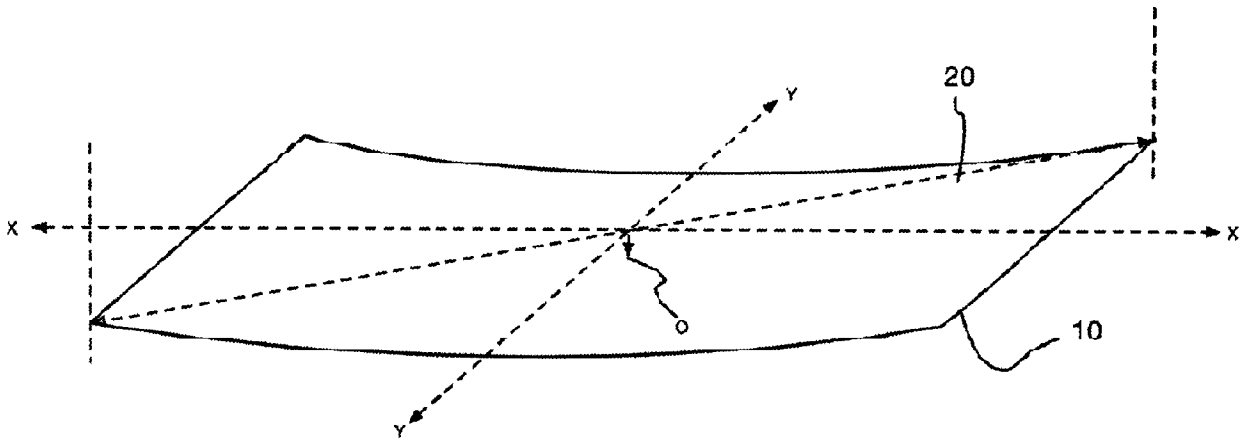


Figure 11a

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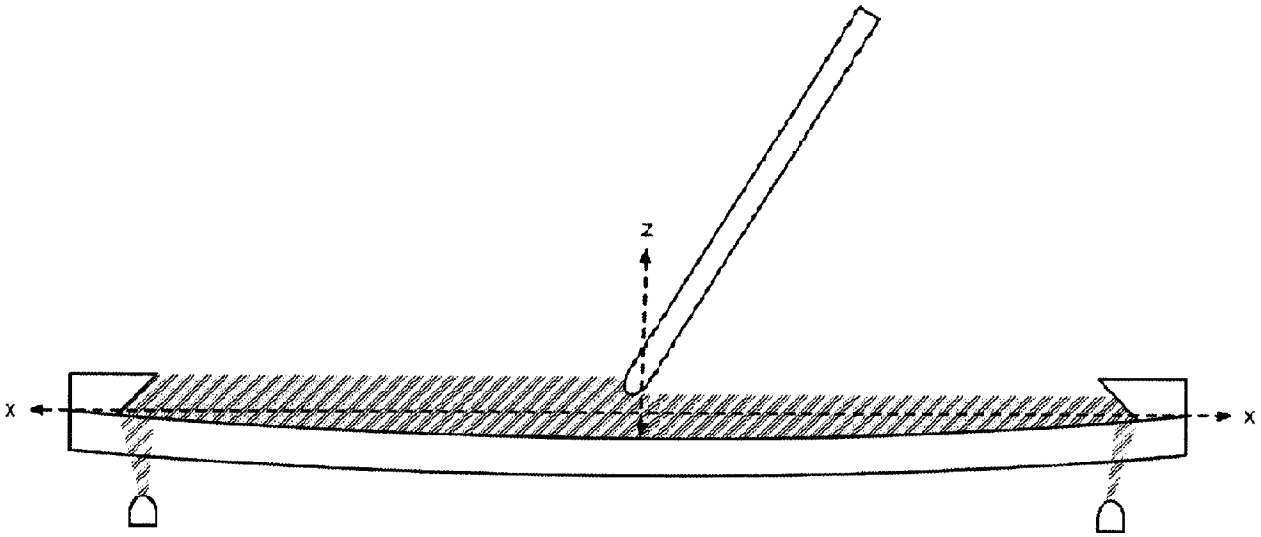


Figure 11b

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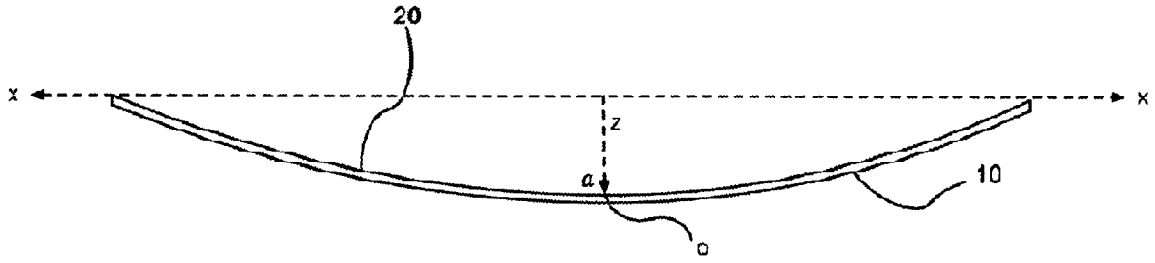


Figure 11c

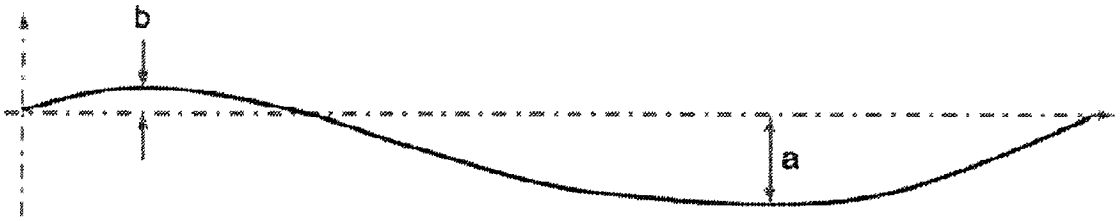


Figure 11d

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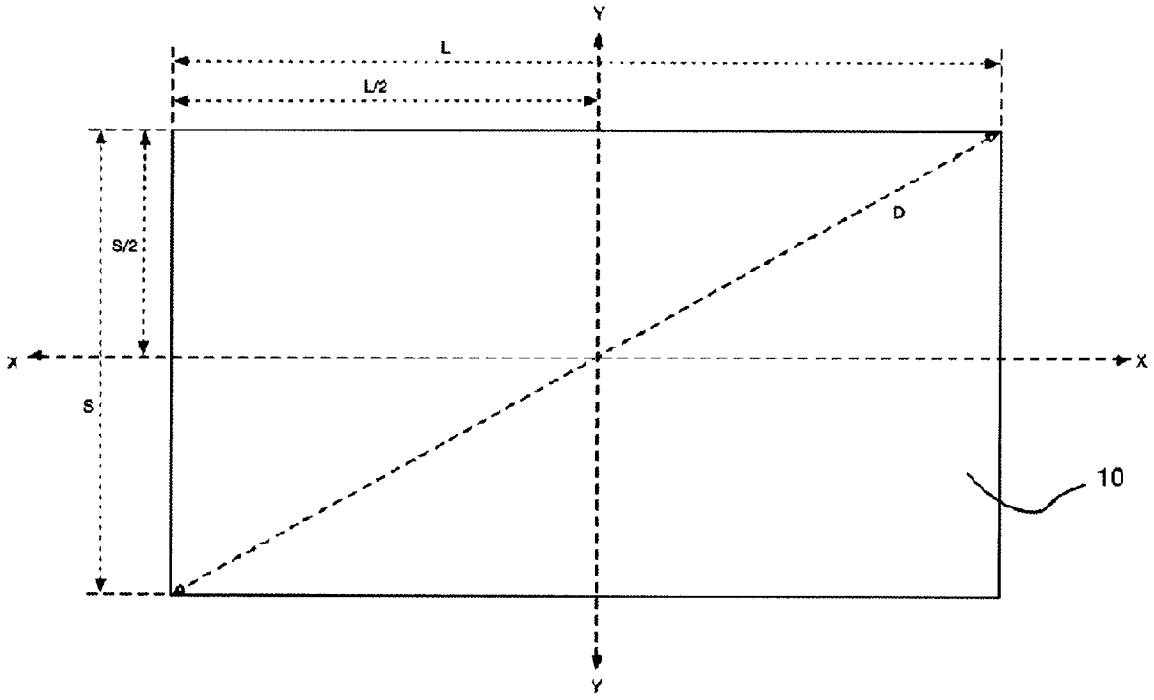


Figure 12a

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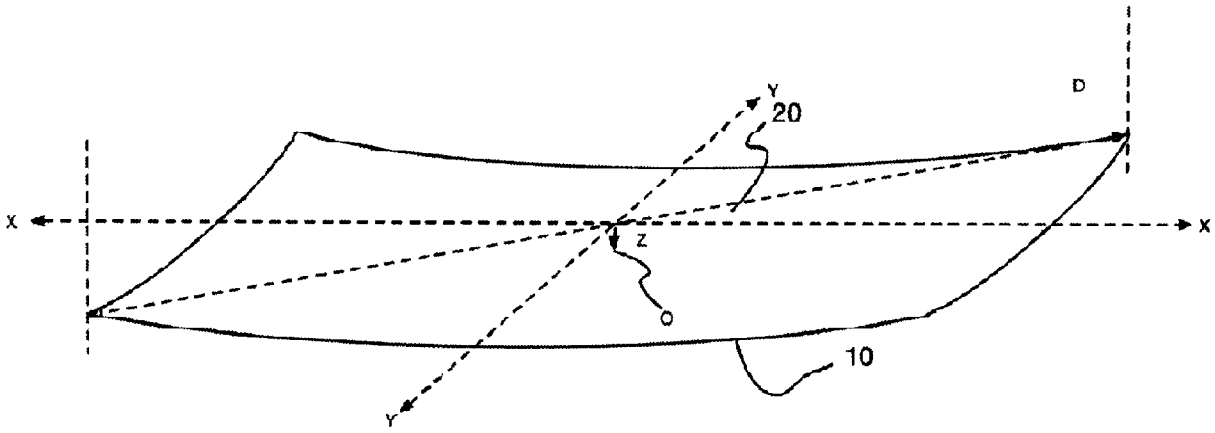


Figure 12b

IPR2024-00013
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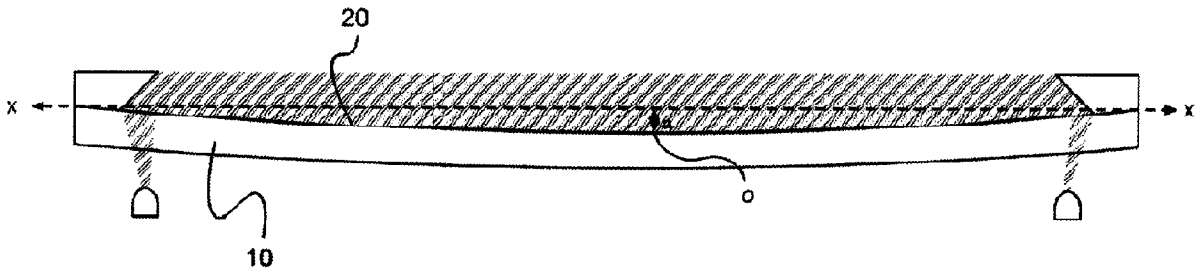


Figure 12c

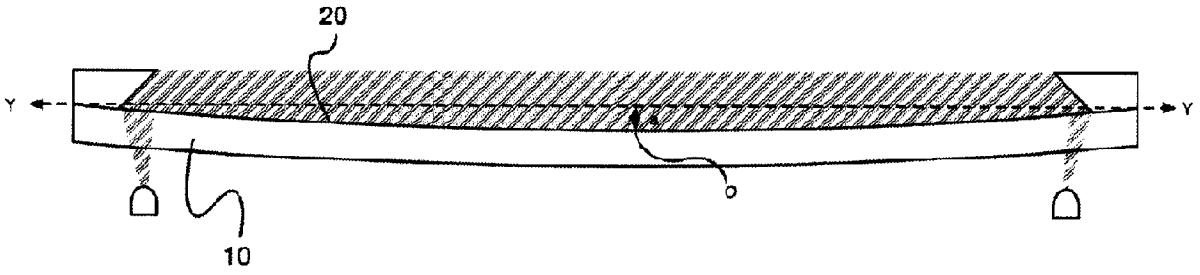


Figure 12d

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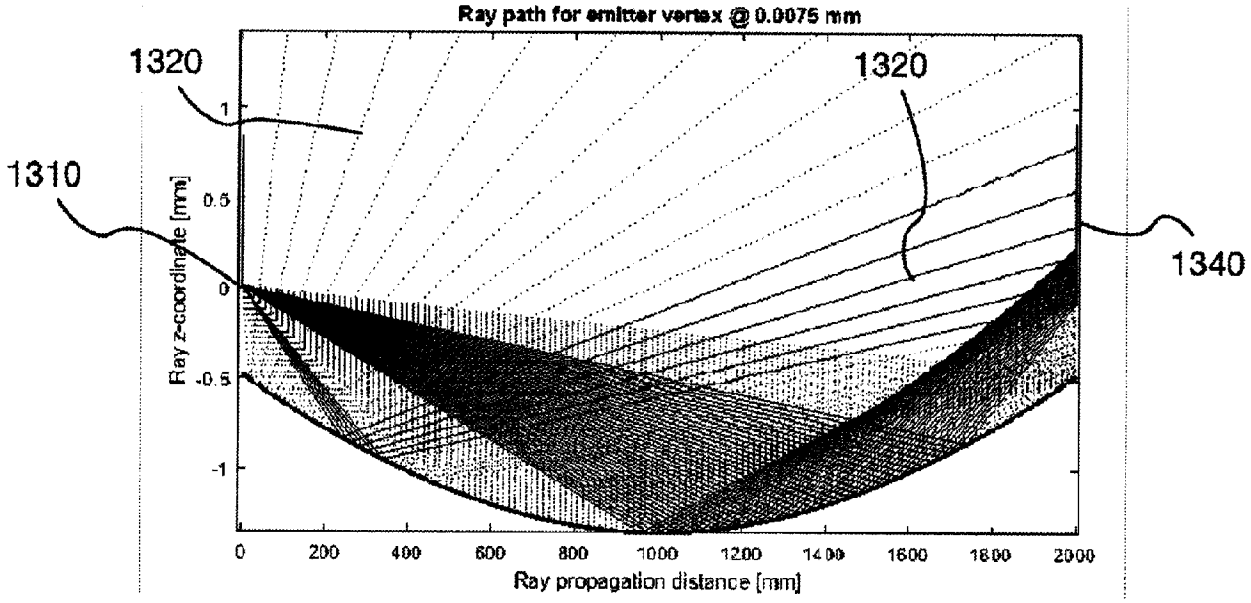

Ray path for emitter vertex @ 0.0075 mm
1320
1320
1310
1340
Ray z-coordinate [mm]
Ray propagation distance [mm]
1
0.5
0
-0.5
-1
0
200
400
600
800
1000
1200
1400
1600
1800
2000

Figure 13a

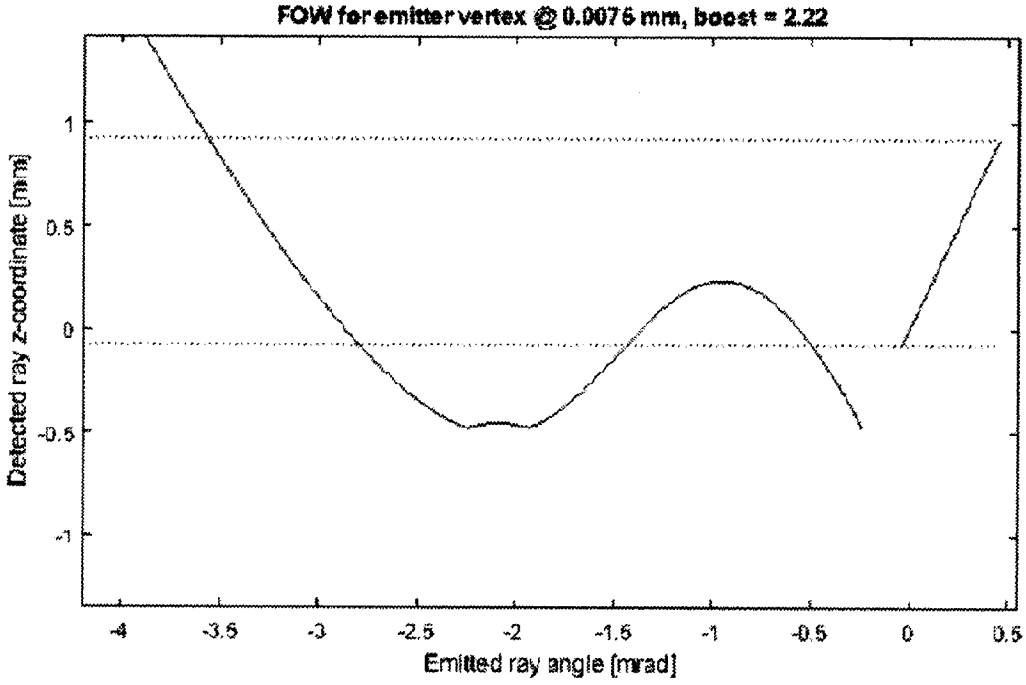


Figure 13b

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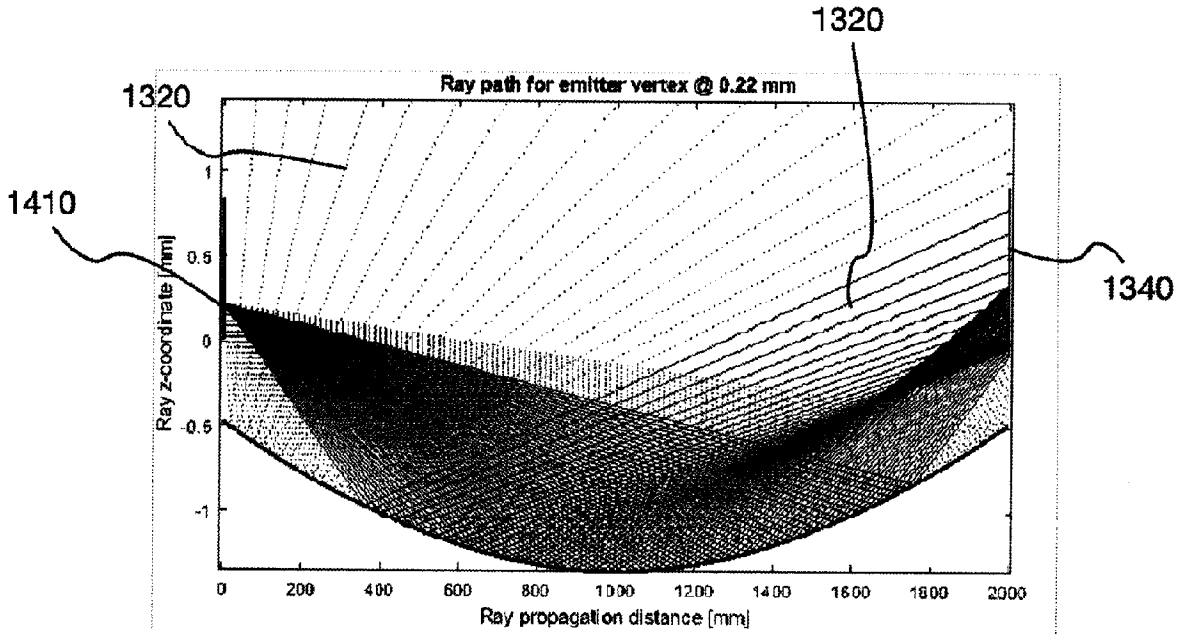


Figure 14a

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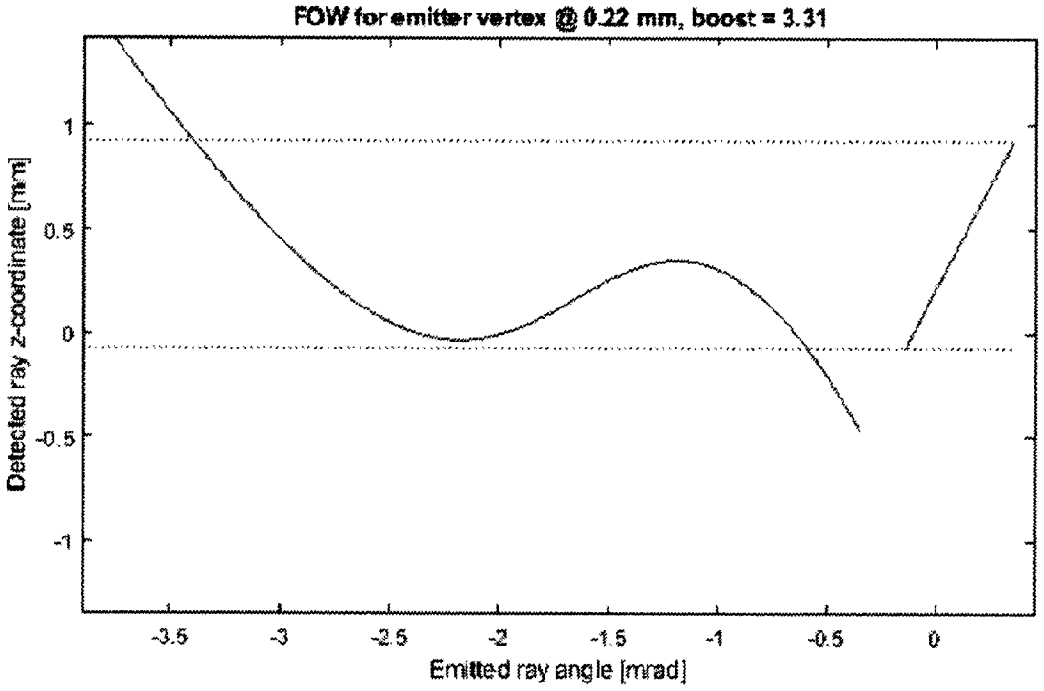


Figure 14b

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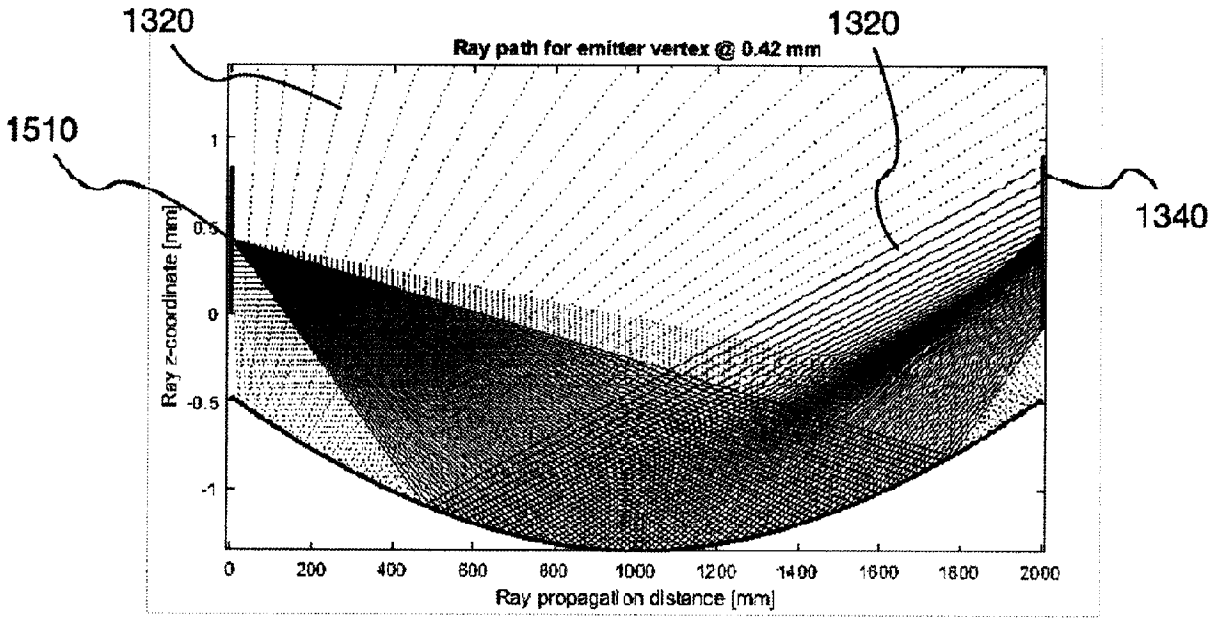


Figure 15a

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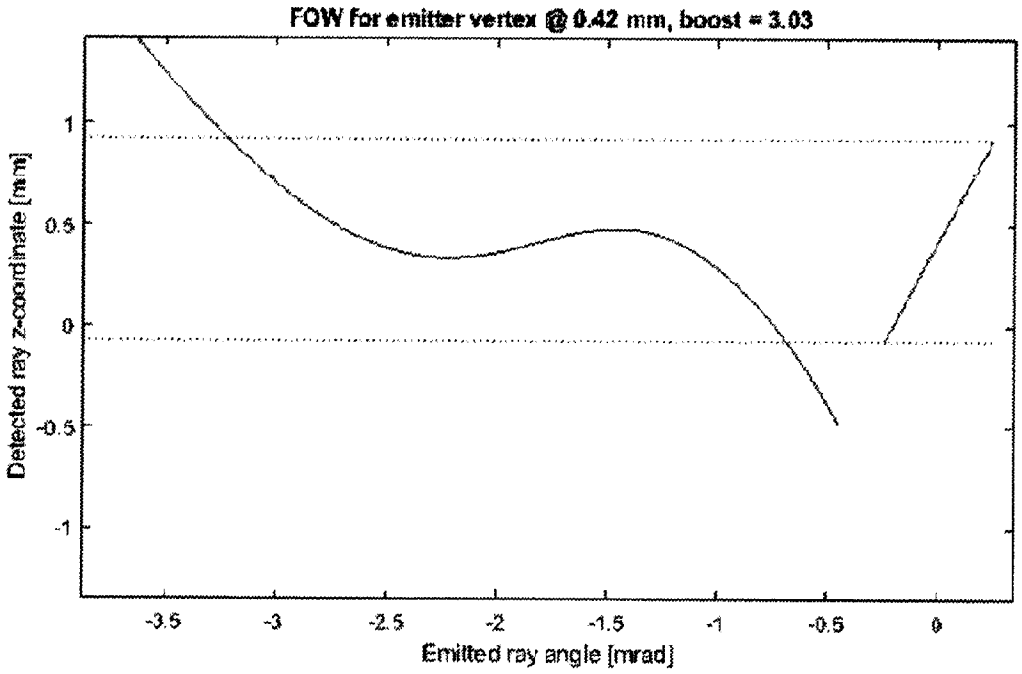


Figure 15b

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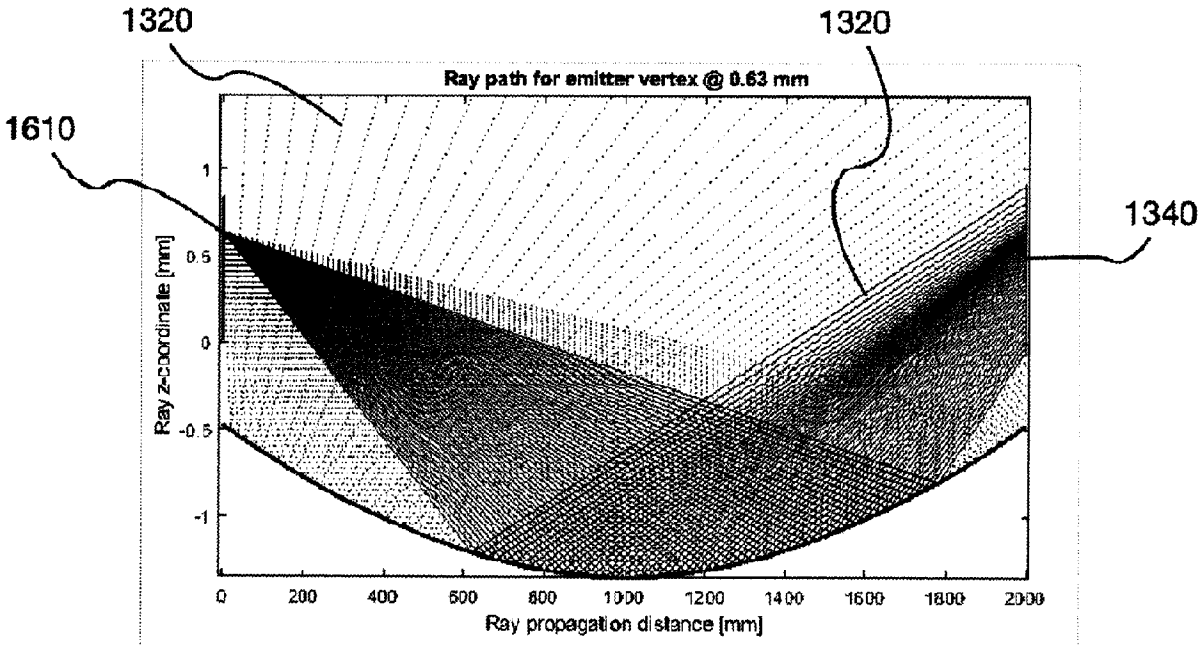


Figure 16a

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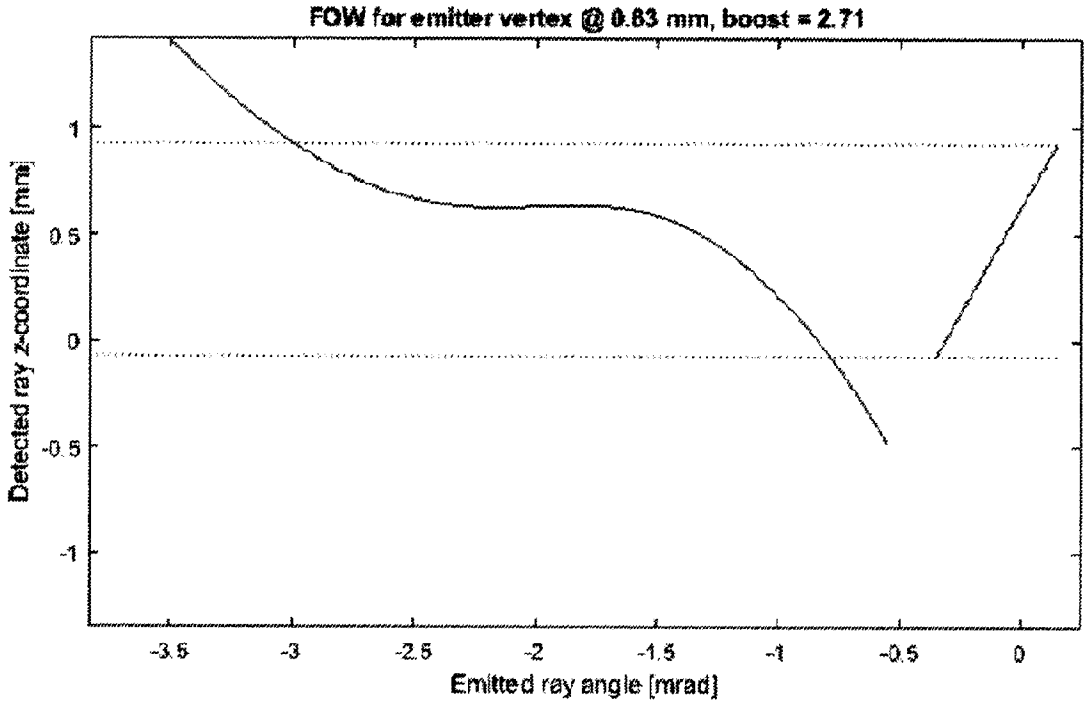


Figure 16b

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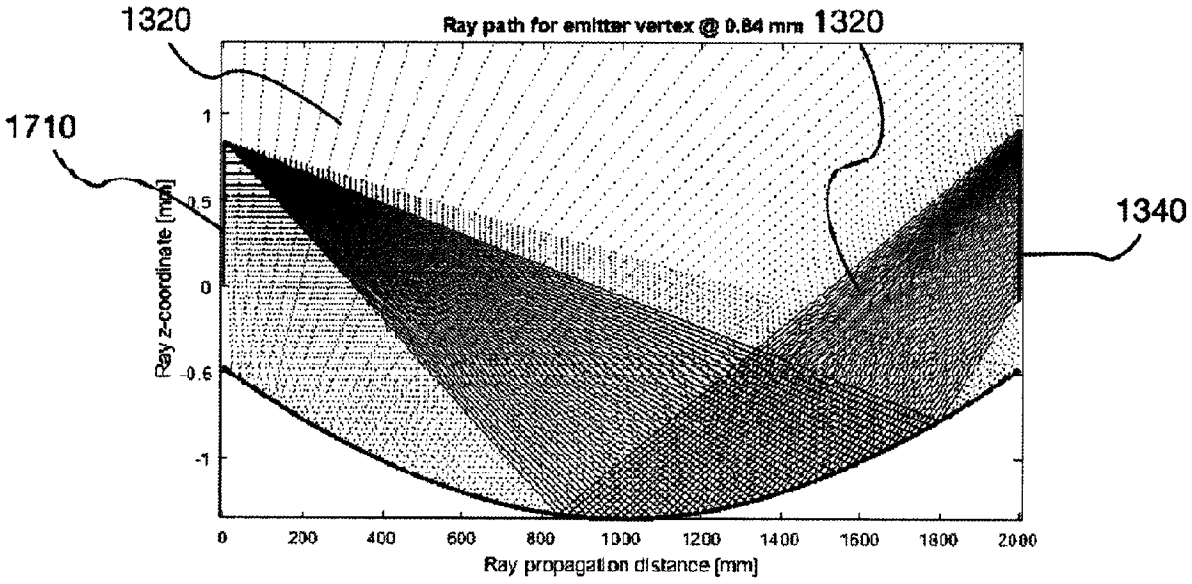


Figure 17a

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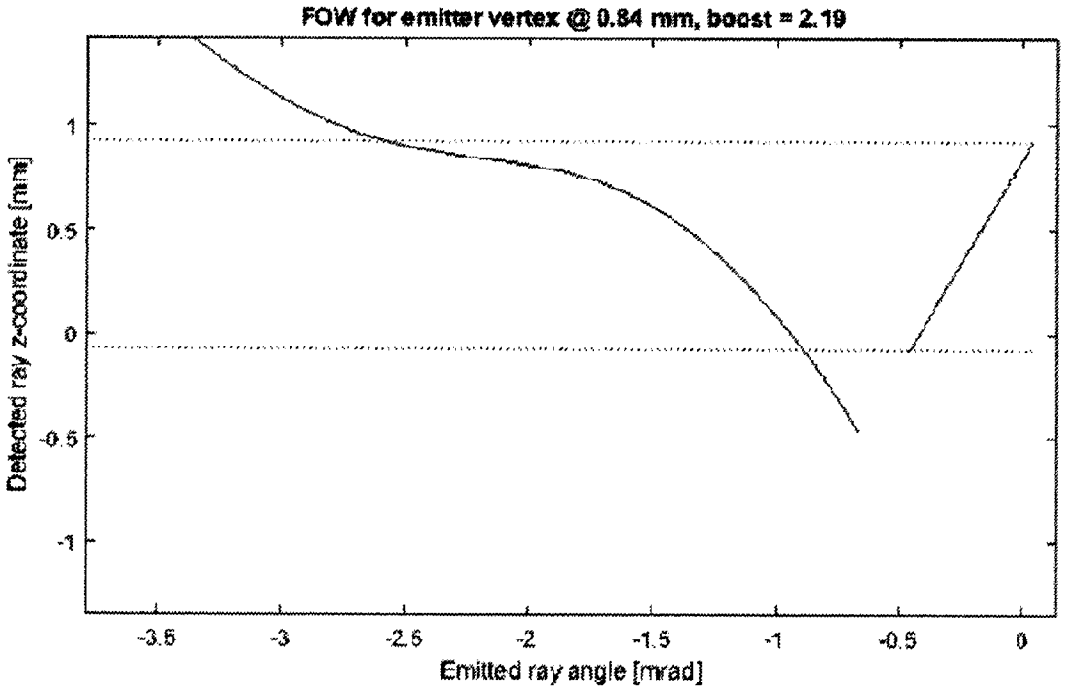


Figure 17b

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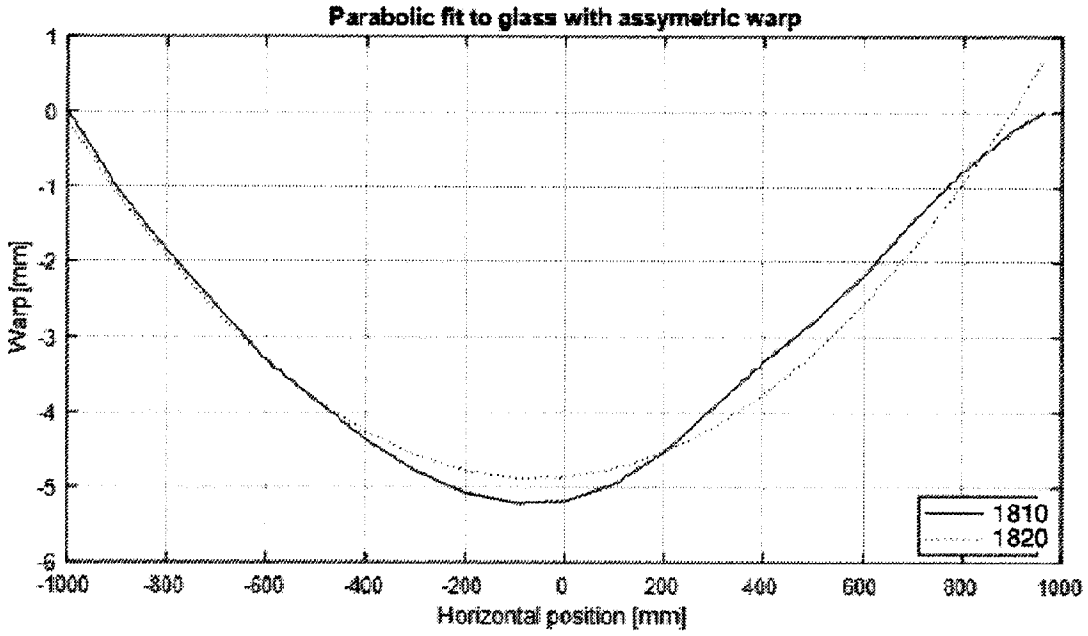


Figure 18a

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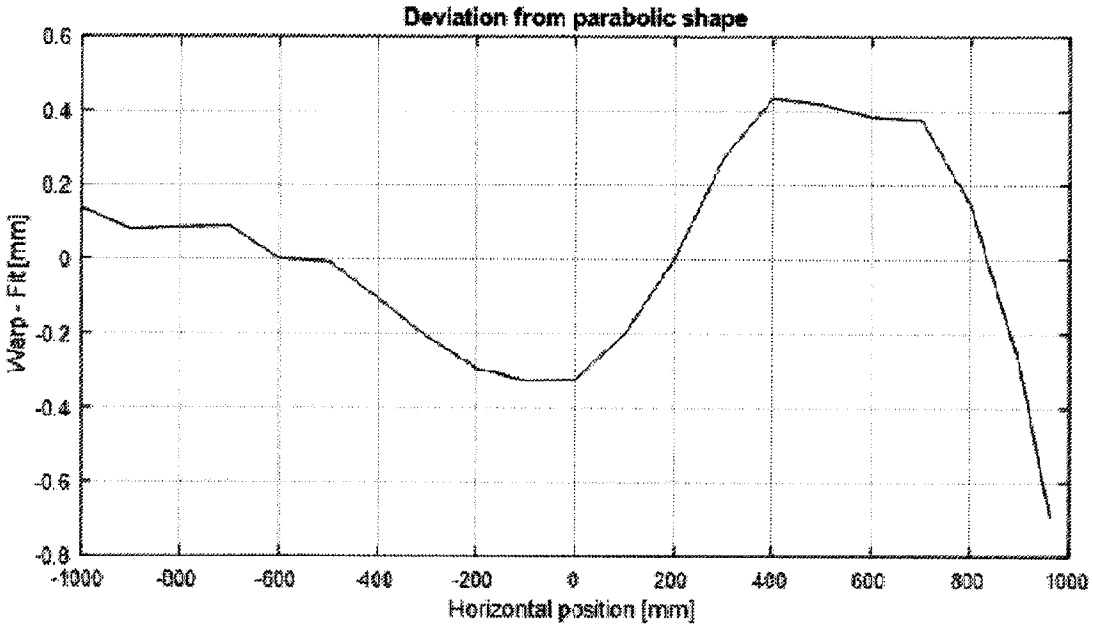


Figure 18b

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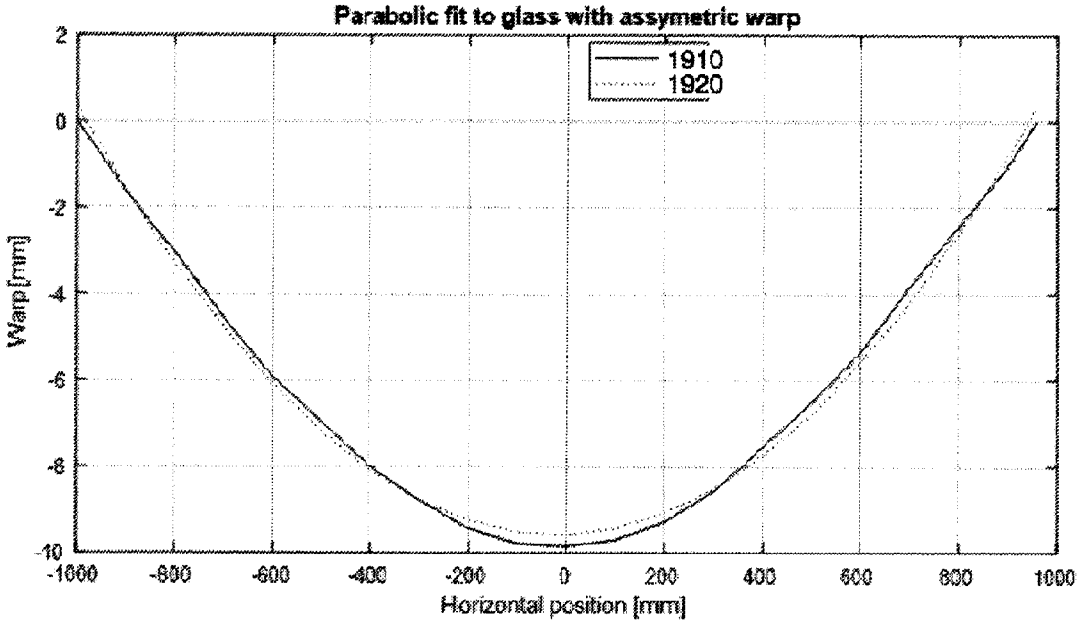


Figure 19a

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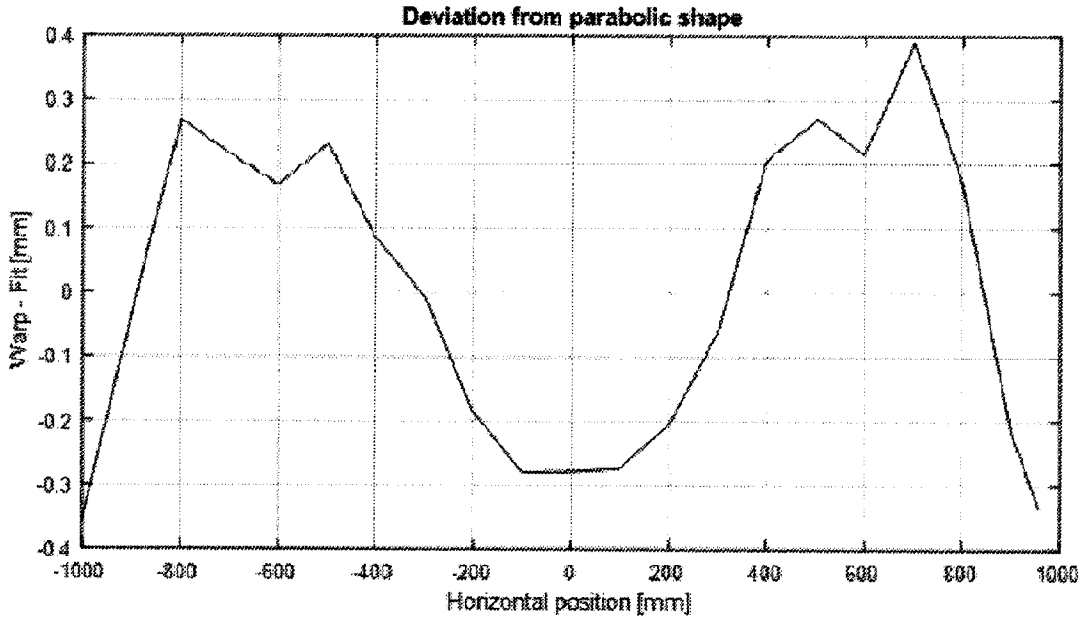

Deviation from parabolic shape
Warp - Fit [mm]
Horizontal position [mm]
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-1000
-800
-600
-400
-200
0
200
400
600
800
1000

Figure 19b

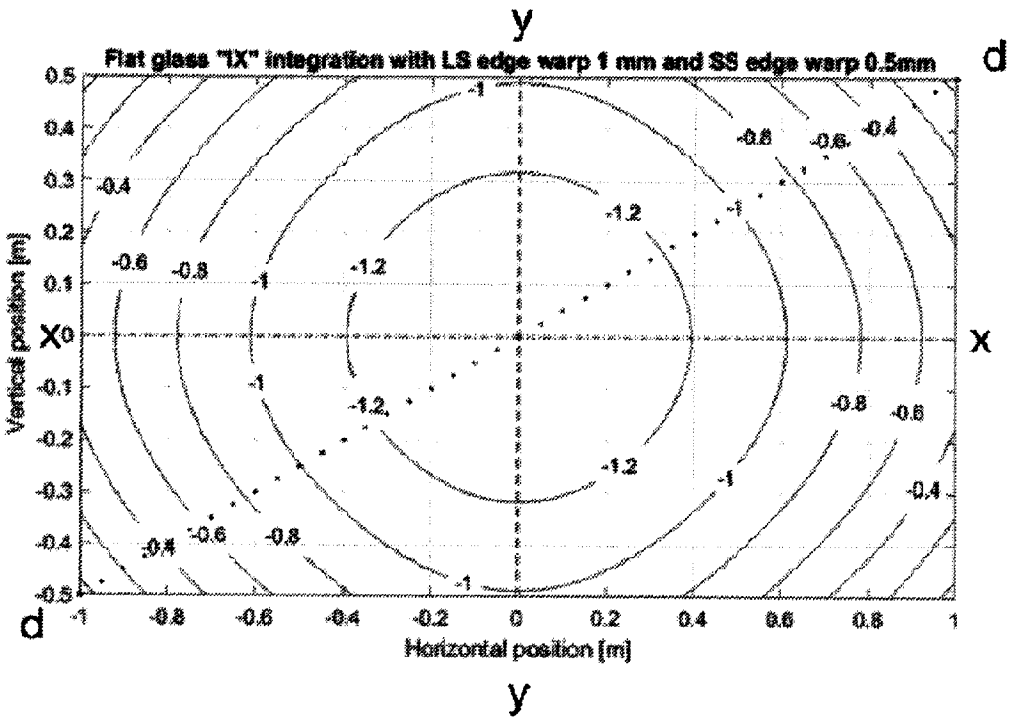


Figure 20a

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 531 of 1254

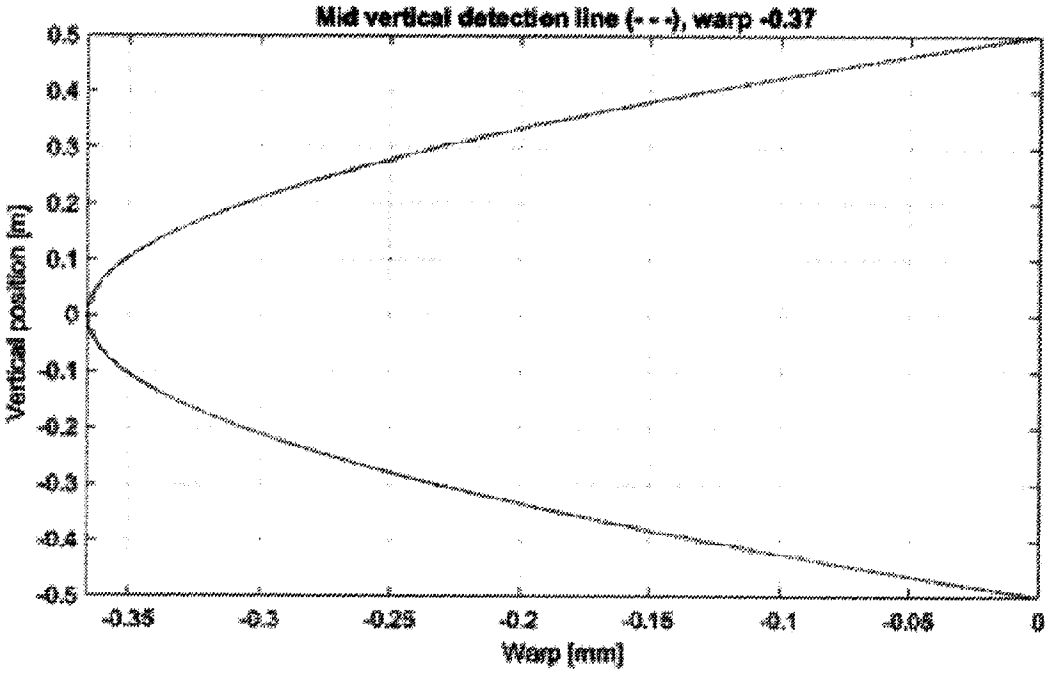


Figure 20b

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 532 of 1254

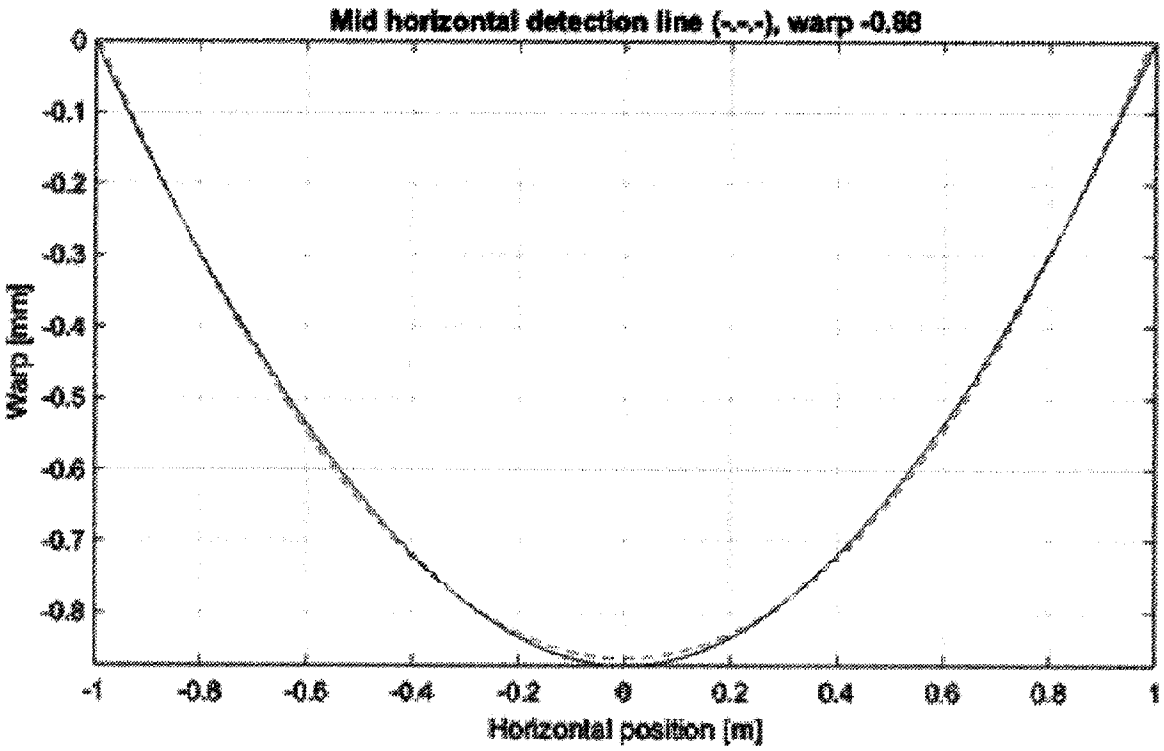


Figure 20c

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 533 of 1254

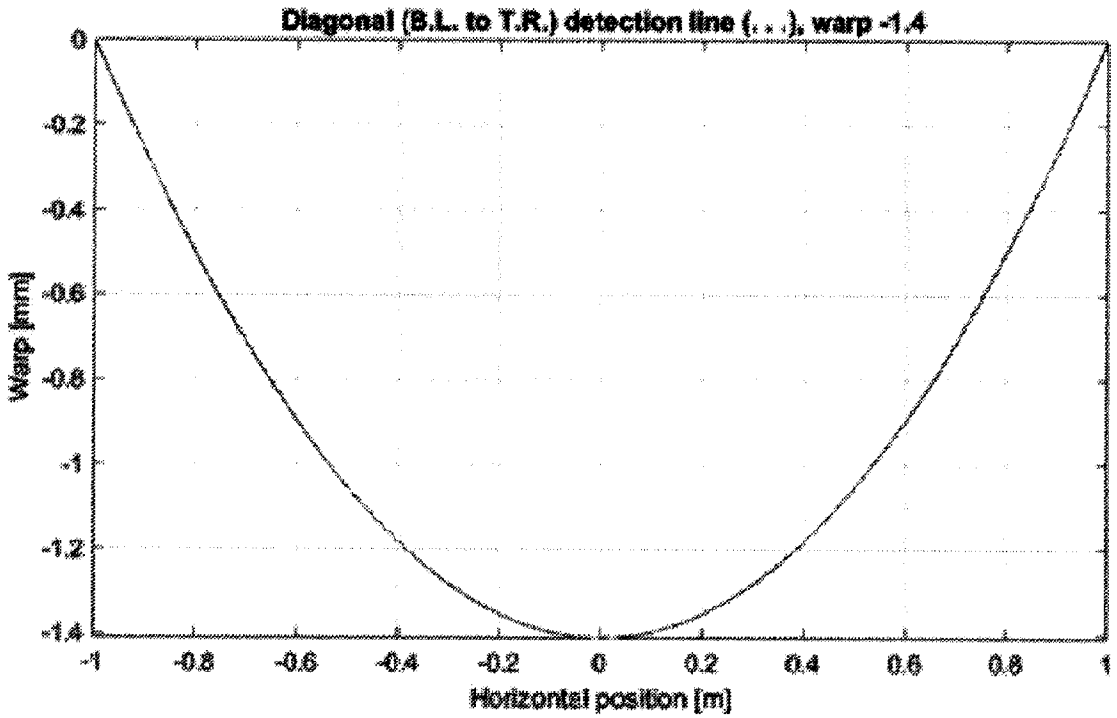


Figure 20d

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 534 of 1254

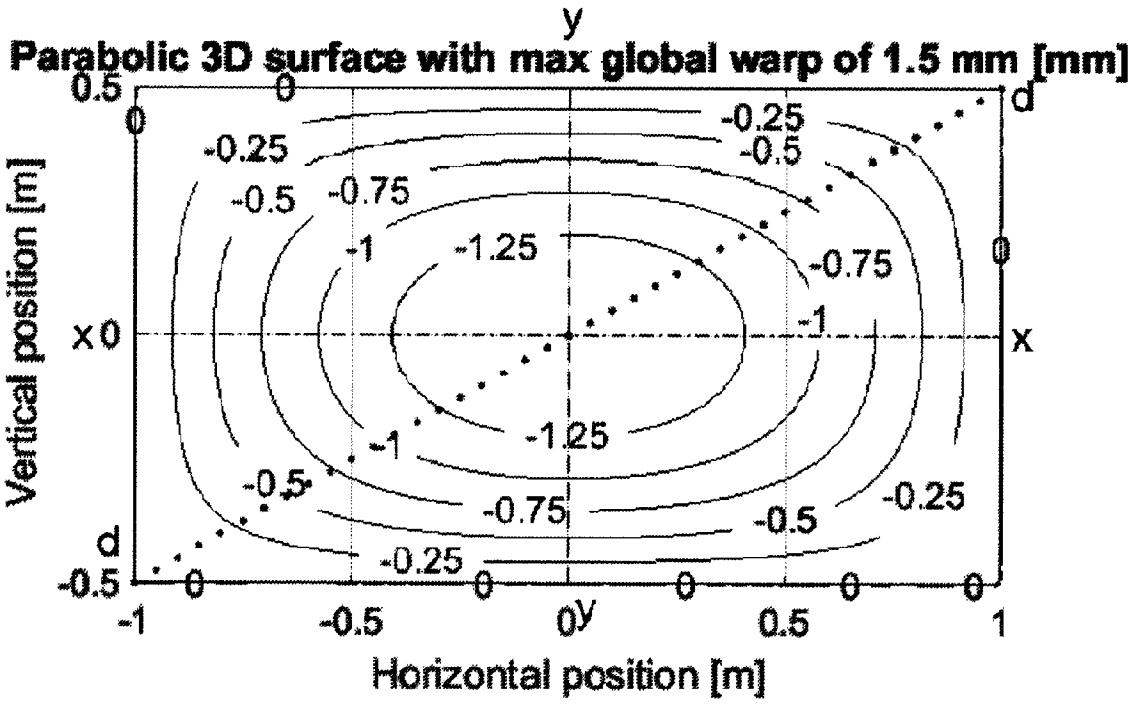


Figure 21a

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 535 of 1254

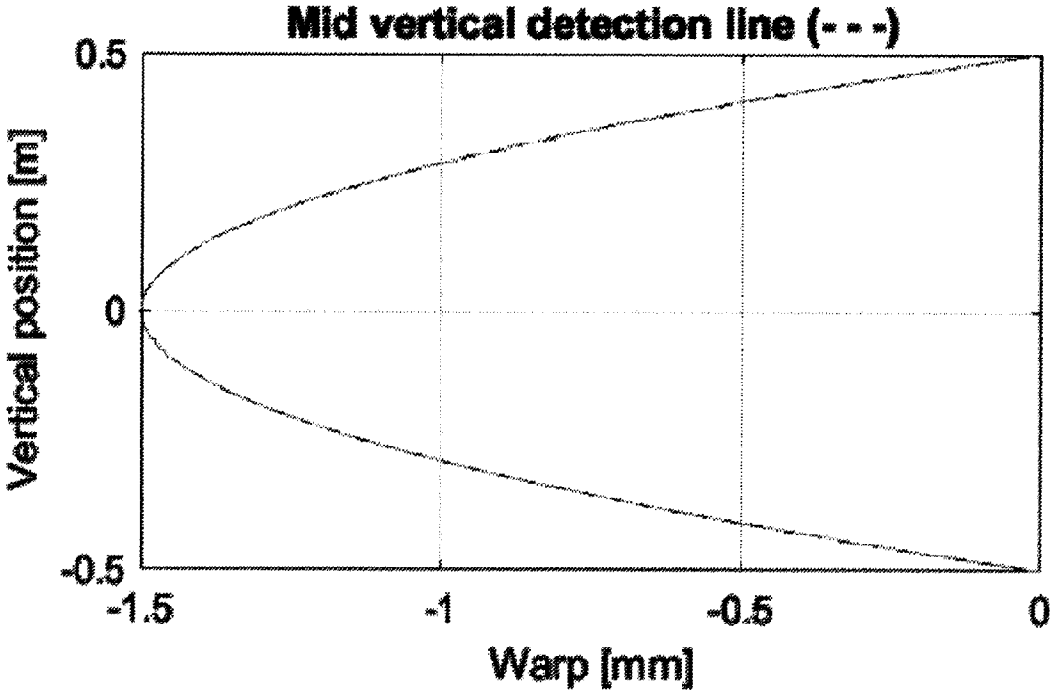


Figure 21b

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 536 of 1254

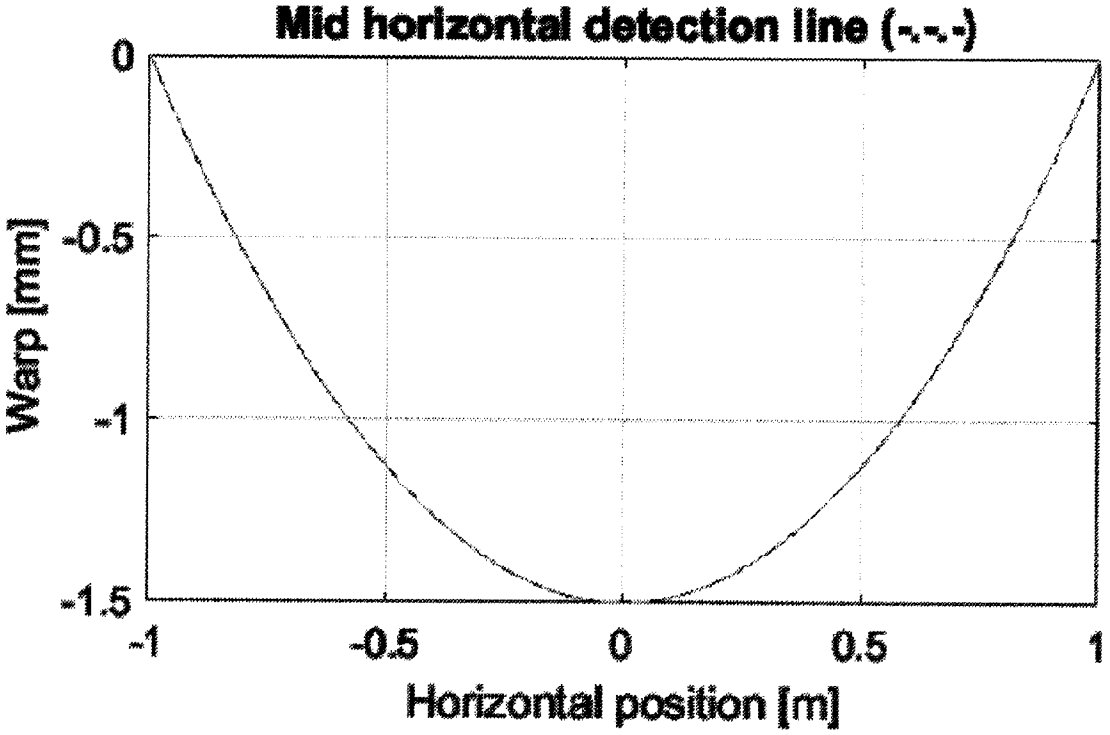

Mid horizontal detection line (-.-.-)
Warp [mm]
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
Horizontal position [m]

Figure 21c

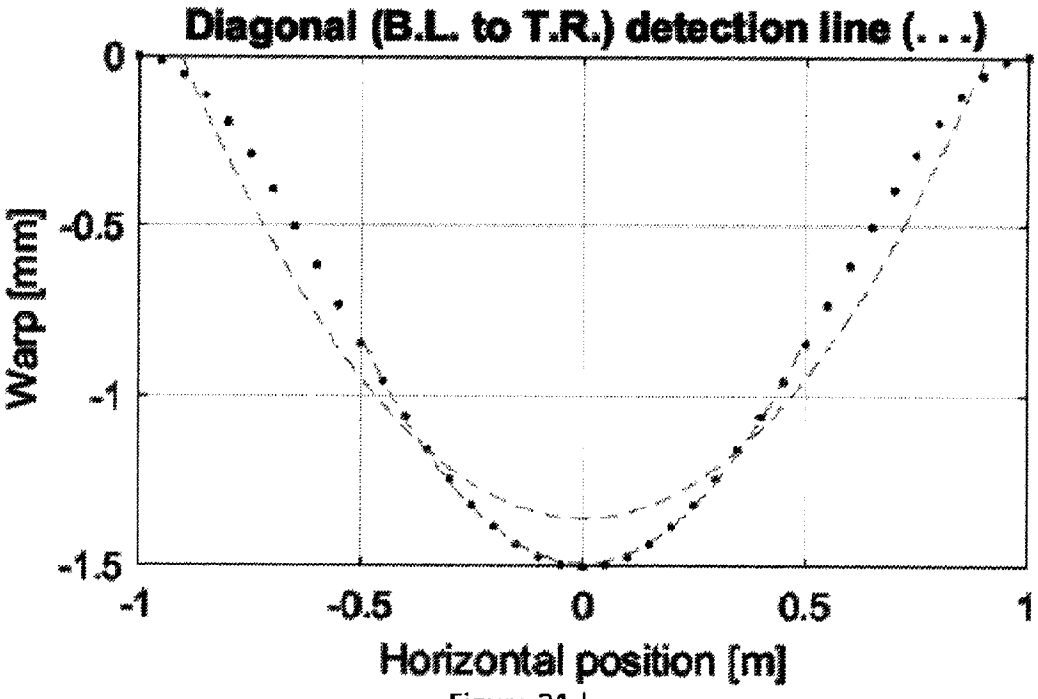


Figure 21d

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 538 of 1254

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/051233

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6031524 A1 (INTERMEC IP CORP), 29 February 2000 (2000-02-29); column 1, line 60 - column 2, line 20 --	1-24
A	US 20160295711 A1 (RYU HYUNJONG ET AL), 6 October 2016 (2016-10-06); whole document --	1-24
A	EP 3043242 A1 (DEXERIALS CORP), 13 July 2016 (2016-07-13); whole document --	1-24
A	WO 2016177592 A1 (AGC GLASS EUROPE), 10 November 2016 (2016-11-10); whole document --	1-24

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
12-03-2018	12-03-2018
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Emil Bäcklund Telephone No. + 46 8 782 28 00

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 539 of 1254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20120062492 A1 (KATOH SATOSHI), 15 March 2012 (2012-03-15); paragraphs [0006]-[0010] --	1-24
A	US 20120045170 A1 (SHIBATA NAOKI ET AL), 23 February 2012 (2012-02-23); whole document -- --------	1-24

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Flatfrog Laboratories AB, Ex. 2002
Page 540 of 1254

Continuation of: second sheet

International Patent Classification (IPC)

G06F 1/16 (2006.01)
G06F 3/01 (2006.01)
G06F 3/03 (2006.01)
G06F 3/041 (2006.01)

US	6031524	A1	29/02/2000	NONE			
US	20160295711	A1	06/10/2016	US	9839145	B2	05/12/2017
				WO	2015111890	A1	30/07/2015
EP	3043242	A1	13/07/2016	CN	105518592	A	20/04/2016
				JP	2015052916	A	19/03/2015
				JP	5848736	B2	27/01/2016
				KR	20160053923	A	13/05/2016
				TW	201523377	A	16/06/2015
				US	20160202801	A1	14/07/2016
				WO	2015033569	A1	12/03/2015
WO	2016177592	A1	10/11/2016	CN	107531547	A	02/01/2018
				KR	20180004141	A	10/01/2018
				TW	201704169	A	01/02/2017
US	20120062492	A1	15/03/2012	US	8648826	B2	11/02/2014
				WO	2010119882	A1	21/10/2010
US	20120045170	A1	23/02/2012	CN	102375179	A	14/03/2012
				JP	2012043136	A	01/03/2012
				KR	20120017403	A	28/02/2012
				TW	201219866	A	16/05/2012

Doc Code: DIST.E.FILE Document Description: Electronic Terminal Disclaimer - Filed	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	16834905
Filing Date	30-Mar-2020
First Named Inventor	Daniel Skagmo
Attorney Docket Number	FFOG.054C5
Title of Invention	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
FlatFrog Laboratories AB	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

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10437389

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.

Applicant claims the following fee status:

○ Small Entity

○ Micro Entity

◉ Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Registration Number 73097

○ A sole inventor

○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application

○ A joint inventor; all of whom are signing this request

Signature	/Harnik Shukla/
Name	Harnik Shukla

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	16834905
Filing Date:	30-Mar-2020
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Filer:	Harnik Shukla/Wendy Castorena
Attorney Docket Number:	FFOG.054C5

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	1814	1	160	160
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**160**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 16834905

Filing Date: 30-Mar-2020

Applicant/Patent under Reexamination: Skagmo

Electronic Terminal Disclaimer filed on June 11, 2020

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt

EFS ID:	39698095
Application Number:	16834905
International Application Number:	
Confirmation Number:	1516
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Customer Number:	20995
Filer:	Harnik Shukla/Wendy Castorena
Filer Authorized By:	Harnik Shukla
Attorney Docket Number:	FFOG.054C5
Receipt Date:	11-JUN-2020
Filing Date:	30-MAR-2020
Time Stamp:	20:03:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	E20206AK03288864
Deposit Account	111410
Authorized User	Wendy Castorena

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	33420 518c85473904c6900d9979c1989dc8ec883f6f99	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30573 25fdb09a6d71e5752681c81bc49cf30b657a132e	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	63993		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	9,207,800 B1	12-08-2015	Eriksson et al.	
	2	2015/0339000 A1	11-26-2015	Lee et al.	
	3	2016/0306501 A1	10-20-2016	Drumm et al.	
	4	3,440,426	04-22-1969	Bush	
	5	3,553,680	01-05-1971	Cooreman	
	6	3,673,327	06-27-1972	Johnson et al.	
	7	4,129,384	12-12-1978	Walker et al.	
	8	4,180,702	12-25-1979	Sick et al.	
	9	4,209,255	06-24-1980	Heynau et al.	
	10	4,213,707	07-22-1980	Evans, Jr.	
	11	4,254,333	03-03-1981	Bergström	
	12	4,254,407	03-03-1981	Tipon	
	13	4,294,543	10-13-1981	Apple et al.	
	14	4,346,376	08-24-1982	Mallos	
	15	4,420,261	12-13-1983	Barlow et al.	
	16	4,484,179	11-20-1984	Kasday	
	17	4,507,557	03-26-1985	Tsikos	
	18	4,521,112	06-04-1985	Kuwabara et al.	
	19	4,542,375	09-17-1985	Alles et al.	
	20	4,550,250	10-29-1985	Mueller et al.	
	21	4,593,191	06-03-1986	Alles	
	22	4,673,918	06-16-1987	Adler et al.	
	23	4,688,933	08-25-1987	Lapeyre	
	24	4,688,993	08-25-1987	Ferris et al.	
	25	4,692,809	09-08-1987	Beining et al.	
	26	4,710,760	12-01-1987	Kasday	
	27	4,736,191	04-05-1988	Matzke et al.	
	28	4,737,626	04-12-1988	Hasegawa	
	29	4,746,770	05-24-1988	McAvinney	

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

__T__[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	4,752,655	06-21-1988	Tajiri et al.	
	31	4,772,763	09-20-1988	Garwin et al.	
	32	4,782,328	11-01-1988	Denlinger	
	33	4,812,833	03-14-1989	Shimauchi	
	34	4,837,430	06-06-1989	Hasegawa	
	35	4,868,912	09-19-1989	Doering	
	36	4,891,829	01-02-1990	Deckman et al.	
	37	4,916,712	04-10-1990	Bender	
	38	4,933,544	06-12-1990	Tamaru	
	39	4,949,079	08-14-1990	Loebner	
	40	4,986,662	01-22-1991	Bures	
	41	4,988,983	01-29-1991	Wehrer	
	42	5,065,185	11-12-1991	Powers et al.	
	43	5,073,770	12-17-1991	Lowbner	
	44	5,105,186	04-14-1992	May	
	45	5,159,322	10-27-1992	Loebner	
	46	5,166,668	11-24-1992	Aoyagi	
	47	5,227,622	07-13-1993	Suzuki	
	48	5,248,856	09-28-1993	Mallicoat	
	49	5,254,407	10-19-1993	Sergerie et al.	
	50	5,345,490	09-06-1994	Finnigan et al.	
	51	5,383,022	01-17-1995	Kaser	
	52	5,483,261	01-09-1996	Yasutake	
	53	5,484,966	01-16-1996	Segen	
	54	5,499,098	03-12-1996	Ogawa	
	55	5,502,568	03-26-1996	Ogawa et al.	
	56	5,525,764	06-11-1996	Junkins et al.	
	57	5,526,422	06-11-1996	Keen	
	58	5,539,514	07-23-1996	Shishido et al.	

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

__T__[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 3 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	5,570,181	10-29-1996	Yasuo et al.	
	60	5,572,251	11-05-1996	Ogawa	
	61	5,577,501	11-26-1996	Flohr et al.	
	62	5,600,105	02-04-1997	Fukuzaki et al.	
	63	5,608,550	03-04-1997	Epstein et al.	
	64	5,672,852	09-30-1997	Fukuzaki et al.	
	65	5,679,930	10-21-1997	Katsurahira	
	66	5,686,942	11-11-1997	Ball	
	67	5,688,933	11-18-1997	Evans et al.	
	68	5,729,249	03-17-1998	Yasutake	
	69	5,736,686	04-07-1998	Perret, Jr. et al.	
	70	5,740,224	04-14-1998	Müller et al.	
	71	5,764,223	06-09-1998	Chang et al.	
	72	5,767,517	06-16-1998	Hawkins	
	73	5,775,792	07-07-1998	Wiese	
	74	5,945,980	08-31-1999	Moissev et al.	
	75	5,945,981	08-31-1999	Paull et al.	
	76	5,959,617	09-28-1999	Bird et al.	
	77	6,061,177	05-09-2000	Fujimoto	
	78	6,067,079	05-23-2000	Shieh	
	79	6,122,394	09-19-2000	Neukermans et al.	
	80	6,141,104	10-31-2000	Schulz et al.	
	81	6,172,667	01-09-2001	Sayag	
	82	6,175,999	01-23-2001	Sloan et al.	
	83	6,227,667	05-08-2001	Halldorsson et al.	
	84	6,229,529	05-08-2001	Yano et al.	
	85	6,333,735	12-25-2001	Anvekar	
	86	6,366,276	04-02-2002	Kunimatsu et al.	
	87	6,380,732	04-30-2002	Gilboa	

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 4 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	6,380,740	04-30-2002	Laub	
	89	6,390,370	05-21-2002	Plesko	
	90	6,429,857	08-06-2002	Masters et al.	
	91	6,452,996	09-17-2002	Hsieh	
	92	6,476,797	11-05-2002	Kurihara et al.	
	93	6,492,633	12-10-2002	Nakazawa et al.	
	94	6,495,832	12-17-2002	Kirby	
	95	6,504,143	01-07-2003	Koops et al.	
	96	6,529,327	03-04-2003	Graindorge	
	97	6,538,644	03-25-2003	Muraoka	
	98	6,587,099	07-01-2003	Takekawa	
	99	6,648,485	11-18-2003	Colgan et al.	
	100	6,660,964	12-09-2003	Benderly	
	101	6,664,498	12-16-2003	Forsman et al.	
	102	6,664,952	12-16-2003	Iwamoto et al.	
	103	6,690,363	02-10-2004	Newton	
	104	6,707,027	03-16-2004	Liess et al.	
	105	6,738,051	05-18-2004	Boyd et al.	
	106	6,748,098	06-08-2004	Rosenfeld	
	107	6,784,948	08-31-2004	Kawashima et al.	
	108	6,799,141	09-28-2004	Stoustrup et al.	
	109	6,806,871	10-19-2004	Yasue	
	110	6,927,384	08-09-2005	Reime et al.	
	111	6,940,286	09-06-2005	Wang et al.	
	112	6,965,836	11-15-2005	Richardson	
	113	6,972,753	12-06-2005	Kimura et al.	
	114	6,985,137	01-10-2006	Kaikuranta	
	115	7,042,444	05-09-2006	Cok	
	116	7,084,859	08-01-2006	Pryor	

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U.S. PATENT DOCUMENTS					
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	117	7,087,907	08-08-2006	Lalovic et al.	
	118	7,133,031	11-07-2006	Wang et al.	
	119	7,176,904	02-13-2007	Satoh	
	120	7,199,932	04-03-2007	Sugiura	
	121	7,359,041	04-15-2008	Xie et al.	
	122	7,397,418	07-08-2008	Doerry et al.	
	123	7,432,893	10-07-2008	Ma et al.	
	124	7,435,940	10-14-2008	Eliasson et al.	
	125	7,436,443	10-14-2008	Hirunuma et al.	
	126	7,442,914	10-28-2008	Eliasson et al.	
	127	7,465,914	12-16-2008	Eliasson et al.	
	128	7,613,375	11-03-2009	Shimizu	
	129	7,629,968	12-08-2009	Miller et al.	
	130	7,646,833	01-12-2010	He et al.	
	131	7,653,883	01-26-2010	Hotelling et al.	
	132	7,655,901	02-02-2010	Idzik et al.	
	133	7,705,835	04-27-2010	Eikman	
	134	7,729,056	06-01-2010	Hwang et al.	
	135	7,847,789	12-07-2010	Kolmykov-Zotov et al.	
	136	7,855,716	12-21-2010	McCreary et al.	
	137	7,859,519	12-28-2010	Tulbert	
	138	7,924,272	04-12-2011	Boer et al.	
	139	7,932,899	04-26-2011	Newton et al.	
	140	7,969,410	06-28-2011	Kakarala	
	141	7,995,039	08-09-2011	Eliasson et al.	
	142	8,013,845	09-06-2011	Ostergaard et al.	
	143	8,031,186	10-04-2011	Ostergaard	
	144	8,077,147	12-13-2011	Krah et al.	
	145	8,093,545	01-10-2012	Leong et al.	

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	146	8,094,136	01-10-2012	Eliasson et al.	
	147	8,094,910	01-10-2012	Xu	
	148	8,149,211	04-03-2012	Hayakawa et al.	
	149	8,218,154	07-10-2012	Østergaard et al.	
	150	8,274,495	09-25-2012	Lee	
	151	8,325,158	12-04-2012	Yatsuda et al.	
	152	8,339,379	12-25-2012	Goertz et al.	
	153	8,350,827	01-08-2013	Chung et al.	
	154	8,384,010	02-26-2013	Hong et al.	
	155	8,407,606	03-26-2013	Davidson et al.	
	156	8,441,467	05-14-2013	Han	
	157	8,445,834	05-21-2013	Hong et al.	
	158	8,466,901	06-18-2013	Yen et al.	
	159	8,482,547	07-09-2013	Cobon et al.	
	160	8,542,217	09-24-2013	Wassvik et al.	
	161	8,567,257	10-29-2013	Van Steenberge et al.	
	162	8,581,884	11-12-2013	Fåhraeus et al.	
	163	8,624,858	01-07-2014	Fyke et al.	
	164	8,686,974	04-01-2014	Christiansson et al.	
	165	8,692,807	04-08-2014	Føhraeus et al.	
	166	8,716,614	05-06-2014	Wassvik	
	167	8,727,581	05-20-2014	Saccomanno	
	168	8,745,514	06-03-2014	Davidson	
	169	8,780,066	07-15-2014	Christiansson et al.	
	170	8,830,181	09-09-2014	Clark et al.	
	171	8,860,696	10-14-2014	Wassvik et al.	
	172	8,872,098	10-28-2014	Bergström et al.	
	173	8,872,801	10-28-2014	Bergström et al.	
	174	8,884,900	11-11-2014	Wassvik	

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	175	8,890,843	11-18-2014	Wassvik et al.	
	176	8,890,849	11-18-2014	Christiansson et al.	
	177	8,928,590	01-06-2015	El Dokor	
	178	8,963,886	02-24-2015	Wassvik	
	179	8,982,084	03-17-2015	Christiansson et al.	
	180	9,024,916	05-05-2015	Christiansson	
	181	9,035,909	05-19-2015	Christiansson	
	182	9,063,617	06-23-2015	Eliasson et al.	
	183	9,086,763	07-21-2015	Johansson et al.	
	184	9,134,854	09-15-2015	Wassvik et al.	
	185	9,158,401	10-13-2015	Christiansson	
	186	9,158,415	10-13-2015	Song et al.	
	187	9,213,445	12-15-2015	King et al.	
	188	9,274,645	03-01-2016	Christiansson et al.	
	189	9,317,168	04-19-2016	Christiansson et al.	
	190	9,323,396	04-26-2016	Han et al.	
	191	9,366,565	06-14-2016	Uvnäs	
	192	9,377,884	06-28-2016	Christiansson et al.	
	193	9,389,732	07-12-2016	Craven-Bartle	
	194	9,411,444	08-09-2016	Christiansson et al.	
	195	9,411,464	08-09-2016	Wallander et al.	
	196	9,430,079	08-30-2016	Christiansson et al.	
	197	9,442,574	09-13-2016	Fåhraeus et al.	
	198	9,547,393	01-17-2017	Christiansson et al.	
	199	9,552,103	01-24-2017	Craven-Bartle et al.	
	200	9,557,846	01-31-2017	Baharav et al.	
	201	9,588,619	03-07-2017	Christiansson et al.	
	202	9,594,467	03-14-2017	Christiansson et al.	
	203	9,618,682	04-11-2017	Yoon et al.	

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	204	9,626,018	04-18-2017	Christiansson et al.	
	205	9,626,040	04-18-2017	Wallander et al.	
	206	9,639,210	05-02-2017	Wallander et al.	
	207	9,678,602	06-13-2017	Wallander	
	208	9,684,414	06-20-2017	Christiansson et al.	
	209	9,710,101	07-18-2017	Christiansson et al.	
	210	9,874,978	01-23-2018	Wall	
	211	10,013,107	007-03-2018	Christiansson et al.	
	212	10,019,113	07-10-2018	Christiansson et al.	
	213	2001/0002694	06-07-2001	Nakazawa et al.	
	214	2001/0005004	06-28-2001	Shiratsuki et al.	
	215	2001/0005308	06-28-2001	Oishi et al.	
	216	2001/0030642	10-18-2001	Sullivan et al.	
	217	2002/0067348	06-06-2002	Masters et al.	
	218	2002/0075243	06-20-2002	Newton	
	219	2002/0118177	08-29-2002	Newton	
	220	2002/0158823	10-31-2002	Zavracky et al.	
	221	2002/0158853	10-31-2002	Sugawara et al.	
	222	2002/0163505	11-07-2002	Takekawa	
	223	2003/0016450	01-23-2003	Bluemel et al.	
	224	2003/0034439	02-20-2003	Reime et al.	
	225	2003/0034935	02-20-2003	Amanai et al.	
	226	2003/0048257	03-13-2003	Mattila	
	227	2003/0052257	03-20-2003	Sumriddetchkajorn	
	228	2003/0095399	05-22-2003	Grenda et al.	
	229	2003/0107748	06-12-2003	Lee	
	230	2003/0137494	07-24-2003	Tulbert	
	231	2003/0156100	08-21-2003	Gettemy	
	232	2003/0160155	08-28-2003	Liess	

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	233	2003/0210537	11-13-2003	Engelmann	
	234	2003/0214486	11-20-2003	Roberts	
	235	2004/0027339	02-12-2004	Schulz	
	236	2004/0032401	02-19-2004	Nakazawa et al.	
	237	2004/0090432	05-13-2004	Takahashi et al.	
	238	2004/0130338	07-08-2004	Wang et al.	
	239	2004/0174541	09-09-2004	Freifeld	
	240	2004/0201579	10-14-2004	Graham	
	241	2004/0212603	10-28-2004	Cok	
	242	2004/0238627	12-02-2004	Silverbrook et al.	
	243	2004/0239702	12-02-2004	Kang et al.	
	244	2004/0245438	12-09-2004	Payne et al.	
	245	2004/0252091	12-16-2004	Ma et al.	
	246	2004/0252867	12-16-2004	Lan et al.	
	247	2005/0012714	01-20-2005	Russo et al.	
	248	2005/0041013	02-24-2005	Tanaka	
	249	2005/0057903	03-17-2005	Choi	
	250	2005/0073508	04-07-2005	Pittel et al.	
	251	2005/0083293	04-21-2005	Dixon	
	252	2005/0128190	06-16-2005	Ryynanen	
	253	2005/0143923	06-30-2005	Keers et al.	
	254	2005/0156914	07-21-2005	Lipman et al.	
	255	2005/0162398	07-28-2005	Eliasson et al.	
	256	2005/0179977	08-18-2005	Chui et al.	
	257	2005/0200613	09-15-2005	Kobayashi et al.	
	258	2005/0212774	09-29-2005	Ho et al.	
	259	2005/0248540	11-10-2005	Newton	
	260	2005/0253834	11-17-2005	Sakamaki et al.	
	261	2005/0276053	12-15-2005	Nortrup et al.	

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	262	2006/0001650	01-05-2006	Robbins et al.	
	263	2006/0001653	01-05-2006	Smits	
	264	2006/0007185	01-12-2006	Kobayashi	
	265	2006/0008164	01-12-2006	Wu et al.	
	266	2006/0017706	01-26-2006	Cutherell et al.	
	267	2006/0017709	01-26-2006	Okano	
	268	2006/0033725	02-16-2006	Marggraff et al.	
	269	2006/0038698	02-23-2006	Chen	
	270	2006/0061861	03-23-2006	Munro et al.	
	271	2006/0114237	06-01-2006	Crockett et al.	
	272	2006/0132454	06-22-2006	Chen et al.	
	273	2006/0139340	06-29-2006	Geaghan	
	274	2006/0158437	07-20-2006	Blythe et al.	
	275	2006/0170658	08-03-2006	Nakamura et al.	
	276	2006/0202974	09-14-2006	Thielman	
	277	2006/0227120	10-12-2006	Eikman	
	278	2006/0255248	11-16-2006	Eliasson	
	279	2006/0256092	11-16-2006	Lee	
	280	2006/0279558	12-14-2006	Van Delden et al.	
	281	2006/0281543	12-14-2006	Sutton et al.	
	282	2006/0290684	12-28-2006	Giraldo et al.	
	283	2007/0014486	01-18-2007	Schiwietz et al.	
	284	2007/0024598	02-01-2007	Miller et al.	
	285	2007/0034783	02-15-2007	Eliasson et al.	
	286	2007/0038691	02-15-2007	Candes et al.	
	287	2007/0052684	03-08-2007	Gruhlke et al.	
	288	2007/0070056	03-29-2007	Sato et al.	
	289	2007/0075648	04-05-2007	Blythe et al.	
	290	2007/0120833	05-31-2007	Yamaguchi et al.	

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	291	2007/0125937	06-07-2007	Eliasson et al.	
	292	2007/0152985	07-05-2007	Ostergaard et al.	
	293	2007/0201042	08-30-2007	Eliasson et al.	
	294	2007/0296688	12-27-2007	Nakamura et al.	
	295	2008/0006766	01-10-2008	Oon et al.	
	296	2008/0007540	01-10-2008	Ostergaard	
	297	2008/0007541	01-10-2008	Eliasson et al.	
	298	2008/0007542	01-10-2008	Eliasson et al.	
	299	2008/0011944	01-17-2008	Chua et al.	
	300	2008/0029691	02-07-2008	Han	
	301	2008/0036743	02-14-2008	Westerman et al.	
	302	2008/0062150	03-13-2008	Lee	
	303	2008/0068691	03-20-2008	Miyatake	
	304	2008/0074401	03-27-2008	Chung et al.	
	305	2008/0088603	04-17-2008	Eliasson et al.	
	306	2008/0121442	05-29-2008	Boer et al.	
	307	2008/0122792	05-29-2008	Izadi et al.	
	308	2008/0122803	05-29-2008	Izadi et al.	
	309	2008/0130979	06-05-2008	Run et al.	
	310	2008/0150846	06-26-2008	Chung et al.	
	311	2008/0150848	06-26-2008	Chung et al.	
	312	2008/0151126	06-26-2008	Yu	
	313	2008/0158176	07-03-2008	Land et al.	
	314	2008/0189046	08-07-2008	Eliasson et al.	
	315	2008/0192025	08-14-2008	Jaeger et al.	
	316	2008/0238433	10-02-2008	Joutsenoja et al.	
	317	2008/0246388	10-09-2008	Cheon et al.	
	318	2008/0252619	10-16-2008	Crockett et al.	
	319	2008/0266266	10-30-2008	Kent et al.	

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	320	2008/0278460	11-13-2008	Arnett et al.	
	321	2008/0284925	11-20-2008	Han	
	322	2008/0291668	11-27-2008	Aylward et al.	
	323	2008/0297482	12-04-2008	Weiss	
	324	2008/0133265	06-05-2008	Silkaitis et al.	
	325	2009/0002340	01-01-2009	Van Genechten	
	326	2009/0006292	01-01-2009	Block	
	327	2009/0040786	02-12-2009	Mori	
	328	2009/0066647	03-12-2009	Kerr et al.	
	329	2009/0067178	03-12-2009	Huang et al.	
	330	2009/0073142	03-19-2009	Yamashita et al.	
	331	2009/0077501	03-19-2009	Partridge et al.	
	332	2009/0085894	04-02-2009	Gandhi et al.	
	333	2009/0091554	04-09-2009	Keam	
	334	2009/0115919	05-07-2009	Tanaka et al.	
	335	2009/0122020	05-14-2009	Eliasson et al.	
	336	2009/0122027	05-14-2009	Newton	
	337	2009/0128508	05-21-2009	Sohn et al.	
	338	2009/0135162	05-28-2009	Van De Wijdeven et al.	
	339	2009/0143141	06-04-2009	Wells et al.	
	340	2009/0153519	06-18-2009	Suarez Rovere	
	341	2009/0161026	06-25-2009	Wu et al.	
	342	2009/0168459	07-02-2009	Holman et al.	
	343	2009/0187842	07-23-2009	Collins et al.	
	344	2009/0189857	07-30-2009	Benko et al.	
	345	2009/0189874	07-30-2009	Chene et al.	
	346	2009/0189878	07-30-2009	Goertz et al.	
	347	2009/0219256	09-03-2009	Newton	
	348	2009/0229892	09-17-2009	Fisher et al.	

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	First Named Inventor	Daniel Skagmo
	Art Unit	2694
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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	349	2009/0251439	10-08-2009	Westerman et al.	
	350	2009/0256817	10-15-2009	Perlin et al.	
	351	2009/0259967	10-15-2009	Davidson et al.	
	352	2009/0267919	10-29-2009	Chao et al.	
	353	2009/0273794	11-05-2009	Østergaard et al.	
	354	2009/0278816	11-12-2009	Colson	
	355	2009/0297009	12-03-2009	Xu et al.	
	356	2010/0033444	02-11-2010	Kobayashi	
	357	2010/0045629	02-25-2010	Newton	
	358	2010/0060896	03-11-2010	Van De Wijdeven et al.	
	359	2010/0066016	03-18-2010	Van De Wijdeven et al.	
	360	2010/0066704	03-18-2010	Kasai	
	361	2010/0073318	03-25-2010	Hu et al.	
	362	2010/0078545	04-01-2010	Leong et al.	
	363	2010/0079407	04-01-2010	Suggs et al.	
	364	2010/0079408	04-01-2010	Leong et al.	
	365	2010/0097345	04-22-2010	Jang et al.	
	366	2010/0097348	04-22-2010	Park et al.	
	367	2010/0097353	04-22-2010	Newton	
	368	2010/0125438	05-20-2010	Audet	
	369	2010/0127975	05-27-2010	Jensen	
	370	2010/0134435	06-03-2010	Kimura et al.	
	371	2010/0142823	06-10-2010	Wang et al.	
	372	2010/0187422	07-29-2010	Kothari et al.	
	373	2010/0193259	08-05-2010	Wassvik	
	374	2010/0229091	09-09-2010	Homma et al.	
	375	2010/0238139	09-23-2010	Goertz et al.	
	376	2010/0245292	09-30-2010	Wu	
	377	2010/0265170	10-21-2010	Norieda	

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	378	2010/0277436	11-04-2010	Feng et al.	
	379	2010/0283785	11-11-2010	Satulovsky	
	380	2010/0284596	11-11-2010	Miao et al.	
	381	2010/0289754	11-18-2010	Sleeman et al.	
	382	2010/0295821	11-25-2010	Chang et al.	
	383	2010/0302196	12-02-2010	Han et al.	
	384	2010/0302209	12-02-2010	Large	
	385	2010/0302210	12-02-2010	Han et al.	
	386	2010/0302240	12-02-2010	Lettvin	
	387	2010/0315379	12-16-2010	Allard et al.	
	388	2010/0321328	12-23-2010	Chang et al.	
	389	2010/0322550	12-23-2010	Trott	
	390	2011/0043490	02-24-2011	Powell et al.	
	391	2011/0049388	03-03-2011	Delaney et al.	
	392	2011/0050649	03-03-2011	Newton et al.	
	393	2011/0051394	03-03-2011	Bailey	
	394	2011/0068256	03-24-2011	Hong et al.	
	395	2011/0069039	03-24-2011	Lee et al.	
	396	2011/0069807	03-24-2011	Dennerlein et al.	
	397	2011/0074725	03-31-2011	Westerman et al.	
	398	2011/0074734	03-31-2011	Wassvik et al.	
	399	2011/0074735	03-31-2011	Wassvik et al.	
	400	2011/0090176	04-21-2011	Christiansson et al.	
	401	2011/0102374	05-05-2011	Wassvik et al.	
	402	2011/0115748	05-19-2011	Xu	
	403	2011/0121323	05-26-2011	Wu et al.	
	404	2011/0122075	05-26-2011	Seo et al.	
	405	2011/0122091	05-26-2011	King et al.	
	406	2011/0122094	05-26-2011	Tsang et al.	

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	407	2011/0134079	06-09-2011	Stark	
	408	2011/0147569	06-23-2011	Drumm	
	409	2011/0157095	06-30-2011	Drumm	
	410	2011/0157096	06-30-2011	Drumm	
	411	2011/0163996	07-07-2011	Wassvik et al.	
	412	2011/0163997	07-07-2011	Kim	
	413	2011/0163998	07-07-2011	Goertz et al.	
	414	2011/0169780	07-14-2011	Goertz et al.	
	415	2011/0175852	07-21-2011	Goertz et al.	
	416	2011/0205186	08-25-2011	Newton et al.	
	417	2011/0216042	09-08-2011	Wassvik et al.	
	418	2011/0221705	09-15-2011	Yi et al.	
	419	2011/0221997	09-15-2011	Kim et al.	
	420	2011/0227036	09-22-2011	Vaufrey	
	421	2011/0227874	09-22-2011	Fåhraeus et al.	
	422	2011/0234537	09-29-2011	Kim et al.	
	423	2011/0254864	10-20-2011	Tsuchikawa et al.	
	424	2011/0261020	10-27-2011	Song et al.	
	425	2011/0267296	11-03-2011	Noguchi et al.	
	426	2011/0291989	12-01-2011	Lee	
	427	2011/0298743	12-08-2011	Machida et al.	
	428	2011/0309325	12-22-2011	Park et al.	
	429	2011/0310045	12-22-2011	Toda et al.	
	430	2012/0019448	01-26-2012	Pitkanen et al.	
	431	2012/0026408	02-02-2012	Lee et al.	
	432	2012/0038593	02-16-2012	Rönkä et al.	
	433	2012/0062474	03-15-2012	Weishaupt et al.	
	434	2012/0068973	03-22-2012	Christiansson et al.	
	435	2012/0086673	04-12-2012	Chien et al.	

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	436	2012/0089348	04-12-2012	Perlin et al.	
	437	2012/0110447	05-03-2012	Chen	
	438	2012/0131490	05-24-2012	Lin et al.	
	439	2012/0141001	06-07-2012	Zhang et al.	
	440	2012/0146930	06-14-2012	Lee	
	441	2012/0153134	06-21-2012	Bergström et al.	
	442	2012/0154338	06-21-2012	Bergström et al.	
	443	2012/0162142	06-28-2012	Christiansson et al.	
	444	2012/0162144	06-28-2012	Fåhraeus et al.	
	445	2012/0169672	07-05-2012	Christiansson	
	446	2012/0181419	07-19-2012	Momtahan	
	447	2012/0182266	07-19-2012	Han	
	448	2012/0188206	07-26-2012	Sparf et al.	
	449	2012/0191993	07-26-2012	Drader et al.	
	450	2012/0200532	08-09-2012	Powell et al.	
	451	2012/0200538	08-09-2012	Christiansson et al.	
	452	2012/0212441	08-23-2012	Christiansson et al.	
	453	2012/0217882	08-30-2012	Wong et al.	
	454	2012/0249478	10-04-2012	Chang et al.	
	455	2012/0256882	10-11-2012	Christiansson et al.	
	456	2012/0268403	10-25-2012	Christiansson	
	457	2012/0268427	10-25-2012	Slobodin	
	458	2012/0274559	11-01-2012	Mathai et al.	
	459	2012/0305755	12-06-2012	Hong et al.	
	460	2013/0021300	01-24-2013	Wassvik	
	461	2013/0021302	01-24-2013	Drumm	
	462	2013/0027404	01-31-2013	Sarnoff	
	463	2013/0044073	02-21-2013	Christiansson et al.	
	464	2013/0055080	02-28-2013	Komer et al.	

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	465	2013/0076697	03-28-2013	Goertz et al.	
	466	2013/0082980	04-04-2013	Gruhlke et al.	
	467	2013/0107569	05-02-2013	Suganuma	
	468	2013/0113715	05-09-2013	Grant et al.	
	469	2013/0120320	05-16-2013	Liu et al.	
	470	2013/0125016	05-16-2013	Pallakoff et al.	
	471	2013/0127790	05-23-2013	Wassvik	
	472	2013/0135258	05-30-2013	King et al.	
	473	2013/0135259	05-30-2013	King et al.	
	474	2013/0141388	06-06-2013	Ludwig et al.	
	475	2013/0154983	06-20-2013	Christiansson et al.	
	476	2013/0155027	06-20-2013	Holmgren et al.	
	477	2013/0158504	06-20-2013	Ruchti et al.	
	478	2013/0181896	07-18-2013	Gruhlke et al.	
	479	2013/0187891	07-25-2013	Eriksson et al.	
	480	2013/0201142	08-08-2013	Suarez Rovere	
	481	2013/0222346	08-29-2013	Chen et al.	
	482	2013/0241887	09-19-2013	Sharma	
	483	2013/0249833	09-26-2013	Christiansson et al.	
	484	2013/0269867	10-17-2013	Trott	
	485	2013/0275082	10-17-2013	Follmer et al.	
	486	2013/0285920	10-31-2013	Colley	
	487	2013/0285968	10-31-2013	Christiansson et al.	
	488	2013/0300716	11-14-2013	Craven-Bartle et al.	
	489	2013/0307795	11-21-2013	Suarez Rovere	
	490	2013/0342490	12-26-2013	Wallander et al.	
	491	2014/0002400	01-02-2014	Christiansson et al.	
	492	2014/0028575	01-30-2014	Parivar et al.	
	493	2014/0028604	01-30-2014	Morinaga et al.	

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	494	2014/0028629	01-30-2014	Drumm et al.	
	495	2014/0036203	02-06-2014	Guillou et al.	
	496	2014/0055421	02-27-2014	Christiansson et al.	
	497	2014/0063853	03-06-2014	Nichol et al.	
	498	2014/0071653	03-13-2014	Thompson et al.	
	499	2014/0085241	03-27-2014	Christiansson et al.	
	500	2014/0092052	04-03-2014	Grunthaner et al.	
	501	2014/0098032	04-10-2014	Ng et al.	
	502	2014/0098058	04-10-2014	Baharav et al.	
	503	2014/0109219	04-17-2014	Rohrweck et al.	
	504	2014/0125633	05-08-2014	Fåhraeus et al.	
	505	2014/0139467	05-22-2014	Ghosh et al.	
	506	2014/0160762	06-12-2014	Dudik et al.	
	507	2014/0192023	07-10-2014	Hoffman	
	508	2014/0232669	08-21-2014	Ohlsson et al.	
	509	2014/0237401	08-21-2014	Krus et al.	
	510	2014/0237408	08-21-2014	Ohlsson et al.	
	511	2014/0237422	08-21-2014	Ohlsson et al.	
	512	2014/0253831	09-11-2014	Craven-Bartle	
	513	2014/0267124	09-18-2014	Christiansson et al.	
	514	2014/0292701	10-02-2014	Christiansson et al.	
	515	2014/0300572	10-09-2014	Ohlsson et al.	
	516	2014/0320460	10-30-2014	Johansson et al.	
	517	2014/0347325	11-27-2014	Wallander et al.	
	518	2014/0362046	12-11-2014	Yoshida	
	519	2014/0368471	12-18-2014	Christiansson et al.	
	520	2014/0375607	12-25-2014	Christiansson et al.	
	521	2015/0002386	01-01-2015	Mankowski et al.	
	522	2015/0009687	01-08-2015	Lin	

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	523	2015/0015497	01-15-2015	Leigh	
	524	2015/0035774	02-05-2015	Christiansson et al.	
	525	2015/0035803	02-05-2015	Wassvik et al.	
	526	2015/0053850	02-26-2015	Uvnäs	
	527	2015/0054759	02-26-2015	Christiansson et al.	
	528	2015/0083891	03-26-2015	Wallander	
	529	2015/0103013	04-16-2015	Huang	
	530	2015/0130769	05-14-2015	Björklund	
	531	2015/0138105	05-21-2015	Christiansson et al.	
	532	2015/0138158	05-21-2015	Wallander et al.	
	533	2015/0138161	05-21-2015	Wassvik	
	534	2015/0205441	07-23-2015	Bergström et al.	
	535	2015/0215450	07-30-2015	Seo et al.	
	536	2015/0242055	08-27-2015	Wallander	
	537	2015/0271481	09-24-2015	Guthrie et al.	
	538	2015/0286698	10-08-2015	Gagnier et al.	
	539	2015/0317036	11-05-2015	Johansson et al.	
	540	2015/0324028	11-12-2015	Wassvik et al.	
	541	2015/0331544	11-19-2015	Bergström et al.	
	542	2015/0331545	11-19-2015	Wassvik et al.	
	543	2015/0331546	11-19-2015	Craven-Bartle et al.	
	544	2015/0331547	11-19-2015	Wassvik et al.	
	545	2015/0332655	11-19-2015	Krus et al.	
	546	2015/0346856	12-03-2015	Wassvik	
	547	2015/0346911	12-03-2015	Christiansson	
	548	2015/0363042	12-17-2015	Krus et al.	
	549	2016/0026337	01-28-2016	Wassvik et al.	
	550	2016/0034099	02-04-2016	Christiansson et al.	
	551	2016/0050746	02-18-2016	Wassvik et al.	

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	552	2016/0070415	03-10-2016	Christiansson et al.	
	553	2016/0070416	03-10-2016	Wassvik	
	554	2016/0124546	05-05-2016	Chen et al.	
	555	2016/0124551	05-05-2016	Christiansson et al.	
	556	2016/0154531	06-02-2016	Wall	
	557	2016/0154532	06-02-2016	Campbell	
	558	2016/0202841	07-14-2016	Christiansson et al.	
	559	2016/0216844	07-28-2016	Bergström	
	560	2016/0224144	08-04-2016	Klinghult et al.	
	561	2016/0299593	10-13-2016	Christiansson et al.	
	562	2016/0328090	11-10-2016	Klinghult	
	563	2016/0328091	11-10-2016	Wassvik et al.	
	564	2016/0334942	11-17-2016	Wassvik	
	565	2016/0342282	11-24-2016	Wassvik	
	566	2016/0357348	12-08-2016	Wallander	
	567	2017/0010688	01-12-2017	Fahraeus et al.	
	568	2017/0090090	03-30-2017	Craven-Bartle et al.	
	569	2017/0102827	04-13-2017	Christiansson et al.	
	570	2017/0115235	04-27-2017	Ohlsson et al.	
	571	2017/0115823	04-27-2017	Huang et al.	
	572	2017/0139541	05-18-2017	Christiansson et al.	
	573	2017/0177163	06-22-2017	Wallander et al.	
	574	2017/0185230	06-29-2017	Wallander et al.	
	575	2017/0293392	10-12-2017	Christiansson et al.	
	576	2017/0344185	11-30-2017	Ohlsson et al.	
	577	2018/0031753	02-01-2018	Craven-Bartle et al.	
	578	2018/0129354	05-10-2018	Christiansson et al.	
	579	2018/0210572	07-26-2018	Wallander et al.	
	580	2018/0225006	08-09-2018	Wall	

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	581	2018/0267672	09-20-2018	Wassvik et al.	
	582	2018/0275788	09-27-2018	Christiansson et al.	
	583	2018/0275830	09-27-2018	Christiansson et al.	
	584	2018/0275831	09-27-2018	Christiansson et al.	
	585	4,751,379	06-14-1988	Sasaki et al.	
	586	6,100,538	08-08-2000	Ogawa	
	587	20070165008 A1	07-19-2007	Crockett	
	588	2013/0234991 A1	09-12-2013	Sparf	
	589	8,913,035	12-16-2014	Lai et al.	
	590	2013/0300714 A1	11-15-2013	Goh et al.	
	591	9,001,086	04-07-2015	Saini	
	592	2008/0080811 A1	04-03-2008	Deane	
	593	2010/0315379 A1	12-16-2010	Allard et al.	
	594	2011/0134079 A1	06-09-2011	Stark	
	595	2011/0141062 A1	06-16-2011	Yu et al.	
	596	2012/0170056 A1	07-05-2012	Jakobsen et al.	
	597	2013/0300714 A1	11-14-2013	Goh et al.	
	598	2015/0131010 A1	05-14-2015	Sugiyama	
	599	2019/0025984 A1	01-24-2019	Weilbacher et al.	
	600	2019/0196657 A1	06-27-2019	Skagmo et al.	
	601	2019/0196658 A1	06-27-2019	Skagmo et al.	
	602	2019/0196659 A1	06-27-2019	Skagmo et al.	
	603	2013/0155655 A1	06-20-2013	Lee et al.	

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	**T[1]**
	604	EP 2 325 735 A2	05-25-2011	Samsung Electronics Co., Ltd.		

Examiner Signature	Date Considered

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 22 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	605	WO 2016/130074 A1	08-18-2016	Flatfrog Laboratories AB		
	606	CN 101019071 B	06-13-2012	QUALCOMM MEMS TECHNOLOGIES INC		
	607	CN 101075168 B	04-02-2014	BEIJING IRTOUCH SYSTEMS CO LTD		
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	621	EP 0931731 A1	07-28-1999	GPAX International, Inc.		
	622	EP 1126236 B1	12-15-2010	RICOH COMPANY LTD		
	623	EP 1457870 B1	08-22-2012	SMART TECHNOLOGIES INC		
	624	EP 1512989 B1	09-02-2009	AVAGO TECHNOLOGIES ECBU IP SG PTE LTD		
	625	EP 1798630 A2	06-20-2007	SONY CORP		

Examiner Signature	Date Considered

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 23 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	626	EP 2077490 A3	01-13-2010	APPLE INC		
	627	EP 2088501 A1	08-12-2009	IDEAN ENTPRISES OY		
	628	EP 2314203 A1	04-27-2011	CANON INC		
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	630	EP 2442180 A1	04-18-2012	SAMSUNG ELECTRONICS CO LTD		
	631	EP 2466429 A1	06-20-2012	FLATFROG LABORATORIES AB		
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Examiner Signature	Date Considered

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	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 24 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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	668	WO 2006/124551 A2	11-23-2006	LEE		
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Examiner Signature	Date Considered

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 25 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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Examiner Signature	Date Considered

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
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SHEET 26 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
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	710	WO 2012/121652 A1	09-13-2012	FLATFROG LABORATORIES AB		
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	712	WO 2012/172302 A1	12-20-2012	ST MICROELECTRONICS RES & DEV		
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	724	WO 2014/055809 A1	04-10-2014	CORNING INC		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	725	AHN, Y., et al., "A slim and wide multi-touch tabletop interface and its applications," BigComp2014, IEEE, 2014, in 6 pages.	
	726	CHOU, N., et al., "Generalized pseudo-polar Fourier grids and applications in regfersting optical coherence tomography images," 43rd Asilomar Conference on Signals, Systems and Computers, Nov. 2009, in 5 pages.	
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Examiner Signature	Date Considered

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	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 28 OF 28	Attorney Docket No.	FFOG.054C5

NON PATENT LITERATURE DOCUMENTS			
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	728	FOURMONT, K., "Non-Equispaced Fast Fourier Transforms with Applications to Tomography," Journal of Fourier Analysis and Applications, Vol. 9, Issue 5, 2003, in 20 pages.	
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Examiner Signature	Date Considered

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INFORMATION DISCLOSURE STATEMENT

First Inventor	:	Daniel Skagmo
App. No.	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. References numbered 1-602 and 604-738 are of record in U.S. patent application No. 16/191,177 , filed November 14, 2018, which is relied upon for an earlier filing date under 35 USC 120. Accordingly, copies of references numbered 603 are not submitted pursuant to 37 CFR 1.98(d).

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed within three months of the filing date or date of national phase entry, with an RCE or before receipt of a First Office Action after an RCE, and no fee is believed to be required.

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 11, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 760-0404

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IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 579 of 1254

STATEMENT REGARDING PRIORITY DOCUMENT
PURSUANT TO 37 CFR 1.55(h)

Inventor	:	Daniel Skagmo
App. No	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

The present application is a Continuation of Application No. 16/191,177, which is a continuation of PCT/SE2018/050109. The certified priority document(s) have been filed and acknowledged by the Office in Application No. 16/191,177. Applicant wishes to rely upon the previously submitted priority documents as provided for under 37 CFR 1.55(h).

The priority claim has been properly identified in an Application Data Sheet within the later of either four months from the actual filing date or 16 months from priority. As such, no fee is believed to be required. The Office is hereby authorized to charge any additional fee or credit any overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 11, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 760-0404

32973565

Electronic Acknowledgement Receipt

EFS ID:	39698838
Application Number:	16834905
International Application Number:	
Confirmation Number:	1516
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Customer Number:	20995
Filer:	Harnik Shukla/Jennifer Neat
Filer Authorized By:	Harnik Shukla
Attorney Docket Number:	FFOG.054C5
Receipt Date:	11-JUN-2020
Filing Date:	30-MAR-2020
Time Stamp:	20:41:01
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		FFOG054C5_IDS.pdf	247177 880aad14a92784f5728d930939bed1b4f13126c3	yes	30

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Information Disclosure Statement (IDS) Form (SB08)	3	30
	Transmittal Letter	1	2

Warnings:					
Information:					
2	Miscellaneous Incoming Letter	FFOG054C5_prioritystmt.pdf	16995 0624724e416b585c62e3fe5c448c4469877e8325	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	264172		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 3	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	6,031,524	02-29-2000	Kunert	
	2	2010/0103133	04-29-2010	Park et al.	
	3	2012/0062492	03-15-2012	Katoh	
	4	2016/0026297	01-28-2016	Shinkai et al.	
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__T__[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 3	Attorney Docket No.	FFOG.054C5

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Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
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ABSTRACT

A low profile touch display can be provided, namely one including an optical detection system with the bulk of the electronics and optics positioned partially or completely below the detecting plane surface. The light source and optical detection system components can be configured so that the exit and entry apertures for light being directed to and/or received from the detection plane are the only members above the touch surface. For instance, a reflective or refractive member at the edge of the touch surface can direct light to detection optics and/or from illumination sources via a pinhole aperture, with the light moving between the detection optics and illumination sources in one or more detection planes above the touch surface. Consequently, the touch screen can have a thin cross section that is more suitable for devices such as mobile phones, PDAs, and other portable computing devices for which minimal device thickness is a priority.

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LOW PROFILE TOUCH PANEL SYSTEMS

PRIORITY CLAIM

[0001] This application claims priority to New Zealand Provisional Patent Application No. 561,038, filed on August 30, 2007 and entitled OPTICAL TOUCHSCREEN ENABLING THIN CROSS SECTION, which is hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present subject matter generally pertains to touch display systems that allow a user to interact with one or more processing devices by touching on or near a surface.

BACKGROUND

[0003] Digitizers and tablets can be incorporated as a coordinate input apparatus in processing units. For instance, the digitizer or tablet can be used alongside one or more display devices (e.g. CRT, LCD, or other display technology) in a touch enabled display assembly. Generally speaking, various systems for detecting an angle (direction) or a position of an object relative to the display area can be used, such as pressure sensitive resistance membrane systems, capacitance systems, electromagnetic induction systems, and the like. As another example, optical systems capable of detecting the angle or the position of the object can be used.

[0004] More particularly, touch screen input devices include resistive, surface capacitive, surface acoustic wave (SAW), infrared (IR), Frustrated Total Internal Reflection (FTIR), Projected capacitive, optical and bending wave. Often, the foregoing touch screen devices (aside from some optical and infrared technologies) require use of a touch enabled transparent cover layer that adds height to the display assembly.

[0005] Certain optical and infrared systems rely on detection of light traveling in optical paths that lie in one or more detection planes in an area ("touch area" herein) above the touched surface. For example, optical imaging for touch screens can use a combination of line-scan or area image cameras, digital signal processing, front or back illumination, and algorithms to determine a point or area of touch. Components used to emit and detect light in the detection plane(s) can be positioned along one or more edges of the touch screen area as part of a bezel surrounding the touch screen area. Optical touch technology often uses

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line-scanning or area cameras orientated along one or more edges of the touch surface to image the bezel and track the movement of any object close to the surface of the touch screen by detecting the interruption of an infrared light source.

[0006] In some systems, the light can be emitted across the surface of the touch screen by IR-LED emitters aligned along the optical axis of the camera to detect the existence or non existence of light reflected by a retro-reflective border. If an object is interrupting light in the detection plane, the object will cast a shadow in the retroreflected light. Based on the direction of the shadow as cast toward multiple detectors and the spatial arrangement of the detectors, the object's location in the detection area can be triangulated. As another example, light can be emitted across the touch area in a grid pattern, with the object's location determined based on where the grid is interrupted.

[0007] For instance, Figure 1 is a cross-sectional view of an exemplary touch detection system 10 in which an optical detection and illumination system 12 and illuminated bezel 14 both extend above a touch surface 18. In this particular example, the optical detection system and illumination system are combined into a single unit as is known in the art. The plane of touch surface 18 in this example corresponds to the top of display screen 16 or a protective layer positioned above the display screen. Light is emitted from illumination source 20 and is directed along an outgoing optical path 20. The light is then retroreflected along return optical path 24, passing into optics 28 (a lens in this example) and detector 26. In this example, the profile of the touch detection system is 3.2mm.

[0008] As is known to those of skill in the art, the triangulation principle can be used to calculate the position at which an object impinges on a detection plane via measurements from two or more detection systems. Figure 2 provides a top view of an exemplary touch detection system 29 which can identify coordinates within a detection plane 31. In this example, two optical detection and illumination systems 30 are provided, with respective exemplary paths 34 and 36 showing the route of light emitted from and returned to the illumination/detection systems 30 via reflective components positioned along edges 32. For example, retroreflective components can be positioned along edges 32 covered by or included in a bezel.

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[0009] When an object interrupts the beams as represented at 33, the location of the interruption can be triangulated based on the change in optical paths across detection plane 31. For example, an object may cast shadows which are detected by illumination/detection systems 30, with location 33 triangulated from the direction of the shadows and the known spatial relationship between illumination/detection systems 30.

[0010] Figure 3 shows a side view of another exemplary touch detection system 40. In this example, illuminated stylus 42 is used to intersect detection plane 44. Light traveling in detection plane 44 may be collected via optics 46 and directed via reflector 48 to detector 50. In this example, detector 50 is interfaced with detector electronics 52 mounted above the touch surface. For example, detector 50, electronics 52, lenses 46, and reflector 58 may all be built into a bezel surrounding screen 58.

[0011] The relative complexity of the optical components used to emit and detect light can lead to a profile height of the bezel that is not suitable for all applications. For example, the bezel height may be too large for use in a handheld computing device, such as a mobile phone, or personal digital assistant (PDA).

[0012] RPO Pty Ltd of Australia, attempts to provide a low profile by having the IR emitters and receivers optically connected by wave guides. In the example of Figure 4, touch-enabled display 60 comprises an LCD display 62 surrounded by a plurality of transmit side waveguides 64 and receive side waveguides 66. Transmit side waveguides provide an optical path from light source 68, while receive side waveguides provide an optical path to detection electronics (ASIC) 70. Light from transmit side waveguides 64 forms a grid pattern across display 62 which can be detected by electronics 70. An object's location on the detection plane can be determined based on interruptions or other disruptions in the expected grid pattern. For example, source 68 may emit infrared or other light, and interruption of the grid may result in a shadow that diminishes the light received at one or more receive side waveguides 66.

[0013] Although waveguides 64 and 66 allow for source 68 and electronics 70 to be positioned below the screen surface, the waveguides add cost and complexity to the touch-enabled display. For example, the waveguides may be fragile and require careful handling. As another example, each of several waveguides must be connected to the touchscreen at one

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end and to electronics 70 at the other end. In short, use of the waveguides can complicate assembly and repair and may lead to a less durable product

SUMMARY

[0014] Objects and advantages of the present subject matter will be apparent to one of ordinary skill in the art upon careful review of the present disclosure and/or practice of one or more embodiments of the claimed subject matter.

[0015] In accordance with one or more aspects of the present subject matter, a low profile touch display can feature a touch surface corresponding to the outer surface of the display or a protective layer over the display. A reflective or refractive member at one or more edges of the touch surface can direct light traveling in one or more detection planes above the touch surface to the detection optics of the touch display via one or more pinhole apertures. The bulk of the electronics and optics of the optical detection system are positioned partially or completely below the plane of the touch surface, with only the refractive or reflective members and the exit and entry apertures for light extending above the touch surface. Consequently, the touch display system can have a thin cross section that is well suited for devices such as mobile phones, PDAs, and other portable computing devices for which minimal device thickness is a priority.

[0016] For example, a touch detection system can include an illuminated bezel positioned at an edge of a touch surface and configured to direct light along one or more optical paths laying in a detection plane (or planes) above the plane of the touch surface. The illuminated bezel may reflect, refract, or otherwise scatter light from one or more sources so that light is directed towards an optical detection system. As mentioned above, the touch surface may, for example, correspond to the surface of a display device or a protective surface (e.g. transparent or semi-transparent glass, plastic, or other material) positioned over the display device.

[0017] The touch detection system can further comprise an optical detection system positioned at an edge of the touch surface and partially or completely below the plane of the touch surface. The term "below" is meant to refer to the vertical positioning of the optical detection system relative to the plane of the touch surface and not necessarily its lateral position relative to the edges of the touch surface.

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[0018] At one or more edges of the touch surface, the system can include an optical assembly extending above the plane of the touch surface so as to intersect with the detection plane(s), with the optical assembly configured to direct light from an optical path (or paths) laying in the detection plane into the detection system via a pinhole aperture.

[0019] In some embodiments, the illuminated bezel is illuminated by an illumination source positioned at least partially below the plane of the touch surface. The illumination source can be configured to direct light toward an optical assembly through a pinhole aperture and into an optical path lying in the detection plane.

[0020] The illumination source may be positioned alongside the detection components of the optical detection system in some implementations and provide illumination via the same optical assembly that receives light returned from the touch area, with the same optical assembly relaying light up to the detection plane from the source. In such embodiments, the illuminated bezel can reflect, refract, or otherwise scatter light towards the detection components.

[0021] However, in other embodiments, the illumination source may be located at a different location on an edge of the touch surface and direct light through a pinhole aperture having the same size as the first pinhole aperture. The pinhole aperture can lead to a second optical assembly positioned at an edge of the touch surface and extending above the plane of the touch surface so as to intersect with the detection plane. Light can be directed up into the second optical assembly, across the touch area, into the first optical assembly, and then into the optical detection system.

[0022] In certain embodiments, the optical assembly or assemblies extend above the plane of the touch surface by a height approximately equal to the diameter of the pinhole aperture(s). For example, if the pinhole aperture is circular, the diameter can refer to the diameter of the circle, or if the aperture is square, the diameter can refer to the diagonal of the square. More generally, the diameter can refer to the maximum distance across the opening measured along a line that passes through the opening. In some embodiments, the pinhole aperture diameter(s) can be equal to or approximately 0.5 mm, although other diameters could be used, as appropriate. As used herein, "approximately" is meant to convey

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that the value is within ±20% of the stated value, thus "approximately" 0.5 mm includes 0.5 mm ±0.1mm. Pinhole apertures can have other shapes in other embodiments.

[0023] The "plane of the touch surface" is used to refer generally to a plane extending through space that, within the touch area, corresponds to the top of the touch surface. For example, the top of the touch surface can correspond to the top of display screen or a protective layer positioned above the display screen in some embodiments.

[0024] Multiple detection systems can be used in some embodiments. For example, a second detection system can be positioned at an edge of the touch surface and configured to receive light directed toward the second detection system via a second pinhole aperture. Depending on the configuration of the touch detection system, a single optical assembly with appropriate characteristics can be used to route light to the respective detection systems, or each detection system can feature a separate corresponding optical assembly extending above the touch surface.

[0025] Some embodiments can include at least one computing device interfaced with the detection system or systems and configured to determine a location at which an object has intersected the detection plane based on data collected from the detection system(s). For example, location may be determined based on the object's disturbance of the propagation of light in the detection plane(s), such as by detecting variances in illumination intensity (e.g. illumination intensity increases and/or shadows). As one particular example, the "triangulation principle" may be used to determine an object's location relative to the touch surface area.

[0026] One or more display systems can be included, the display system(s) having a surface positioned parallel to or corresponding the touch surface. For example, an LCD or other type of display can comprise the touch surface. The display systems can, in some embodiments, be interfaced with the at least one computing device. Accordingly, the computing device(s), in conjunction with the touch detection system and displays, can provide a touch-enabled display for use in operating the computing device(s).

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] A full and enabling disclosure including the best mode of practicing the appended claims and directed to one of ordinary skill in the art is set forth more particularly

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in the remainder of the specification. The specification makes reference to the following appended figures, in which use of like reference numerals in different features is intended to illustrate like or analogous components:

[0028] Figure 1 is a diagram illustrating an exemplary prior art illumination and detection system which is positioned above a touch surface;

[0029] Figure 2 is a diagram generally illustrating the triangulation principle employed in various prior art systems;

[0030] Figure 3 is a diagram illustrating an optical touch system including detection components above the detection plane in another exemplary prior art system;

[0031] Figure 4 generally illustrates one prior art solution in which illumination and detection components are positioned behind a touch surface through use of waveguide structures;

[0032] Figure 5 is a diagram illustrating an exemplary low profile touch detection system according to some aspects of the present subject matter;

[0033] Figure 6 shows a portion of the exemplary low profile touch detection system shown in Figure 5 in closer detail;

[0034] Figure 7 shows a portion of another exemplary low profile touch detection system according to some aspects of the present subject matter; and

[0035] Figure 8 is a block diagram illustrating an exemplary touch panel display system as interfaced with an exemplary computing device according to some aspects of the present subject matter.

DETAILED DESCRIPTION

[0036] Reference will now be made in detail to various and alternative exemplary embodiments and to the accompanying drawings, with like numerals representing substantially identical structural elements. Each example is provided by way of explanation, and not as a limitation. It will be apparent to those skilled in the art that modifications and variations can be made without departing from the scope or spirit of the disclosure and claims. For instance, features illustrated or described as part of one embodiment may be used

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on another embodiment to yield a still further embodiment. Thus, it is intended that the instant disclosure includes modifications and variations as come within the scope of the appended claims and their equivalents.

[0037] Turning now to Figure 5, an exemplary touch detection system 80 configured in accordance with one or more aspects of the present subject matter is shown. In this example, an illuminated bezel 82 directs light from source 86 along optical paths 88 and 90 which lie in detection planes above touch surface 84. Bezel 82 can be illuminated in any suitable way as will be noted below. As illustrated, touch surface 84 intersects with the surface of display 85, which is a liquid crystal display (LD) panel. It will be understood that in some embodiments, touch surface 84 may be above the actual surface of a display, such as when a covering is included on the surface of the display.

[0038] Optical detection system 92 is operative to detect light traveling in optical paths such as 88 and 90. Optical detection system 92 in this example comprises lens 98, detector 99, and related electronics. For instance, detector 99 may comprise a CMOS or other suitable light detector interfaced with an ASIC or other suitable circuitry to filter or otherwise process the output of detector 99. Of course, any suitable detection technology appropriate for detecting light from source 86 can be used. Further, although lens 98 is shown in this example for purposes of clarity, more complex optics may be used, including additional lenses, filters, and/or other suitable components.

[0039] Light traveling along optical paths 88 and 90 is directed into detection system 92 via a pinhole aperture 96 having a diameter d, which may be viewed in closer detail in Figure 6. Although in this example pinhole aperture 96 is round and its size is expressed as a diameter in the traditional sense, it will be understood that pinhole apertures can have other shapes; in such cases, its diameter or size would refer to the length from one side to the other of the aperture, passing through the center.

[0040] Optical assembly 94 is positioned at an edge of touch surface 84 and acts to direct light from one or more detection planes towards pinhole aperture 96. Optical assembly 94 extends above touch surface 84 to a profile height P equal or approximately equal to the diameter d of pinhole aperture 96. For instance, diameter d (and thus the profile height of optical assembly 94) may be approximately 0.5 mm in some embodiments.

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[0041] In example of Figures 5 and 6, optical assembly 94 is configured to direct light using refraction. Namely, a first facet F1 of the assembly 94 faces on the outside toward the touch detection area, while a second facet, F2, does not. Light entering facet F2 enters the assembly and is directed out of facet F1. Due to refraction the direction of light traveling from facet F2 to F1, and vice versa, is altered. Thus, optical detection system 92 can be positioned at least partially below the plane of touch surface 84.

[0042] In Figure 5, optical detection system 92 is positioned outside the edges of touch surface 84 and partially below the plane of touch surface 84, while in Figure 6 detection system 92 is depicted as entirely below the plane of touch surface 84. The relative distance between pinhole aperture 96 and optical assembly 94 can vary; in some embodiments, the aperture is minimally spaced from optical assembly 94.

[0043] Figure 7 is an illustration of another exemplary touch detection system 180 as viewed in cross section. In this example, optical detection system 192 is positioned completely below touch surface 184. Similarly to system 92 in the examples of Figures 5-6, optical detection system 192 comprises a lens (198) and detector (199). In this example, optical assembly 194 comprises a first facet F1 facing toward the detection area and a second facet F2 partially facing away from the detection area. In this example, facet F2 is configured to reflect rays traveling in optical paths 88 and 90 downward through pinhole aperture 196. This facilitates placement of optical detector assembly 192 completely below touch surface 184. Optical assembly 194 extends above touch surface 184 to a profile height P equal or approximately equal to the diameter d of pinhole aperture 196. As noted above, in some embodiments, d is equal or approximately equal to 0.5 mm.

[0044] In any event, an optical assembly 82, 94, 194 can comprise any suitable material or materials. For instance, in some embodiments, polycarbonate or acrylic plastics can have suitable cost, durability, and clarity characteristics.

[0045] Figure 8 is a block diagram illustrating an exemplary touch detection system 280 as interfaced to an exemplary display 250 and a computing device 201 in accordance with certain aspects of the present subject matter. Computing device 201 may be functionally coupled to touch screen system 200, by hardwire and/or wireless connections. Computing device 201 may be any suitable computing device, including, but not limited to a

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processor-driven device such as a personal computer, a laptop computer, a handheld computer, a personal digital assistant (PDA), a digital and/or cellular telephone, a pager, a video game device, etc. These and other types of processor-driven devices will be apparent to those of skill in the art. As used in this discussion, the term "processor" can refer to any type of programmable logic device, including a microprocessor or any other type of similar device.

[0046] Computing device 201 may include, for example, a processor 202, a system memory 204, and various system interface components 206. The processor 202, system memory 204, a digital signal processing (DSP) unit 205 and system interface components 206 may be functionally connected via a system bus 208. The system interface components 206 may enable the processor 202 to communicate with peripheral devices. For example, a storage device interface 210 can provide an interface between the processor 202 and a storage device 211 (removable and/or non-removable), such as a disk drive. A network interface 212 may also be provided as an interface between the processor 202 and a network communications device (not shown), so that the computing device 201 can be connected to a network.

[0047] A display screen interface 214 can provide an interface between the processor 202 and display device 250. For instance, interface 214 may provide data in a suitable format for rendering by display device 250. Although not illustrated, computing device 201 may include additional components dictated by its intended function. For example, if computing device 201 comprises a cellular telephone, appropriate transmission and reception components may be included. As another example, computing device 201 may include networking components as noted above, such as a radio transmitter/receiver for communication using one or more wireless standards such as those governed by IEEE 802.11.

[0048] In this example, touch screen 250 is bounded by edges 251, 252, 253, and 254. For instance, a bezel may be used to protect the edges of screen 250. Further, the edges of touch surface 284 correspond to edges 251, 252, 253, and 254. As was noted above, touch surface 284 may correspond to the outer surface of display 250 or may correspond to the outer surface of a protective material positioned on display 250. Although in this example

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the touch screen is enabled to detect an object's position relative to the entire display area, in other embodiments, the system may be operative to detect an object's position relative to only a part of the display area.

[0049] In any event, Figure 8 further illustrates a plurality of light sources 282A and 282B positioned at edge 252 and optical detection assemblies 292A and 292B positioned along edge 254. Since sources 282 and assemblies 292 are at least partially below touch surface 284, sources 282 and assemblies 292 are illustrated in phantom. In this example, optical assemblies 286A and 286B are shown along edge 252 for relaying light from sources 282 to optical paths in one or more detection planes above touch surface 284, while optical assemblies 294A and 294B are shown along edge 254 for relaying light from the detection plane(s) to detection assemblies 292.

[0050] One or more input/output ("I/O") port interfaces 216 may be provided as an interface between the processor 202 and various input and/or output devices. For example, the detection assemblies 292 or other suitable components of the touch screen system may be connected to the computing device 201 via an input port and may provide input signals to the processor 202 via an input port interface 216. Similarly, the light sources 282 of the touch screen system may be connected to the computing device 201 by way of an output port and may receive output signals (e.g. illumination timing and level controls) from the processor 202 via an output port interface 216.

[0051] A number of program modules may be stored in the system memory 204 and/or any other computer-readable media associated with the storage device 211 (e.g., a hard disk drive) or otherwise accessible by computing device 201. The program modules may include an operating system 217. The program modules may also include an information display program module 219 comprising computer-executable instructions for displaying images or other information on a display screen 250. Other aspects of the exemplary embodiments of the invention may be embodied in a touch screen control program module 221 for controlling the energy sources 282 and/or detector assemblies 292 and/or for calculating touch locations and discerning interaction states relative to the touch screen 250 based on signals received from the detector assemblies.

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[0052] In some embodiments, a DSP unit is included for performing some or all of the functionality ascribed to the Touch Panel Control program module 221. As is known in the art, a DSP unit 205 may be configured to perform many types of calculations including filtering, data sampling, and triangulation and other calculations and to control the modulation and/or other characteristics of light sources 282. The DSP unit 205 may include a series of scanning imagers, digital filters, and comparators implemented in software. The DSP unit 205 may therefore be programmed for calculating touch locations and discerning other interaction characteristics as known in the art.

[0053] The processor 202, which may be controlled by the operating system 217, can be configured to execute the computer-executable instructions of the various program modules. Methods in accordance with one or more aspects of the present subject matter may be carried out due to execution of such instructions. Furthermore, the images or other information displayed by the information display program module 219 may be stored in one or more information data files 223, which may be stored on any computer readable medium associated with the computing device 201.

[0054] As discussed above, when a user touches on or near the touch screen 250, a variation will occur in the intensity of the energy beams that are directed across the surface of the touch screen in one or more detection planes. The detector assemblies 292 are configured to detect the intensity of the energy beams reflected or otherwise scattered across the surface of the touch screen 250 and should be sensitive enough to detect variations in such intensity. Information signals produced by the detector assemblies 292 and/or other components of the touch screen display system may be used by the computing device 201 to determine the location of the touch relative to the touch screen 250. Computing device 201 may also determine the appropriate response to a touch on or near touch screen 250.

[0055] In accordance with some implementations, data from the detector assemblies may be periodically processed by the computing device 201 to monitor the typical intensity level of the energy beams directed along the detection plane(s) when no touch is present. This allows the system to account for, and thereby reduce the effects of, changes in ambient light levels and other ambient conditions. Computing device 201 may optionally increase or decrease the intensity of the energy beams emitted by the light sources 282, as needed.

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Subsequently, if a variation in the intensity of the energy beams is detected by the detector assemblies, the computing device 201 can process this information to determine that a touch has occurred on or near the touch screen 250.

[0056] The location of a touch relative to the area of touch screen 250 may be determined, for example, by processing information received from each detector assembly 292 and performing one or more well-known triangulation calculations. By way of illustration, the computing device 201 may receive information from each detector assembly 292 that can be used to identify the position of an area of increased or decreased energy beam intensity relative to each detector assembly. The location of the area of decreased energy beam intensity relative to each detector assembly may be determined in relation to the coordinates of one or more pixels, or virtual pixels, of screen 250. The location of the area of increased or decreased energy beam intensity relative to each detector may then be triangulated, based on the geometry between the detector assemblies 292 to determine the actual location of the touch relative to the touch screen 250.

[0057] Any such calculations to determine touch location and/or interaction state can include algorithms to compensate for discrepancies (e.g., lens distortions, ambient conditions, damage to or impediments on the touch screen 100 or other touched surface, etc.), as applicable.

[0058] The locations and number of illumination sources 282, optical assemblies 286 and 294, and detector assemblies 292 in Figure 8 are for purposes of example only. For instance, more or fewer illumination sources 282 and corresponding optical assemblies 286 could be used. Similarly more or fewer detector assemblies 292 and corresponding optical assemblies 294 could be used.

[0059] For example, rather than using triangulation, the system may establish a grid across the display surface using a plurality of illumination pinhole apertures and corresponding receiving pinhole apertures configured to direct light down to optical detection assemblies. For good resolution, several illumination sources and corresponding detection assemblies could be used.

[0060] In some embodiments, rather than discrete optical assemblies 294A and 294B, a continuous optical assembly can be provided along an edge, with the detector assemblies

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292 and corresponding pinhole apertures located along the edge at different locations. Similarly, a continuous optical assembly 286 could be used in conjunction with multiple sources 282.

[0061] In certain embodiments, optical units comprising both detector assemblies and illumination sources are used. For instance, a detector assembly can include illumination sources that illuminate a retroreflector that returns the light to its point of origin. See, for instance, U.S. Patent No. 6,362,468. In such embodiments, the same optical assembly and pinhole aperture could be used to route light from the illumination sources and across the detection plane and also return retroreflected light.

[0062] The above examples referred to various illumination sources and it should be understood that any suitable radiation source can be used. For instance, light emitting diodes (LEDs) may be used to generate infrared (IR) radiation that is directed over one or more optical paths in the detection plane. However, other portions of the EM spectrum or even other types of energy may be used as applicable with appropriate sources, detection systems, and optical (or other) units that redirect the energy to and from the detection plane.

[0063] Several of the above examples were presented in the context of a touch-enabled display. However, it will be understood that the principles disclosed herein could be applied even in the absence of a display screen when the position of an object relative to an area is to be tracked.

[0064] The various systems discussed herein are not limited to any particular hardware architecture or configuration. As was noted above, a computing device can include any suitable arrangement of components that provide a result conditioned on one or more inputs. Suitable computing devices include multipurpose microprocessor-based computer systems accessing stored software, but also application-specific integrated circuits and other programmable logic, and combinations thereof. Any suitable programming, scripting, or other type of language or combinations of languages may be used to implement the teachings contained herein in software.

[0065] Embodiments of the methods disclosed herein may be executed by one or more suitable computing devices. Such system(s) may comprise one or more computing devices adapted to perform one or more embodiments of the methods disclosed herein. As

noted above, such devices may access one or more computer-readable media that embody computer-readable instructions which, when executed by at least one computer, cause the at least one computer to implement one or more embodiments of the methods of the present subject matter. When software is utilized, the software may comprise one or more components, processes, and/or applications. Additionally or alternatively to software, the computing device(s) may comprise circuitry that renders the device(s) operative to implement one or more of the methods of the present subject matter.

[0066] Any suitable computer-readable medium or media may be used to implement or practice the presently-disclosed subject matter, including, but not limited to, diskettes, drives, magnetic-based storage media, optical storage media, including disks (including CD-ROMS, DVD-ROMS, and variants thereof), flash, RAM, ROM, and other memory devices, and the like.

[0067] While the present subject matter has been described in detail with respect to specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing may readily produce alterations to, variations of, and equivalents to such embodiments. Accordingly, it should be understood that the present disclosure has been presented for purposes of example rather than limitation, and does not preclude inclusion of such modifications, variations and/or additions to the present subject matter as would be readily apparent to one of ordinary skill in the art

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WHAT IS CLAIMED:

1. A touch detection system comprising:

an optical detection system positioned at an edge of a touch surface and positioned at least partially below a plane of the touch surface, the plane of the touch surface corresponding to the top of the touch surface; and

an optical assembly positioned at an edge of the touch surface and extending above the plane of the touch surface so as to intersect with a detection plane above the plane of the touch surface, the optical assembly configured to refract light from an optical path in the detection plane into the optical detection system via a pinhole aperture;

wherein the optical assembly defines a profile height above the plane of the touch surface, the profile height approximately equal to the diameter of the pinhole aperture.

2. The touch detection system set forth in claim 1, wherein the profile height is equal to the diameter of the pinhole aperture.

3. The touch detection system set forth in claim 1, wherein the profile height is less than 1 mm.

4. The touch detection system set forth in claim 3, wherein the pinhole aperture diameter is less than or equal to 0.5 mm.

5. The touch detection system set forth in claim 1, further comprising:

an illumination source positioned at least partially below the plane of the touch surface and configured to direct light toward the optical assembly through the pinhole aperture; and

an illuminated bezel at an edge of the touch surface, the illuminated bezel comprising a surface that reflects light traveling towards the bezel in the detection plane back into the detection plane.

6. The touch detection system set forth in claim 1, further comprising:

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an illumination source positioned at least partially below the plane of the touch surface; and

an illuminated bezel at an edge of the touch surface, the illuminated bezel comprising a second optical assembly positioned at an edge of the touch surface and extending above the plane of the touch surface so as to intersect with the detection plane;

wherein the illumination source is configured to direct light toward the second optical assembly and the second optical assembly is configured to refract light received from the illumination source into the optical path lying in the detection plane.

7. The touch detection system set forth in claim 6, wherein the second optical assembly defines a profile height approximately equal to the size of the pinhole aperture.

8. The touch detection system set forth in claim 1, further comprising:

at least a second optical detection system, the second optical detection system positioned an edge of the touch surface and configured to receive light directed toward the second detection system via a pinhole aperture; and

at least one computing device interfaced with the first and second optical detection systems and configured to determine a location at which an object has intersected the detection plane based on data collected from the optical detection systems.

9. The touch detection system set forth in claim 1, further comprising a display system having a top surface positioned parallel to or corresponding to the touch surface.

10. The touch detection system set forth in claim 1, wherein the detection system is positioned completely below the plane of the touch surface.

11. A touch detection system comprising:

an illuminated bezel positioned at an edge of a touch surface and configured to direct light along an optical path laying in a detection plane above a plane of the touch surface, the plane of the touch surface corresponding to the top of the touch surface;

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a plurality of detection systems positioned along an edge of the touch surface and positioned at least partially below the plane of the touch surface; and

at least one optical assembly positioned at an edge of the touch surface and extending above the plane of the touch surface so as to intersect with the detection plane, the optical assembly configured to direct light from an optical path laying in the detection plane into the respective detection systems via a pinhole aperture corresponding to each detection system;

wherein the optical assembly extends above the touch surface by a height approximately equal to the diameter of the pinhole apertures.

12. The touch detection system set forth in claim 11,

further comprising an illumination source positioned at least partially below the touch surface and configured to direct light toward the optical assembly through the pinhole aperture; and

wherein the illuminated bezel comprises a surface that reflects light traveling towards the bezel in the detection plane back into the detection plane.

13. The touch detection system set forth in claim 11,

further comprising an illumination source positioned at least partially below the plane of the touch surface;

wherein the illuminated bezel comprises a second optical assembly positioned at an edge of the touch surface and extending above the plane of the touch surface so as to intersect with the detection plane; and

wherein the illumination source is configured to direct light toward the second optical assembly and the second optical assembly is configured to direct light received from the illumination source into the optical path lying in the detection plane.

14. The touch detection system set forth in claim 11, wherein the diameter of each pinhole aperture is less than or equal to 0.5 mm.

15. The touch detection system set forth in claim 11, further comprising:

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at least one computing device interfaced with the detection systems and configured to determine a location at which an object has intersected the detection plane based on data collected from the detection systems.

16. The touch detection system set forth in claim 15, further comprising a display system having a surface positioned parallel to or corresponding to the touch surface, the display system interfaced with the at least one computing device.

17. A touch-enabled display device, comprising:

a display screen having a surface and an area;

a detection system, with at least a portion of the detection system positioned vertically below the screen surface;

an illumination system, with at least a portion of the illumination system positioned vertically below the screen surface;

a computing device configured to determine the location at which an object has changed the transmission of light across a touch area, the touch area being coextensive with at least a part of the area of the display screen; and

at least one optical assembly positioned along at least one edge of the screen, the optical assembly comprising a first facet that faces toward the interior of the touch area and a second facet that does not face toward the interior of the touch area;

wherein the at least one optical assembly is configured so that light entering the assembly at the first facet is directed to exit the optical assembly at the second facet and light entering the optical assembly at the second facet is directed to exit the optical assembly at the first facet; and

wherein the display device is configured so that light is emitted from the illumination system and is directed into the second facet of the optical assembly before crossing the touch area.

18. The touch-enabled display device set forth in claim 17, wherein the display device is configured so that:

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the illumination system and detection system are separate from one another; and

light is emitted from the illumination system into a first optical assembly, crosses the touch area, and enters a second optical assembly which directs the light into the detection system via a pinhole aperture.

19. The touch-enabled display device set forth in claim 17, wherein the optical assembly is configured to direct light by reflection.

20. The touch-enabled display device set forth in claim 17, wherein the optical assembly is configured to direct light by refracting light at the first facet.

21. The touch-enabled display device set forth in claim 17, wherein the optical assembly at is configured so that:

light traveling in an optical path in a plane parallel to the plane of the touch surface and intersecting with the first facet is directed by the optical assembly to travel in an optical path in a plane that is not parallel to the plane of the touch surface and intersecting with the second facet.

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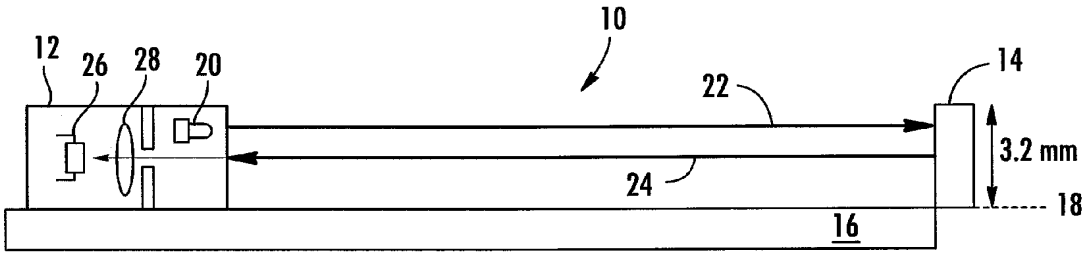


FIG. 1
PRIOR ART

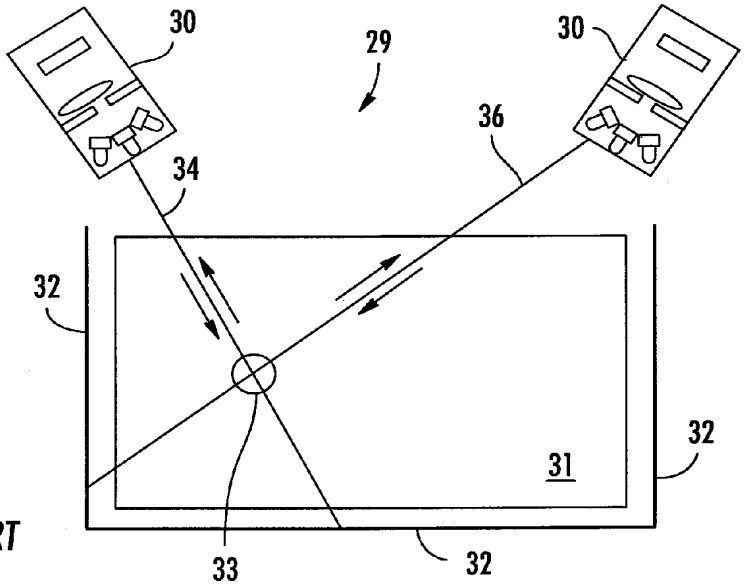


FIG. 2
PRIOR ART

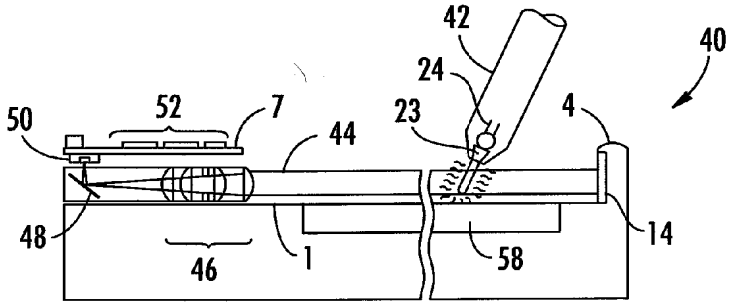


FIG. 3
PRIOR ART

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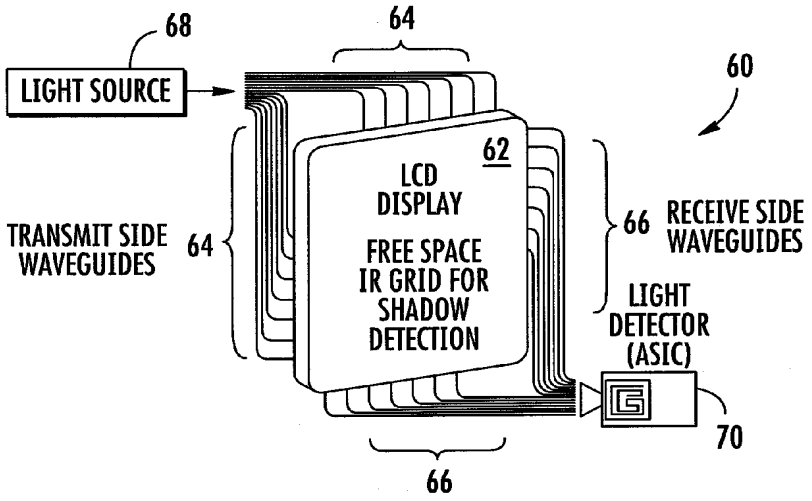


FIG. 4
PRIOR ART

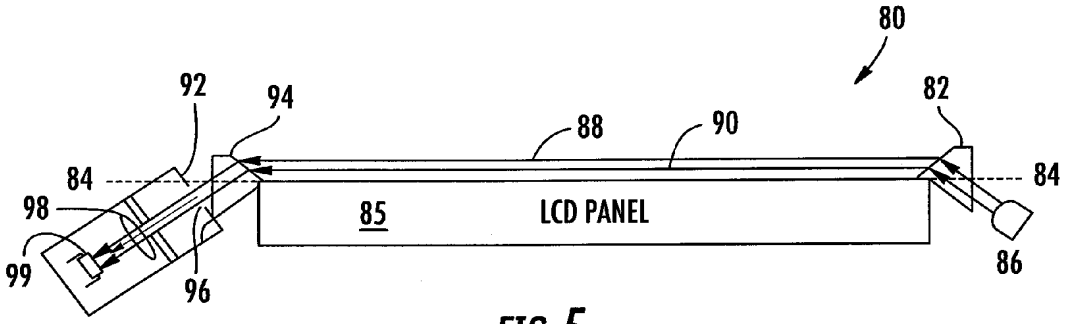


FIG. 5

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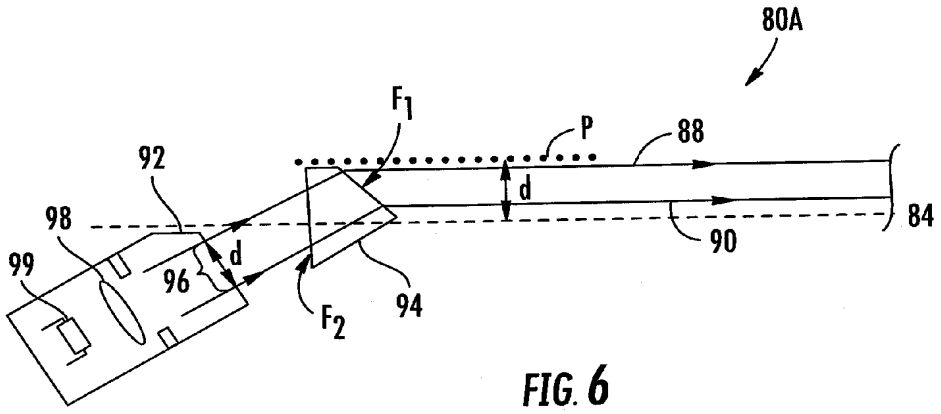


FIG. 6

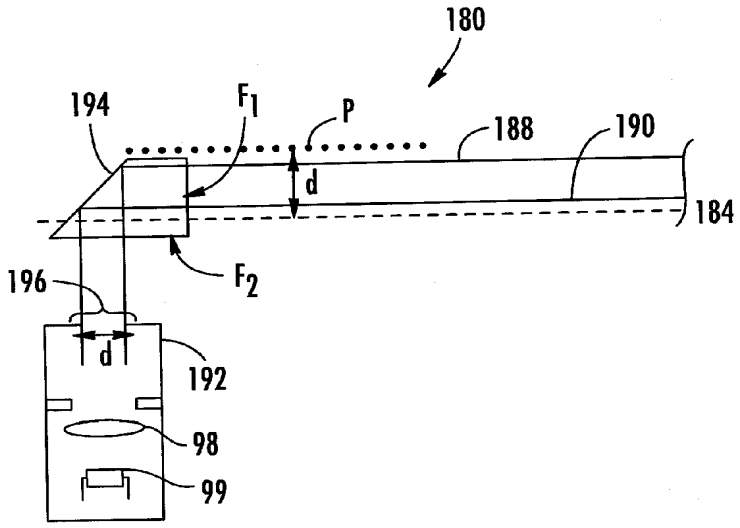


FIG. 7

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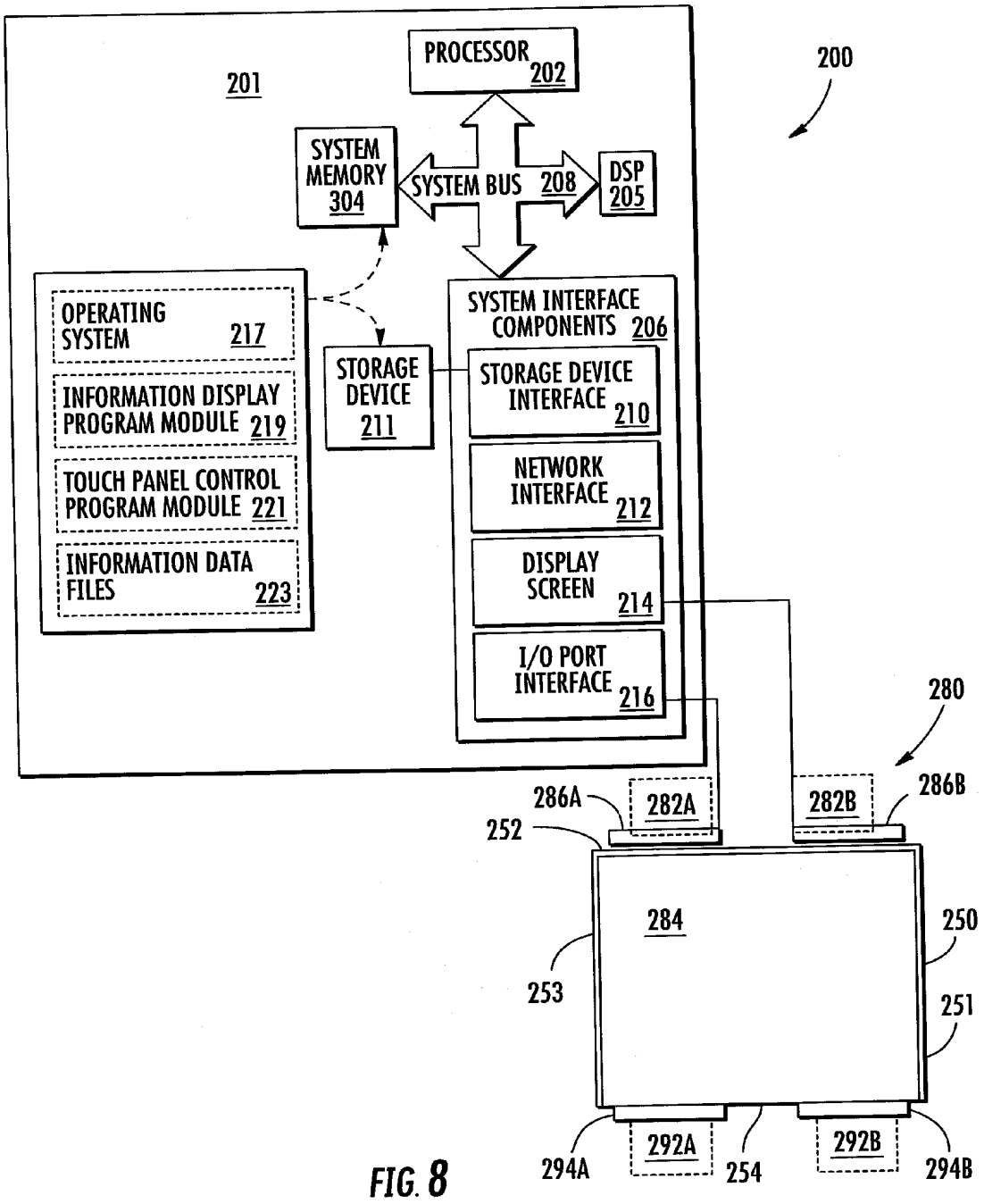


FIG. 8

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Espacenet

CN100501657C Touch panel device and its locating method

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Touch panel device and its locating method

Abstract

The invention discloses the localization method of a kind of touch panel device and touch panel device, it is in conjunction with the infrared scan technology of infrared scan module and the camera technique of camera head, obtain the coordinate position of all possible touch point by the infrared scan technology, and in conjunction with the camera head shot picture, determine the coordinate of actual touch point and the color and the size of actual touch thing, color and size according to the actual touch thing, it can be to the independent tracing management of variant touch objects, and cost is low, simple in structure, response speed is fast and reliability is high.

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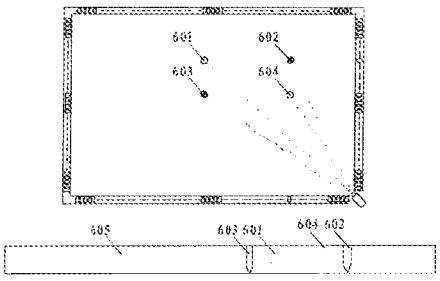
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权利要求书 2 页 说明书 9 页 附图 4 页

[54] 发明名称

一种触摸屏装置及触摸屏装置的定位方法

[57] 摘要

本发明公开了一种触摸屏装置及触摸屏装置的定位方法，其结合红外扫描模块的红外扫描技术与摄像装置的摄像技术，通过红外扫描技术获取所有可能的触摸点的坐标位置，并结合摄像装置所拍摄的图片，确定实际的触摸点的坐标以及实际触摸物的颜色和大小，根据实际触摸物的颜色和大小，其可以对各不同的触摸物单独跟踪管理，成本低、结构简单、响应速度快且可靠性高。



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1、一种触摸屏装置，其特征在于，包括：

红外扫描模块，该红外扫描模块包括横向及纵向的红外发射模块、红外接收模块；

摄像装置，该摄像装置位于可拍摄到由所述红外扫描模块所组成的红外扫描网的位置，用于采集触摸物数据；

主控制模块，用于收集所述红外接收模块采集的触摸数据及所述摄像装置所采集的触摸物数据，并计算实际触摸点信息，向主机设备发送，或者直接将所述收集的数据发送给所述主机设备，由所述主机设备计算出所述实际触摸点信息。

2、根据权利要求 1 所述的触摸屏装置，其特征在于，所述实际触摸点的信息包括所述实际触摸点的触摸坐标，或者所述实际触摸点的触摸坐标及所述实际触摸物的颜色和/或大小信息。

3、根据权利要求 1 所述的触摸屏装置，其特征在于，所述摄像装置位于横向发射模块和纵向发射模块的交界处。

4、根据权利要求 1 所述的触摸屏装置，其特征在于，所述摄像装置的光轴中心线平行于所述红外扫描网或者位于所述红外扫描网内。

5、根据权利要求 1 所述的触摸屏装置，其特征在于，通过采用至少一种方式以提高拍摄装置的清晰度：

增加外部光源辅助装置；

使用带高反光材料的触摸物和/或在所述触摸物上使用高反光材料的配件。

6、根据权利要求 1 至 5 任意一项所述的触摸屏装置，其特征在于，在同一个扫描周期内，所述摄像装置与所述红外扫描模块同步工作或者以先后顺序工作。

7、一种触摸屏装置的定位方法，其特征在于，包括步骤：

S101：启动红外扫描，在有触摸物存在的情况下，记录被所述触摸物所遮

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挡的红外接收管的位置信息;

S102：以可拍摄到红外扫描网的位置拍摄一幅图片，在有触摸物存在的情况下，根据所述图片分析所述触摸物的角度信息;

S103：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合所述步骤 S102 中的角度信息，分析出实际触摸物的数据信息，所述数据信息包括实际触摸物的触摸点的坐标信息。

8、根据权利要求 7 所述的定位方法，其特征在于：所述步骤 S101、S102 可以交换顺序或者同步进行。

9、根据权利要求 7 或 8 所述的定位方法，其特征在于：

在所述步骤 S102 中还包括：根据所述图片分析所述触摸物的颜色和/或大小信息;

在所述步骤 S103 中，所述数据信息还包括所述实际触摸物的颜色和/或大小信息。

10、根据权利要求 9 所述的定位方法，其特征在于：所述实际触摸物的颜色信息与其笔迹的颜色相对应和/或所述实际触摸物的大小信息与其笔迹的粗细相对应。

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一种触摸屏装置及触摸屏装置的定位方法

技术领域

本发明涉及触摸屏领域，特别涉及一种触摸屏装置及触摸屏装置的定位方法。

背景技术

触摸屏作为一种新型的计算机输入设备，使人机交互更为直观，由于给用户带来的极大地便利性，触摸屏技术除了应用于个人便携式信息产品外，应用领域已遍及信息家电、公共信息、电子游戏、办公自动化设备等各个领域。目前的无源触摸屏技术主要包括红外、电阻、电容、表面声波等几种，对于单点定位都比较成熟，例如用手指触摸显示屏幕即可操作主机等等，使用方便，但是若只能识别单点触摸，其本质上只是代替了传统的鼠标、键盘等输入设备，多点同时操作主机甚至是多人同时操作主机的应用需求将变得尤为突出，成为触摸屏技术未来的发展方向。

根据红外、电阻、电容、表面声波式的触摸屏实现的技术原理，在此基础上难以实现多点触摸，但将其硬件加以适当改进就可以实现多点定位技术，由于各种方式实现定位的技术原理及成本不同，改进所需的成本、难度及可靠性也必然不同。

公开号为 CN1942853A 的专利文献公开了一种具有透明电容传感介质的触摸面板。电容传感介质分布在不同的电极层总，层内的电极互相平行，层与层之间的电极相互垂直，从而组成了触摸屏的像素阵列，当屏幕被触摸时，电容传感节点产生电容变化，就会被监控电路检测到。这种触摸屏装置内部结构复杂，成本非常高，并且表面容易刮伤，造成永久性损坏，随着屏幕尺寸的增加，复杂程度和价格将成倍增加，所以多用于小尺寸触摸屏幕。公开号为 CN1912816A 的专利文献公开了一种基于摄像头的仅支持单点的触摸屏，它采用两个或以上的摄像头从不同角度对平行于显示屏幕的平面进行监控，根据所拍摄图片识别触摸动作，由于大角度取景会造成图片变形，而最终引起计算的触

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摸坐标数据不准，此外，这种方案只能识别单点触摸，不适应多点触摸的发展需求。

发明内容

本发明的目的在于提供一种结构简单、响应速度快、可靠性高且可支持多点触摸的触摸屏装置及触摸屏装置的定位方法。

为达到上述目的，本发明采用以下技术方案：

一种触摸屏装置，包括：

红外扫描模块，该红外扫描模块包括横向及纵向的红外发射模块、红外接收模块；

摄像装置，该摄像装置位于可拍摄到由所述红外扫描模块所组成的红外扫描网的位置，用于采集触摸物数据；

主控制模块，用于收集所述红外接收模块采集的触摸数据及所述摄像装置所采集的触摸物数据，并计算实际触摸点信息，向主机设备发送，或者直接将所述收集的数据发送给所述主机设备，由所述主机设备计算出所述实际触摸点信息。

一种触摸屏装置的定位方法，包括步骤：

S101：启动红外扫描，在有触摸物存在的情况下，记录被所述触摸物所遮挡的红外接收管的位置信息；

S102：以可拍摄到红外扫描网的位置拍摄一幅图片，在有触摸物存在的情况下，根据所述图片分析所述触摸物的角度信息；

S103：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合所述步骤 S102 中的角度信息，分析出实际触摸物的数据信息，所述数据信息包括实际触摸物的触摸点的坐标信息。

其中，所述步骤 S101、S102 可以交换顺序或者同步进行。

根据本发明的触摸屏装置及触摸屏装置的定位方法，其同时利用了红外扫

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描模块的红外扫描技术以及摄像装置的图像摄制技术，并结合这两种技术对触摸物进行分析，既支持单点触摸，也支持多点触摸，可以多人同时操作，结构简单、响应速度快且可靠性高。

附图说明

图 1 是本发明实施例的触摸屏装置的结构示意图；

图 2 是本发明实施例的红外扫描模块的工作原理示意图；

图 3 是本发明实施例中摄像装置工作原理示意图；

图 4 是本发明实施例的摄像装置拍摄方法示意图；

图 5 是本发明实施例的红外扫描模块扫描多点触摸示意图；

图 6 是本发明实施例的红外扫描模块结合摄像装置采集的多点触摸示意图；

图 7 是本发明实施例的触摸屏装置的定位方法的流程示意图。

具体实施方式

参见图 1 所示，是本发明实施例的触摸屏装置的结构示意图，如图所示，101 是纵向的红外发射模块，102 是横向的红外发射模块，103 是纵向的红外接收模块，104 是横向的红外接收模块，101、102、103 与 104 共同组成本发明中的红外扫描模块，105 是摄像装置，此外，106、107 是一对配对的红外管，108、109 是纵向和横向的红外扫描线，其中，所有的纵向红外扫描线几乎平行，所有的横向扫描线几乎平行，由横、纵两个方向的红外扫描线组成了红外扫描网。

其中，摄像装置可放置在任意一个地方或者角落，只需该摄像装置可拍摄到整个红外扫描网，此外，摄像装置的镜头的光轴中心线最好平行于所述红外扫描网构成的平面，或者该光轴中心线可直接位于该平面内。

在上述红外发射模块与红外接收模块中，每一对红外发射接收管都是同步工作的，一个红外管用于发射，一个红外管用于接收，用以检测在这一对红外发射接收管对应的扫描线上是否有遮挡物。红外发射模块按照一定的时序将所

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有红外发射管逐个点亮一段时间，使其逐个处于工作状态，而红外接收模块在同一时刻检测配对的接收管上的信号变化，以信号的有无或者强弱来判断是否有遮挡。在一个扫描周期内，所有的发射管点亮一次，所有的红外发射管可以先后点亮，也可以分区同时点亮，根据应用需要的不同而有所不同。当只有一个触摸点时，横向和纵向的红外扫描线被遮挡，接收模块检测到信号产生了变化，这样便唯一确定了两个扫描线的交点就是实际的触摸点；当有 N 个（N 大于或等于 2）触摸点时，在横纵两方向上最少都能检测到 N 个遮挡点，最多能检测 N^2 个触摸点，而仅仅根据遮挡点数据无法判断实际有多少个触摸点以及各触摸点的位置坐标，但能分析出所有可能的合理触摸点组合。

在同一个扫描周期内，摄像装置与红外扫描模块可以是同步工作也可以是以先后顺序工作，摄像装置从平行于红外扫描网的方向取景，取一定的高度即可，数据量非常小，然后从拍摄到的图片数据中提取触摸物的角度位置信息、颜色和大小信息。主控制模块根据摄像装置分析的数据与红外扫描模块得出的几种触摸点组合坐标综合分析，确定实际的触摸点坐标数据、各触摸物的颜色及大小，然后发送给主机设备，或者是，主控制器将收集到的摄像装置分析的数据以及红外扫描模块所得的坐标组合数据直接发送给主机设备，由主机设备计算分析坐标数据及触摸物的颜色和大小等其他数据，其中，主机设备可以是计算机。

参见图 2 所示，是本发明实施例的红外扫描模块工作原理示意图。在一个扫描周期内，所有的红外发射管被点亮一段时间，即在这一段时间内工作，所有的接收管检测一次信号变化，而在同一个时刻内，只有一对红外发射接收管在工作。在本发明的触摸屏装置工作之前，需对系统进行初始化，启动一次扫描，并将此时红外接收管所检测到的信号全部记录下来作为基准值，作为之后的判断依据，此后可进入正常的工作状态。在触摸屏装置正常工作的情况下，若没有触摸点，那么所有的红外接收管所检测到的信号均接近于各自的信号基准值或者相等，当有触摸点时，该触摸点所对应的红外接收管所检测到的信号就会与信号基准值相差较大，当这个相差值大于或者等于预定值时，即可判定存在触摸点。如图 2 所示，207 是一个触摸点，此时在纵向的红外扫描中，红外

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发射管 201 发射的红外线被遮挡，而红外接收管 203 此时检测到的信号与信号基准值相差较大，即大于或者等于预定值，主控制器将记录下信号发生变化的红外接收管的编号，而该编号可以进一步换算成虚拟的位置坐标。根据同样的原理，红外接收管 204 也将检测到信号发生了变化，且该变化值大于或者等于了预定值，主控制器计算出虚拟的位置坐标，由横、纵两个方向所检测到的虚拟坐标值即可确定触摸点，再将该虚拟的坐标映射为实际的触摸坐标。

参见图 3 所示，是本发明实施例的摄像装置的工作原理示意图，如图所示，摄像装置所放置的位置必须能够拍摄到整个的扫描网，也就是可以拍摄到整个屏幕。在没有触摸点的情况下，摄像装置仅能拍摄到红外触摸装置的内框，因此，可以以此为背景色，当有触摸的情况下，将拍摄到的照片与背景色进行对比分析，可提取出触摸物的角度信息、触摸物的颜色以及大小。

其中，角度位置的计算可以是以镜头的光轴中心线为准，以偏移的角度计算，也可以是以其他的任何以镜头为中心的线作为计算基准，虽然选取的计算基准不同，但最终均可换算成图 3 中 302 的角度信息。为了方便计算触摸物的实际大小，以镜头为中心将屏幕分成了若干个扇形区，在某一个扇形区内拍摄同一大小的触摸物的大小也相等，由于镜头的不同，在使用前需建立实物大小与距离的查询表或者计算公式。

如图 4 所示，是本发明实施例的摄像装置的拍摄方法示意图，如图所示，401 是横纵两个方向的红外扫描模块组成的红外扫描网平面，402 是显示设备平面，403 是摄像装置的镜头广轴中心线，该镜头广轴中心线平行于红外扫描网平面或在这个平面内，404、405 是摄像装置的取景范围，需可以拍摄到整个显示设备，406 是拍摄图片的高度，根据需要可以进行适当的调整，407 是触摸物，408 是摄像装置拍摄到的图片，其中图片中的触摸物可能只是实际触摸物的一部份。根据摄像装置所拍摄到的图片 408，从图片中提取出触摸物的颜色及大小，并根据触摸物距离图片的最左端或者最有短的距离查表或者计算得出触摸物的角度信息。这个计算过程可以是由摄像装置完成，摄像装置将计算所得结果发送给主控制模块，也可以是摄像装置将所拍得的图片发送给主控制模块，由主

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控制模块执行计算的过程。随后，主控制模块根据红外接收模块所采集的触摸数据，以及该图片中所采集的触摸物数据，综合计算出实际的触摸物的位置坐标、颜色以及大小，并发送给主机设备，或者是主控制模块将所采集的上述触摸数据和触摸物数据发送给主机设备，由主机设备计算出实际的触摸物的坐标、颜色以及大小。

根据触摸物的颜色以及大小等信息，主机设备可以对每个操作者的使用状态进行单独的跟踪管理，比如：无缘的粗蓝色笔画出来的线是蓝色的粗线，用无缘的细红色笔画出来的线是细红线，这使得在交互式的多媒体应用中显得更生动、直观，且还可以应用于其他各场合。

此外，由于在触摸屏的应用中，实时性的要求比较高，且摄像装置一般都采用摄像头，摄像头的曝光时间比较短，为了达到更好的拍摄效果，提高摄像装置的清晰度，可以采用以下几种方案：

1、在无缘笔（相当于触摸物）上涂上高反光材料，即使用带高反光材料的触摸物或者是在触摸物上使用高反光材料的配件，例如中空的笔套，从而笔套可以方便地套在笔上或者手指上；

2、将摄像装置放置在横向发射模块和纵向发射模块的交界处，从而可以以红外发射管作为光源；

3、为摄像装置增加外部辅助光源。

如图 5 所示，是本发明实施例的红外扫描模块扫描多点触摸的示意图，502、503 分别为两个触摸点，按照红外扫描模块的扫描原理，红外接收模块将在红外接收管 505、506、507、508 处检测到红外信号变化超过了预定值，并可判定对应方位可能存在触摸物，由此，可能的触摸点最多有 4 个，即 501、502、503、504，但无法确定实际上有多少个触摸点，其可能的组合有以下几种：

（1）501、504；

（2）502、503；

（3）501、503、504；

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（4）501、502、504;

（5）501、502、503;

（6）502、503、504;

（7）501、502、503、504。

如此可见，仅仅根据红外扫描的方式无法确定实际的触摸点数。

如图 6 所示，是本发明实施例中红外扫描模块结合摄像装置所采集的多点触摸的示意图，605 是摄像装置所拍摄到的图片，601、602、603、604 是通过红外扫描所得到的可能的触摸物，602、603 是拍摄到的触摸物，从图片中提取出触摸物的偏离角度、颜色、以及大小，再结合红外扫描所得的结果，即可综合分析得出实际的触摸物有 602、603，排除了其他的可能，在分析出触摸物的坐标位置后，可计算出各触摸物偏离镜头的距离，再通过查表或者计算得出触摸物的实际大小，并将触摸物的坐标信息、颜色以及大小向主机设备发送。

如上所述，本发明的触摸屏装置同时利用到了红外扫描技术与图像摄制技术，从而可达到以下优点:

1、定位技术采用红外扫描为主，摄像采集为辅，响应速度快，且稳定可靠;

2、同时支持单点触摸和多点触摸，且由于可采集触摸物的颜色以及大小信息，可以分别跟踪每个触摸点，从而可以对不同的触摸物进行的同一个触摸动作做出不同的响应，使应用变得更灵活、生动;

3、成本低、安装方便，可应用于平板电视、前投、背投等系统，且特别适用于大屏幕显示系统。

参见图 7 所示，是本发明的触摸屏装置定位方法的流程示意图，如图所示，本发明的定位方法包括步骤:

S101：启动一次红外扫描，记录当前状态下的红外接收管所检测到的信号强度值;

S102：启动红外扫描，根据红外接收管所接收到的信号，判断是否存在遮

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挡触摸物，若有，记录当前的位置信息；

其中，上述判断是否存在遮挡物的方式可以是：

根据红外接收管是否检测到信号来判断是否具有遮挡物，若没有检测到任何信号，则可判定在这对红外发射接收管之间存在遮挡物，并记录当前的位置信息；

还可以是，根据红外接收管所接收到的信号，计算出该信号相对于所述记录的信号强度值的变化值，若变化值大于或者等于预定值，则判定存在遮挡触摸物，并记录当前的位置信息；

S103：以可拍摄到红外扫描网的位置拍摄一幅图片，并根据所述图片分析是否有触摸物，若有触摸物，分析所述触摸物的角度信息，并可分析出该触摸物的颜色以及大小信息；

S104：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合步骤 S103，分析出实际触摸物的数据信息，包括实际触摸物的坐标信息，还包括实际触摸物的颜色以及大小信息，其中上述分析过程可以是在触摸屏装置中进行，触摸屏装置分析完成后将分析结构发送给后续处理的主机设备，也可以是在进行后续处理的主机设备中进行。

S105：重复步骤 S102 至 S104。

其中，所述步骤 S103 与 S104 可以是以先后顺序进行，也可以是同时进行。

此外，在标注触摸物的触摸轨迹时，根据触摸物的颜色以及大小等信息，可以使标注的轨迹的颜色与大小与相应的触摸物的颜色与大小相对应，从而可以对每个操作者的使用状态进行单独的跟踪管理，例如：无缘的粗蓝色笔画出来的线是蓝色的粗线，用无缘的细红色笔画出来的线是细红线，这使得在交互式的多媒体应用中显得更生动、直观，且还可以应用于其他各场合。

根据本发明的定位方法，其可达到以下有以效果：

1、定位技术采用红外扫描为主，摄像采集为辅，响应速度快，且稳定可靠；

2、同时支持单点触摸和多点触摸，且由于可采集触摸物的颜色以及大小信

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息，可以分别跟踪每个触摸点，从而可以对不同的触摸物做出的同一个触摸动作做出不同的响应，使应用变得更灵活、生动。

以上所述的本发明实施方式，并不构成对本发明保护范围的限定。任何在本发明的精神和原则之内所作的修改、等同替换和改进等，均应包含在本发明的权利要求保护范围之内。

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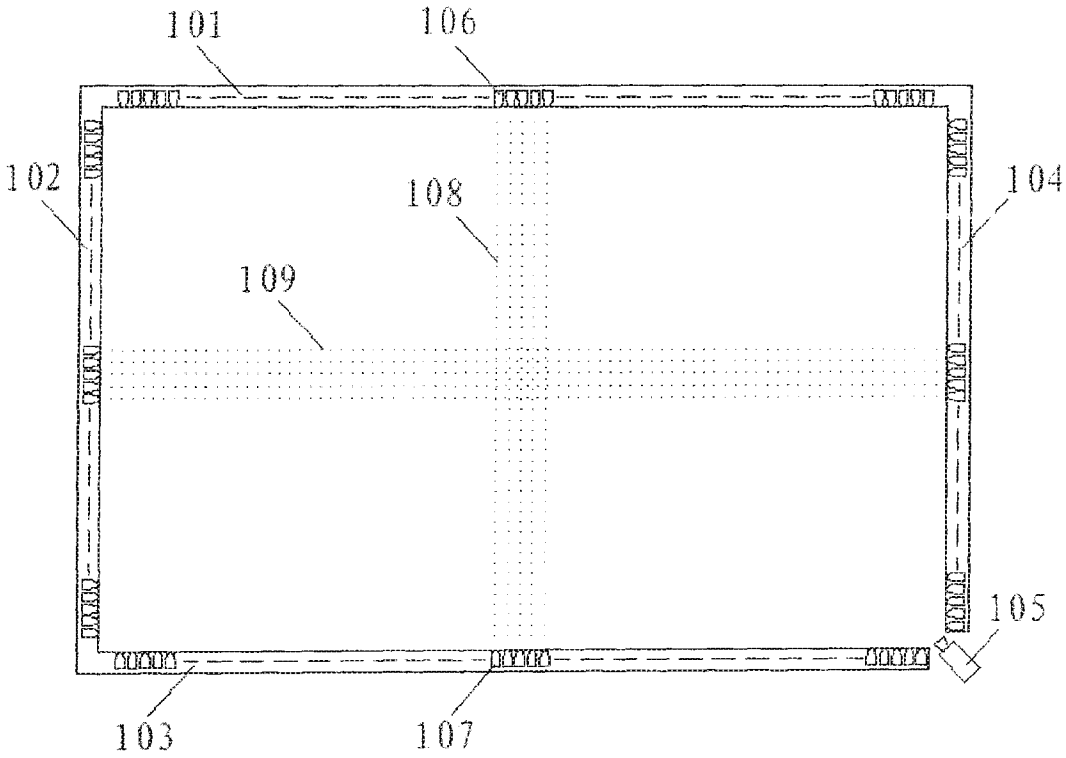


图 1

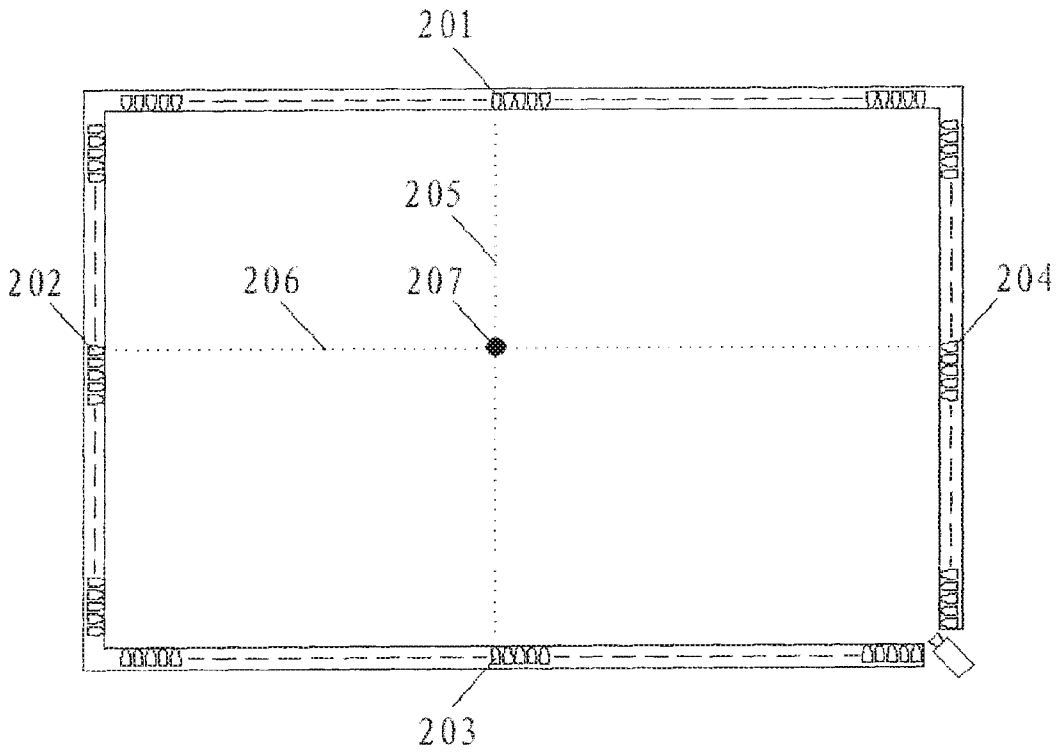


图 2

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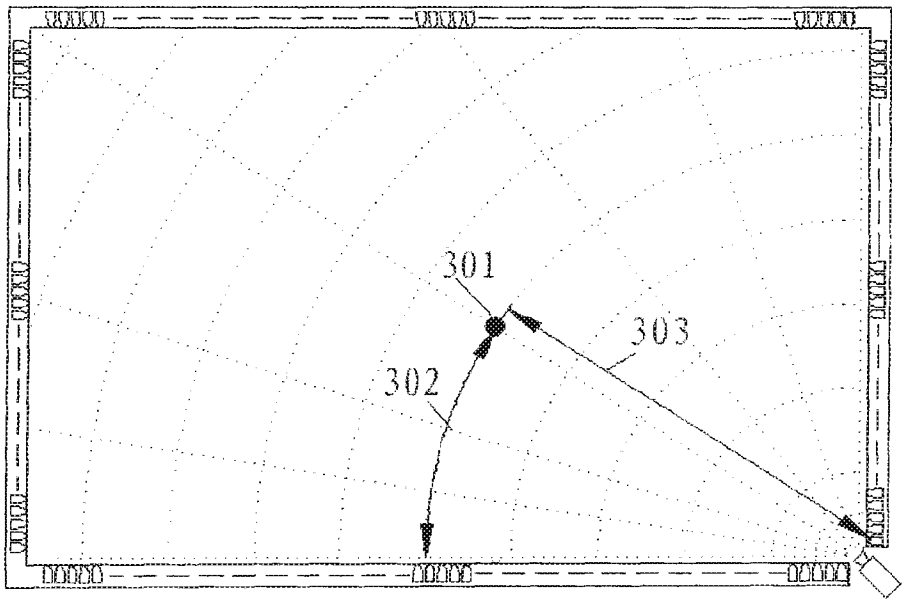


图 3

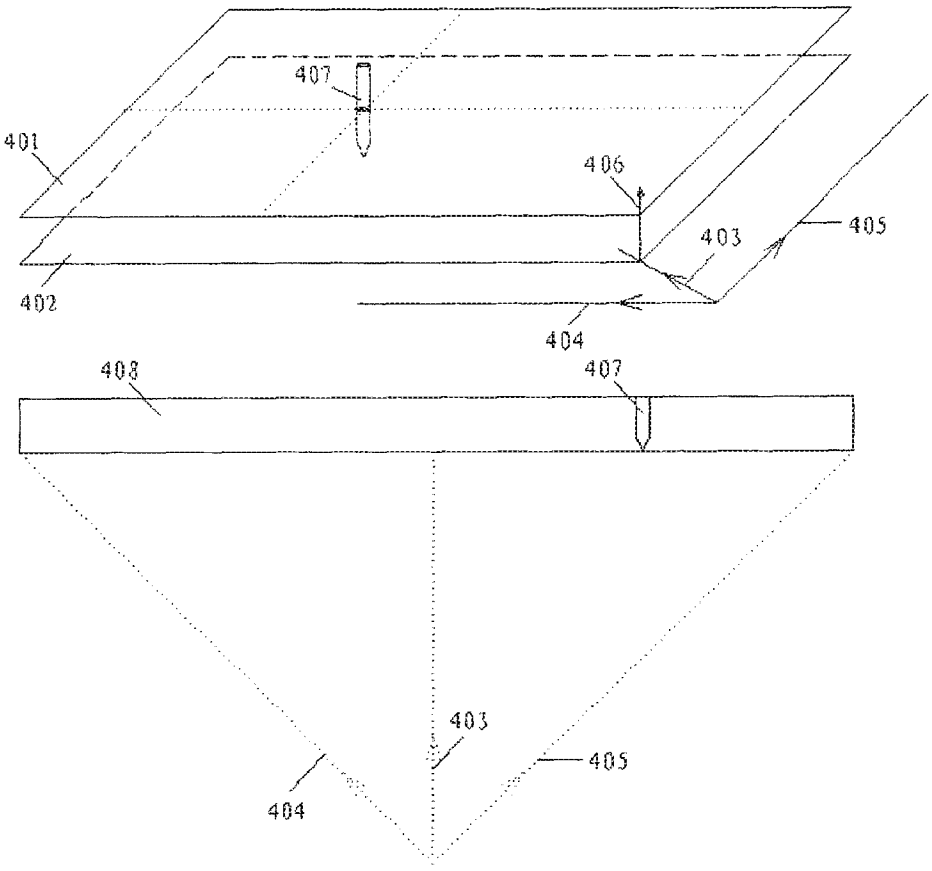


图 4

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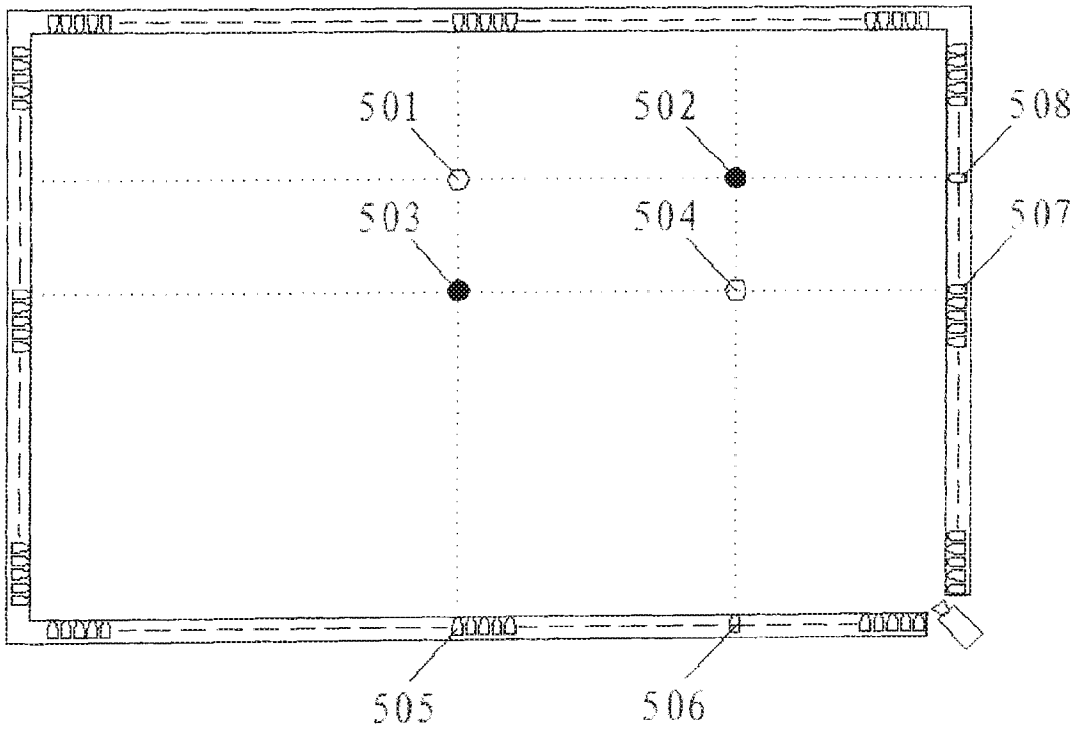


图 5

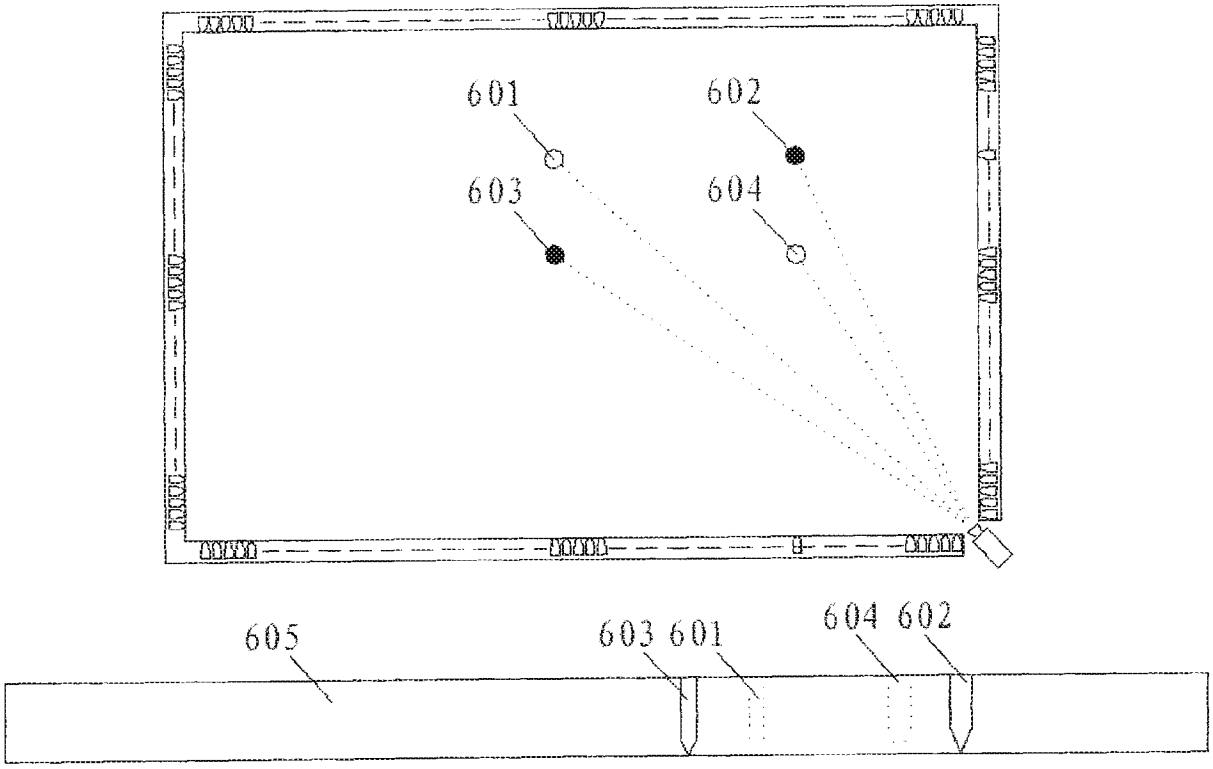


图 6

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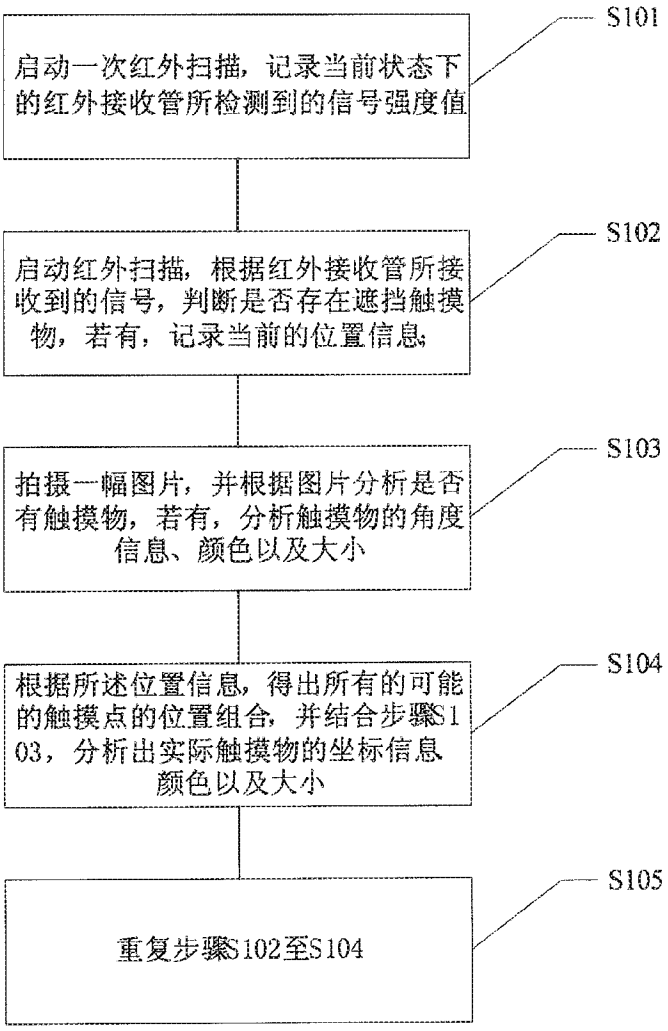


图 7

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CN101882034A Device and method for discriminating color of touch pen of touch device

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Device and method for discriminating color of touch pen of touch device

Abstract

The invention relates to a device and a method for discriminating the color of a touch pen of a touch device. The method mainly comprises the following steps of: determining the imaging position of the touch pen in an image shot by the color discrimination camera through an image subtraction method or by computing the position of the touch pen on a touch screen; selecting a sampling area by taking the position as a center; respectively solving the average values of R, G, B values of pixel points in the sampling area, and converting a result to an HSV (Hue Saturation Value) color space for adjustment; and converting the adjusted H, S V values back to RGB (Red-Green-Blue) formats, and outputting the RGB color values as ultimately determined colors to a display screen for display. The invention can more accurately discriminate the color of the touch pen of the touch device, effectively improves the condition that the display color is slant dark and has easy operation.

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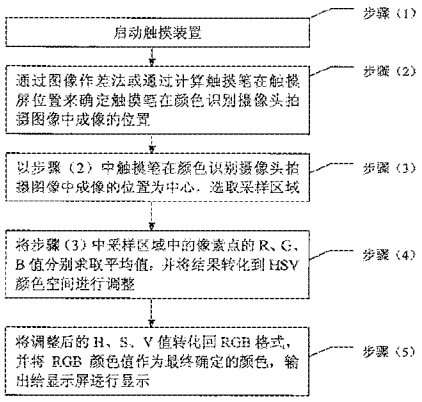
权利要求书 2 页 说明书 6 页 附图 5 页

(54)发明名称

触摸装置的触摸笔颜色识别装置及方法

(57)摘要

本发明涉及触摸装置的触摸笔颜色识别装置及方法，其方法主要步骤是：通过图像作差法或通过计算触摸笔在触摸屏位置来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置；以该位置为中心，选取采样区域；将采样区域中的像素点的R、G、B值分别求取平均值，并将结果转化到HSV颜色空间进行调整；将调整后的H、S、V值转化回RGB格式，并将RGB颜色值作为最终确定的颜色，输出给显示屏进行显示。本发明能够更准确的对触摸装置的笔色进行识别，且有效的改善了显示颜色偏暗的情况，运算简单。



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1. 触摸装置的触摸笔颜色识别装置，其特征在于：包括用于确定触摸笔位置的定位摄像头，红外光源，用于拍摄触摸笔颜色的颜色识别摄像头，控制单元以及显示单元；其中，定位摄像头水平放置在屏幕的上边框，颜色识别摄像头倾斜放置在屏幕的上边框的左上角或右上角，定位摄像头的光轴与颜色识别摄像头的光轴在同一平面上，红外光源设在屏幕的上边框；控制单元分别与摄像头定位装置、颜色识别摄像头及显示单元连接；

所述控制单元用于通过图像作差法或通过计算触摸笔在触摸屏的位置来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，并用于以触摸笔在颜色识别摄像头所拍摄图像中成像的位置为中心来选取采样区域，然后将采样区域中像素点求 RGB 值的平均值，并将平均值转化到 HSV 颜色空间进行调整，最后再转化为 RGB 颜色值输出给显示屏进行显示。

2. 根据权利要求 1 所述的触摸笔颜色识别装置，其特征在于：所述定位摄像头包括与红外光源并排放置的第一定位摄像头和第二定位摄像头；第一定位摄像头和第二定位摄像头分别与控制单元连接，且均采用黑白摄像头；所述黑白摄像头的镜头配有红外滤光片。

3. 根据权利要求 1 所述的触摸笔颜色识别装置，其特征在于：所述颜色识别摄像头采用彩色摄像头，所述彩色摄像头配有闪光灯装置，所述彩色摄像头的镜头配有红外截止滤光片，所述闪光灯装置发出的光的波长小于红外波长。

4. 基于权利要求 1 所述触摸笔颜色识别装置的触摸装置的触摸笔颜色识别方法，其特征在于包括以下步骤：

(1) 启动触摸装置；

(2) 通过图像作差法或通过计算触摸笔在触摸屏的位置，来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置；

(3) 以步骤 (2) 中触摸笔在颜色识别摄像头所拍摄图像中成像的位置为中心，选取采样区域；

(4) 将步骤 (3) 中采样区域中的像素点的 R、G、B 值分别求取平均值，并将平均值转化到 HSV 颜色空间进行调整，得到调整后的 H、S、V 值；

(5) 将调整后的 H、S、V 值转化回 RGB 格式，并将 RGB 颜色值作为最终确定的颜色，输出给显示屏进行显示。

5. 根据权利要求 4 所述的触摸笔颜色识别方法，其特征在于，所述步骤 (2) 中，通过图像作差法来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，包括以下步骤：

(1-1) 在触摸装置上未放置触摸笔的情况下，通过颜色识别摄像头拍摄此时的图像并保存在控制单元的第一存储单元中，作为背景图像；

(1-2) 判断定位摄像头所拍摄的当前帧图像中是否有光斑，若否，进入步骤 (1-3)；若是，进入步骤 (1-4)；

(1-3) 更新第一存储单元中的背景图像：将颜色识别摄像头所拍摄的当前帧图像作为新的背景图像，替换掉步骤 (1-1) 中所保存的背景图像，然后返回步骤 (1-2)；

(1-4) 颜色识别摄像头启动闪光灯装置并进行拍摄，并保存所拍摄的当前帧图像在控制单元的第二存储单元中，作为前景图像；

(1-5) 将第一存储单元中的背景图像，以及第二存储单元中的前景图像都进行灰色世界法白平衡处理，并且进行复制，并对背景图像的复制图像、前景图像的复制图像都进行灰色世界法白平衡、彩色图像灰度化处理；

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(1-6) 对背景图像的复制图像、前景图像的复制图像进行逐像素作差运算，将差值最大的像素点在图像中的坐标位置 (x, y) 作为触摸笔在图像上的位置。

6. 根据权利要求 4 所述的触摸笔颜色识别方法，其特征在于，所述步骤 (2) 中，通过计算触摸笔在触摸屏的位置来确定触摸笔在颜色识别摄像头拍摄图像中成像的位置，包括以下步骤：

(2-1) 启动定位摄像头进行拍摄；

(2-2) 判断所拍摄图像中是否有触摸点，若否，返回步骤 (2-1)，若有，进入步骤 (2-3)；

(2-3) 计算触摸点在触摸屏的位置 a(x1, y1)，同时启动颜色识别摄像头进行拍摄；

(2-4) 根据颜色识别摄像头的放置位置以及步骤 (2-3) 中计算出的触摸点在触摸屏位置 a(x1, y1)，确定触摸笔在颜色识别摄像头的拍摄图像中的成像位置。

7. 根据权利要求 4-6 中任一项所述的触摸笔颜色识别方法，其特征在于，所述步骤 (4) 中，在 HSV 颜色空间进行调整，包括以下步骤：

(4-1) 判断 S 值是否为非零值，若是，进入步骤 (4-2)，若否，进入步骤 (4-3)；

(4-2) 对 H 值进行非等间量化法调整；

(4-3) 判断 V 值是否小于 0.5，若是，将数值 0 赋值给 V，若否，将数值 1 赋值给 V。

8. 根据权利要求 7 所述的触摸笔颜色识别方法，其特征在于：所述步骤 (4-2) 中的非等间量化法为 6 级量化法、8 级量化法或者 16 级量化法。

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触摸装置的触摸笔颜色识别装置及方法

技术领域

[0001] 本发明涉及人机交互领域，特别涉及触摸装置的触摸笔颜色识别装置及方法。

背景技术

[0002] 现有的人机交互技术中，基于摄像头定位的触摸技术具有准确率高、能实现多点触摸、维护简单等优点，因此人们也越来越青睐于基于摄像头定位的触摸技术。基于摄像头定位触摸技术，如申请号为 200910039968.4、公开号为 CN101566898A 的中国发明专利申请“电子显示系统的定位装置及方法”，具有成本低、实现简单等特点。但是通常我们还需要反映出触摸笔的颜色，然后在显示屏上显示相应的颜色，便于区别不同颜色触摸笔的触摸操作，同时也使得触摸更具有直观性。但现有技术的颜色识别通常只是简单的从拍摄图像中提取触摸点处像素的灰度值直接作为显示颜色进行显示，使得显示的笔画颜色容易与实际触摸笔颜色出现偏差，且颜色偏暗。

发明内容

[0003] 本发明的首要目的在于克服现有技术的缺点与不足，提供触摸装置的触摸笔颜色识别装置，解决了现有颜色识别容易出现偏差，且显示颜色偏暗的技术问题。

[0004] 本发明的另一目的是提供触摸装置的触摸笔颜色识别方法，该方法基于上述触摸装置的触摸笔颜色识别装置。

[0005] 本发明的首要目的是通过下述技术方案实现：本触摸装置的触摸笔颜色识别装置，包括用于确定触摸笔位置的定位摄像头，红外光源，用于拍摄触摸笔颜色的颜色识别摄像头，控制单元以及显示单元；其中，定位摄像头水平放置在屏幕的上边框，颜色识别摄像头倾斜放置在屏幕的上边框的左上角或右上角，定位摄像头的光轴与颜色识别摄像头的光轴在同一平面上，红外光源设在屏幕的上边框；控制单元分别与摄像头定位装置、颜色识别摄像头及显示单元连接；所述控制单元用于通过图像作差法或通过计算触摸笔在触摸屏的位置来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，并用于以触摸笔在颜色识别摄像头所拍摄图像中成像的位置为中心来选取采样区域，然后将采样区域中像素点求 RGB 值的平均值，并将平均值转化到 HSV 颜色空间进行调整，最后再转化为 RGB 颜色值输出给显示屏进行显示。

[0006] 所述定位摄像头包括与红外光源并排放置的第一定位摄像头和第二定位摄像头；第一定位摄像头和第二定位摄像头分别与控制单元连接，且均采用黑白摄像头；所述黑白摄像头的镜头配有红外滤光片。

[0007] 所述颜色识别摄像头采用彩色摄像头，所述彩色摄像头配有闪光灯装置，所述彩色摄像头的镜头配有红外截止滤光片，所述闪光灯装置发出的光的波长小于红外波长。

[0008] 本发明的另一目的是通过下述技术方案实现：本触摸装置的触摸笔颜色识别方法，包括以下步骤：

[0009] (1) 启动触摸装置；

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[0010] (2) 通过图像作差法或通过计算触摸笔在触摸屏的位置，来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置；

[0011] (3) 以步骤 (2) 中触摸笔在颜色识别摄像头所拍摄图像中成像的位置为中心，选取采样区域；

[0012] (4) 将步骤 (3) 中采样区域中的像素点的 R、G、B 值分别求取平均值，并将平均值转化到 HSV 颜色空间进行调整，得到调整后的 H、S、V 值；

[0013] (5) 将调整后的 H、S、V 值转化回 RGB 格式，并将 RGB 颜色值作为最终确定的颜色，输出给显示屏进行显示。

[0014] 所述步骤 (2) 中，通过图像作差法来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，包括以下步骤：

[0015] (1-1) 在触摸装置上未放置触摸笔的情况下，通过颜色识别摄像头拍摄此时的图像并保存在控制单元的第一存储单元中，作为背景图像；

[0016] (1-2) 判断定位摄像头所拍摄的当前帧图像中是否有光斑，若否，进入步骤 (1-3)；若是，进入步骤 (1-4)；

[0017] (1-3) 更新第一存储单元中的背景图像：将颜色识别摄像头所拍摄的当前帧图像作为新的背景图像，替换掉步骤 (1-1) 中所保存的背景图像，然后返回步骤 (1-2)；

[0018] (1-4) 颜色识别摄像头启动闪光灯装置并进行拍摄，并保存所拍摄的当前帧图像在控制单元的第二存储单元中，作为前景图像；

[0019] (1-5) 将第一存储单元中的背景图像，以及第二存储单元中的前景图像都进行灰色世界法白平衡处理，并且进行复制，并对背景图像的复制图像、前景图像的复制图像都进行灰色世界法白平衡、彩色图像灰度化处理；

[0020] (1-6) 对背景图像的复制图像、前景图像的复制图像进行逐像素作差运算，将差值最大的像素点在图像中的坐标位置 (x，y) 作为触摸笔在图像上的位置。

[0021] 所述步骤 (2) 中，通过计算触摸笔在触摸屏的位置来确定触摸笔在颜色识别摄像头拍摄图像中成像的位置，包括以下步骤：

[0022] (2-1) 启动定位摄像头进行拍摄；

[0023] (2-2) 判断所拍摄图像中是否有触摸点，若否，返回步骤 (2-1)，若有，进入步骤 (2-3)；

[0024] (2-3) 计算触摸点在触摸屏的位置 a(x1，y1)，同时启动颜色识别摄像头进行拍摄；

[0025] (2-4) 根据颜色识别摄像头的放置位置以及步骤 (2-3) 中计算出的触摸点在触摸屏位置 a(x1，y1)，确定触摸笔在颜色识别摄像头的拍摄图像中的成像位置。

[0026] 所述步骤 (4) 中，在 HSV 颜色空间进行调整，包括以下步骤：

[0027] (4-1) 判断 S 值是否为非零值，若是，进入步骤 (4-2)，若否，进入步骤 (4-3)；

[0028] (4-2) 对 H 值进行非等间量化法调整；

[0029] (4-3) 判断 V 值是否小于 0.5，若是，将数值 0 赋值给 V，若否，将数值 1 赋值给 V。

[0030] 其中，所述步骤 (4-2) 中的非等间量化法为 6 级量化法、8 级量化法或者 16 级量化法。

[0031] 与现有技术相比，本发明具有如下的优点及有益效果：

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[0032] 1、在定位装置识别到有触摸时，才打开闪光灯，促发颜色识别摄像头进行拍摄，然后再进行后续的触摸笔颜色识别，不用对颜色识别摄像头拍摄的每一帧图像进行笔色识别处理，能有效提高图像处理速度，进而提高响应速度。

[0033] 2、能更准确的对触摸装置的触摸笔颜色进行识别，且有效的改善了显示颜色偏暗的情况，减少周围环境和触摸笔位置的不同导致的亮度变化影响到对触摸笔颜色的判断，有效减少误判、运算简单。

附图说明

[0034] 图 1 是本发明触摸装置的触摸笔颜色识别装置的结构示意图；

[0035] 图 2 是本发明触摸装置的触摸笔颜色识别方法的流程示意图；

[0036] 图 3 是本发明通过图像作差法来确定触摸笔位置的流程示意图；

[0037] 图 4 是本发明通过计算触摸笔在触摸屏位置来确定触摸笔位置的流程示意图；

[0038] 图 5 是本发明的 HSV 颜色空间调整中 H 值非等间量化示意图。

具体实施方式

[0039] 下面结合实施例及附图，对本发明作进一步的详细说明，但本发明的实施方式不限于此。

[0040] 实施例 1

[0041] 参见图 1，本发明触摸装置的触摸笔颜色识别装置包括：两个用于确定触摸笔位置的第一定位摄像头 101 和第二定位摄像头 102，红外光源 106，一个用于拍摄触摸笔颜色的颜色识别摄像头 103，控制单元 104 以及显示屏 105；其中，颜色识别摄像头 103 为广角镜头，拍摄角度为 110°，将其倾斜放置在屏幕的上边框的左上角或右上角，使其能拍摄到除上边框之外的屏幕的其余三个边框；而定位摄像头 101、102 为鱼眼镜头，两者的拍摄角度都为 180°，将两者水平放置在屏幕的上边框，亦使其能拍摄到除上边框之外的屏幕的其余三个边框；101、102、103 三个摄像头的光轴需在同一平面上，该平面与屏幕平面平行，且二者距离（即光轴所在的平面与屏幕所在的平面的距离）不超过 2cm；红外光源 106 紧贴屏幕上边框，朝向均向下，其发射的红外光能散射照亮除屏幕上边框之外其余三个边框，控制单元 104 分别与第一定位摄像头 101、第二定位摄像头 102、颜色识别摄像头 103、显示屏 105 连接。

[0042] 所述用于确定触摸笔位置的第一定位摄像头 101 和第二定位摄像头 102 均采用镜头配有红外滤光片的黑白摄像头，拍摄的图像为黑白二值图像，且图像为带装图像，这样可以提高处理速度。通过该两个定位摄像头对触摸笔坐标位置进行定位的技术为现有技术，本专利不作详细展开描述。所述颜色识别摄像头 103 采用彩色摄像头，彩色摄像头配有闪光灯装置，且彩色摄像头的镜头配有红外截止滤光片。闪光灯装置发出的光的波长小于红外波长；由于红外波长约为 760nm，因此闪光灯装置所发出的光的波长小于 760nm。

[0043] 这样，配有红外滤光片的第一定位摄像头 101 和第二定位摄像头 102，可以忽略掉可见光的影响，进行对触摸笔的定位；配有上述闪光灯装置，且镜头配有红外截止滤光片的彩色摄像头，可以忽略掉红外光的影响，进而确保颜色识别摄像头所拍摄图像的颜色不受红外光影响，且闪光灯装置能确保在比较暗的环境下也能清晰的拍摄到触摸笔的颜色。

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[0044] 控制单元 104 用于通过图像作差法或通过计算触摸笔在触摸屏的位置，来确定触摸笔在颜色识别摄像头 103 所拍摄图像中成像的位置，并用于以触摸笔在颜色识别摄像头 103 所拍摄图像中成像的位置为中心来选取采样区域，然后将采样区域中像素点求 RGB 值的平均值，并将平均值转化到 HSV 颜色空间进行调整，最后再转化为 RGB 颜色值输出给显示屏 105 进行显示。

[0045] 参见图 2，本发明触摸装置的触摸笔颜色识别方法，包括以下步骤：

[0046] (1) 启动触摸装置；

[0047] (2) 通过图像作差法，来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置；

[0048] (3) 以步骤 (2) 中触摸笔在颜色识别摄像头所拍摄图像中成像的位置为中心，选取采样区域；例如，以 (x，y) 为中心，R 为半径选取区域作为采样区域，R 可以由用户根据实际情况进行定义；

[0049] (4) 将步骤 (3) 中采样区域中的像素点的 R、G、B 值分别求取平均值，并将平均值转化到 HSV 颜色空间进行调整，得到调整后的 H、S、V 值；

[0050] (5) 将调整后的 H、S、V 值转化回 RGB 格式，并将 RGB 颜色值作为最终确定的颜色，输出给显示屏进行显示。

[0051] 参见图 3，本实施例在所述步骤 (2) 中，采用通过图像作差法来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，包括以下步骤：

[0052] (1-1) 在触摸装置上未放置触摸笔的情况下，通过颜色识别摄像头拍摄此时的图像并保存在控制单元的第一存储单元中，作为背景图像；

[0053] (1-2) 判断定位摄像头所拍摄的当前帧图像 (即判断第一定位摄像头或第二定位摄像头所拍摄的当前帧图像) 中是否有光斑，若否，进入步骤 (1-3)；若是，进入步骤 (1-4)；

[0054] (1-3) 更新第一存储单元中的背景图像：将颜色识别摄像头所拍摄的当前帧图像作为新的背景图像，替换掉步骤 (1-1) 中所保存的背景图像，然后返回步骤 (1-2)；

[0055] (1-4) 颜色识别摄像头启动闪光灯装置并进行拍摄，并保存所拍摄的当前帧图像在控制单元的第二存储单元中，作为前景图像；

[0056] (1-5) 将第一存储单元中的背景图像，以及第二存储单元中的前景图像都进行灰色世界法白平衡处理，并且进行复制，并对背景图像的复制图像、前景图像的复制图像都进行灰色世界法白平衡、彩色图像灰度化处理；

[0057] (1-6) 对背景图像的复制图像、前景图像的复制图像进行逐像素作差运算，将差值最大的像素点在图像中的坐标位置 (x，y) 作为触摸笔在图像上的位置。

[0058] 所述步骤 (1-2) 中通过判断第一定位摄像头 101 或第二定位摄像头 102 所拍摄图像中是否有光斑，来确定是否有触摸笔放入触摸装置。具体判断可以通过设定像素灰度值阈值，若连续 n 个像素灰度值超过所设定的像素灰度值阈值，则认为存在光斑，n 可以由用户根据实际触摸笔大小情况进行设定，若不满足上述条件，则认为不存在光斑。

[0059] 所述步骤 (1-5) 中，进行的灰色世界法白平衡处理，可以有效改善偏色对图像色彩的影响，使得颜色的提取以及处理更加精确。

[0060] 所述步骤 (4) 中，将从步骤 (3) 中采样区域内所有像素点的 R、G、B 值分别求取平

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均值，将求取到的平均值 R1、G1、B1 代入 RGB 转化到 HSV 的公式里（该公式为公知算法，在此不作详述），可以得到相应的 H、S、V 值。

[0061] 所述步骤 (4) 中的在 HSV 颜色空间进行调整，包括以下步骤：

[0062] (4-1) 判断 S 值是否为非零值，若是，进入步骤 (4-2)，若否，进入步骤 (4-3)；

[0063] (4-2) 对 H 值进行非等间量化法调整；

[0064] (4-3) 判断 V 值是否小于 0.5，若是，将数值 0 赋值给 V，若否，将数值 1 赋值给 V。

[0065] 其中，步骤 (4-1) 的作用在于通过饱和度 S 来区分识别彩色的触摸笔和非彩色（白、灰、黑）的触摸笔，S 为零时，判断为非彩色的触摸笔，需要进一步判断 V 值；S 为非零值时，判断为彩色的触摸笔，需要进行进一步的 H 值判断。

[0066] 所述步骤 (4-3) 中，V 值小于 0.5，则认为触摸笔是黑色，将数值 0 赋值给 V；若 V 值大于或等于 0.5，则认为触摸笔是白色，将数值 1 赋值给 V。

[0067] 所述步骤 (4-2) 中的非等间量化法为 6 级量化法、8 级量化法或者 16 级量化法。本实施例采用 8 级量化法。

[0068] 参见图 5，在 R、G、B 分别相隔 120 度的圆环里，非等间量化成了 8 个区间，分别为：

[0069] 区间一 (h <= 20° &&h > 315°)

[0070] 区间二 (20° < h <= 40°)

[0071] 区间三 (40° < h <= 75°)

[0072] 区间四 (75° < h <= 155°)

[0073] 区间五 (155° < h <= 190°)

[0074] 区间六 (190° < h <= 270°)

[0075] 区间七 (270° < h <= 295°)

[0076] 区间八 (295° < h <= 315°)

[0077] 其中，h 为本实施例中用平均值 R1、G1、B1 代入 RGB 转化到 HSV 的公式里得到相应的 H 值，若 h 值落到区间一，则 h 值调节为 0°；若 h 值落到区间二，则 h 值调节为 30°；若 h 值落到区间三，则 h 值调节为 58°；若 h 值落到区间四，则 h 值调节为 120°；若 h 值落到区间五，则 h 值调节为 173°；若 h 值落到区间六，则 h 值调节为 240°；若 h 值落到区间七，则 h 值调节为 282°；若 h 值落到区间八，则 h 值调节为 300°。即，一般判断 h 值落到哪个区间，就把哪个区间的中间值赋给 h。

[0078] 实施例 2

[0079] 本实施例的触摸装置的触摸笔颜色识别装置结构与实施例 1 相同，不同之处在于工作流程中的步骤 (2)，其余步骤均相同。本实施例的步骤 (2)，采用通过计算触摸笔在触摸屏位置，来确定触摸笔在颜色识别摄像头所拍摄图像中成像的位置，如图 4 所示，其包括以下步骤：

[0080] (2-1) 启动定位摄像头进行拍摄；

[0081] (2-2) 判断所拍摄图像中是否有触摸点（即是否有光斑），若否，返回步骤 (2-1)，若有，进入步骤 (2-3)；

[0082] (2-3) 计算触摸点在触摸屏位置 a(x1, y1)，同时启动颜色识别摄像头进行拍摄（即触发颜色识别摄像头的闪光灯装置闪亮，从而促发颜色识别摄像头进行拍摄）；

[0083] (2-4) 根据颜色识别摄像头的放置位置以及步骤 (2-3) 中计算出的触摸点在触摸

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屏位置 a(x1, y1)，确定步骤 (2-3) 触摸笔在颜色识别摄像头的拍摄图像中的成像位置。

[0084] 其中，所述步骤 (2-3) 计算触摸点在触摸屏的位置 a(x1,y1) 的计算方法为现有技术，本发明不作详述。

[0085] 所述步骤 (2-4) 中，根据颜色识别摄像头的放置位置以及步骤 (2-3) 中计算出的触摸点在触摸屏位置 a(x1,y1)，确定步骤 (2-3) 触摸笔在颜色识别摄像头的拍摄图像中的成像位置为：将 a(x1, y1) 代入颜色识别摄像头的成像公式（该公式为公知公式，本实施例不作详述），即可计算出所述步骤 (2-3) 触摸笔在颜色识别摄像头的拍摄图像中的成像位置。

[0086] 上述实施例为本发明较佳的实施方式，但本发明的实施方式并不受所述实施例的限制，其他的任何未背离本发明的精神实质与原理下所作的改变、修饰、替代、组合、简化，均应为等效的置换方式，都包含在本发明的保护范围之内。

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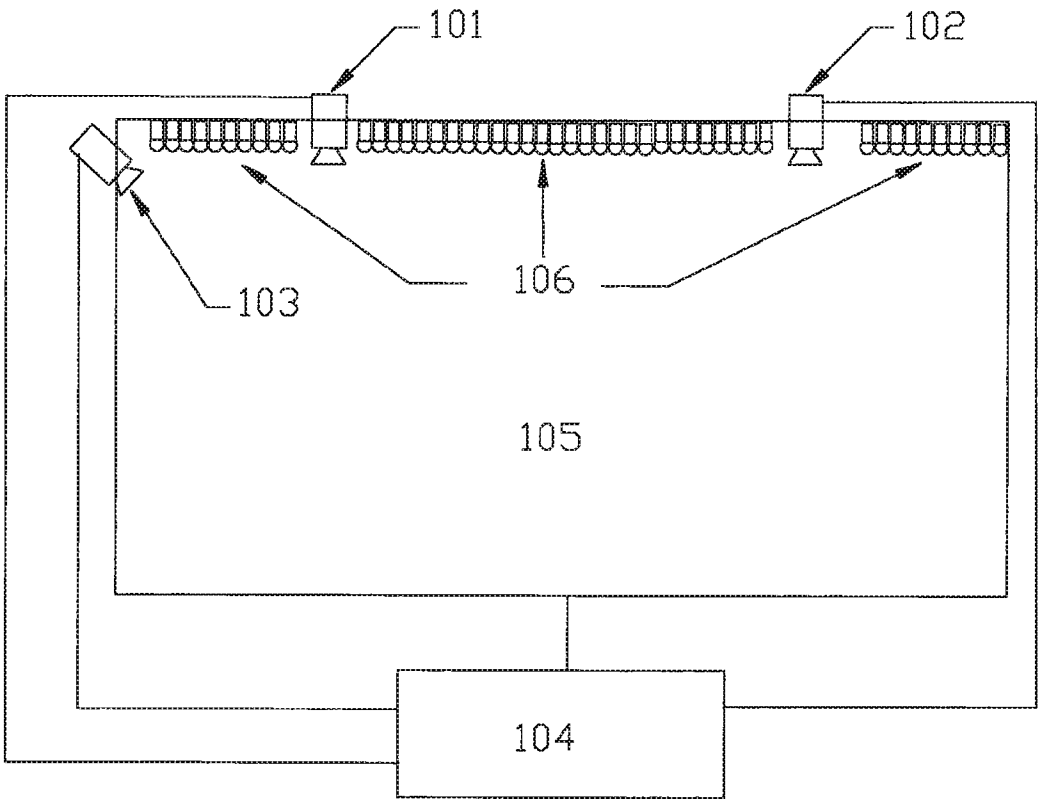


图 1

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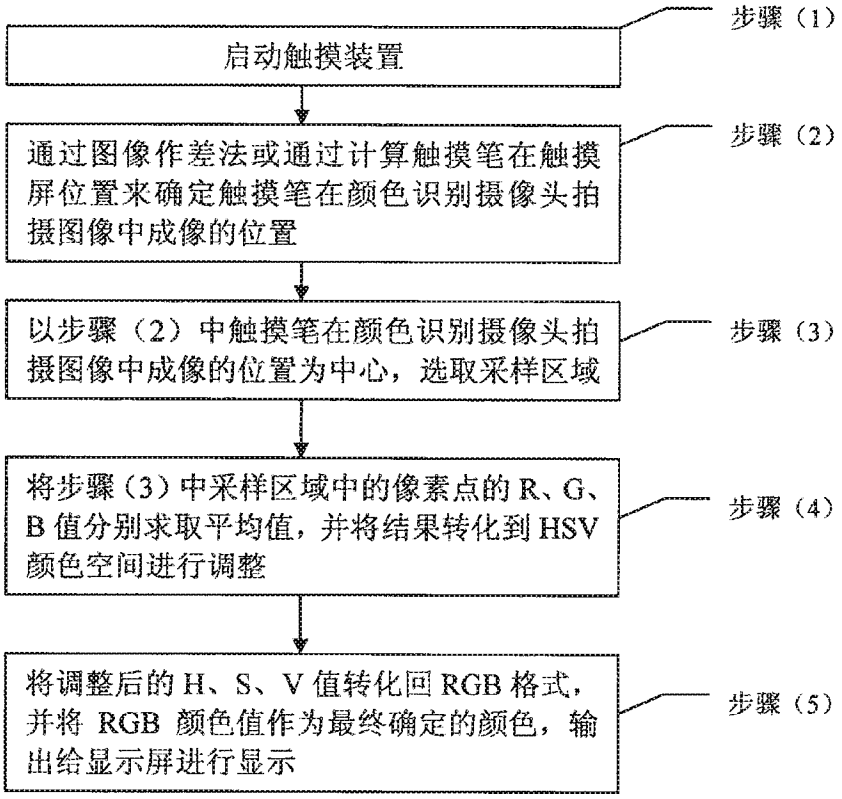


图 2

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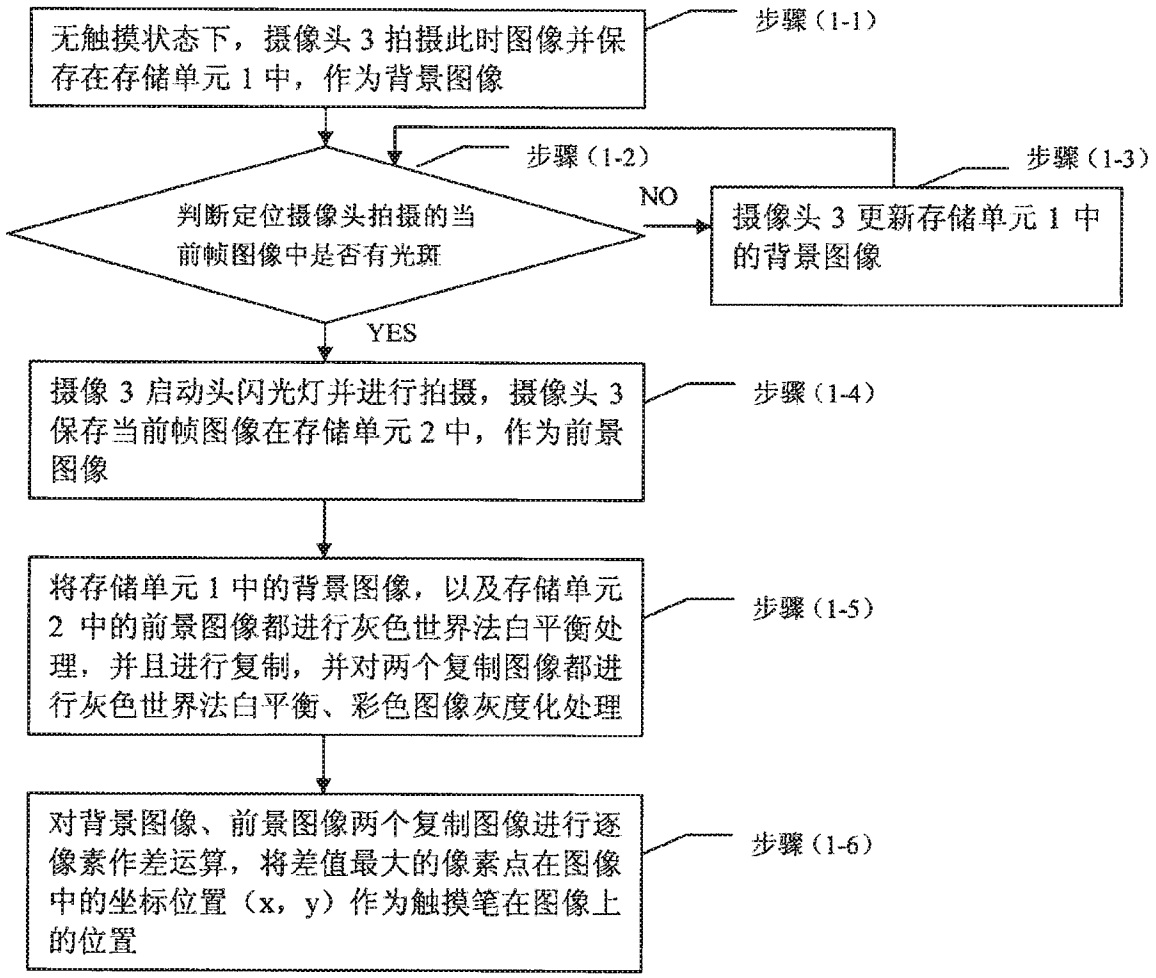


图 3

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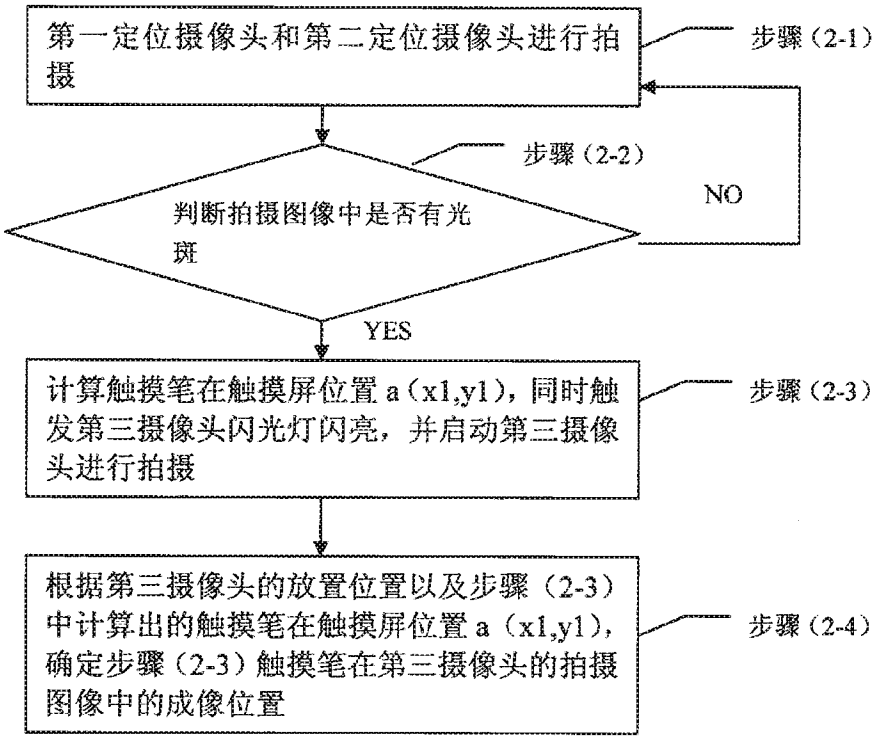


图 4

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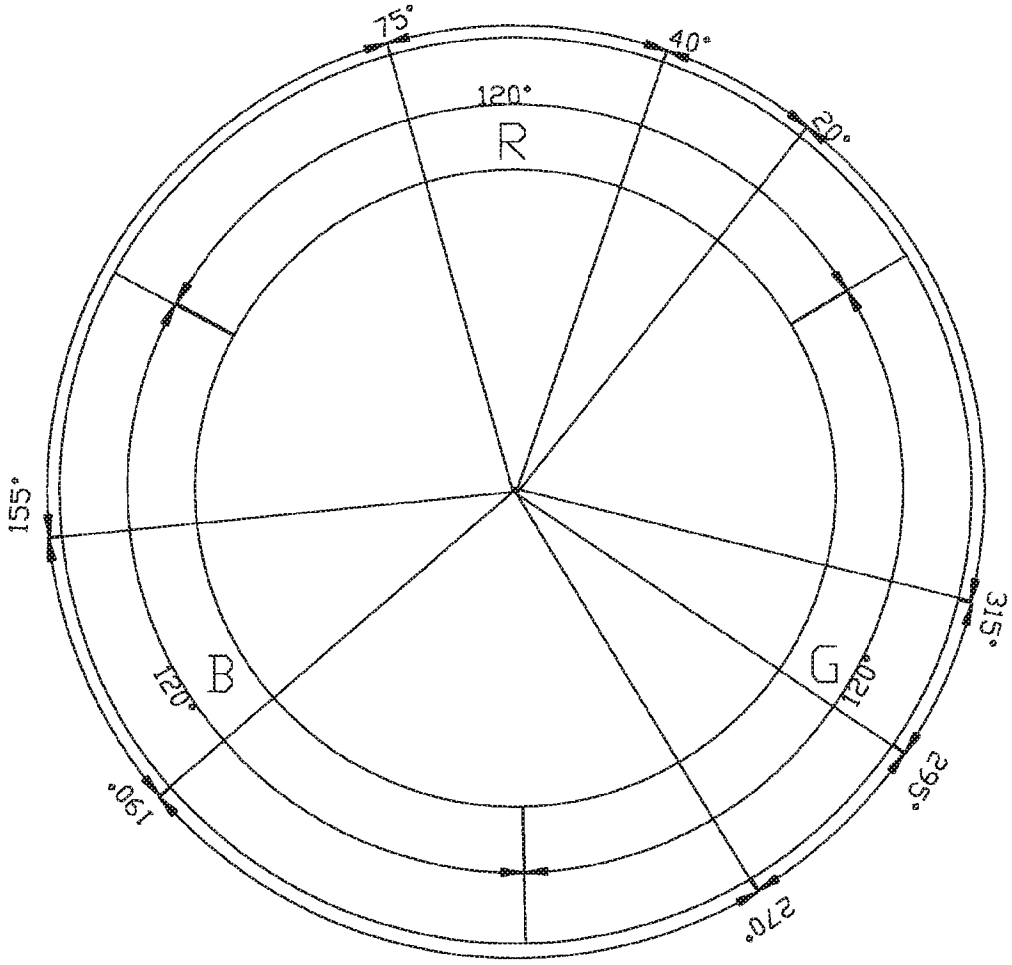


图 5

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Espacenet

Bibliographic data: CN201465071 (U) — 2010-05-12

Infrared touch screen frame structure

Inventor(s): WEI HE ± (HE WEI)

Applicant(s): WEI HE ± (HE WEI)

Classification: **- international:** ***G06F3/042***
- cooperative:

Application number: CN20092060781U 20090720

Priority number(s): CN20092060781U 20090720

Abstract of CN201465071 (U)

The utility model discloses an infrared touch screen frame structure, which comprises four frames which are arranged at the periphery of a touch screen and are provided with circuit boards inside thereof; a right angle connecting component is arranged between two adjacent frames; positive guide rail shafts are respectively arranged at two ends of the right angle connecting component; and sliding guide rail grooves matched with the positive guide rail shafts are formed in the frames and are perpendicular to the circuit boards. The infrared touch screen frame structure has the advantages of firm structure, easy installation, good stability of connected integral structure and good appearance and visual effects.

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DESCRIPTION CN201465071

The utility model discloses a frame structure of an infrared touch screen, which comprises four bezels provided with a circuit board disposed around the periphery of the touch screen, and a right angle connection component is respectively arranged between two adjacent frames, the right angle connection The two ends of the assembly are respectively provided with a positive rail shaft, and a sliding rail groove matched with the positive rail shaft is disposed in the frame, and the sliding rail slot is perpendicular to the circuit board. The utility model has the advantages that the structure is firm, the installation is easy, the overall structure stability after connection is good, and the visual effect of the appearance is good.

Infrared touch screen frame structure

Technical field

The utility model relates to a frame structure of an infrared touch screen.

Background technique

a frame structure for a touch screen frame for fixing an infrared ray emitting and receiving circuit board used in an existing infrared touch screen, which is composed of a frame disposed along four sides of the touch screen, and a circuit board is respectively disposed in each of the frames, and correspondingly disposed thereon Infrared transceiver unit. The splicing between adjacent two frames at the four corners of the touch screen is usually in a misaligned manner, that is, one of the frames is pressed against the end of the adjacent frame. The frame structure is not compact enough, and is not aesthetically pleasing. The frame needs to be cut multiple times during

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installation, and the steps are complicated.

Summary of the invention

The purpose of the utility model is to provide a frame structure of an infrared touch screen which is simple in structure, convenient in installation and beautiful in appearance.

The technical solution of the utility model is: a frame structure of an infrared touch screen, comprising a frame with a circuit board inside, and a right angle connection component is respectively arranged between two adjacent frames, and two of the right angle connection components The ends are respectively provided with a positive rail shaft, and a sliding rail groove matched with the positive rail shaft is disposed in the frame, and the sliding rail slot is perpendicular to the circuit board.

The front rail shafts at both ends of the right angle connecting component are respectively inserted into the sliding rail slots in the adjacent frame, so that the adjacent two frames are plugged and integrated into one by a right angle connecting component, which is convenient to install, and does not need to be cut by using a tool, and the right angle connecting component can be used. The material is made in the same shape as the shape of the frame, and the overall structure of the touch screen frame structure is high and the visual effect is good.

a side rail shaft perpendicular to the positive rail axis is disposed on the right angle connecting component, and a side sliding slot matched with the side rail shaft is disposed in the frame, and the side rail shaft and the side sliding slot are matched with each other. It can increase the stability of the connection between the right-angle connecting component and the frame, and at the same time set two mutually perpendicular axes, which is also conducive to accurate positioning during installation.

Electrically connected connector pins are respectively disposed at two ends of the right angle connecting component, and a connector terminal mated with the connector pin is respectively disposed on the circuit board in the frame, and the pin header is connected through the connector The circuit boards in the adjacent two frames are connected for easy installation, and are also convenient to be made into standard parts, thereby reducing the number of processes in the field.

A screw hole is arranged on the front rail shaft for fixing the right angle connecting component to the frame, which can improve the firmness of the connection.

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The utility model has the advantages that the structure is firm, the installation is easy, the overall structure stability after connection is good, and the visual effect of the appearance is good.

DRAWINGS

Figure 1 is a cross-sectional structural view of a bezel according to an embodiment of the present invention;

Figure 2 is a schematic structural view of an embodiment of the present invention;

Figure 3 is an enlarged view of a portion A of Figure 2;

Figure 4 is a structural view of a right angle connecting assembly in the embodiment of the present invention;

Figure 5 is another perspective view of the right angle connecting assembly in the embodiment of the present invention;

1、
Sliding rail groove, 2, filter, 3, infrared transceiver unit, 4, frame, 5, circuit board, 6, side rail shaft, 7, positive rail shaft, 8, screw hole, 9, connector pin, 10 , side chute, 11, right angle connection assembly, 12, connector terminal.

Detailed ways

Example:

Referring to FIG. 1-5, a frame structure of an infrared touch screen includes an integrally formed hollow frame 4, and a circuit board 5 with an infrared transceiver unit 3 is disposed therein, and a filter 2 is disposed on the frame 4 for protection. Infrared transceiver unit 3.

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During installation, the circuit board 5 is on and the infrared transceiver unit 3 is below, which can reduce the gap between the infrared transceiver unit and the touch screen surface, and can improve the accuracy of touch recognition. A right angle connecting assembly 11 is disposed between two adjacent frames 4, and two ends of the right angle connecting assembly 11 are respectively provided with a positive rail shaft 7 and a side rail shaft 6 perpendicular to the positive rail shaft 7, The sliding rail slot 1 is matched with the front rail shaft 7 in the frame 4, and the sliding rail slot 1 is perpendicular to the circuit board 5. The side rail 4 is also provided with a side sliding slot 10 matched with the side rail shaft 6. The slide rail groove 1 and the side slide grooves 10 are also perpendicular to each other.

Electrically connected connector pins 9 are respectively disposed at two ends of the right angle connecting component 11, and the connector terminals 12 mated with the connector pins 9 are respectively disposed on the circuit board 5 in the frame 4, and the pins are arranged through the connectors. 9 electrically connects the circuit boards 5 in the adjacent two frames 4.

The positive rail shaft 7 of the right angle connecting assembly 11 is provided with a screw hole 8 which can be fixed to the bezel 4 using a screw.

The detailed description above is a detailed description of one of the possible embodiments of the present invention, and is not intended to limit the scope of the invention. In the scope of the patent in this case.

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CLAIMS CN201465071

1.

A frame structure of an infrared touch screen includes four bezels disposed on a periphery of the touch screen and having a circuit board, wherein a right angle connection component is respectively disposed between two adjacent frames, and the right angle connection component The two ends are respectively provided with a positive rail shaft, and a sliding rail groove is formed in the frame with the positive rail shaft, and the sliding rail slot is perpendicular to the circuit board.

2.

The frame structure of an infrared touch screen according to claim 1, wherein a side rail shaft perpendicular to the positive rail axis is disposed on the right angle connecting component, and the side is provided in the frame Side chute with rail shaft fit.

3.

The frame structure of an infrared touch screen according to claim 1 or 2, wherein an electrical connection connector pin is disposed at each end of the right angle connection component, and a circuit board in the frame is provided There are respectively connector terminals that cooperate with the connector pins.

4.

The frame structure of an infrared touch screen according to claim 3, wherein a screw hole is provided on the front rail shaft.

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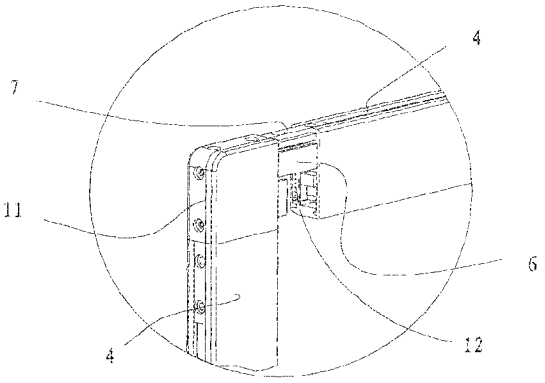
权利要求书 1 页 说明书 2 页 附图 2 页

(54)实用新型名称

红外线触摸屏框架结构

(57)摘要

本实用新型公开了一种红外线触摸屏的框架结构，包括设置在触摸屏周边的四个内部设有电路板的边框，在相邻的两个所述边框之间分别设有直角连接组件，该直角连接组件的两端分别设有正导轨轴，在所述边框内设有与正导轨轴配合的滑动导轨槽，且该滑动导轨槽与所述电路板垂直。本实用新型的优点是：结构牢固，安装容易，连接后整体结构稳定性好，外观视觉效果佳。



CN 201465071 U

1. 一种红外线触摸屏的框架结构，包括设置在触摸屏周边的四个内部设有电路板的边框，其特征在于：在相邻的两个所述边框之间分别设有直角连接组件，该直角连接组件的两端分别设有正导轨轴，在所述边框内设有与正导轨轴配合的滑动导轨槽，且该滑动导轨槽与所述电路板垂直。

2. 根据权利要求 1 所述的一种红外线触摸屏的框架结构，其特征在于：在所述直角连接组件上设有与所述正导轨轴垂直的侧导轨轴，在所述边框内设有与该侧导轨轴配合的侧滑槽。

3. 根据权利要求 1 或 2 所述的一种红外线触摸屏的框架结构，其特征在于：在所述的直角连接组件的两端分别设有电连接的连接器排针，在所述边框内的电路板上分别设有与连接器排针配合的连接器端子。

4. 根据权利要求 3 所述的一种红外线触摸屏的框架结构，其特征在于：在所述正导轨轴上设有螺孔。

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红外线触摸屏框架结构

技术领域

[0001] 本实用新型涉及一种红外线触摸屏的框架结构。

背景技术

[0002] 在现有的红外线触摸屏中所使用的用于固定红外线发射、接收电路板的触摸屏框架的框架结构，其由沿触摸屏四边设置的边框组成，每个边框内分别设置电路板，其上设置相应的红外线收发单元。在触摸屏四角处的相邻两个边框之间的拼接，通常采用错位方式，即其中一个边框压在相邻边框的端头上。这样框架结构不够紧凑，不美观，安装时需要多次切割边框，步骤复杂。

发明内容

[0003] 本实用新型的目的是提供一种结构简单、安装方便且外形美观的红外线触摸屏的框架结构。

[0004] 本实用新型的技术解决方案是：一种红外线触摸屏的框架结构，包括内部设有电路板的边框，在相邻的两个所述边框之间分别设有直角连接组件，该直角连接组件的两端分别设有正导轨轴，在所述边框内设有与正导轨轴配合的滑动导轨槽，且该滑动导轨槽与所述电路板垂直。

[0005] 直角连接组件两端的正导轨轴分别插入相邻边框内的滑动导轨槽内，这样相邻两个边框通过直角连接组件插接拼接成一体，安装方便，无需使用工具进行切割，直角连接组件可以使用与边框外形一致的材料制作，触摸屏框架结构整体美观度高，视觉效果好。

[0006] 在所述直角连接组件上设有与所述正导轨轴垂直的侧导轨轴，在所述边框内设有与该侧导轨轴配合的侧滑槽，设置相互配合的侧导轨轴和侧滑槽，可以增加直角连接组件与边框连接的稳固程度，同时设置的两种互相垂直的轴，也利于安装时的准确定位。

[0007] 在所述的直角连接组件的两端分别设有电连接的连接器排针，在所述边框内的电路板上分别设有与连接器排针配合的连接器端子，通过连接器排针将相邻两个边框内的电路板连接起来，方便安装，同时也方便制作成标准件，减少现场制作的工序。

[0008] 在所述正导轨轴上设有螺孔，用于将直角连接组件固定在边框上，可以提高连接的牢固度。

[0009] 本实用新型的优点是：结构牢固，安装容易，连接后整体结构稳定性好，外观视觉效果佳。

附图说明

[0010] 附图 1 为本实用新型实施例中边框的剖视结构图；

[0011] 附图 2 为本实用新型实施例的结构示意图；

[0012] 附图 3 为图 2 中 A 部的放大图；

[0013] 附图 4 为本实用新型实施例中直角连接组件的结构视图；

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[0014] 附图 5 为本实用新型实施例中直角连接组件的另一方向视图；

[0015] 1、滑动导轨槽，2、滤光片，3、红外线收发单元，4、边框，5、电路板，6、侧导轨轴，7、正导轨轴，8、螺孔，9、连接器排针，10、侧滑槽，11、直角连接组件，12、连接器端子。

具体实施方式

[0016] 实施例：

[0017] 参阅图 1-5，一种红外线触摸屏的框架结构，包括一体成型中空的边框 4，其内部设有带有红外线收发单元 3 的电路板 5，边框 4 上设有滤光片 2，用来保护红外线收发单元 3。安装时，电路板 5 在上，红外线收发单元 3 在下，这样可以减少红外线收发单元与触摸屏表面的间隙，可以提高触摸识别的精度。在相邻的两个所述边框 4 之间设有直角连接组件 11，该直角连接组件 11 的两端分别设有正导轨轴 7，以及与所述正导轨轴 7 垂直的侧导轨轴 6，边框 4 内分别设有与正导轨轴 7 配合的滑动导轨槽 1，且该滑动导轨槽 1 与所述电路板 5 垂直，边框 4 内还设有与侧导轨轴 6 配合的侧滑槽 10，滑动导轨槽 1 和侧滑槽 10 也相互垂直。

[0018] 在直角连接组件 11 的两端分别设有电连接的连接器排针 9，在边框 4 内的电路板 5 上分别设有与连接器排针 9 配合的连接器端子 12，通过连接器排针 9 将相邻两个边框 4 内的电路板 5 电连接起来。

[0019] 直角连接组件 11 的正导轨轴 7 上设有螺孔 8，可以使用螺钉将其固定在边框 4 上。

[0020] 上列详细说明是针对本实用新型之一可行实施例的具体说明，该实施例并非用以限制本实用新型的专利范围，凡未脱离本实用新型所为的等效实施或变更，均应包含于本案的专利范围中。

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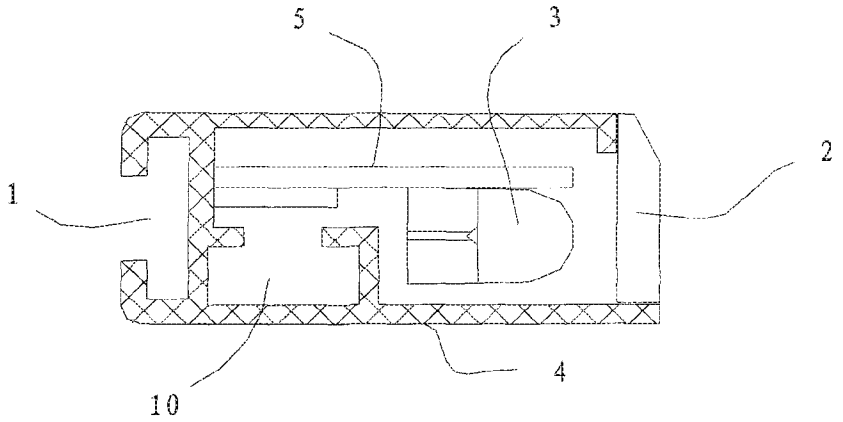


图 1

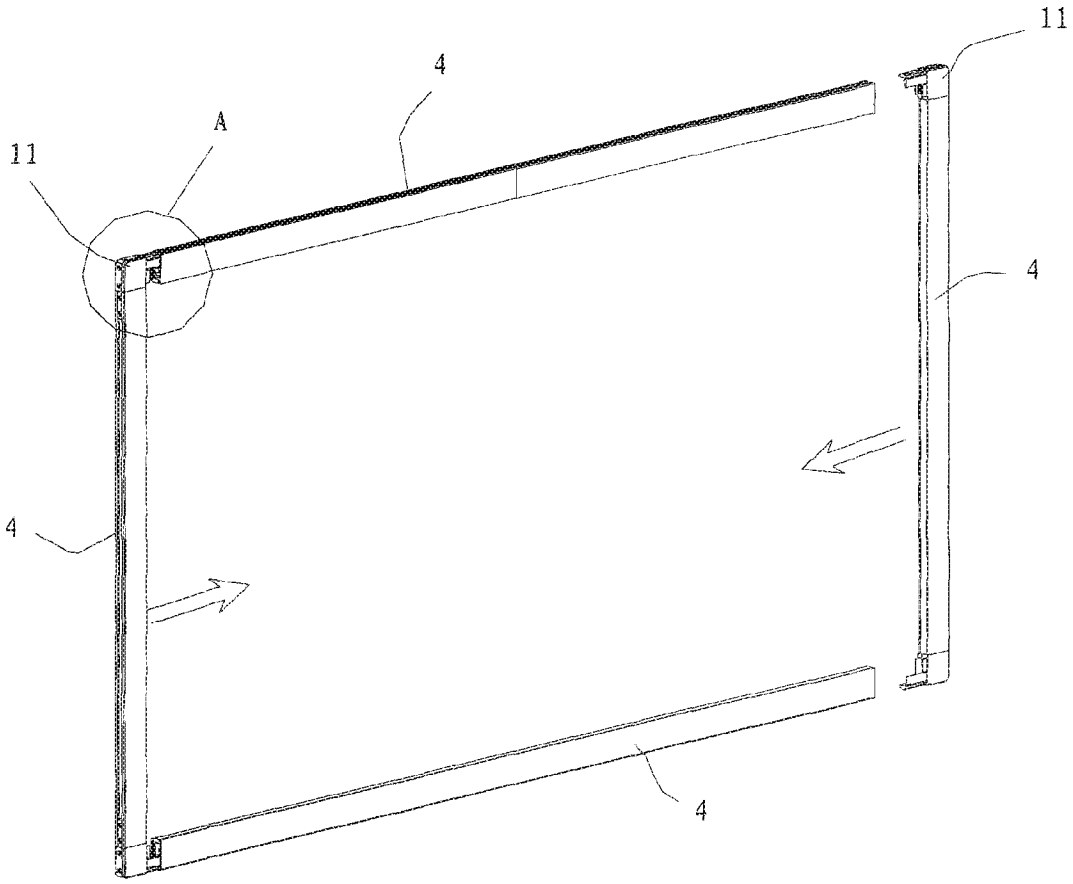


图 2

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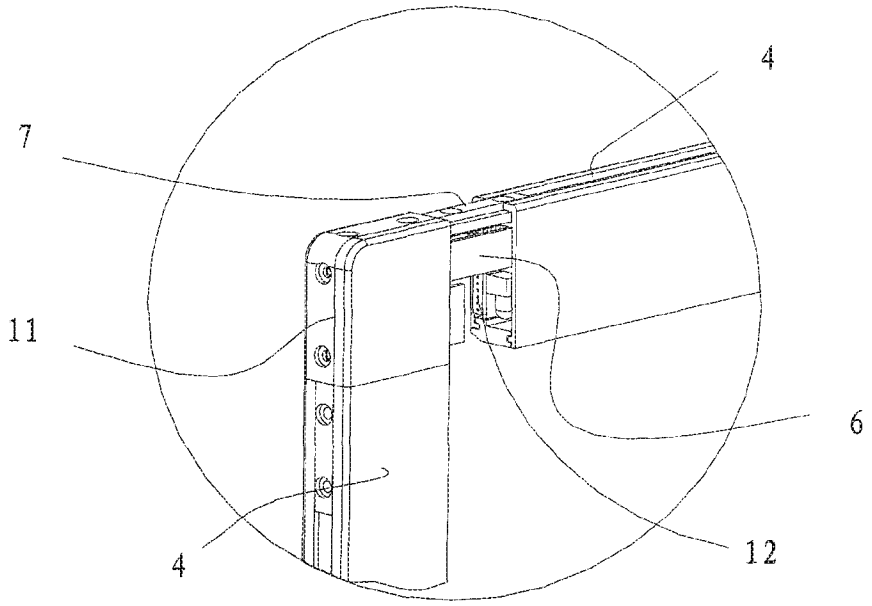


图 3

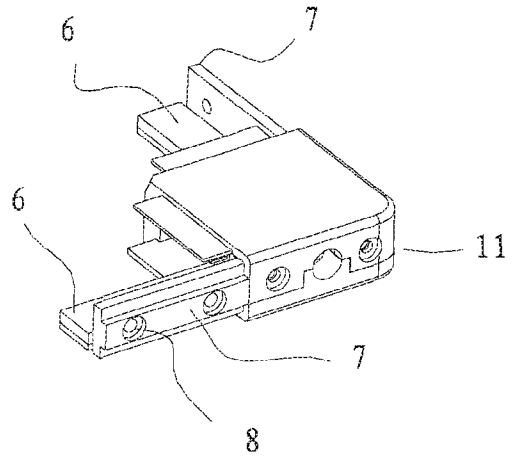


图 4

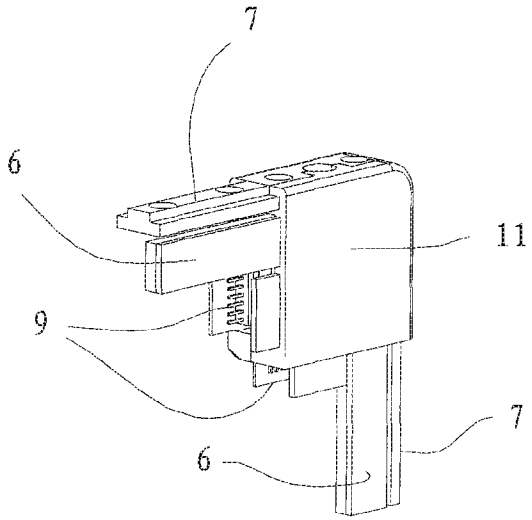


图 5

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Espacenet

Bibliographic data: CN203189466 (U) — 2013-09-11

Axial locking device

Inventor(s): TAN LIANGCHUN; QIAN YAGANG; ZHANG JIANHUA ± (TAN LIANGCHUN, ; QIAN YAGANG, ; ZHANG JIANHUA)

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Classification: **- international:** ***F16B21/10***
- cooperative:

Application number: CN20132107364U 20130310

Priority number(s): CN20132107364U 20130310

Abstract of CN203189466 (U)

The utility model relates to an axial locking device. The axial locking device comprises a steel shaft provided with a locating groove, a base, an axial locking ring and a locking bolt, and further comprises a locking ring, an internal thread gear ring and a locking sheet. The steel shaft penetrates through the base, the axial locking ring is fixed on the steel shaft in a matched mode through the locking bolt and the locating groove and closely adjacent to the base, and the locking ring and the steel shaft are fixedly connected to the other side of the base. The internal thread gear ring and the locking ring are matched and connected through threads and closely adjacent to the base, and the locking sheet is rotationally connected with the locking ring. After the axial locking device is installed, the internal thread gear ring is screwed, a gear of the internal thread gear ring is locked with the locking sheet so that the gear can not rotate, and then the locking operation of the axial locking device is completed.

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DESCRIPTION CN203189466

The utility model relates to an axial locking device, which comprises a steel shaft with a positioning groove, a base, an axial locking ring and a locking bolt, and further comprises a locking ring, an internal thread ring gear and a locking piece. The steel shaft passes through the base, and the axial locking ring is fixed on the steel shaft and abuts against the base by the locking bolt, and the locking ring is fixedly connected to the steel shaft at the base On the side, the internal thread ring gear is threadedly coupled to the locking ring and abuts against the base, and the locking piece is rotatably coupled to the locking ring. After the axial locking device of the utility model is installed, after the internal thread ring gear is tightened, the locking device is used to clamp the gear of the internal thread ring gear to make it unable to rotate, thereby completing the locking operation of the axial locking device.

Axial locking device

Technical field

The utility model relates to a locking device, in particular to an axial locking device.

Background technique

Axial locking devices are required for the installation of metal shafts and other components on large machines such as textile machines to ensure the stability of the machine during operation. Most of the locking devices for locking and fixing steel shafts on large machines such as textile machines are mostly constructed. It is complicated and difficult to adjust the position of the locking device, which is inconvenient to use.

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Summary of the invention

The purpose of the utility model is to provide an axial locking device which is simple in structure and convenient to use.

The technical solution for achieving the object of the present invention is as follows:

An axial locking device includes a base, an axial locking ring, a locking bolt, and a steel shaft passing through the base and having a positioning groove, and further includes a locking ring, an internal thread ring gear and a locking piece. The axial locking ring is fixed to the steel shaft by a locking bolt and a positioning groove, the axial locking ring abuts the base, and the locking ring is fixedly connected with the steel shaft on the other side of the base. The internal thread ring gear is threadedly engaged with the locking ring, the internal thread ring gear abuts against the base, one end of the locking piece is rotatably connected with the locking ring, and the other end of the locking piece is internally threaded The outer gear of the ring is in the tooth groove.

The axial locking device further includes a steel sleeve that is sleeved on the steel shaft and fixedly coupled to the steel shaft, and the locking ring is fixedly mounted on the steel sleeve.

The axial locking device further includes an inner ring needle bearing, the inner ring needle bearing is disposed in the base, and the inner ring needle bearing is sleeved on the steel sleeve.

The axial locking device further includes an inner thrust ball bearing and an outer thrust ball bearing, the inner thrust ball bearing is sleeved on the steel sleeve, and the inner thrust ball bearing is located between the inner thread ring gear and the base, The two ends of the inner thrust ball bearing are in close contact with the inner thread ring gear and the base respectively.

The axial locking device further includes an outer thrust ball bearing, the outer thrust ball bearing is sleeved on the steel shaft, and the outer thrust ball bearing is located between the axial locking ring and the base, and the outer thrust ball bearing The two ends are in close contact with the axial locking ring and the base respectively.

The axial locking device further includes an inner dustproof nylon ring, and the inner dustproof nylon ring is sleeved on the inner thrust ball bearing.

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The axial locking device further includes an outer dustproof nylon ring, and the outer dustproof nylon ring is sleeved on the outer thrust ball bearing.

After adopting the above structure, after the axial locking device of the utility model is installed, the locking effect of the steel shaft can be realized by rotating the internal thread ring gear and the locking piece, the structure is simple, the installation and disassembly are quick, convenient and reliable.

DRAWINGS

The present invention will be further described in detail below in conjunction with the drawings and specific embodiments.

Figure 1 is a schematic view showing the structure of the axial locking device of the present invention.

In the figure: 1 is the steel shaft, 2 is the base, 3 is the steel sleeve, 4 is the locking ring, 5 is the internal thread ring locking piece, 6 is the internal thread ring gear, 7 is the internal thrust ball bearing, 8 is External thrust ball bearings, 9 is the axial locking ring, 10 is the locking bolt, 11 is the positioning groove, 12 is the inner dustproof nylon ring, 13 is the fixing bolt, 14 is the connecting bolt, 15 is the inner ring needle bearing , 16 is the outer dustproof nylon ring.

Detailed ways

1 and 2, the axial locking device of the present invention comprises a steel shaft 1 with a positioning groove 11, a base 2, and further includes a steel sleeve 3, a locking ring 4, a locking piece 5, and an internal thread tooth. a ring 6, an inner thrust ball bearing 7, an outer thrust ball bearing 8, an axial locking ring 9, a locking bolt 10, and an inner ring needle bearing 15, the steel shaft 1 passing through the base 2, the axial direction The locking ring 9 is fixed on the steel shaft 1 by the locking bolt 10 and the positioning groove 11 . The outer thrust ball bearing 8 is sleeved on the steel shaft 1 and simultaneously contacts the axial locking ring 10 and the base 2 . The steel sleeve 3 is sleeved on the steel shaft 1 and is in contact with the outer thrust ball bearing 8 through the base 2, and the inner ringless needle bearing 15 is disposed in the base 2 and sleeved on the steel sleeve 3, the inner The thrust ball bearing 7 is sleeved on the steel sleeve 1 and is in contact with the base 2, and the locking ring 4 is fixed on the steel sleeve 3 by the fixing bolts 13, and the locking ring 4 and the locking piece 5 are rotated by the connecting

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bolts 14. When the connecting bolt 14 is tightened, the locking piece 5 can be fixed, and the internal thread ring gear 6 is screw-fitted with the locking ring 4, and the internal thread ring gear 6 is in contact with the inner thrust ball bearing 7. The axial locking device further comprises an inner dustproof nylon ring 12 and an outer dustproof nylon ring 16, the inner dustproof nylon ring 12 is set on the inner thrust ball bearing, and the outer dustproof nylon ring 16 is set on the outer thrust Ball bearing 8 on.

After the axial locking device of the utility model is installed, after the internal thread ring gear 6 is screwed, the rotary locking piece 5 is caught in the tooth groove of the external gear of the internal thread ring gear 6, and then the connecting bolt 14 is tightened to make the internal thread The locking operation of the axial locking device is completed when the ring gear 6 cannot be rotated.

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CLAIMS CN203189466

1.

An axial locking device comprising a base (2), an axial locking ring (9), a locking bolt (10) and a steel shaft with a positioning groove (11) passing through the base (2) 1), characterized in that it further comprises a locking ring (4), an internal thread ring gear (6) and a locking piece (5), the axial locking ring (9) being positioned by the locking bolt (10) The groove (11) is fixedly fixed to the steel shaft (1), the axial locking ring (9) abuts against the base (2), and the locking ring (4) is fixedly connected to the steel shaft (1) at the base On the other side of (2), the internal thread ring gear (6) is threadedly engaged with the locking ring (4), the internal thread ring gear (6) abuts against the base (2), the locking piece (5) One end is rotatably connected with the locking ring (4), and the other end of the locking piece (5) is caught in the external gear groove of the internal thread ring (6).

2.

The axial locking device according to claim 1, wherein the axial locking device further comprises a steel sleeve (3), the steel sleeve (3) is sleeved on the steel shaft (1) and is connected to the steel The shaft (1) is fixedly connected, and the locking ring (4) is fixedly mounted on the steel sleeve (3).

3.

The axial locking device according to claim 2, wherein said axial locking device further comprises an inner ring needle bearing (15), said inner ring needle bearing (15) being disposed at the base In the seat (2), the inner ring needle bearing (15) is sleeved on the steel sleeve (3).

4.

The axial locking device according to claim 2, wherein said axial locking device further comprises an inner thrust

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ball bearing (7) and an outer thrust ball bearing (8), said inner thrust ball bearing (7) Covered on a steel sleeve (3), the inner thrust ball bearing (7) is located in the middle of the inner thread ring gear (6) and the base (2), and the two ends of the inner thrust ball bearing (7) are respectively The internal thread ring (6) and the base (2) are in close contact.

5.

The axial locking device according to claim 1, wherein said axial locking device further comprises an outer thrust ball bearing (8), said outer thrust ball bearing (8) being sleeved on the steel shaft (2) The outer thrust ball bearing (8) is located between the axial locking ring (9) and the base (2), and the two ends of the outer thrust ball bearing (8) are respectively axially locked (9) And the base (2) is in close contact.

6.

The axial locking device according to claim 4, wherein the axial locking device further comprises an inner dustproof nylon ring (12), and the inner dustproof nylon ring (12) is sleeved inside the thrust ball. On the bearing (7).

7.

The axial locking device according to claim 5, wherein the axial locking device further comprises an outer dustproof nylon ring (16), and the outer dustproof nylon ring (16) is sleeved on the outer thrust ball bearing. (8) Upper.

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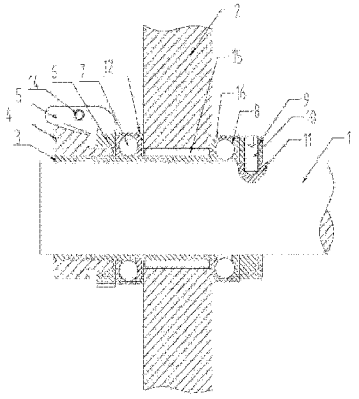
权利要求书1页 说明书2页 附图1页

(54)实用新型名称

轴向锁紧装置

(57)摘要

本实用新型涉及一种轴向锁紧装置，包括带有定位槽的钢轴、基座、轴向锁紧圈以及锁紧螺栓，还包括锁紧圈、内螺纹齿圈以及锁紧片，所述钢轴穿过基座，所述轴向锁紧圈通过锁紧螺栓与定位槽配合固定在钢轴上并紧靠基座，所述锁紧圈与钢轴固定连接在基座的另一侧，所述内螺纹齿圈与锁紧圈螺纹配合连接并紧靠基座，所述锁紧片与锁紧圈转动连接。本实用新型轴向锁紧装置安装完成后，将内螺纹齿圈旋紧后，用锁紧片卡住内螺纹齿圈的齿轮使其无法转动即完成了轴向锁紧装置的锁紧操作。



CN 203189466 U

1. 一种轴向锁紧装置，包括基座(2)、轴向锁紧圈(9)、锁紧螺栓(10)以及穿过基座(2)且带有定位槽(11)的钢轴(1)，其特征在于：还包括锁紧圈(4)、内螺纹齿圈(6)以及锁紧片(5)，所述轴向锁紧圈(9)通过锁紧螺栓(10)与定位槽(11)配合固定在钢轴(1)，所述轴向锁紧圈(9)紧靠基座(2)，所述锁紧圈(4)与钢轴(1)固定连接在基座(2)的另一侧，所述内螺纹齿圈(6)与锁紧圈(4)螺纹配合，所述内螺纹齿圈(6)紧靠基座(2)，所述锁紧片(5)一端与锁紧圈(4)转动连接，所述锁紧片(5)的另一端卡在内螺纹齿圈(6)的外齿轮齿槽里。

2. 根据权利要求 1 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括钢套(3)，所述钢套(3)套在钢轴(1)上并与钢轴(1)固定连接，所述锁紧圈(4)固定安装在钢套(3)上。

3. 根据权利要求 2 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括无内圈滚针轴承(15)，所述无内圈滚针轴承(15)设置在基座(2)内，所述无内圈滚针轴承(15)套在钢套(3)上。

4. 根据权利要求 2 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括内推力球轴承(7)以及外推力球轴承(8)，所述内推力球轴承(7)套在钢套(3)上，所述内推力球轴承(7)位于内螺纹齿圈(6)和基座(2)的中间，所述内推力球轴承(7)的两端分别与内螺纹齿圈(6)及基座(2)紧密接触。

5. 根据权利要求 1 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括外推力球轴承(8)，所述外推力球轴承(8)套在钢轴(2)上，所述外推力球轴承(8)位于轴向锁紧圈(9)与基座(2)中间，所述外推力球轴承(8)的两端分别与轴向锁紧圈(9)及基座(2)紧密接触。

6. 根据权利要求 4 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括内防尘尼龙圈(12)，所述内防尘尼龙圈(12)套在内推力球轴承(7)上。

7. 根据权利要求 5 所述的轴向锁紧装置，其特征在于：所述轴向锁紧装置还包括外防尘尼龙圈(16)，所述外防尘尼龙圈(16)套在外推力球轴承(8)上。

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轴向锁紧装置

技术领域

[0001] 本实用新型涉及一种锁紧装置，特别是一种轴向锁紧装置。

背景技术

[0002] 纺织机等大型机械上的金属轴等零件安装时都需要轴向锁紧装置以保证机器运行时的稳定性，目前用于纺织机等大型机械上的锁紧固定钢轴的锁紧装置大多结构复杂且不易调整锁紧装置的位置，使用很不方便。

发明内容

[0003] 本实用新型的目的是提供一种结构简单、使用方便的轴向锁紧装置。

[0004] 实现本实用新型目的的技术方案如下：

[0005] 一种轴向锁紧装置，包括基座、轴向锁紧圈、锁紧螺栓以及穿过基座且带有定位槽的钢轴，还包括锁紧圈、内螺纹齿圈以及锁紧片，所述轴向锁紧圈通过锁紧螺栓与定位槽配合固定在钢轴，所述轴向锁紧圈紧靠基座，所述锁紧圈与钢轴固定连接在基座的另一侧，所述内螺纹齿圈与锁紧圈螺纹配合，所述内螺纹齿圈紧靠基座，所述锁紧片一端与锁紧圈转动连接，所述锁紧片的另一端卡在内螺纹齿圈的外齿轮齿槽里。

[0006] 所述轴向锁紧装置还包括钢套，所述钢套套在钢轴上并与钢轴固定连接，所述锁紧圈固定安装在钢套上。

[0007] 所述轴向锁紧装置还包括无内圈滚针轴承，所述无内圈滚针轴承设置在基座内，所述无内圈滚针轴承套在钢套上。

[0008] 所述轴向锁紧装置还包括内推力球轴承以及外推力球轴承，所述内推力球轴承套在钢套上，所述内推力球轴承位于内螺纹齿圈和基座的中间，所述内推力球轴承的两端分别与内螺纹齿圈及基座紧密接触。

[0009] 所述轴向锁紧装置还包括外推力球轴承，所述外推力球轴承套在钢轴上，所述外推力球轴承位于轴向锁紧圈与基座中间，所述外推力球轴承的两端分别与轴向锁紧圈及基座紧密接触。

[0010] 所述轴向锁紧装置还包括内防尘尼龙圈，所述内防尘尼龙圈套在内推力球轴承上。

[0011] 所述轴向锁紧装置还包括外防尘尼龙圈，所述外防尘尼龙圈套在外推力球轴承上。

[0012] 采用上述结构后，本实用新型轴向锁紧装置安装完成后通过旋转内螺纹齿圈及锁紧片即可实现对钢轴的锁紧效果，结构简单，安装、拆卸迅速，方便可靠。

附图说明

[0013] 下面结合附图和具体实施方式对本实用新型作进一步详细的说明。

[0014] 图 1 为本实用新型轴向锁紧装置的结构示意图。

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[0015] 图中：1 为钢轴，2 为基座，3 为钢套，4 为锁紧圈，5 为内螺纹齿圈锁紧片，6 为内螺纹齿圈，7 为内推力球轴承，8 为外推力球轴承，9 为轴向锁紧圈，10 为锁紧螺栓，11 为定位槽，12 为内防尘尼龙圈，13 为固定螺栓，14 为连接螺栓，15 为无内圈滚针轴承，16 为外防尘尼龙圈。

具体实施方式

[0016] 由图 1 和图 2 可知，本实用新型轴向锁紧装置包括带有定位槽 11 的钢轴 1、基座 2，还包括钢套 3、锁紧圈 4、锁紧片 5、内螺纹齿圈 6、内推力球轴承 7、外推力球轴承 8、轴向锁紧圈 9、锁紧螺栓 10 以及无内圈滚针轴承 15，所述钢轴 1 穿过基座 2，所述轴向锁紧圈 9 通过锁紧螺栓 10 与定位槽 11 配合固定在钢轴 1 上，所述外推力球轴承 8 套在钢轴 1 上并同时与轴向锁紧圈 10 及基座 2 接触，所述钢套 3 套在钢轴 1 上并且穿过基座 2 与外推力球轴承 8 接触，所述无内圈滚针轴承 15 设置在基座 2 内并套在钢套 3 上，所述内推力球轴承 7 套在钢套 1 上并与基座 2 接触，所述锁紧圈 4 通过固定螺栓 13 固定在钢套 3 上，所述锁紧圈 4 与锁紧片 5 以连接螺栓 14 转动连接，当连接螺栓 14 拧紧后可使锁紧片 5 固定不动，所述内螺纹齿圈 6 与锁紧圈 4 螺纹配合连接，所述内螺纹齿圈 6 与内推力球轴承 7 接触。所述轴向锁紧装置还包括内防尘尼龙圈 12 和外防尘尼龙圈 16，所述内防尘尼龙圈 12 套在内推力球轴承上，所述外防尘尼龙圈 16 套在外推力球轴承 8 上。

[0017] 本实用新型轴向锁紧装置安装完成后，将内螺纹齿圈 6 旋紧后，旋转锁紧片 5 卡在内螺纹齿圈 6 的外齿轮的齿槽里后拧紧连接螺栓 14，使内螺纹齿圈 6 无法转动即完成了轴向锁紧装置的锁紧操作。

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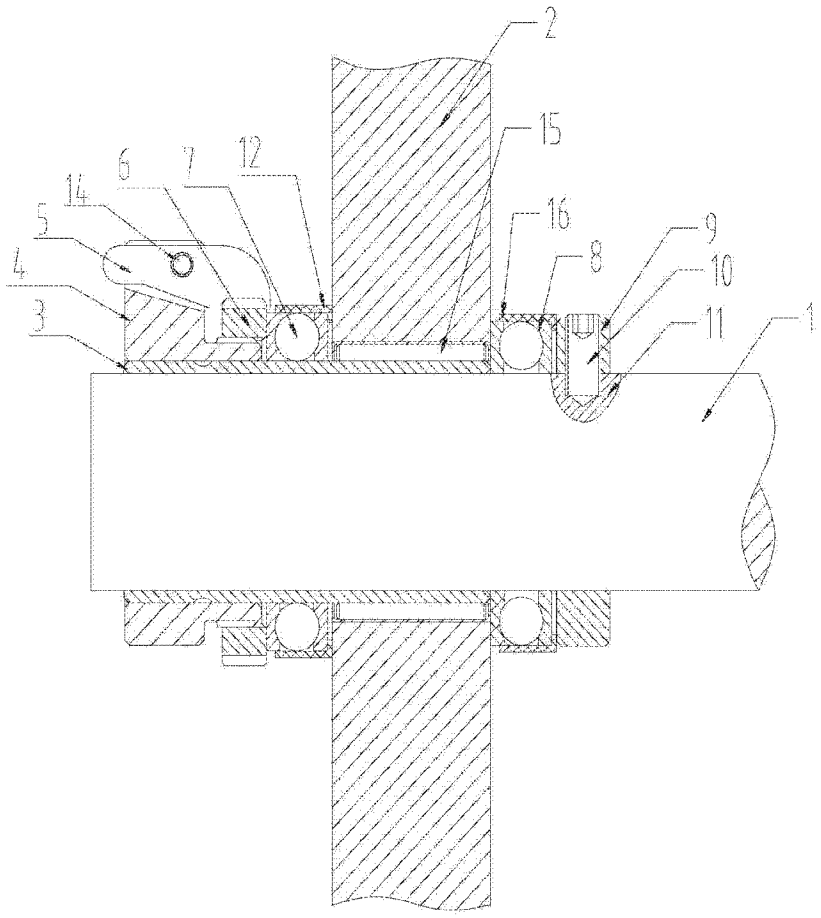


图 1

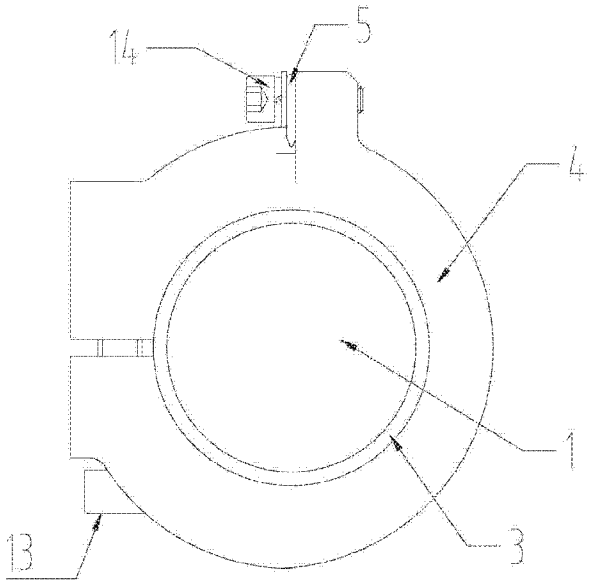


图 2

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Espacenet

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Touch control display module

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- cooperative:

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Abstract of CN203224848 (U)

Provided is a touch control display module, comprising a display and a first panel. The display comprises a display panel, a rubber frame encircling the display panel, and at least two first positioning parts disposed on the rubber frame. A first panel is disposed on the display, and is composed of a guard plate and at least two second positioning parts disposed on the guard plate. The first positioning part is combined with the second positioning part, enabling the first panel to be fixed to the display panel, with respect to the first panel. The touch control display module is advantageous in that during the assembling process of the touch control display module, with the assistance of the first positioning part and the second positioning part, abnormal problems between the first panel and the display are not easy to occur; the assembling yield rate of the touch control display module can be further improved.

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DESCRIPTION CN203224848

A touch display module includes a display and a first panel. The display comprises a display panel, a plastic frame surrounding the display panel, and at least two first positioning portions disposed on the plastic frame. The first panel is disposed on the display. The first panel includes at least two second positioning portions on the protection panel and the protection panel. The first positioning portion is combined with the second positioning portion to fix the relative position of the first panel and the display panel. In the assembly process of the touch display module of the present invention, with the assistance of the first positioning portion and the second positioning portion, an abnormal problem is less likely to occur between the first panel and the display, thereby improving the touch display of the present invention. Module assembly yield.

Touch display module

Technical field

The utility model relates to a display module, and in particular to a touch display module.

Background technique

With the rapid development and application of information technology, wireless mobile communication and information appliances, in order to achieve more convenient carrying, lighter weight and more user-friendly operation, many information products have been transformed by traditional keyboard or mouse input devices. To use a touch device as an input device. Touch panels have been widely used in various electronic products due to their user interface advantages, especially mobile electronic products such as mobile phones or tablet

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computers. According to the sensing principle, the touch panel can be divided into a resistive type, a capacitive type, and an optical type. Among them, the capacitive touch panel has a better sensing effect, and has become the mainstream of today's touch panels.

Generally, a touch display device mainly includes a display and a touch panel. In the assembly process of the touch display device, an assembly tool is often used to position the touch panel and the display, and then the touch panel is bonded to the display with double-sided tape. In the production of different sizes of touch display devices, assembly tools must be separately prepared, and the tolerances of the assembly tools and the labor hours assembled by the tools often result in an increase in production costs. In addition, when the tool tolerance is too large, the alignment between the display and the touch panel is prone to abnormality, and the display area is offset or the chip trace of the display is exposed.

Summary of the invention

The utility model provides a touch display module, which has high assembly yield.

The utility model provides a touch display module, which comprises a display and a first panel. The display comprises a display panel, a plastic frame surrounding the display panel, and at least two first positioning portions disposed on the plastic frame. The first panel is disposed on the display, and the first panel includes at least two second positioning portions on the protection panel and the protection panel. The first positioning portion is respectively coupled to the second positioning portion to fix the relative position of the first panel and the display.

In an embodiment of the present invention, the first positioning portion is a protrusion extending toward the first panel, and the second positioning portion is a recess corresponding to the protrusion.

In an embodiment of the present invention, the first panel further includes a touch sensing layer, and the touch sensing layer is located between the protection board and the display.

In an embodiment of the present invention, the display panel includes an active component substrate, an opposite substrate with respect to the active component substrate, and a display medium layer and touch sensing disposed between the active component substrate and the opposite substrate. The layer is disposed between the opposite substrate and the display medium layer.

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In an embodiment of the present invention, the display panel includes an active component substrate, an opposite substrate with respect to the active component substrate, and a display medium layer and touch sensing disposed between the active component substrate and the opposite substrate. The layer is disposed between the touch sensing layer and the display medium layer.

In an embodiment of the present invention, the display panel includes an active component substrate, an opposite substrate with respect to the active component substrate, and a display medium layer and touch sensing disposed between the active component substrate and the opposite substrate. The layer, the touch sensing layer is located between the active component substrate and the display medium layer.

In an embodiment of the invention, the protective plate has a first surface and a second surface opposite to the first surface, wherein the first surface is located between the display and the second surface. The recess extends through the first surface and toward the second surface, and the recess does not penetrate the second surface.

In an embodiment of the invention, the recesses penetrate through the protective plate.

In an embodiment of the invention, the touch display module further includes a plurality of masks. The shielding is disposed on the second surface of the protection panel and respectively covers the recess.

In an embodiment of the present invention, each of the first positioning portions includes a first positioning sub-portion and a second positioning sub-portion. The first positioning sub-port connects the second positioning sub-section with the plastic frame. The maximum diameter of the second positioning subsection is greater than the largest diameter of the first positioning subsection.

In an embodiment of the present invention, the first positioning sub-portion is a cylinder, and the second positioning sub-portion has a bottom surface directly connected to the column body, a top surface opposite to the bottom surface, and a surrounding bottom surface and a top surface And connect the bottom surface of the bottom surface and the top surface. The area of the bottom surface is larger than the area of the top surface. Moreover, the cross-sectional area of the cylinder that is cut by the reference plane is smaller than the area of the bottom surface, wherein the reference plane is parallel to the display surface of the display.

In an embodiment of the present invention, the cross-sectional area of the second positioning sub-portion that is cut by the reference plane gradually decreases as the reference plane moves away from the display.

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In an embodiment of the invention, the second positioning portion includes a third positioning sub-section and a fourth positioning sub-portion. The third positioning sub-portion is located between the fourth positioning sub-portion and the display, wherein the maximum diameter of the fourth positioning sub-portion is greater than the maximum caliber of the third positioning sub-portion.

In an embodiment of the present invention, the first positioning sub-portion is engaged in the third positioning sub-portion, and the second positioning sub-portion is engaged in the fourth positioning sub-portion.

In an embodiment of the invention, the first positioning portion includes a base and a plurality of claws connected to the base. There is at least one elastic space between the claws.

In an embodiment of the present invention, the base is engaged in the third positioning sub-portion, and the claw is engaged in the fourth positioning sub-portion.

In an embodiment of the present invention, the first positioning portion is a plurality of recesses extending toward the first panel, and the second positioning portion is a plurality of protrusions corresponding to the recesses.

In an embodiment of the invention, the touch display module further includes a colloid. The colloid is disposed between the display and the first panel. The gel is adapted to conform the first panel to the display.

In an embodiment of the invention, the colloid is a double-sided tape, a water glue or a combination thereof.

Based on the above, in the assembly process of the touch display module of the present invention, by the assistance of the first positioning portion and the second positioning portion, an abnormal problem is less likely to occur between the first panel and the display, thereby improving the utility model. The assembly yield of the touch display module.

DRAWINGS

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FIG. 1A is a perspective view of a touch display module according to an embodiment of the present invention.

FIG. 1B is an exploded view of a touch display module according to an embodiment of the present invention.

1C is a partial enlarged view of the first positioning portion of FIG. 1B.

FIG. 1D is a partial enlarged view of the second positioning portion of FIG. 1B.

2A to 2C are cross-sectional views showing other embodiments of the present invention.

FIG. 3A is a partial enlarged view of a first positioning portion of the touch display module according to an embodiment of the present invention.

FIG. 3B is a partial enlarged view of a second positioning portion of the touch display module according to an embodiment of the present invention.

Fig. 4A is a cross-sectional view of the first positioning portion of Fig. 1C taken along line A-A'.

Figure 4B is a cross-sectional view of the second positioning portion of Figure 1D taken along line B-B'.

5 is a cross-sectional view of the touch display module of FIG. 1A taken along line I-I'.

6A is a cross-sectional view of a touch display module according to another embodiment of the present invention.

Figure 6B is a cross-sectional view of the first panel of Figure 6A assembled with the display.

FIG. 7A is a perspective view of a touch display module according to still another embodiment of the present invention.

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7B is a cross-sectional view of the touch display module along line C-C' of still another embodiment of the present invention.

8A to 8C are cross-sectional views showing the assembly process of the display of Fig. 7A and the first panel.

[Main component symbol description]

100、100A: touch display module

110、110d, 110e, 110f, 210, 410: display

111: Display surface

112、212、412: First positioning part

112a: first positioning subsection

112b: second positioning subsection

112c: bottom

112d: top surface

112e: circumferential surface

114: Display panel

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115： Counter substrate

115a: upper surface

115b: lower surface

116： Plastic frame

117： Active component substrate

118： Display media layer

120、220、320、420： First panel

122、222、322、422： Second positioning part

122a: third positioning subsection

122b: fourth positioning subsection

122c: surface

124、324： Protection board

124a: the first surface

124b, 324b: second surface

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126D, 126e, 126f: touch sensing layer

D1, d2: diameter

D3, d4: caliber

340: Shield

412a: base

412b: claw

412c: elastic space

412d: bevel

412e: bulge

412f: elastic arm

422a: surface

422b: side wall

Detailed ways

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Referring to FIG. 1A to FIG. 1D , the touch display module 100 of the present invention includes a display 110 and a first panel 120 . The display 110 includes at least two first positioning portions 112. The first panel 120 is disposed on the display 110. The first panel 120 includes at least two second positioning portions 122. The first positioning portion 112 is coupled to the second positioning portion 122 to fix the relative position of the first panel 120 and the display 110. As a result, during the assembly process of the touch display module 100, the problem of alignment abnormality is less likely to occur between the first panel 120 and the display 110. Moreover, the man-hours of the display 110 and the first panel 120 can be effectively shortened by the assistance of the first positioning portion 112 and the second positioning portion 122.

The display 110 of this embodiment includes a display panel 114 and a plastic frame 116. The first panel 120 of the present embodiment includes a protection board 124 and a touch sensing layer 126 disposed on the protection board 124. The touch sensing layer 126 is located between the protection board 124 and the display 110. The touch sensing layer 126 can be directly connected to the protection board 124. Therefore, the first panel 120 in this embodiment can be regarded as a touch panel. In this embodiment, the protection plate 124 is, for example, a rigid substrate, but the present invention is not limited thereto.

The relative position of the touch sensing layer in the display module may be different in different forms depending on the design manner of the display module, which will be described below. 2A, 2B and 2C are cross-sectional views of other embodiments of the present invention, respectively. In FIG. 2A, the display 110d includes an active component substrate 117, an opposite substrate 115 with respect to the active component substrate 117, a display medium layer 118 disposed between the active component substrate 117 and the opposite substrate 115, and a touch sensing. Layer 126d. In this embodiment, the opposite substrate 115 is located between the touch sensing layer 126d and the display medium layer 118, and the touch sensing layer 126d is disposed on an upper surface 115a of the opposite substrate 115. In the embodiment shown in FIG. 2B , the touch sensing layer 126 e of the display 110 e is located between the opposite substrate 115 and the display medium layer 118 . In other words, the touch sensing layer 126e is disposed on the lower surface 115b of the opposite substrate 115 opposite to the upper surface 115a. In addition, in FIG. 2C, the touch sensing layer 126f of the display 110f is located between the active component substrate 117 and the display medium layer 118. In the embodiment of FIG. 2B and FIG. 2C, the touch sensing layers 126e, 126f are all disposed within the display. In the above-described embodiments, the touch sensing layers are all disposed in the display, so the first panel disposed outside the display only has a protective plate.

In detail, in the embodiment, the first positioning portion 112 can be disposed on the plastic frame 116 of the display 110. Further, the material of the first positioning portion 112 and the material of the plastic frame 116 can be the same. On the other hand, the second positioning portion 122 may be formed on the protective plate 124 of the first panel 120. In this embodiment, the first positioning portion 112 may be a protrusion extending toward the first panel 120, and the second positioning portion 122 may be a recess corresponding to the protrusion. However, the present invention does not limit the first positioning portion on the display as a protrusion, and the

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second positioning portion on the first panel is a recess. An embodiment will be described below. 3A and 3B are partially enlarged views of a first positioning portion and a second positioning portion of a touch display module according to another embodiment of the present invention. In this embodiment, the second positioning portion 222 can be a protrusion extending toward the display 210, and the first positioning portion 212 can be a recess corresponding to the protrusion. The relative position of the first panel 220 and the display 210 can also be fixed by the second positioning portion 222 and the first positioning portion 212 being coupled to each other.

Hereinafter, the design of the positioning unit will be described in detail. For convenience of the description herein, the following description will be made with the embodiment shown in FIGS. 1A to 1D, but the present invention does not limit this design. Fig. 4A is a cross-sectional view taken along line A-A' of Fig. 1C. Fig. 4B is a cross-sectional view taken along line B-B' of Fig. 1D. In FIG. 4A, the first positioning portion 112 is a protrusion, and each of the first positioning portions 112 includes a first positioning sub-portion 112a and a second positioning sub-portion 112b. The first positioning sub-portion 112a connects the second positioning sub-portion 112b with the bezel 116. The maximum diameter d1 of the second positioning sub-portion 112b may be greater than the maximum diameter d2 of the first positioning sub-portion 112a. Specifically, the first positioning sub-portion 112a may be a cylinder, and the second positioning sub-portion 112b is similar to a cone. Still further, the second positioning sub-portion 112b has a bottom surface 112c directly connected to the first positioning sub-portion 112a, a top surface 112d opposite to the bottom surface 112c, and a surrounding bottom surface 112c and a top surface 112d and connecting the bottom surface 112c and the top surface 112d The circumferential surface 112e. In this embodiment, the area of the bottom surface 112c may be larger than the area of the top surface 112d. Moreover, the cross-sectional area of the first positioning sub-portion 112a cut by a reference plane may be smaller than the area of the bottom surface 112c. The reference plane referred to herein in this embodiment is a plane parallel to the X-Y plane shown by the coordinate axis of Fig. 1C. The plane is parallel to the display surface 111 of the display 110, wherein the display surface 111 refers to the plane in which the display panel 114 is located. Overall, the appearance of the second positioning sub-portion 112b of the present embodiment is similar to the shape of the mushroom head. In other words, as the distance of the reference plane from the display 110 in the positive Z direction of the coordinate axis increases, the cross-sectional area of the second positioning sub-portion 112b cut by the reference plane gradually decreases.

In contrast, the form of the second positioning portion 122 corresponding to the first positioning portion 112 will be described in detail below. In FIG. 4B, the protective plate 124 of the first panel 120 has a first surface 124a and a second surface 124b relative to the first surface 124a. The first surface 124a is located between the display 110 and the second surface 124b. The second positioning portion 122 (ie, the recess) extends through the first surface 124a and toward the second surface 124b. In this embodiment, the second positioning portion 122 may not penetrate the second surface 124b. In detail, each of the second positioning portions 122 includes a third positioning sub-portion 122a and a fourth positioning sub-portion 122b. The third positioning sub-portion 122a is located between the fourth positioning sub-portion 122b and the display 110. The maximum aperture d3 of the fourth positioning sub-portion 122b is greater than the maximum aperture d4 of the third positioning sub-portion 122a. In this embodiment, the third positioning sub-portion 122a may be a cylindrical recess having a

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smaller diameter and a thicker thickness, and the fourth positioning sub-portion 122b may be a disc-shaped recess having a larger diameter and a thinner thickness.

Figure 5 is a cross-sectional view taken along line I-I' of Figure 1A. Referring to FIG. 5, after the first panel 120 is assembled with the display 110, the first positioning sub-portion 112a of the first positioning portion 112 can be engaged to the third positioning sub-portion 122a of the second positioning portion 122, and the second positioning is performed. The sub-portion 112b can be engaged in the fourth positioning sub-portion 122b. The bottom surface 112c of the second positioning sub-portion 112b may overlap on a surface 122c of the fourth positioning sub-portion 122b. In this way, the first positioning portion 112 and the second positioning portion 122 can be firmly coupled, thereby fixing the relative position of the first panel 120 and the display 110.

In addition, in order to enhance the fixing effect of the display 110 and the first panel 120 of the present embodiment, the touch display module 100 of the present invention may further include a colloid 130. As shown in FIG. 1B and FIG. 5, the colloid 130 can be disposed between the display 110 and the first panel 120, so that the first panel 120 is more firmly attached to the display 110. In the present embodiment, the colloid 130 is, for example, a double-sided tape, a water gel, a combination of the two, or other suitable adhesive.

It should be noted that the configurations of the first positioning portion and the second positioning portion of the present invention are not limited to the protrusions and recesses each having two sub-portions. All of the structures that can be formed on the first panel and the display, and thereby the structure can fix the relative positions of the first panel and the display, which can be used as the positioning portion of the present invention.

As shown in FIG. 4B, the second positioning portion 122 of the above embodiment does not penetrate the protection plate 124. Therefore, when the first panel 120 is assembled with the display 110, the surface of the protection plate 124 does not have an opening. However, in other embodiments of the present invention, the first panel can reduce the thickness in response to the demand for thinning. At this time, the positioning structure of the display and the first panel can be effectively molded and functioned, and the second positioning is performed. The portion 122 can also extend through the protective plate 124. 6A is a cross-sectional view of a touch display module according to another embodiment of the present invention. 6B is a cross-sectional view of the first panel of FIG. 6A assembled with the display. The difference between the touch display device 100A shown in FIG. 6B and the touch display device 100 shown in FIG. 5 is that the second positioning portion 322 of the first panel 320 can penetrate the protection plate as shown in FIG. 6A and FIG. 6B. 324. When the first panel 320 is assembled with the display 110, the second positioning portion 322 can still be engaged with the first positioning portion 112. It is to be noted that the touch display device 100A of the present embodiment may further include a plurality of masks 340 because the second positioning portion 322 can penetrate the protection board 324. The shield 340 is disposed on the second surface 324b of the protection plate 324 and covers the second positioning portion 322, respectively. As a result, the second positioning portion 322 does not easily

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affect the appearance of the touch display device 100A. The shield 340 is, for example, a plastic insulating sheet (mylar), but the invention is not limited thereto.

Hereinafter, another embodiment will be described to explain the design of the present invention when at least one of the positioning portions is a protrusion. FIG. 7A is a perspective view of a touch display module according to still another embodiment of the present invention. Figure 7B is a cross-sectional view of Figure 7A taken along line C-C'. For the sake of clarity, the first panel is omitted in Figures 7A and 7B. 8A to 8C illustrate an assembly process of the display of Fig. 7A and the first panel. Referring to FIG. 7A and FIG. 7B , in the embodiment, the first positioning portion 412 can be a protrusion, and the second positioning portion 422 is, for example, a recess, which is the same as the foregoing embodiment, and details are not described herein. . In the present embodiment, each of the first positioning portions 412 includes a base 412a and a plurality of claws 412b coupled to the base 412a. There is at least one elastic space 412c between the claws 412b.

The claw 412b can have a slope 412d, a protrusion 412e, and a resilient arm 412f. The projection 412e is adapted to overlap the surface 422a of the second positioning portion 422 when the first panel 420 is engaged with the display 410. The elastic arm 412f connects the projection 412e and the base 412a. The elastic arm 412f can store the elastic position energy to cause the buckle 412b to be reset without permanent deformation. As shown in FIG. 8A, when the first panel 420 and the display 410 begin assembly, the pawl 412b begins to enter the second positioning portion 422 on the first panel 420. As shown in FIG. 8B, in the process in which the claw 412b enters the second positioning portion 422, the slope 412d and the projection 412e can be pressed by the side wall 422b of the second positioning portion 422. At this time, the elastic arm 412f generates a deflection, and the elastic space 412c between the claws 412b becomes small. At this time, the elastic arm 412f can store the elastic potential energy. As shown in Figure 8C. When the claw 412b is no longer pressed by the recessed side wall 422b, the elastic arm 412f drives the buckle 412b to be reset, and the protruding portion 412e overlaps the plane 422a of the second positioning portion 422, thereby causing the first panel 420 and the display. The relative position of 410 is fixed.

In summary, in the assembly process of the touch display module according to an embodiment of the present invention, by the assistance of the first positioning portion and the second positioning portion, an abnormal problem is less likely to occur between the first panel and the display, and further Increase the assembly rate of the touch display module. In addition, with the aid of the first positioning portion and the second positioning portion, the manufacturer can save time to adjust the existing positioning tool, and the working time required for assembling the touch display module is effectively reduced.

Although the present invention has been disclosed in the above embodiments, it is not intended to limit the present invention, and any person skilled in the art can make some changes without departing from the spirit and scope of the present invention. And the scope of protection of the present invention is subject to the definition of

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the scope of the appended patent application.

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CLAIMS CN203224848

1.

A touch display module, comprising: a display panel, a display panel, a plastic frame surrounding the display panel, and at least two first positioning portions disposed on the plastic frame; and a first panel The first panel includes a protection panel and at least two second positioning portions disposed on the protection panel, wherein the first positioning portion is respectively coupled with the second positioning portion, and the first panel is The relative position to the display is fixed.

2.

The touch display module of claim 1 , wherein the first positioning portion is a plurality of protrusions extending toward the first panel, and the second positioning portion is opposite to the protrusion A plurality of depressions corresponding to the object.

3.

The touch display module of claim 2, wherein the first panel further comprises a touch sensing layer, and the touch sensing layer is located between the protection board and the display.

4.

The touch display module according to claim 2, wherein the display panel comprises an active component substrate, a pair of substrates opposite to the active component substrate, and the active component substrate and the opposite direction a display medium layer and a touch sensing layer between the substrates, wherein the touch sensing layer is located between the opposite substrate and the display medium layer.

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5.
The touch display module according to claim 2, wherein the display panel comprises an active component substrate, a pair of substrates opposite to the active component substrate, and the active component substrate and the a display medium layer and a touch sensing layer between the opposite substrates, the opposite substrate being located between the touch sensing layer and the display medium layer.

6.
The touch display module according to claim 2, wherein the display panel comprises an active component substrate, a pair of substrates opposite to the active component substrate, and the active component substrate and the a display medium layer and a touch sensing layer between the opposite substrates, the touch sensing layer being located between the active component substrate and the display medium layer.

7.
The touch display module according to claim 2, wherein the protection panel has a first surface and a second surface opposite to the first surface, the first surface being located at the display and the Between the second surfaces, wherein the recess extends through the first surface and toward the second surface, and the recess does not penetrate the second surface.

8.
The touch display module of claim 2, wherein the recess extends through the protection plate.

9.
The touch display module of claim 8 , wherein the touch display module further comprises a plurality of masks disposed on the second surface of the protection panel and covering the recesses respectively.

10.
The touch display module of claim 2, wherein the first positioning portion comprises a first positioning sub-portion and a second positioning sub-portion, the first positioning sub-portion connecting the second positioning The sub-portion and the plastic frame, wherein a maximum diameter of the second positioning sub-portion is greater than a maximum diameter of the first positioning sub-portion.

11.
The touch display module as claimed in claim 10, wherein the first positioning sub-portion is a cylinder, and the second positioning sub-portion has a bottom surface directly connected to the column body, relative to the a top

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surface of the bottom surface and a circumferential surface surrounding the bottom surface and the top surface and connecting the bottom surface and the top surface, wherein an area of the bottom surface is larger than an area of the top surface, and the pillar is A cross-sectional area cut by a reference plane is smaller than an area of the bottom surface, the reference plane being parallel to a display surface of the display.

12.

The touch display module of claim 11 , wherein a cross-sectional area of the second positioning sub-section that is cut by the reference plane is gradually reduced as the reference plane is away from the display.

13.

The touch display module of claim 10, wherein the second positioning portion comprises: a third positioning sub-portion and a fourth positioning sub-portion, wherein the third positioning sub-portion is located in the fourth positioning sub-portion And the display, wherein a maximum aperture of the fourth positioning sub-portion is greater than a maximum aperture of the third positioning sub-portion.

14.

The touch display module of claim 13 , wherein the first positioning sub-port is engaged in the third positioning sub-portion, and the second positioning sub-port is engaged in the fourth positioning sub-portion .

15.

The touch display module of claim 2, wherein the first positioning portion comprises a base and a plurality of claws connected to the base, and at least one elastic space exists between the claws.

16.

The touch display module of claim 15 , wherein the second positioning portion comprises: a third positioning sub-portion and a fourth positioning sub-portion, wherein the third positioning sub-portion is located in the fourth positioning sub-portion Between the displays, wherein the maximum aperture of the fourth positioning sub-portion is greater than the maximum aperture of the third positioning sub-portion.

17.

The touch display module of claim 16 , wherein the base is engaged in the third positioning sub-section, and the claw is engaged in the fourth positioning sub-section.

18.

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The touch display module of claim 3, wherein the first positioning portion is a plurality of recesses extending toward the first panel, and the second positioning portion is a plurality of protrusions corresponding to the recesses .

19.

The touch display module as claimed in claim 1 , further comprising a glue disposed between the display and the first panel, the glue being adapted to attach the first panel to the display.

20.

The touch display module according to claim 19, wherein the colloid is a double-sided tape, a water glue or a combination thereof.

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(12)实用新型专利

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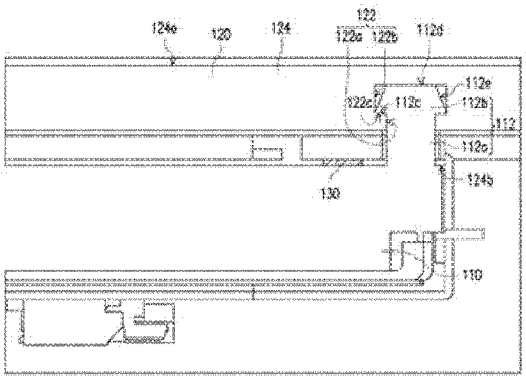
权利要求书2页 说明书6页 附图8页

(54)实用新型名称

一种触控显示模块

(57)摘要

一种触控显示模块，包括显示器及第一面板。显示器包括显示面板、环绕显示面板的胶框及设置在胶框上的至少二第一定位部。第一面板配置于显示器上。第一面板包括保护板及保护板上的至少二第二定位部。第一定位部与第二定位部结合，而使第一面板与显示面板的相对位置固定。在本实用新型的触控显示模块的组装过程中，由第一定位部与第二定位部的辅助，第一面板与显示器之间便不易产生异常的问题，进而提高本实用新型的触控显示模块的组装良率。



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1. 一种触控显示模块，其特征在于，包括：

一显示器，包括一显示面板、环绕该显示面板的一胶框及设置在该胶框上的至少二第一定位部；以及

一第一面板，配置于该显示器上，该第一面板包括一保护板及设置在该保护板上的至少二第二定位部，其中该第一定位部分别与该第二定位部结合，而使该第一面板与该显示器的相对位置固定。

2. 如权利要求 1 所述的触控显示模块，其特征在于，所述第一定位部为朝向所述第一面板延伸的多个凸起物，而所述第二定位部为与所述凸起物对应的多个凹陷。

3. 如权利要求 2 所述的触控显示模块，其特征在于，所述第一面板还包括一触控感测层，且所述触控感测层位于所述保护板与所述显示器之间。

4. 如权利要求 2 所述的触控显示模块，其特征在于，所述显示面板包括一主动组件基板、相对于该主动组件基板的一对向基板、配置于所述主动组件基板与所述对向基板之间的一显示介质层及一触控感测层，所述触控感测层位于所述对向基板与所述显示介质层之间。

5. 如权利要求 2 所述的触控显示模块，其特征在于，所述显示面板包括一主动组件基板、相对于所述主动组件基板的一对向基板、及配置于所述主动组件基板与所述对向基板之间的一显示介质层及一触控感测层，所述对向基板位于所述触控感测层与所述显示介质层之间。

6. 如权利要求 2 所述的触控显示模块，其特征在于，所述显示面板包括一主动组件基板、相对于所述主动组件基板的一对向基板、及配置于所述主动组件基板与所述对向基板之间的一显示介质层及一触控感测层，所述触控感测层位于所述主动组件基板与所述显示介质层之间。

7. 如权利要求 2 所述的触控显示模块，其特征在于，所述保护板具有一第一表面以及相对于所述第一表面的一第二表面，所述第一表面位于所述显示器与所述第二表面之间，其中所述凹陷贯穿所述第一表面并朝所述第二表面延伸，且所述凹陷未贯穿所述第二表面。

8. 如权利要求 2 所述的触控显示模块，其特征在于，所述凹陷贯穿该保护板。

9. 如权利要求 8 所述的触控显示模块，其特征在于，所述触控显示模块还包括多个遮蔽物，配置于所述保护板的所述第二表面上且分别覆盖所述凹陷。

10. 如权利要求 2 所述的触控显示模块，其特征在于，所述第一定位部包括一第一定位子部以及一第二定位子部，所述第一定位子部连接所述第二定位子部与所述胶框，其中所述第二定位子部的最大直径大于所述第一定位子部的最大直径。

11. 如权利要求 10 所述的触控显示模块，其特征在于，所述第一定位子部为一柱体，所述第二定位子部具有与所述柱体直接连接的一底面、相对于所述底面的一顶面以及环绕所述底面及所述顶面并连接所述底面与所述顶面的一周面，其中所述底面的面积大于所述顶面的面积，且所述柱体被一参考平面所截出的截面积小于所述底面的面积，所述参考平面与所述显示器的显示面平行。

12. 如权利要求 11 所述的触控显示模块，其特征在于，所述第二定位子部被该参考平面所截出的截面积随着该参考平面远离该显示器而逐渐缩小。

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13. 如权利要求 10 所述的触控显示模块，其特征在于，所述第二定位部包括：一第三定位子部以及一第四定位子部，第三定位子部位于该第四定位子部与该显示器之间，其中该第四定位子部的最大口径大于该第三定位子部的最大口径。

14. 如权利要求 13 所述的触控显示模块，其特征在于，该第一定位子部卡合于该第三定位子部中，而该第二定位子部卡合于该第四定位子部中。

15. 如权利要求 2 所述的触控显示模块，其特征在于，该第一定位部包括一基座以及与该基座连接的多个扣爪，该扣爪之间存在至少一弹性空间。

16. 如权利要求 15 所述的触控显示模块，其特征在于，该第二定位部包括：一第三定位子部以及一第四定位子部，第三定位子部位于该第四定位子部与该显示器之间，其中该第四定位子部的最大口径大于该第三定位子部的最大口径。

17. 如权利要求 16 所述的触控显示模块，其特征在于，该基座卡合于该第三定位子部中，而该扣爪扣合于该第四定位子部中。

18. 如权利要求 3 所述的触控显示模块，其特征在于，该第一定位部为朝向该第一面板延伸的多个凹陷，而该第二定位部为与该凹陷对应的多个凸起物。

19. 如权利要求 1 所述的触控显示模块，其特征在于，还包括一胶体，设置于该显示器与该第一面板之间，该胶体适于使该第一面板贴合于该显示器上。

20. 如权利要求 19 所述的触控显示模块，其特征在于，该胶体为双面胶、水胶或其组合。

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一种触控显示模块

技术领域

[0001] 本实用新型是有关于一种显示模块，且特别是有关于一种触控显示模块。

背景技术

[0002] 随着信息技术、无线移动通讯和信息家电的快速发展与应用，为了达到携带更便利、体积更轻巧化以及操作更人性化的目的，许多信息产品已由传统的键盘或鼠标等输入设备，转变为使用触控装置作为输入设备。触控面板因具有操作界面人性化的优点，目前已广泛地被应用在各式电子产品中，特别是移动电子产品，如手机或平板计算机等。以感测原理来区分，触控面板可分为电阻式、电容式以及光学式。其中，以电容式触控面板的感测效果较好，而成为现今触控面板的主流。

[0003] 一般来说，触控显示设备主要包括一显示器以及一触控面板。在触控显示设备的组装过程中，常使用一组装工具将触控面板与显示器定位后，再以双面胶将触控面板与显示器黏合在一起。在生产不同尺寸触控显示设备就须分别准备组装工具，且组装工具制作的公差以及利用工具组装的工时，往往造成生产成本的提高。此外，当工具公差过大时，显示器及触控面板之间对位易发生异常，而使得显示区偏移或显示器的芯片走线外露。

[0004] 发明内容

[0005] 本实用新型提供一种触控显示模块，其组装良率高。

[0006] 本实用新型提供一种触控显示模块，包括显示器及第一面板。显示器包括显示面板、环绕显示面板的胶框及设置在胶框上的至少二第一定位部。第一面板配置于显示器上，第一面板包括保护板及保护板上的至少二第二定位部，第一定位部分别与第二定位部结合，而使第一面板与显示器的相对位置固定。

[0007] 在本实用新型的一实施例中，上述的第一定位部为朝向第一面板延伸的凸起物，而第二定位部为与凸起物对应的凹陷。

[0008] 在本实用新型的一实施例中，上述的第一面板还包括触控感测层，且触控感测层位于保护板与显示器之间。

[0009] 在本实用新型的一实施例中，上述的显示面板包括主动组件基板、相对于主动组件基板的对向基板、及配置于主动组件基板与对向基板之间的显示介质层及触控感测层，该触控感测层位于该对向基板与该显示介质层之间。

[0010] 在本实用新型的一实施例中，上述的显示面板包括主动组件基板、相对于主动组件基板的对向基板、及配置于主动组件基板与对向基板之间的显示介质层及触控感测层，该对向基板位于该触控感测层与该显示介质层之间。

[0011] 在本实用新型的一实施例中，上述的显示面板包括主动组件基板、相对于主动组件基板的对向基板、及配置于主动组件基板与对向基板之间的显示介质层及触控感测层，触控感测层位于主动组件基板与显示介质层之间。

[0012] 在本实用新型的一实施例中，上述的保护板具有第一表面以及相对于第一表面的第二表面，其中第一表面位于显示器与第二表面之间。凹陷贯穿第一表面并朝第二表面延

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伸，且凹陷未贯穿第二表面。

[0013] 在本实用新型的一实施例中，上述的凹陷贯穿保护板。

[0014] 在本实用新型的一实施例中，触控显示模块还包括多个遮蔽物。所述的遮蔽物配置于保护板的第二表面上且分别覆盖凹陷。

[0015] 在本实用新型的一实施例中，上述的每一第一定位部包括第一定位子部以及第二定位子部。第一定位子部连接第二定位子部与胶框。第二定位子部的最大直径大于第一定位子部的最大直径。

[0016] 在本实用新型的一实施例中，上述的第一定位子部为柱体，而第二定位子部具有与柱体直接连接的一底面、相对于底面的一顶面以及环绕底面及顶面并连接底面与顶面的一周面。底面之面积大于顶面之面积。并且，柱体被参考平面所截出的截面积小于底面的面积，其中参考平面与显示器的显示面平行。

[0017] 在本实用新型的一实施例中，上述的第二定位子部被参考平面所截出的截面积随着参考平面远离显示器而逐渐缩小。

[0018] 在本实用新型的一实施例中，上述的第二定位部包括第三定位子部以及第四定位子部。第三定位子部位于第四定位子部与显示器之间，其中第四定位子部的最大口径大于第三定位子部的最大口径。

[0019] 在本实用新型的一实施例中，上述的第一定位子部卡合于第三定位子部中，而第二定位子部卡合于第四定位子部中。

[0020] 在本实用新型的一实施例中，上述的第一定位部包括基座以及与基座连接的多个扣爪。扣爪之间存在至少一弹性空间。

[0021] 在本实用新型的一实施例中，上述基座卡合于第三定位子部中，而扣爪扣合于第四定位子部中。

[0022] 在本实用新型的一实施例中，上述的第一定位部为朝向第一面板延伸的多个凹陷，而第二定位部为与凹陷对应的多个凸起物。

[0023] 在本实用新型的一实施例中，触控显示模块还包括胶体。所述的胶体设置于显示器与第一面板之间。胶体适于使第一面板贴合于显示器上。

[0024] 在本实用新型的一实施例中，上述的胶体为双面胶、水胶或其组合。

[0025] 基于上述，在本实用新型的触控显示模块的组装过程中，由第一定位部与第二定位部的辅助，第一面板与显示器之间便不易产生异常的问题，进而提高本实用新型的触控显示模块的组装良率。

附图说明

[0026] 图 1A 为本实用新型的一实施例的触控显示模块的立体图。

[0027] 图 1B 为本实用新型的一实施例的触控显示模块的爆炸图。

[0028] 图 1C 为图 1B 的第一定位部的局部放大图。

[0029] 图 1D 为图 1B 的第二定位部的局部放大图。

[0030] 图 2A 至图 2C 为本实用型的其他实施例的剖面图。

[0031] 图 3A 为本实用新型的一实施例的触控显示模块的第一定位部的局部放大图。

[0032] 图 3B 为本实用新型的一实施例的触控显示模块的第二定位部的局部放大图。

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[0033] 图 4A 为图 1C 的第一定位部沿 A-A' 线段的剖面图。

[0034] 图 4B 为图 1D 的第二定位部沿 B-B' 线段的剖面图。

[0035] 图 5 为图 1A 的触控显示模块沿 I-I' 线段的剖面图。

[0036] 图 6A 为本实用新型的另一实施例的触控显示模块的剖面图。

[0037] 图 6B 为图 6A 的第一面板与显示器组装的剖面图。

[0038] 图 7A 为本实用新型再一实施例的触控显示模块的立体图。

[0039] 图 7B 为本实用新型再一实施例的触控显示模块沿着 C-C' 线段的剖面图。

[0040] 图 8A 至图 8C 为图 7A 的显示器与第一面板组装过程的剖面图。

[0041] 【主要组件符号说明】

[0042] 100、100A :触控显示模块

[0043] 110、110d、110e、110f、210、410 :显示器

[0044] 111 :显示面

[0045] 112、212、412 :第一定位部

[0046] 112a :第一定位子部

[0047] 112b :第二定位子部

[0048] 112c :底面

[0049] 112d :顶面

[0050] 112e :周面

[0051] 114 :显示面板

[0052] 115 :对向基板

[0053] 115a :上表面

[0054] 115b :下表面

[0055] 116 :胶框

[0056] 117 :主动组件基板

[0057] 118 :显示介质层

[0058] 120、220、320、420 :第一面板

[0059] 122、222、322、422 :第二定位部

[0060] 122a :第三定位子部

[0061] 122b :第四定位子部

[0062] 122c :表面

[0063] 124、324 :保护板

[0064] 124a :第一表面

[0065] 124b、324b :第二表面

[0066] 126d、126e、126f :触控感测层

[0067] d1、d2 :直径

[0068] d3、d4 :口径

[0069] 340 :遮蔽物

[0070] 412a :基座

[0071] 412b :扣爪

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[0072] 412c :弹性空间

[0073] 412d :斜面

[0074] 412e :凸出部

[0075] 412f :弹性臂

[0076] 422a :表面

[0077] 422b :侧壁

具体实施方式

[0078] 请参考图 1A 至图 1D，本实用新型的触控显示模块 100 包括显示器 110 及第一面板 120。显示器 110 包括至少二第一定位部 112。第一面板 120 配置于显示器 110 上。第一面板 120 包括至少二第二定位部 122。第一定位部 112 与第二定位部 122 结合，而使第一面板 120 与显示器 110 的相对位置固定。如此一来，在触控显示模块 100 的组装过程中，第一面板 120 与显示器 110 之间便不易发生对位异常的问题。此外，由第一定位部 112 与第二定位部 122 的辅助，显示器 110 与第一面板 120 贴合的工时也可有效地缩短。

[0079] 本实施例的显示器 110 包括显示面板 114 及胶框 116。本实施例的第一面板 120 包括保护板 124 以及配置于保护板 124 上的触控感测层 126，触控感测层 126 位于保护板 124 与显示器 110 之间。触控感测层 126 可与保护板 124 直接连接，因此在本实施例的第一面板 120 即可视为一触控面板。在本实施例中，保护板 124 例如为一硬质基板，但本实用新型不以此为限。

[0080] 触控感测层在显示模块中的相对位置，随着显示模块的设计方式不同更可有不同的形式，以下再举实施例说明。图 2A、2B 及图 2C 分别为本实用新型的其他实施例的剖面图。在图 2A 中，显示器 110d 包括主动组件基板 117、相对于主动组件基板 117 的对向基板 115、配置于主动组件基板 117 与对向基板 115 之间的显示介质层 118、以及一触控感测层 126d。在本实施例中，对向基板 115 是位于触控感测层 126d 与显示介质层 118 之间，触控感测层 126d 即为设置在对向基板 115 的一上表面 115a 上。而在图 2B 所示的实施例中，显示器 110e 的触控感测层 126e 位于对向基板 115 与显示介质层 118 之间。换言之，触控感测层 126e 即为设置在对向基板 115 的相对于上表面 115a 的一下表面 115b 上。此外，在图 2C 中，显示器 110f 的触控感测层 126f 位于主动组件基板 117 与显示介质层 118 之间。在图 2B 与图 2C 的实施例中，触控感测层 126e、126f 皆为设置在显示器之内。在以上所述的实施例中，触控感测层皆设置在显示器中，因此设置在显示器之外的第一面板仅会具有一保护板。

[0081] 详言之，在本实施例中，第一定位部 112 可设置在显示器 110 的胶框 116 上。进一步而言，第一定位部 112 的材质与胶框 116 的材质可相同。另一方面，第二定位部 122 可形成于第一面板 120 的保护板 124 上。在本实施例中，第一定位部 112 可为朝向第一面板 120 延伸的凸起物，而第二定位部 122 可为与此凸起物对应的凹陷。然而，本实用新型并不限定显示器上的第一定位部为凸起物，而第一面板上的第二定位部为凹陷。以下举一实施例说明。图 3A 及图 3B 分别为本实用新型的另一实施例的触控显示模块的第一定位部及第二定位部的局部放大图。在本实施例中，第二定位部 222 可为朝向显示器 210 延伸的凸起物，而第一定位部 212 可为与凸起物对应的凹陷。由第二定位部 222 与第一定位部 212 互相结合

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也可使第一面板 220 与显示器 210 的相对位置固定。

[0082] 以下，将详细说明上述定位部的设计方式。为方便本文说明，以下将以图 1A 至图 1D 所示实施例说明，然而本实用新型并不限制此设计方案。图 4A 为根据图 1C 的线段 A-A' 所示的剖面图。图 4B 为根据图 1D 的线段 B-B' 所绘的剖面图。在图 4A 中，第一定位部 112 为一凸起物，且每一第一定位部 112 包括一第一定位子部 112a 以及一第二定位子部 112b。第一定位子部 112a 连接第二定位子部 112b 与胶框 116。第二定位子部 112b 的最大直径 d1 可大于第一定位子部 112a 的最大直径 d2。具体而言，第一定位子部 112a 可为一柱体，而第二定位子部 112b 近似于圆锥体。还进一步地说，第二定位子部 112b 具有与第一定位子部 112a 直接连接的底面 112c、相对于底面 112c 的顶面 112d，以及环绕底面 112c 及顶面 112d 并连接底面 112c 与顶面 112d 的周面 112e。在本实施例中，底面 112c 的面积可大于顶面 112d 的面积。并且，第一定位子部 112a 被一参考平面所截出的截面积可小于底面 112c 的面积。本实施例在此所指的参考平面为与图 1C 的坐标轴所示的 X-Y 平面平行的平面。所述的平面与显示器 110 的显示面 111 平行，其中显示面 111 是指显示面板 114 所在的平面。整体而言，本实施例的第二定位子部 112b 的外观类似于香菇头的外形。换言之，随着参考平面沿着坐标轴的正 Z 方向远离显示器 110 的距离增加，第二定位子部 112b 被参考平面所截出的截面积会逐渐缩小。

[0083] 相对地，以下详述与第一定位部 112 相对应的第二定位部 122 的形式。在图 4B 中，第一面板 120 的保护板 124 具有第一表面 124a 以及相对于第一表面 124a 的第二表面 124b。第一表面 124a 位于显示器 110 与第二表面 124b 之间。第二定位部 122（即凹陷）贯穿第一表面 124a 并朝第二表面 124b 延伸。在本实施例中，第二定位部 122 可不贯穿第二表面 124b。详细地说，每一第二定位部 122 包括一第三定位子部 122a 以及一第四定位子部 122b。第三定位子部 122a 位于第四定位子部 122b 与显示器 110 之间。第四定位子部 122b 的最大口径 d3 大于第三定位子部 122a 的最大口径 d4。在本实施例中，第三定位子部 122a 可为直径较小且厚度较厚的圆柱形凹陷，而第四定位子部 122b 可为直径较大且厚度较薄的圆盘形凹陷。

[0084] 图 5 为沿着图 1A 的线段 I-I' 所绘的剖面图。请参考图 5，第一面板 120 与显示器 110 组装完成后，第一定位部 112 的第一定位子部 112a 可卡合至第二定位部 122 的的第三定位子部 122a，而第二定位子部 112b 可卡合于第四定位子部 122b 中。第二定位子部 112b 的底面 112c 可搭接在第四定位子部 122b 的一表面 122c 上。如此一来，第一定位部 112 与第二定位部 122 便可稳固地结合，进而使第一面板 120 与显示器 110 的相对位置固定。

[0085] 此外，为加强本实施例的显示器 110 与第一面板 120 的固定效果，本实用新型的触控显示模块 100 可进一步地包括一胶体 130。如图 1B 及图 5 所示，胶体 130 可设置于显示器 110 与第一面板 120 之间，而使第一面板 120 更牢固地贴附在显示器 110 上。在本实施例中，胶体 130 例如是双面胶、水胶、上述两者的组合或其他适当的黏着物。

[0086] 需说明的是，本实用新型的第一定位部与第二定位部的结构形式并不限于皆具有两个子部的凸起物及凹陷。所有可形成在第一面板及显示器上的结构，且由此结构可固定第一面板及显示器的相对位置，其皆可作为本实用新型的定位部。

[0087] 如图 4B 所示，上述的实施例的第二定位部 122 并未贯穿保护板 124，所以当第一面板 120 与显示器 110 组装后，保护板 124 的表面不会有开孔。然而，在本实用新型的其他实

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施例中，第一面板可因应薄型化的需求降低厚度，此时，为保持显示器与第一面板的定位结构仍可有效地被成型并且发挥作用，第二定位部 122 也可贯穿保护板 124。图 6A 为本实用新型的另一实施例的触控显示模块的剖面图。图 6B 为图 6A 的第一面板与显示器组装后的剖面示意图。图 6B 所示的触控显示设备 100A 与图 5 所示的触控显示设备 100 的差异之处在于：如图 6A 及图 6B 所示，第一面板 320 的第二定位部 322 可贯穿保护板 324。当第一面板 320 与显示器 110 组装时，第二定位部 322 仍可与第一定位部 112 卡合定位。值得注意的是，由于第二定位部 322 可贯穿保护板 324，故本实施例的触控显示设备 100A 可进一步包括多个遮蔽物 340。遮蔽物 340 配置于保护板 324 的第二表面 324b 上且分别覆盖第二定位部 322。如此一来，第二定位部 322 便不易影响触控显示设备 100A 外观。遮蔽物 340 例如是塑料材质的绝缘贴片 (mylar)，但本实用新型不以此为限。

[0088] 以下，将再举一实施例说明当本实用新型的其中至少一个定位部为凸起物时的设计方式。图 7A 为本实用新型再一实施例的触控显示模块的立体图。图 7B 为图 7A 沿着 C-C' 线段的剖面图。为清楚起见，图 7A 及图 7B 省略第一面板。图 8A 至图 8C 示出图 7A 的显示器与第一面板的组装过程。请参考图 7A 及图 7B，在本实施例中，第一定位部 412 可为凸起物，而第二定位部 422 例如是凹陷，此凹陷且与前述实施例相同，于此便不再赘述。在本实施例中，每一第一定位部 412 包括基座 412a 以及与基座 412a 连接的多个扣爪 412b。扣爪 412b 之间存在至少一弹性空间 412c。

[0089] 扣爪 412b 可具有一斜面 412d、一凸出部 412e 以及一弹性臂 412f。凸出部 412e 适于在第一面板 420 与显示器 410 卡合时，搭接在第二定位部 422 的表面 422a 上。弹性臂 412f 连接凸出部 412e 与基座 412a。弹性臂 412f 可在不发生永久形变的情况下储存弹性位能以带动扣爪 412b 复位。如图 8A 所示，当第一面板 420 与显示器 410 开始组装时，扣爪 412b 开始进入位于第一面板 420 上的第二定位部 422。如图 8B 所示，在扣爪 412b 进入第二定位部 422 的过程中，斜面 412d 及凸出部 412e 可被第二定位部 422 的侧壁 422b 挤压。此时，弹性臂 412f 产生一挠曲，而使扣爪 412b 间的弹性空间 412c 变小。此时，弹性臂 412f 可储存弹性位能。如图 8C 所示。在扣爪 412b 不再被凹陷的侧壁 422b 挤压时，弹性臂 412f 带动扣爪 412b 复位，凸出部 412e 搭接在第二定位部 422 的平面 422a 上，进而使得第一面板 420 与显示器 410 的相对位置固定。

[0090] 综上所述，在本实用新型一实施例的触控显示模块的组装过程中，由第一定位部与第二定位部的辅助，第一面板与显示器之间便不易产生异常的问题，进而使触控显示模块的组装率上升。此外，由第一定位部与第二定位部的辅助，制造者可节省去调整现有定位工具的时间，而使组装触控显示模块所需的工时有效降低。

[0091] 虽然本实用新型已以实施例公开如上，然其并非用以限定本实用新型，任何所属技术领域中具有通常知识者，在不脱离本实用新型的精神和范围内，当可作些许的更动与润饰，故本实用新型的保护范围当视后附的申请专利范围所界定者为准。

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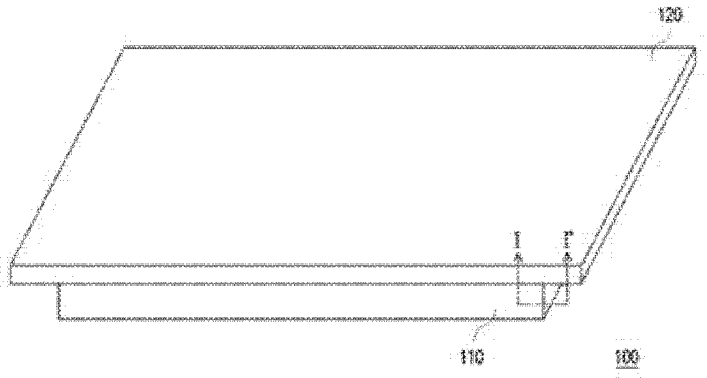


图 1A

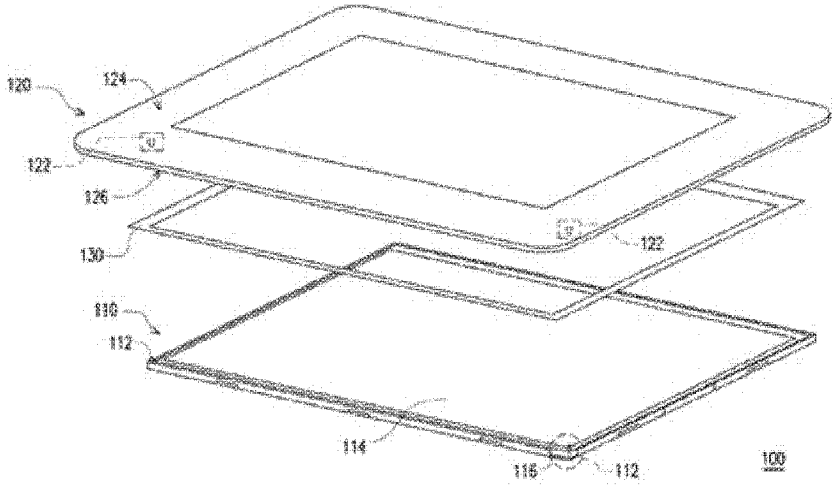


图 1B

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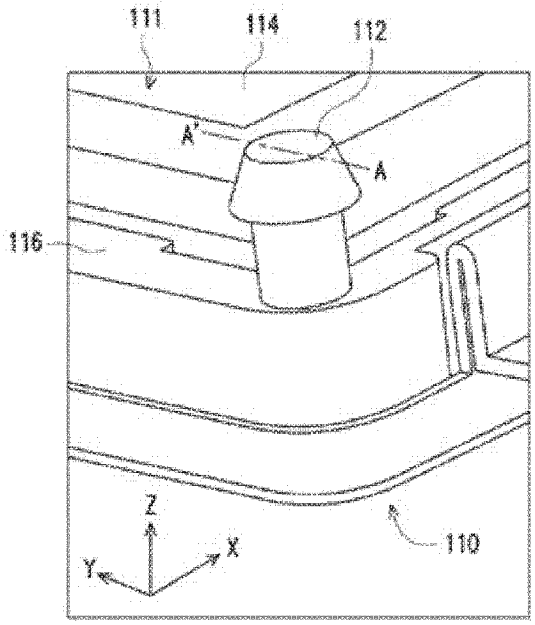


图 1C

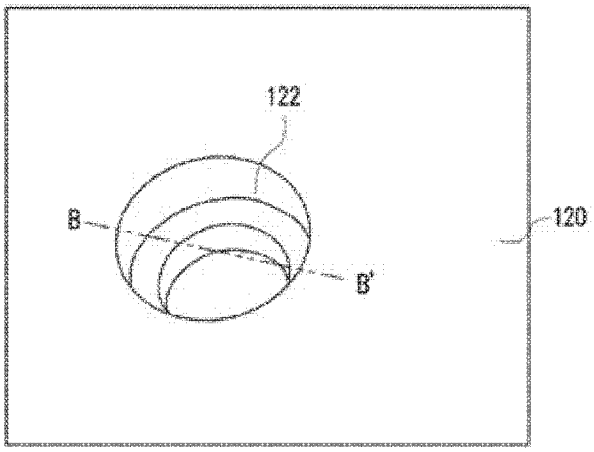


图 1D

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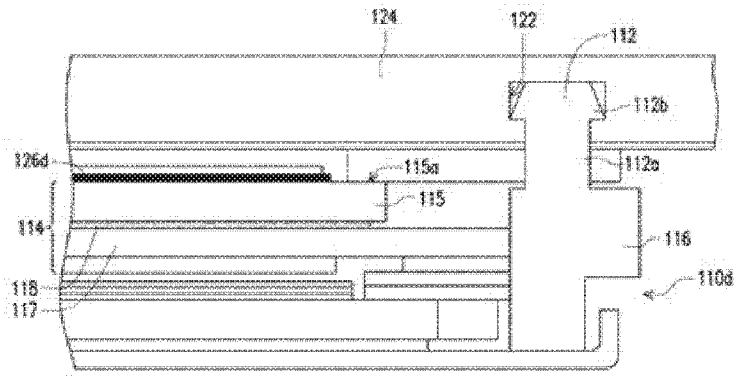


图 2A

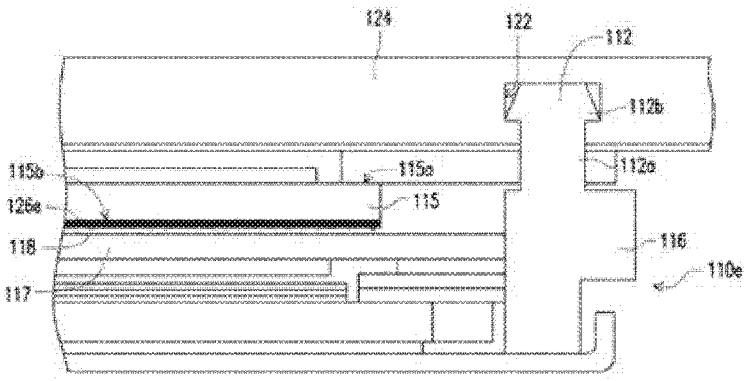


图 2B

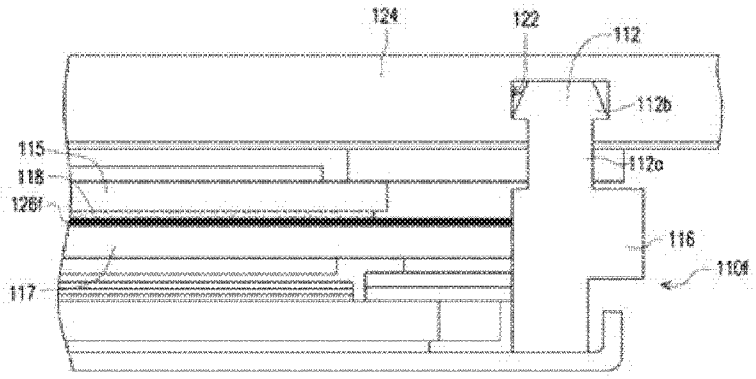


图 2C

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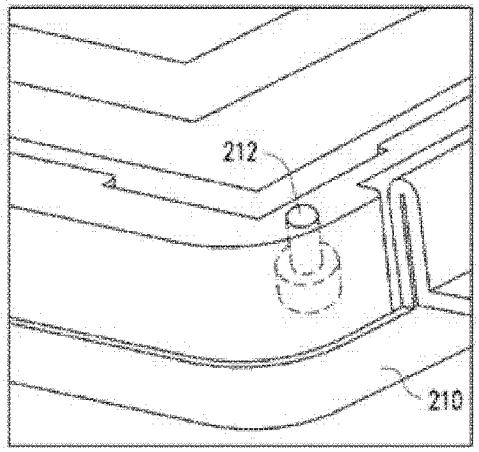


图 3A

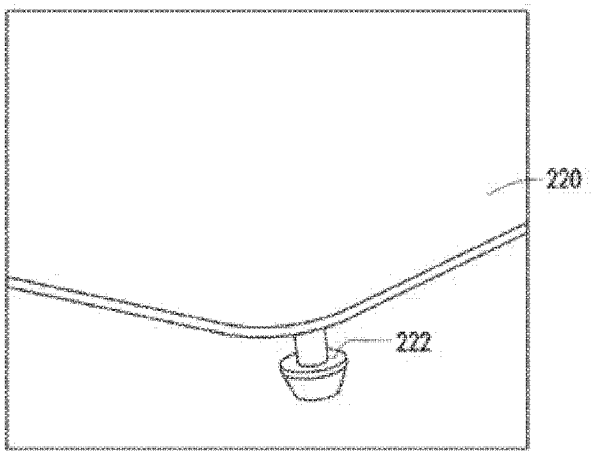


图 3B

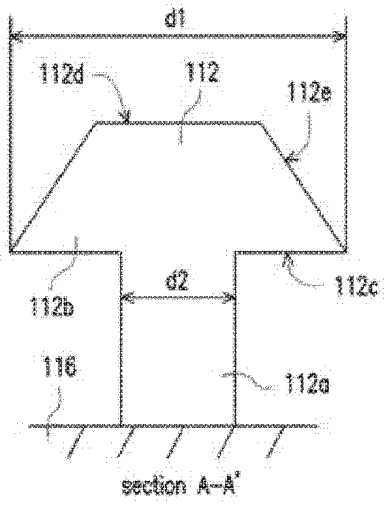


图 4A

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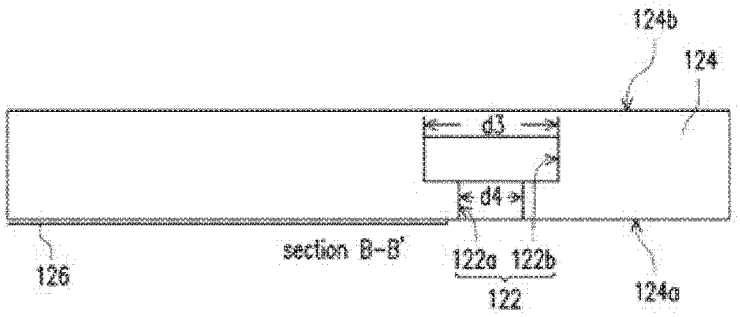


图 4B

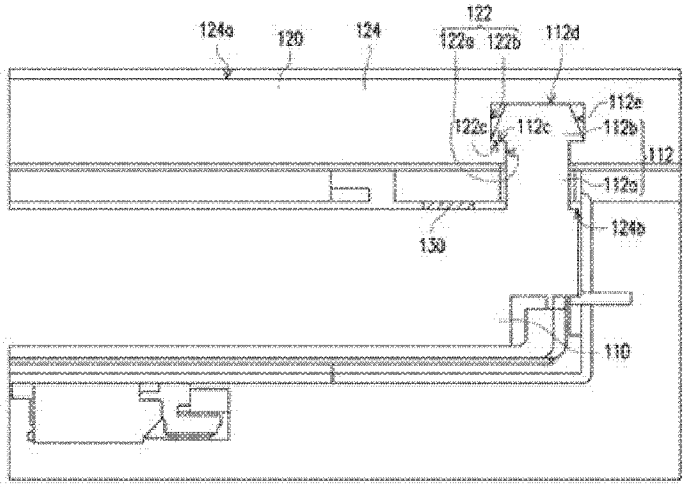


图 5

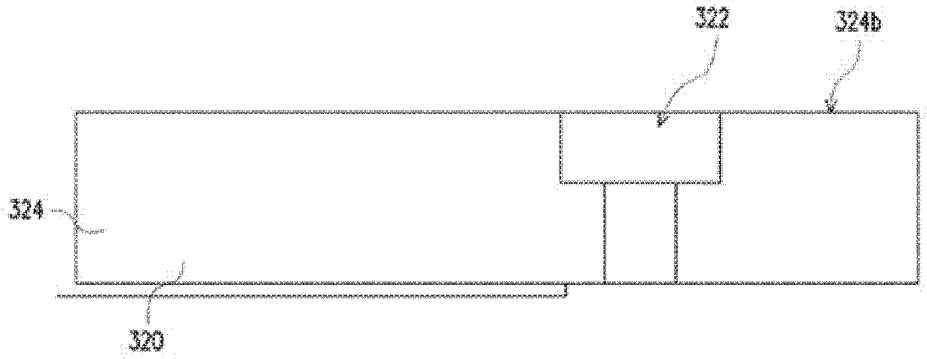


图 6A

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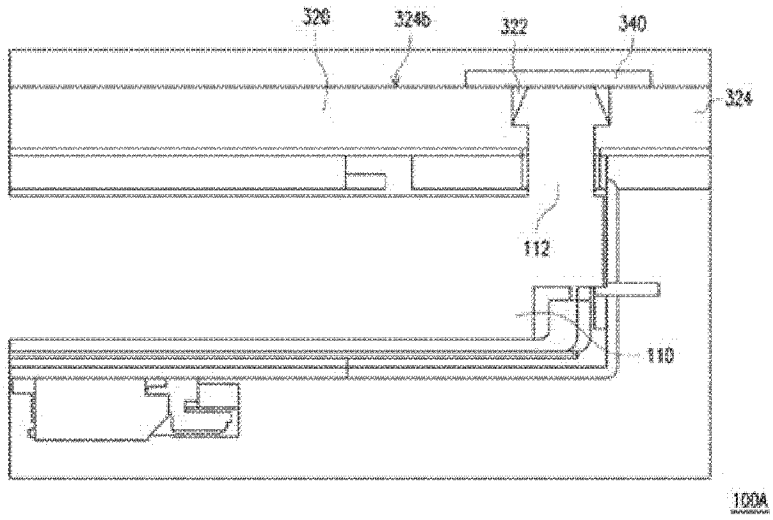


图 6B

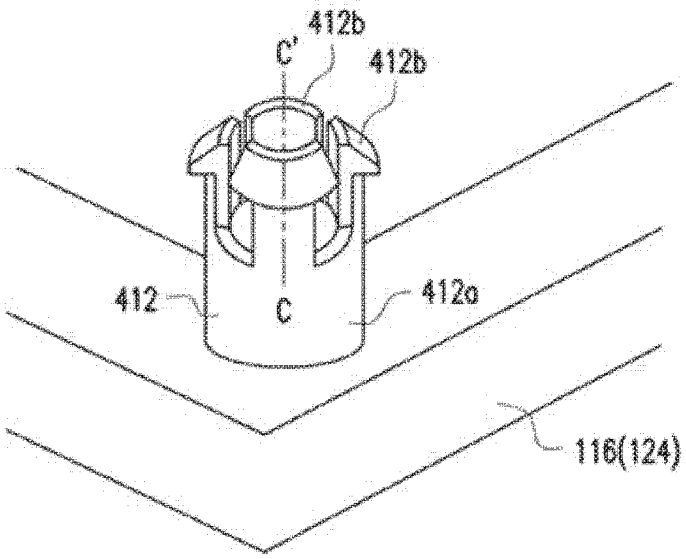


图 7A

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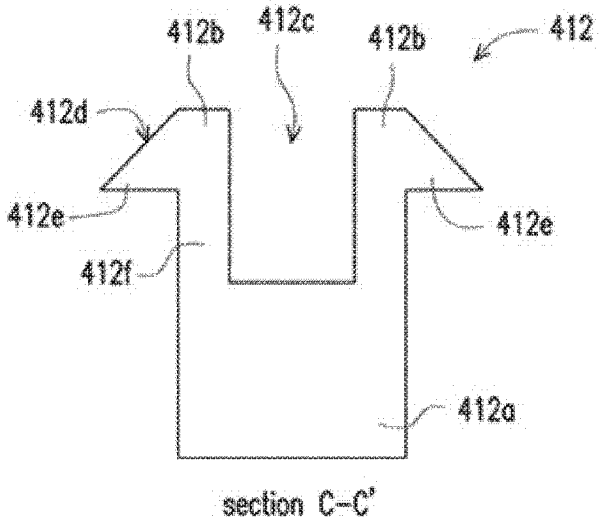


图 7B

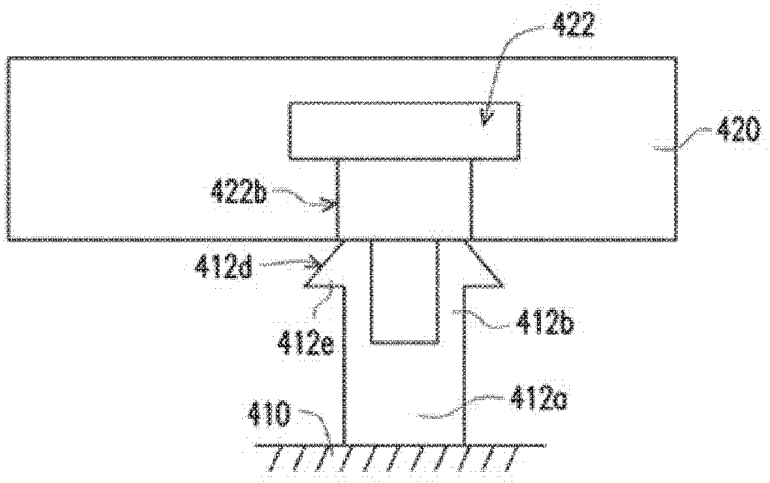


图 8A

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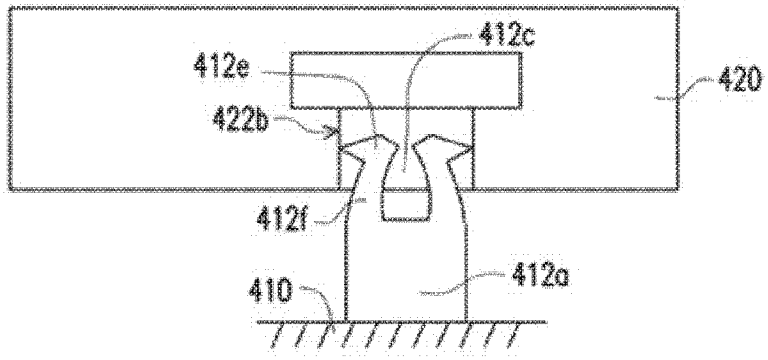


图 8B

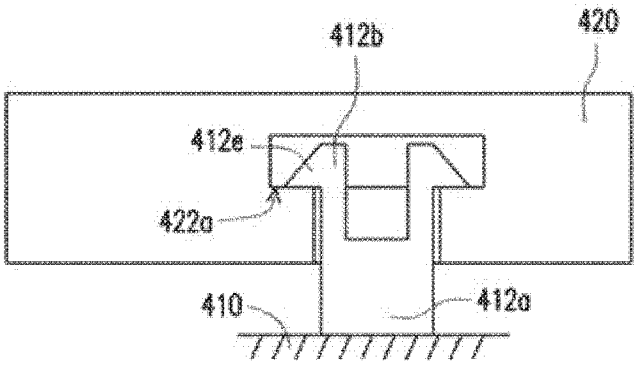


图 8C

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Espacenet

CN100501657C Touch panel device and its locating method

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Inventors: CHUNJING ZHOU [CN],XIANGLIN XU [CN]

Classifications:
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Published as: **CN101174191A;** CN100501657C

Touch panel device and its locating method

Abstract

The invention discloses the localization method of a kind of touch panel device and touch panel device, it is in conjunction with the infrared scan technology of infrared scan module and the camera technique of camera head, obtain the coordinate position of all possible touch point by the infrared scan technology, and in conjunction with the camera head shot picture, determine the coordinate of actual touch point and the color and the size of actual touch thing, color and size according to the actual touch thing, it can be to the independent tracing management of variant touch objects, and cost is low, simple in structure, response speed is fast and reliability is high.

[19] 中华人民共和国国家知识产权局

[51] Int. Cl.
G06F 3/042 (2006.01)

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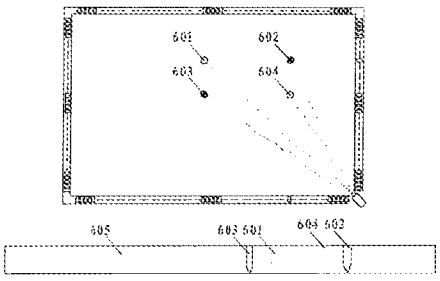
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权利要求书 2 页 说明书 9 页 附图 4 页

[54] 发明名称

一种触摸屏装置及触摸屏装置的定位方法

[57] 摘要

本发明公开了一种触摸屏装置及触摸屏装置的定位方法，其结合红外扫描模块的红外扫描技术与摄像装置的摄像技术，通过红外扫描技术获取所有可能的触摸点的坐标位置，并结合摄像装置所拍摄的图片，确定实际的触摸点的坐标以及实际触摸物的颜色和大小，根据实际触摸物的颜色和大小，其可以对各不同的触摸物单独跟踪管理，成本低、结构简单、响应速度快且可靠性高。



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1、一种触摸屏装置，其特征在于，包括：

红外扫描模块，该红外扫描模块包括横向及纵向的红外发射模块、红外接收模块；

摄像装置，该摄像装置位于可拍摄到由所述红外扫描模块所组成的红外扫描网的位置，用于采集触摸物数据；

主控制模块，用于收集所述红外接收模块采集的触摸数据及所述摄像装置所采集的触摸物数据，并计算实际触摸点信息，向主机设备发送，或者直接将所述收集的数据发送给所述主机设备，由所述主机设备计算出所述实际触摸点信息。

2、根据权利要求 1 所述的触摸屏装置，其特征在于，所述实际触摸点的信息包括所述实际触摸点的触摸坐标，或者所述实际触摸点的触摸坐标及所述实际触摸物的颜色和/或大小信息。

3、根据权利要求 1 所述的触摸屏装置，其特征在于，所述摄像装置位于横向发射模块和纵向发射模块的交界处。

4、根据权利要求 1 所述的触摸屏装置，其特征在于，所述摄像装置的光轴中心线平行于所述红外扫描网或者位于所述红外扫描网内。

5、根据权利要求 1 所述的触摸屏装置，其特征在于，通过采用至少一种方式以提高拍摄装置的清晰度：

增加外部光源辅助装置；

使用带高反光材料的触摸物和/或在所述触摸物上使用高反光材料的配件。

6、根据权利要求 1 至 5 任意一项所述的触摸屏装置，其特征在于，在同一个扫描周期内，所述摄像装置与所述红外扫描模块同步工作或者以先后顺序工作。

7、一种触摸屏装置的定位方法，其特征在于，包括步骤：

S101：启动红外扫描，在有触摸物存在的情况下，记录被所述触摸物所遮

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挡的红外接收管的位置信息;

S102：以可拍摄到红外扫描网的位置拍摄一幅图片，在有触摸物存在的情况下，根据所述图片分析所述触摸物的角度信息;

S103：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合所述步骤 S102 中的角度信息，分析出实际触摸物的数据信息，所述数据信息包括实际触摸物的触摸点的坐标信息。

8、根据权利要求 7 所述的定位方法，其特征在于：所述步骤 S101、S102 可以交换顺序或者同步进行。

9、根据权利要求 7 或 8 所述的定位方法，其特征在于：

在所述步骤 S102 中还包括：根据所述图片分析所述触摸物的颜色和/或大小信息;

在所述步骤 S103 中，所述数据信息还包括所述实际触摸物的颜色和/或大小信息。

10、根据权利要求 9 所述的定位方法，其特征在于：所述实际触摸物的颜色信息与其笔迹的颜色相对应和/或所述实际触摸物的大小信息与其笔迹的粗细相对应。

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一种触摸屏装置及触摸屏装置的定位方法

技术领域

本发明涉及触摸屏领域，特别涉及一种触摸屏装置及触摸屏装置的定位方法。

背景技术

触摸屏作为一种新型的计算机输入设备，使人机交互更为直观，由于给用户带来的极大地便利性，触摸屏技术除了应用于个人便携式信息产品外，应用领域已遍及信息家电、公共信息、电子游戏、办公自动化设备等各个领域。目前的无源触摸屏技术主要包括红外、电阻、电容、表面声波等几种，对于单点定位都比较成熟，例如用手指触摸显示屏幕即可操作主机等等，使用方便，但是若只能识别单点触摸，其本质上只是代替了传统的鼠标、键盘等输入设备，多点同时操作主机甚至是多人同时操作主机的应用需求将变得尤为突出，成为触摸屏技术未来的发展方向。

根据红外、电阻、电容、表面声波式的触摸屏实现的技术原理，在此基础上难以实现多点触摸，但将其硬件加以适当改进就可以实现多点定位技术，由于各种方式实现定位的技术原理及成本不同，改进所需的成本、难度及可靠性也必然不同。

公开号为 CN1942853A 的专利文献公开了一种具有透明电容传感介质的触摸面板。电容传感介质分布在不同的电极层总，层内的电极互相平行，层与层之间的电极相互垂直，从而组成了触摸屏的像素阵列，当屏幕被触摸时，电容传感节点产生电容变化，就会被监控电路检测到。这种触摸屏装置内部结构复杂，成本非常高，并且表面容易刮伤，造成永久性损坏，随着屏幕尺寸的增加，复杂程度和价格将成倍增加，所以多用于小尺寸触摸屏幕。公开号为 CN1912816A 的专利文献公开了一种基于摄像头的仅支持单点的触摸屏，它采用两个或以上的摄像头从不同角度对平行于显示屏幕的平面进行监控，根据所拍摄图片识别触摸动作，由于大角度取景会造成图片变形，而最终引起计算的触

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摸坐标数据不准，此外，这种方案只能识别单点触摸，不适应多点触摸的发展需求。

发明内容

本发明的目的在于提供一种结构简单、响应速度快、可靠性高且可支持多点触摸的触摸屏装置及触摸屏装置的定位方法。

为达到上述目的，本发明采用以下技术方案：

一种触摸屏装置，包括：

红外扫描模块，该红外扫描模块包括横向及纵向的红外发射模块、红外接收模块；

摄像装置，该摄像装置位于可拍摄到由所述红外扫描模块所组成的红外扫描网的位置，用于采集触摸物数据；

主控制模块，用于收集所述红外接收模块采集的触摸数据及所述摄像装置所采集的触摸物数据，并计算实际触摸点信息，向主机设备发送，或者直接将所述收集的数据发送给所述主机设备，由所述主机设备计算出所述实际触摸点信息。

一种触摸屏装置的定位方法，包括步骤：

S101：启动红外扫描，在有触摸物存在的情况下，记录被所述触摸物所遮挡的红外接收管的位置信息；

S102：以可拍摄到红外扫描网的位置拍摄一幅图片，在有触摸物存在的情况下，根据所述图片分析所述触摸物的角度信息；

S103：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合所述步骤 S102 中的角度信息，分析出实际触摸物的数据信息，所述数据信息包括实际触摸物的触摸点的坐标信息。

其中，所述步骤 S101、S102 可以交换顺序或者同步进行。

根据本发明的触摸屏装置及触摸屏装置的定位方法，其同时利用了红外扫

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描模块的红外扫描技术以及摄像装置的图像摄制技术，并结合这两种技术对触摸物进行分析，既支持单点触摸，也支持多点触摸，可以多人同时操作，结构简单、响应速度快且可靠性高。

附图说明

图 1 是本发明实施例的触摸屏装置的结构示意图；

图 2 是本发明实施例的红外扫描模块的工作原理示意图；

图 3 是本发明实施例中摄像装置工作原理示意图；

图 4 是本发明实施例的摄像装置拍摄方法示意图；

图 5 是本发明实施例的红外扫描模块扫描多点触摸示意图；

图 6 是本发明实施例的红外扫描模块结合摄像装置采集的多点触摸示意图；

图 7 是本发明实施例的触摸屏装置的定位方法的流程示意图。

具体实施方式

参见图 1 所示，是本发明实施例的触摸屏装置的结构示意图，如图所示，101 是纵向的红外发射模块，102 是横向的红外发射模块，103 是纵向的红外接收模块，104 是横向的红外接收模块，101、102、103 与 104 共同组成本发明中的红外扫描模块，105 是摄像装置，此外，106、107 是一对配对的红外管，108、109 是纵向和横向的红外扫描线，其中，所有的纵向红外扫描线几乎平行，所有的横向扫描线几乎平行，由横、纵两个方向的红外扫描线组成了红外扫描网。

其中，摄像装置可放置在任意一个地方或者角落，只需该摄像装置可拍摄到整个红外扫描网，此外，摄像装置的镜头的光轴中心线最好平行于所述红外扫描网构成的平面，或者该光轴中心线可直接位于该平面内。

在上述红外发射模块与红外接收模块中，每一对红外发射接收管都是同步工作的，一个红外管用于发射，一个红外管用于接收，用以检测在这一对红外发射接收管对应的扫描线上是否有遮挡物。红外发射模块按照一定的时序将所

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有红外发射管逐个点亮一段时间，使其逐个处于工作状态，而红外接收模块在同一时刻检测配对的接收管上的信号变化，以信号的有无或者强弱来判断是否有遮挡。在一个扫描周期内，所有的发射管点亮一次，所有的红外发射管可以先后点亮，也可以分区同时点亮，根据应用需要的不同而有所不同。当只有一个触摸点时，横向和纵向的红外扫描线被遮挡，接收模块检测到信号产生了变化，这样便唯一确定了两个扫描线的交点就是实际的触摸点；当有 N 个（N 大于或等于 2）触摸点时，在横纵两方向上最少都能检测到 N 个遮挡点，最多能检测 N^2 个触摸点，而仅仅根据遮挡点数据无法判断实际有多少个触摸点以及各触摸点的位置坐标，但能分析出所有可能的合理触摸点组合。

在同一个扫描周期内，摄像装置与红外扫描模块可以是同步工作也可以是以先后顺序工作，摄像装置从平行于红外扫描网的方向取景，取一定的高度即可，数据量非常小，然后从拍摄到的图片数据中提取触摸物的角度位置信息、颜色和大小信息。主控制模块根据摄像装置分析的数据与红外扫描模块得出的几种触摸点组合坐标综合分析，确定实际的触摸点坐标数据、各触摸物的颜色及大小，然后发送给主机设备，或者是，主控制器将收集到的摄像装置分析的数据以及红外扫描模块所得的坐标组合数据直接发送给主机设备，由主机设备计算分析坐标数据及触摸物的颜色和大小等其他数据，其中，主机设备可以是计算机。

参见图 2 所示，是本发明实施例的红外扫描模块工作原理示意图。在一个扫描周期内，所有的红外发射管被点亮一段时间，即在这一段时间内工作，所有的接收管检测一次信号变化，而在同一个时刻内，只有一对红外发射接收管在工作。在本发明的触摸屏装置工作之前，需对系统进行初始化，启动一次扫描，并将此时红外接收管所检测到的信号全部记录下来作为基准值，作为之后的判断依据，此后可进入正常的工作状态。在触摸屏装置正常工作的情况下，若没有触摸点，那么所有的红外接收管所检测到的信号均接近于各自的信号基准值或者相等，当有触摸点时，该触摸点所对应的红外接收管所检测到的信号就会与信号基准值相差较大，当这个相差值大于或者等于预定值时，即可判定存在触摸点。如图 2 所示，207 是一个触摸点，此时在纵向的红外扫描中，红外

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发射管 201 发射的红外线被遮挡，而红外接收管 203 此时检测到的信号与信号基准值相差较大，即大于或者等于预定值，主控制器将记录下信号发生变化的红外接收管的编号，而该编号可以进一步换算成虚拟的位置坐标。根据同样的原理，红外接收管 204 也将检测到信号发生了变化，且该变化值大于或者等于了预定值，主控制器计算出虚拟的位置坐标，由横、纵两个方向所检测到的虚拟坐标值即可确定触摸点，再将该虚拟的坐标映射为实际的触摸坐标。

参见图 3 所示，是本发明实施例的摄像装置的工作原理示意图，如图所示，摄像装置所放置的位置必须能够拍摄到整个的扫描网，也就是可以拍摄到整个屏幕。在没有触摸点的情况下，摄像装置仅能拍摄到红外触摸装置的内框，因此，可以以此为背景色，当有触摸的情况下，将拍摄到的照片与背景色进行对比分析，可提取出触摸物的角度信息、触摸物的颜色以及大小。

其中，角度位置的计算可以是以镜头的光轴中心线为准，以偏移的角度计算，也可以是以其他的任何以镜头为中心的线作为计算基准，虽然选取的计算基准不同，但最终均可换算成图 3 中 302 的角度信息。为了方便计算触摸物的实际大小，以镜头为中心将屏幕分成了若干个扇形区，在某一个扇形区内拍摄同一大小的触摸物的大小也相等，由于镜头的不同，在使用前需建立实物大小与距离的查询表或者计算公式。

如图 4 所示，是本发明实施例的摄像装置的拍摄方法示意图，如图所示，401 是横纵两个方向的红外扫描模块组成的红外扫描网平面，402 是显示设备平面，403 是摄像装置的镜头广轴中心线，该镜头广轴中心线平行于红外扫描网平面或在这个平面内，404、405 是摄像装置的取景范围，需可以拍摄到整个显示设备，406 是拍摄图片的高度，根据需要可以进行适当的调整，407 是触摸物，408 是摄像装置拍摄到的图片，其中图片中的触摸物可能只是实际触摸物的一部份。根据摄像装置所拍摄到的图片 408，从图片中提取出触摸物的颜色及大小，并根据触摸物距离图片的最左端或者最有短的距离查表或者计算得出触摸物的角度信息。这个计算过程可以是由摄像装置完成，摄像装置将计算所得结果发送给主控制模块，也可以是摄像装置将所拍得的图片发送给主控制模块，由主

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控制模块执行计算的过程。随后，主控制模块根据红外接收模块所采集的触摸数据，以及该图片中所采集的触摸物数据，综合计算出实际的触摸物的位置坐标、颜色以及大小，并发送给主机设备，或者是主控制模块将所采集的上述触摸数据和触摸物数据发送给主机设备，由主机设备计算出实际的触摸物的坐标、颜色以及大小。

根据触摸物的颜色以及大小等信息，主机设备可以对每个操作者的使用状态进行单独的跟踪管理，比如：无缘的粗蓝色笔画出来的线是蓝色的粗线，用无缘的细红色笔画出来的线是细红线，这使得在交互式的多媒体应用中显得更生动、直观，且还可以应用于其他各场合。

此外，由于在触摸屏的应用中，实时性的要求比较高，且摄像装置一般都采用摄像头，摄像头的曝光时间比较短，为了达到更好的拍摄效果，提高摄像装置的清晰度，可以采用以下几种方案：

1、在无缘笔（相当于触摸物）上涂上高反光材料，即使用带高反光材料的触摸物或者是在触摸物上使用高反光材料的配件，例如中空的笔套，从而笔套可以方便地套在笔上或者手指上；

2、将摄像装置放置在横向发射模块和纵向发射模块的交界处，从而可以以红外发射管作为光源；

3、为摄像装置增加外部辅助光源。

如图 5 所示，是本发明实施例的红外扫描模块扫描多点触摸的示意图，502、503 分别为两个触摸点，按照红外扫描模块的扫描原理，红外接收模块将在红外接收管 505、506、507、508 处检测到红外信号变化超过了预定值，并可判定对应方位可能存在触摸物，由此，可能的触摸点最多有 4 个，即 501、502、503、504，但无法确定实际上有多少个触摸点，其可能的组合有以下几种：

（1）501、504；

（2）502、503；

（3）501、503、504；

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（4）501、502、504;

（5）501、502、503;

（6）502、503、504;

（7）501、502、503、504。

如此可见，仅仅根据红外扫描的方式无法确定实际的触摸点数。

如图 6 所示，是本发明实施例中红外扫描模块结合摄像装置所采集的多点触摸的示意图，605 是摄像装置所拍摄到的图片，601、602、603、604 是通过红外扫描所得到的可能的触摸物，602、603 是拍摄到的触摸物，从图片中提取出触摸物的偏离角度、颜色、以及大小，再结合红外扫描所得的结果，即可综合分析得出实际的触摸物有 602、603，排除了其他的可能，在分析出触摸物的坐标位置后，可计算出各触摸物偏离镜头的距离，再通过查表或者计算得出触摸物的实际大小，并将触摸物的坐标信息、颜色以及大小向主机设备发送。

如上所述，本发明的触摸屏装置同时利用到了红外扫描技术与图像摄制技术，从而可达到以下优点:

1、定位技术采用红外扫描为主，摄像采集为辅，响应速度快，且稳定可靠;

2、同时支持单点触摸和多点触摸，且由于可采集触摸物的颜色以及大小信息，可以分别跟踪每个触摸点，从而可以对不同的触摸物进行的同一个触摸动作做出不同的响应，使应用变得更灵活、生动;

3、成本低、安装方便，可应用于平板电视、前投、背投等系统，且特别适用于大屏幕显示系统。

参见图 7 所示，是本发明的触摸屏装置定位方法的流程示意图，如图所示，本发明的定位方法包括步骤:

S101：启动一次红外扫描，记录当前状态下的红外接收管所检测到的信号强度值;

S102：启动红外扫描，根据红外接收管所接收到的信号，判断是否存在遮

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挡触摸物，若有，记录当前的位置信息；

其中，上述判断是否存在遮挡物的方式可以是：

根据红外接收管是否检测到信号来判断是否具有遮挡物，若没有检测到任何信号，则可判定在这对红外发射接收管之间存在遮挡物，并记录当前的位置信息；

还可以是，根据红外接收管所接收到的信号，计算出该信号相对于所述记录的信号强度值的变化值，若变化值大于或者等于预定值，则判定存在遮挡触摸物，并记录当前的位置信息；

S103：以可拍摄到红外扫描网的位置拍摄一幅图片，并根据所述图片分析是否有触摸物，若有触摸物，分析所述触摸物的角度信息，并可分析出该触摸物的颜色以及大小信息；

S104：根据所述位置信息，得出所有的可能的触摸点的位置组合，并结合步骤 S103，分析出实际触摸物的数据信息，包括实际触摸物的坐标信息，还包括实际触摸物的颜色以及大小信息，其中上述分析过程可以是在触摸屏装置中进行，触摸屏装置分析完成后将分析结构发送给后续处理的主机设备，也可以是在进行后续处理的主机设备中进行。

S105：重复步骤 S102 至 S104。

其中，所述步骤 S103 与 S104 可以是以先后顺序进行，也可以是同时进行。

此外，在标注触摸物的触摸轨迹时，根据触摸物的颜色以及大小等信息，可以使标注的轨迹的颜色与大小与相应的触摸物的颜色与大小相对应，从而可以对每个操作者的使用状态进行单独的跟踪管理，例如：无缘的粗蓝色笔画出来的线是蓝色的粗线，用无缘的细红色笔画出来的线是细红线，这使得在交互式的多媒体应用中显得更生动、直观，且还可以应用于其他各场合。

根据本发明的定位方法，其可达到以下有以效果：

1、定位技术采用红外扫描为主，摄像采集为辅，响应速度快，且稳定可靠；

2、同时支持单点触摸和多点触摸，且由于可采集触摸物的颜色以及大小信

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息，可以分别跟踪每个触摸点，从而可以对不同的触摸物做出的同一个触摸动作做出不同的响应，使应用变得更灵活、生动。

以上所述的本发明实施方式，并不构成对本发明保护范围的限定。任何在本发明的精神和原则之内所作的修改、等同替换和改进等，均应包含在本发明的权利要求保护范围之内。

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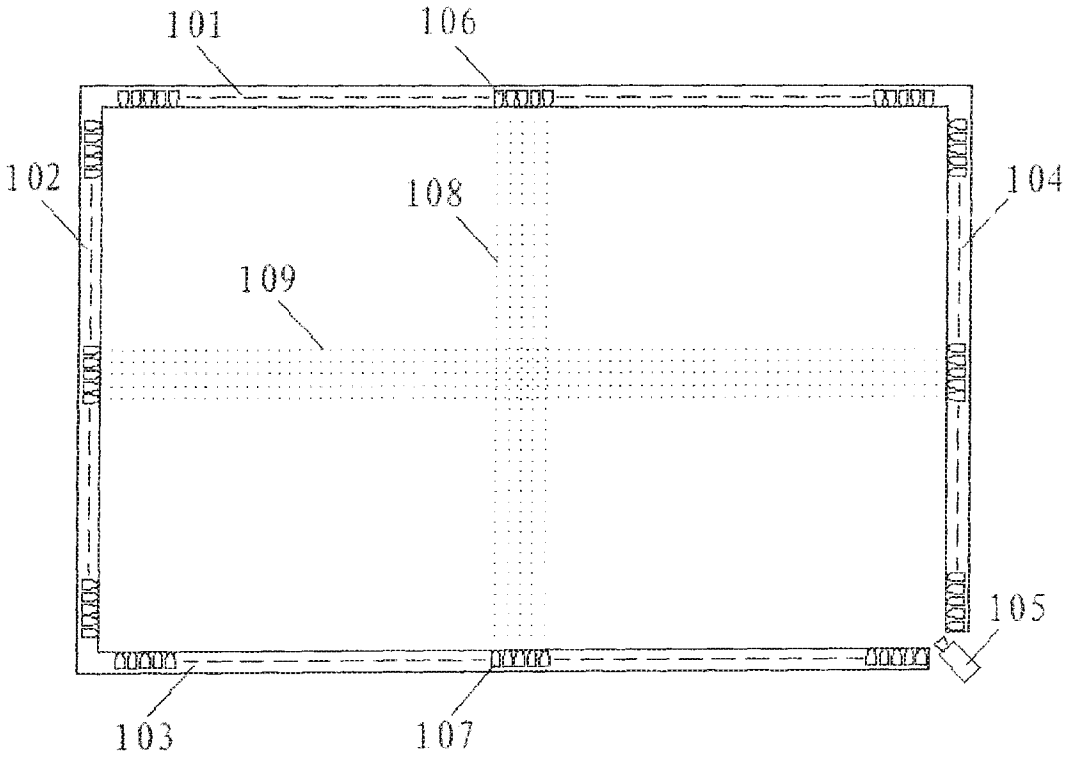


图 1

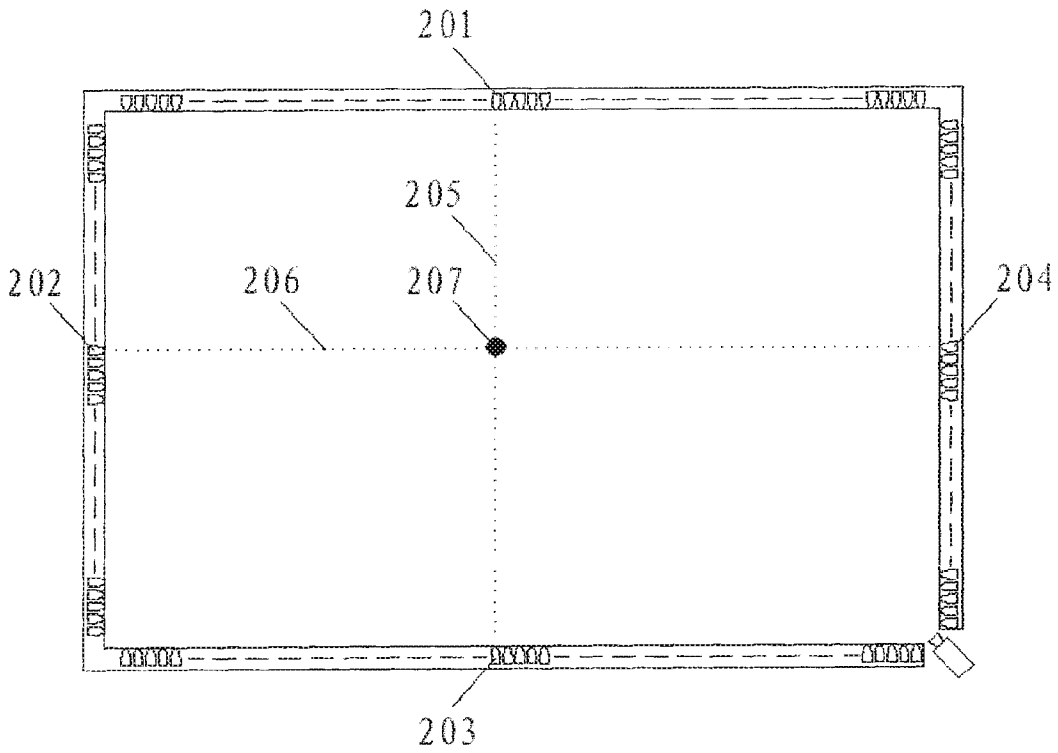


图 2

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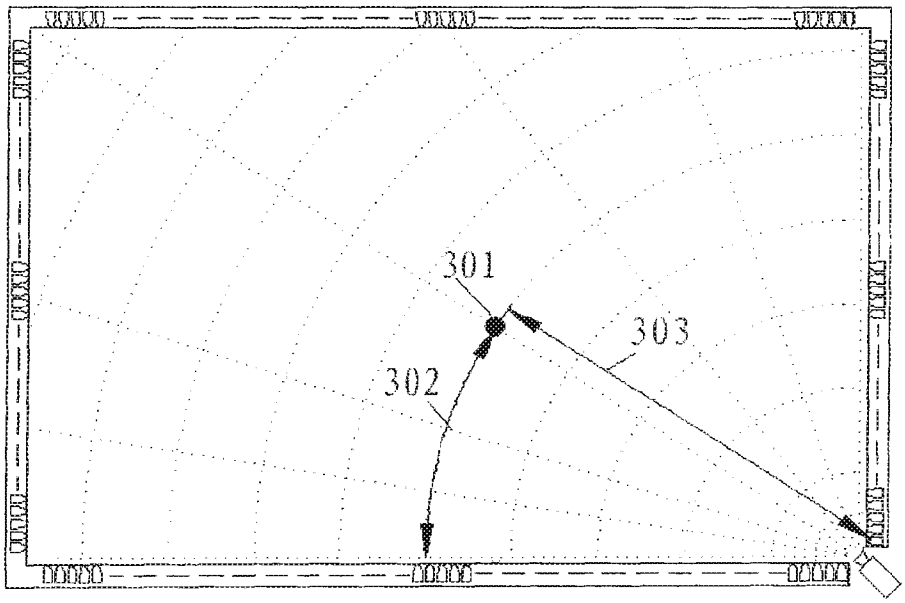


图 3

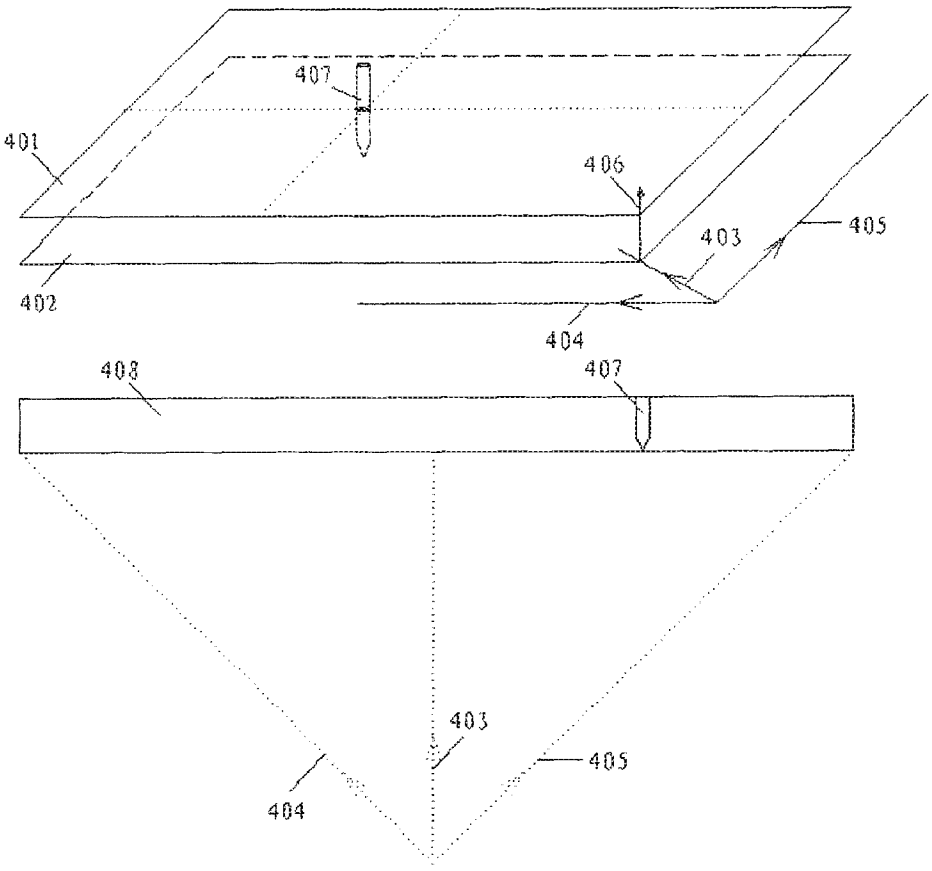


图 4

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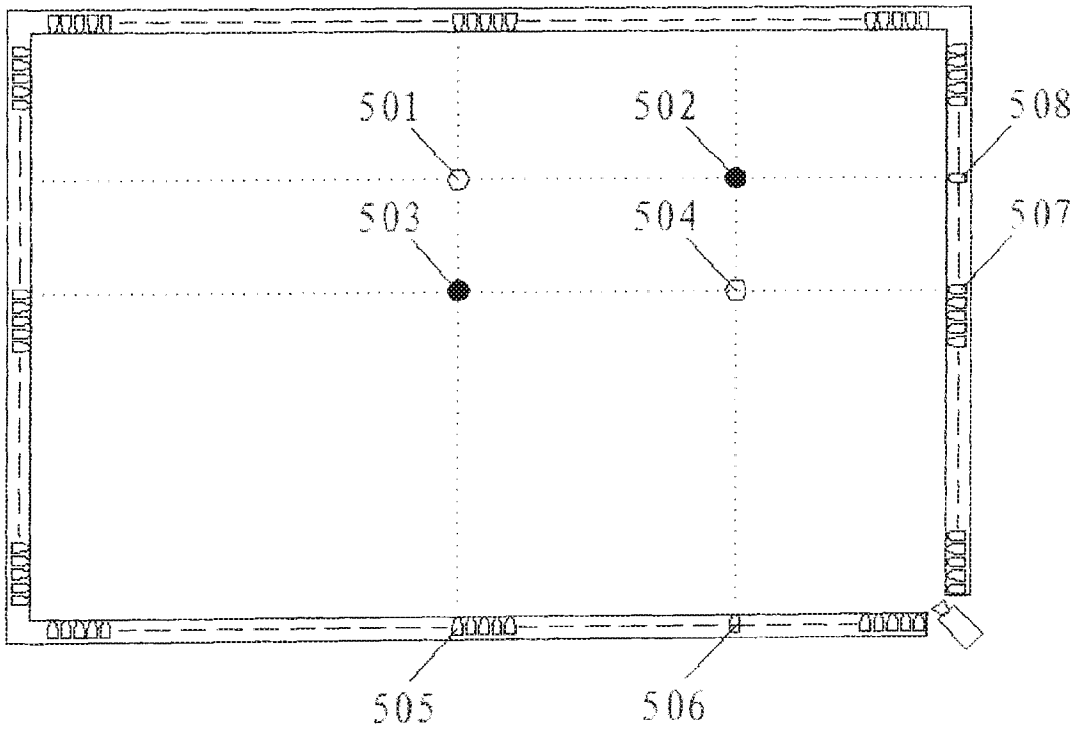


图 5

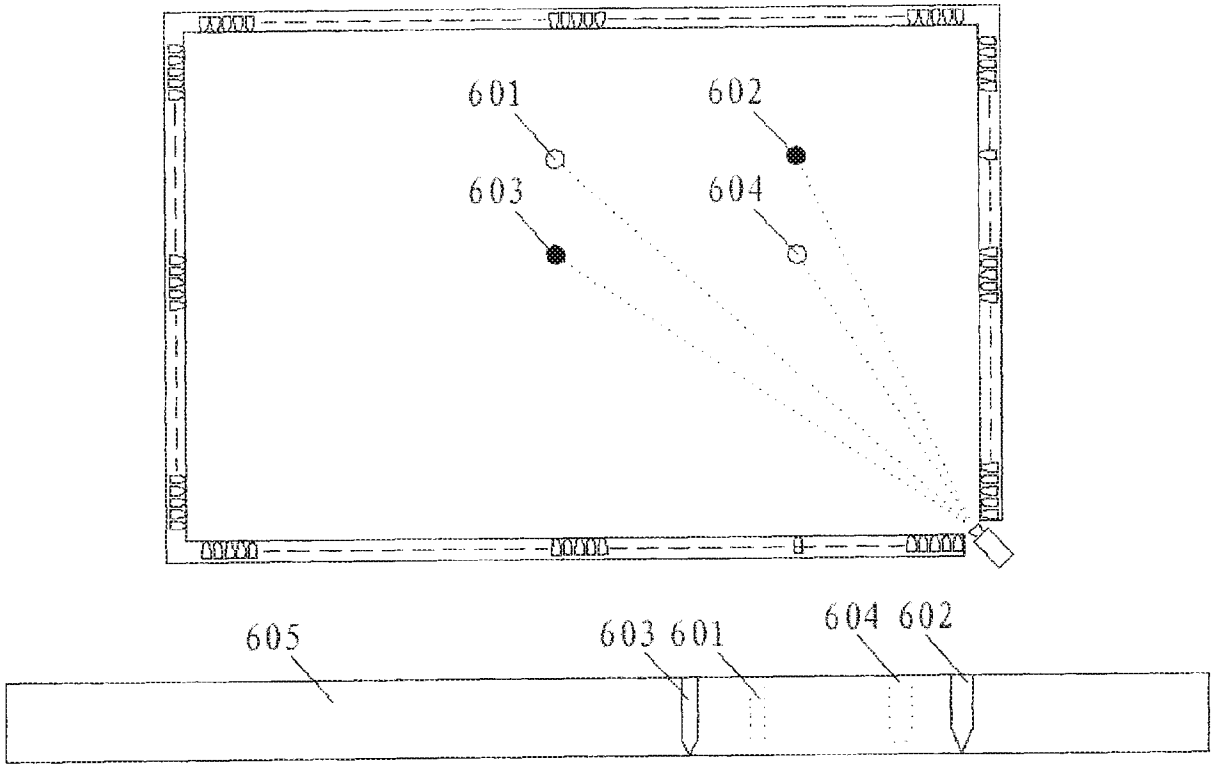


图 6

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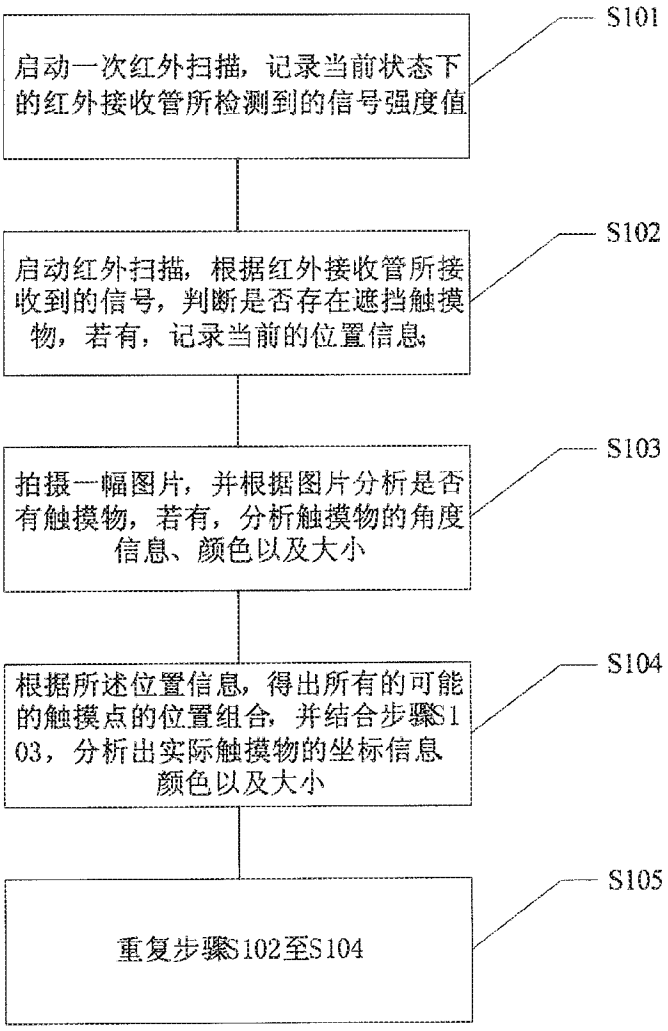


图 7

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Espacenet

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Touch -sensitive screen and LCD module laminating tool group

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Abstract of CN205015574 (U)

The utility model discloses a touch -sensitive screen and LCD module laminating tool group, include: a second tool for inciting somebody to action the first tool of liquid crystal display panel and touch -sensitive screen laminating and being used for whole and backlight unit laminating after liquid crystal display panel and the touch -sensitive screen laminating, first tool includes: first bottom plate and four first locating pieces being connected with first bottom plate four angles respectively, first locating piece is equipped with a liquid crystal display panel location portion and touch -sensitive screen location portion with first bottom plate junction, the second tool includes: second bottom plate and four second locating pieces being connected with second bottom plate four angles respectively, the second locating piece is equipped with the 2nd liquid crystal display panel location portion and backlight unit location portion with second bottom plate junction. The utility model discloses adopt earlier appearance frame counterpoint mode to be in the same place liquid crystal display panel with the touch pad laminating, guarantee the product display area uniformity of frame all around, adopt appearance frame counterpoint mode and backlight unit laminating to be in the same place again, guarantee backlight unit's overall dimension well.

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DESCRIPTION CN205015574

The utility model discloses a touch panel and a liquid crystal module bonding fixture group, comprising: a first fixture for bonding a liquid crystal panel and a touch screen, and an overall and a backlight module for bonding the liquid crystal panel and the touch screen; a first jig; the first jig includes: a first bottom plate and four first positioning blocks respectively connected to the four corners of the first bottom plate, and the first positioning block and the first bottom plate are provided with a first a liquid crystal panel positioning portion and a touch screen positioning portion; the second fixture includes: a second bottom plate and four second positioning blocks respectively connected to the four corners of the second bottom plate, and the second positioning block and the second bottom plate are provided with a second connection The liquid crystal panel positioning portion and the backlight module positioning portion. The utility model firstly adopts the outer frame alignment manner to fit the liquid crystal panel and the touch panel together to ensure the consistency of the border around the display area of the product, and then adopts the outer frame alignment manner and the backlight module to be closely attached. Ensure the size of the backlight module.

Touch screen and LCD module bonding fixture set

Technical field

The utility model relates to the technical field of liquid crystal touch screen production, in particular to a touch screen and a liquid crystal module bonding fixture.

Background technique

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At present, with the development of technology and the touch of electronic display products, more and more touch screen and LCD module products have appeared in the market; however, in the production process, the touch screen and the liquid crystal module are used together. The alignment method is two ways of capturing the alignment of the outline frame and the alignment of the capture display area:

1. When the matching frame is used to fit the position, the fixture is used to capture the shape of the touch screen and the LCD module, and the tolerance of the two sides of the fixture is adjusted to ensure the tolerance of the fitting, as shown in Figure 1.

2. When the position of the display area is used to fit the position, the CCD lens is used to project the border of the display area of the touch screen and the liquid crystal module onto the computer display, and the distance between the two frames of the display area is adjusted by the computer to ensure the fit. The tolerances are shown in Figure 2.

With the development of science and technology, the surface color of many touch screen covers has been diversified, not just black covers, which causes defects in the two methods of conformation alignment described above. The first one is to capture the alignment of the outline of the frame, although it can guarantee the fit of the shape, but can not guarantee that the display area of the two is centered (the surrounding frame size is symmetrical). The so-called frame asymmetry phenomenon is that when the touch screen is attached to the liquid crystal module, as shown in FIG. 3, a black border having a width of about 1 mm exists around the visible area of the liquid crystal module, that is, a display area and a visible area may appear. Black border, the size of the border around the display area is inconsistent after the fit. When the touch screen is a bright color cover, the size of the black border is asymmetrical. The second is to capture the alignment of the display area border. Although it can ensure that the size of the surrounding area of the visible area is symmetrical after the bonding, the outer dimensions of the backlight module on the LCD module cannot be controlled, as shown in Figure 4.

Therefore, the prior art has drawbacks and needs improvement.

Utility model content

The purpose of the utility model is to overcome the deficiencies of the prior art, and provide a touch panel and a liquid crystal module bonding fixture set, which can well solve the problem that the border sizes of the display areas of the liquid crystal module are inconsistent in the prior art, and cannot Ensure the size of the backlight module.

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The technical solution of the utility model is as follows: The utility model provides a touch panel and a liquid crystal module bonding fixture set, comprising: a first treatment for bonding a liquid crystal panel and a touch screen which have not been assembled with the backlight module together And a second jig for integrally bonding the liquid crystal panel and the touch screen to the backlight module; the first jig includes: a first bottom plate, and the first bottom plate respectively Four first positioning blocks connected to the four corners, the first positioning block and the first bottom plate are provided with a first liquid crystal panel positioning portion and a touch screen positioning portion; the second fixture includes: a second bottom plate And a second second positioning block respectively connected to the four corners of the second bottom plate, wherein the second positioning block and the second bottom plate are connected with a second liquid crystal panel positioning portion and a backlight module positioning portion.

In the first positioning block, the first liquid crystal panel positioning portion and the touch screen positioning portion are arranged in a step, and the first liquid crystal panel positioning portion is located below the touch screen positioning portion.

In the second positioning block, the second liquid crystal panel positioning portion and the backlight module positioning portion are arranged in a step, and the backlight module positioning portion is located below the second liquid crystal panel positioning portion.

The first positioning block is further provided with a first groove, the first groove is connected with the touch screen positioning portion; any of the second positioning blocks is further provided with a second groove, the second The groove is connected to the positioning portion of the second liquid crystal panel, and the second positioning block is further provided with a third groove, and the third groove is connected to the positioning portion of the second liquid crystal panel and the positioning portion of the backlight module.

The first positioning block is integrally formed with the first bottom plate, and the second positioning block is integrally formed with the second bottom plate.

According to the above solution, the touch screen and the liquid crystal module of the utility model are attached to the jig set, and the jig set is used to firstly align the liquid crystal panel and the touch panel by using the outer frame alignment manner, thereby ensuring the border of the product display area. Consistency, and then the shape border alignment mode and the backlight module are attached together, which can well ensure the outer dimensions of the backlight module, and the utility model can also reduce the backlight loss well.

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DRAWINGS

FIG. 1 is a schematic diagram of the prior art in which the capture frame is used to fit the position.

FIG. 2 is a schematic diagram of the prior art in which the frame of the capture display area is aligned.

FIG. 3 is a schematic diagram showing a black border appearing in a visible area of a liquid crystal module in the prior art.

FIG. 4 is a schematic diagram of the appearance of the backlight module being uncontrollable when the frame of the capture display area is aligned in the prior art.

FIG. 5 is a schematic structural view of the first fixture in the touch panel and the liquid crystal module bonding fixture set of the present invention.

Figure 6 is an enlarged view of a portion A in Figure 5.

FIG. 7 is a schematic structural view of a second jig in a touch panel and a liquid crystal module bonding jig set according to the present invention.

Figure 8 is an enlarged view of B in Figure 7.

Detailed ways

The present invention will be described in detail below in conjunction with the accompanying drawings and specific embodiments.

Referring to FIG. 5 to FIG. 8 , the present invention provides a touch panel and a liquid crystal module bonding jig set. The jig set can be used to solve the problem that the border size of the display area of the liquid crystal module is inconsistent and cannot be solved in the prior art. The problem of ensuring the size of the backlight

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module. The fixture set includes: a first jig 20 for bonding a liquid crystal panel that has not been assembled with a backlight module and a touch screen, and an integral and backlight module for bonding the liquid crystal panel and the touch screen together A second jig 40 that is attached together.

Specifically, the first jig 20 includes: a first bottom plate 22, and four first positioning blocks 24 respectively connected to four corners of the first bottom plate 22, the first positioning block 24 and the first A first liquid crystal panel positioning portion 26 and a touch screen positioning portion 28 are provided at a joint of the bottom plate 22. In the first positioning block 24 , the first liquid crystal panel positioning portion 26 and the touch screen positioning portion 28 are arranged in a step, and the first liquid crystal panel positioning portion 26 is located below the touch screen positioning portion 28 . The second jig 40 includes a second bottom plate 42 and four second positioning blocks 44 respectively connected to the four corners of the second bottom plate 42 . The second positioning block 44 and the second bottom plate 42 . The second liquid crystal panel positioning portion 46 and the backlight module positioning portion 48 are provided at the connection. In the second positioning block 44, the second liquid crystal panel positioning portion 46 and the backlight module positioning portion 48 are arranged in a stepped manner, and the backlight module positioning portion 48 is located in the second liquid crystal panel positioning portion 46. Below.

Further, the first positioning block 24 is further provided with a first recess 25, and the first recess 25 is connected to the touch screen positioning portion 28, and the first recess 25 can be used to assist the liquid crystal panel with After the touch screen is attached, the whole fixture is quickly disassembled from the first jig 20 to improve work efficiency. The second positioning block 44 is further provided with a second recess 45. The second recess 45 is connected to the second liquid crystal panel positioning portion 46, and the other second positioning block 44 is further provided with a second recess 44. The three recesses 47 are connected to the second liquid crystal panel positioning portion 46 and the backlight module positioning portion 48. The second and third recesses 45 and 47 can assist the liquid crystal panel and the touch screen. After the backlight module is attached, the whole fixture is quickly disassembled from the second fixture 40 to improve work efficiency.

The first positioning block 24 is integrally formed with the first bottom plate 22, and the second positioning block 44 is integrally formed with the second bottom plate 42, which has high production efficiency and is convenient for reducing the production cost of the fixture set.

The specific bonding principle is that the liquid crystal panel is placed in the receiving space formed by the first liquid crystal panel positioning portion 26 of the four first positioning blocks 24 and the first bottom plate 22, and the touch screen is placed on the touch screen of the four first positioning blocks 24. In the accommodating space formed by the positioning portion 28 and the first bottom plate 22, the first jig 20 is used to capture the outer border of the touch screen and the outer frame of the liquid crystal panel, and the alignment is completed, and the touch screen and the liquid crystal panel are attached together. The liquid crystal panel of the assembled

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backlight module is attached to the touch panel, and the alignment of the outer frame is used for alignment, which can ensure the consistency of the border around the display area. Then, the backlight module is placed in the accommodating space formed by the backlight module positioning portion 48 and the second bottom plate 42 of the four second positioning blocks 44, and the touch screen and the liquid crystal panel are bonded together to form the whole body. In the accommodating space formed by the second liquid crystal panel positioning portion 46 and the second bottom plate 22 of the second positioning block 44, the second jig 40 captures the overall outer frame formed by the touch panel and the liquid crystal panel. And the outer frame of the backlight module completes the alignment, and the liquid crystal panel and the backlight module are attached together to complete the bonding of the touch screen and the liquid crystal module, so as to ensure the outer dimensions after the bonding.

In summary, the utility model provides a touch panel and a liquid crystal module bonding fixture group, and the utility model adopts the outer frame alignment manner to firstly laminate the liquid crystal panel and the touch panel to ensure the product display area. The consistency of the surrounding frames, and then the alignment of the outline frame and the backlight module are attached together, which can well ensure the outer dimensions of the backlight module, and the utility model can also reduce the backlight loss well.

The above are only the preferred embodiments of the present invention, and are not intended to limit the present invention. Any modifications, equivalent substitutions and improvements made within the spirit and principles of the present invention should be included in the present invention. Within the scope of protection.

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CLAIMS CN205015574

1.
A touch panel and a liquid crystal module bonding fixture set, comprising: a first fixture for bonding a liquid crystal panel not assembled with a backlight module and a touch screen, and a liquid crystal panel a second jig attached to the touch screen and integrated with the backlight module; the first jig includes: a first bottom plate, and four first ends respectively connected to the four corners of the first bottom plate a positioning block, the first positioning block and the first bottom plate are provided with a first liquid crystal panel positioning portion and a touch screen positioning portion; the second jig includes: a second bottom plate, and the second and the second Four second positioning blocks connected to the four corners of the bottom plate, and a second liquid crystal panel positioning portion and a backlight module positioning portion are disposed at the connection between the second positioning block and the second bottom plate.

2.
The touch panel and the liquid crystal module bonding fixture set according to claim 1, wherein in the first positioning block, the first liquid crystal panel positioning portion and the touch screen positioning portion are arranged in a stepped manner, The first liquid crystal panel positioning portion is located below the touch screen positioning portion.

3.
The touch panel and the liquid crystal module bonding fixture set according to claim 1 , wherein in the second positioning block, the second liquid crystal panel positioning portion and the backlight module positioning portion are arranged in a step shape. The backlight module positioning portion is located below the second liquid crystal panel positioning portion.

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4.

The touch panel and the liquid crystal module bonding fixture set according to claim 1, wherein any one of the first positioning blocks is further provided with a first groove, and the first groove is connected with the touch screen positioning portion. The second positioning block is further provided with a second groove, the second groove is connected to the second liquid crystal panel positioning portion, and the other second positioning block is further provided with a third groove. Each of the third grooves is connected to the second liquid crystal panel positioning portion and the backlight module positioning portion.

5.

The touch panel and the liquid crystal module bonding jig set according to any one of claims 1 to 4, wherein the first positioning block is integrally formed with the first bottom plate, and the second positioning block and the second bottom plate are integrally formed. One piece.

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(12)实用新型专利

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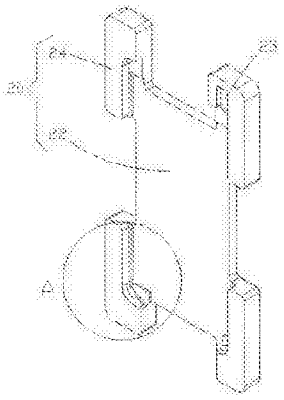
权利要求书1页 说明书3页 附图7页

(54)实用新型名称

触摸屏与液晶模组贴合治具组

(57)摘要

本实用新型公开一种触摸屏与液晶模组贴合治具组，包括：用于将液晶面板与触摸屏贴合的第一治具、及用于将液晶面板与触摸屏贴合后的整体与背光模组贴合的第二治具；第一治具包括：第一底板及分别与第一底板四个角连接的四个第一定位块，第一定位块与第一底板连接处设有第一液晶面板定位部及触摸屏定位部；第二治具包括：第二底板及分别与第二底板四个角连接的四个第二定位块，第二定位块与第二底板连接处设有第二液晶面板定位部及背光模组定位部。本实用新型先采用外形边框对位方式将液晶面板与触摸板贴合在一起，保证产品显示区域四周边框的一致性，再采用外形边框对位方式与背光模组贴合在一起，很好地保证背光模组的外形尺寸。



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1. 一种触摸屏与液晶模组贴合治具组，其特征在于，包括：用于将还没与背光模组组装的液晶面板与触摸屏贴合在一起的第一治具、以及用于将液晶面板与触摸屏贴合在一起的整体与背光模组贴合在一起的第二治具；所述第一治具包括：第一底板、以及分别与所述第一底板四个角连接的四个第一定位块，所述第一定位块与所述第一底板连接处设有第一液晶面板定位部以及触摸屏定位部；所述第二治具包括：第二底板、以及分别与所述第二底板四个角连接的四个第二定位块，所述第二定位块与所述第二底板连接处设有第二液晶面板定位部以及背光模组定位部。

2. 根据权利要求 1 所述的触摸屏与液晶模组贴合治具组，其特征在于，在所述第一定位块中，所述第一液晶面板定位部与触摸屏定位部呈阶梯状设置，所述第一液晶面板定位部位于所述触摸屏定位部的下方。

3. 根据权利要求 1 所述的触摸屏与液晶模组贴合治具组，其特征在于，在所述第二定位块中，所述第二液晶面板定位部与背光模组定位部呈阶梯状设置，所述背光模组定位部位于所述第二液晶面板定位部的下方。

4. 根据权利要求 1 所述的触摸屏与液晶模组贴合治具组，其特征在于，任一所述第一定位块上还设有第一凹槽，所述第一凹槽与触摸屏定位部连接；任一所述第二定位块上还设有第二凹槽，所述第二凹槽与第二液晶面板定位部连接，另一所述第二定位块上还设有第三凹槽，所述第三凹槽均与第二液晶面板定位部及背光模组定位部连接。

5. 根据权利要求 1 至 4 任一项所述的触摸屏与液晶模组贴合治具组，其特征在于，所述第一定位块与第一底板一体成型，所述第二定位块与第二底板一体成型。

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触摸屏与液晶模组贴合治具组

技术领域

[0001] 本实用新型涉及液晶触摸屏生产技术领域，尤其涉及一种触摸屏与液晶模组贴合治具。

背景技术

[0002] 目前，随着科技的发展，电子显示产品的触控化，市场出现了越来越多的触摸屏与液晶模组贴合产品；但，在生产过程中，触摸屏与液晶模组贴合时所用的对位方式分别为捕抓外形边框对位与捕抓显示区域边框对位两种方法：

[0003] 一、采用捕抓外形边框对位进行贴合时，通过治具捕抓触摸屏与液晶模组的外形边框，通过调整治具上两边的固定距离来保证贴合的公差，如图 1 所示；

[0004] 二、采用捕抓显示区域边框对位进行贴合时，使用 CCD 镜头将触摸屏与液晶模组的显示区域边框分别投影到电脑显示上，通过电脑显示调整显示区域两个边框的距离来保证贴合的公差，如图 2 所示。

[0005] 随着科学技术的发展，许多触摸屏盖板的表面颜色呈多元化发展，而不仅仅为黑色盖板，这会造成以上所描述的两种贴合对位方法都存在缺陷。第一种是捕抓外形边框的对位方式虽然可以保证外形的贴合尺寸，但无法保证到两者的显示区域居中对应（四周的边框大小对称）。所谓边框不对称现象就是触摸屏与液晶模组贴合时，如图 3 所示，液晶模组可视区域四周存在宽度约为 1mm 的黑色边框，也就是说显示区域与可视区域之间会出现黑色边框，贴合后显示区域四周边框大小不一致。当触摸屏为亮色盖板时，此黑色边框四周大小不对称会非常明显。第二种是捕抓显示区域边框对位，虽然能保证贴合后可视区域四周大小边对称，但是液晶模组上的背光模组外形尺寸将无法得到管控，如图 4 所示。

[0006] 因此，现有技术存在缺陷，需要改进。

实用新型内容

[0007] 本实用新型的目的是克服现有技术的不足，提供一种触摸屏与液晶模组贴合治具组，很好地解决了现有技术中液晶模组显示区域四周边框大小不一致的问题，以及无法保证背光模组外形尺寸。

[0008] 本实用新型的技术方案如下：本实用新型提供一种触摸屏与液晶模组贴合治具组，包括：用于将还没与背光模组组装的液晶面板与触摸屏贴合在一起的第一治具、以及用于将液晶面板与触摸屏贴合在一起的整体与背光模组贴合在一起的第二治具；所述第一治具包括：第一底板、以及分别与所述第一底板四个角连接的四个第一定位块，所述第一定位块与所述第一底板连接处设有第一液晶面板定位部以及触摸屏定位部；所述第二治具包括：第二底板、以及分别与所述第二底板四个角连接的四个第二定位块，所述第二定位块与所述第二底板连接处设有第二液晶面板定位部以及背光模组定位部。

[0009] 在所述第一定位块中，所述第一液晶面板定位部与触摸屏定位部呈阶梯状设置，所述第一液晶面板定位部位于所述触摸屏定位部的下方。

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[0010] 在所述第二定位块中，所述第二液晶面板定位部与背光模组定位部呈阶梯状设置，所述背光模组定位部位于所述第二液晶面板定位部的下方。

[0011] 任一所述第一定位块上还设有第一凹槽，所述第一凹槽与触摸屏定位部连接；任一所述第二定位块上还设有第二凹槽，所述第二凹槽与第二液晶面板定位部连接，另一所述第二定位块上还设有第三凹槽，所述第三凹槽均与第二液晶面板定位部及背光模组定位部连接。

[0012] 所述第一定位块与第一底板一体成型，所述第二定位块与第二底板一体成型。

[0013] 采用上述方案，本实用新型的触摸屏与液晶模组贴合治具组，应用该治具组先采用外形边框对位方式将液晶面板与触摸板贴合在一起，保证了产品显示区域四周边框的一致性，之后再采用外形边框对位方式与背光模组贴合在一起，可以很好地保证背光模组的外形尺寸，本实用新型还能够很好地降低背光损耗。

附图说明

[0014] 图 1 为现有技术中采用捕抓外形边框对位进行贴合的原理图。

[0015] 图 2 为现有技术中采用捕抓显示区域边框对位进行贴合的原理图。

[0016] 图 3 为现有技术中液晶模组可视区域出现黑色边框的示意图。

[0017] 图 4 为现有技术中采用捕抓显示区域边框对位时出现背光模组外形尺寸无法管控的示意图。

[0018] 图 5 为本实用新型触摸屏与液晶模组贴合治具组中第一治具的结构示意图。

[0019] 图 6 为图 5 中 A 处的放大图。

[0020] 图 7 为本实用新型触摸屏与液晶模组贴合治具组中第二治具的结构示意图。

[0021] 图 8 为图 7 中 B 处的放大图。

具体实施方式

[0022] 以下结合附图和具体实施例，对本实用新型进行详细说明。

[0023] 请参阅图 5 至图 8，本实用新型提供一种触摸屏与液晶模组贴合治具组，利用该治具组可以很好解决现有技术中存在液晶模组显示区域四周边框大小不一致以及无法保证背光模组外形尺寸的问题。该治具组包括：用于将还没与背光模组组装的液晶面板与触摸屏贴合在一起的第一治具 20、以及用于将液晶面板与触摸屏贴合在一起的整体与背光模组贴合在一起的第二治具 40。

[0024] 具体的，所述第一治具 20 包括：第一底板 22、以及分别与所述第一底板 22 四个角连接的四个第一定位块 24，所述第一定位块 24 与所述第一底板 22 连接处设有第一液晶面板定位部 26 以及触摸屏定位部 28。在所述第一定位块 24 中，所述第一液晶面板定位部 26 与触摸屏定位部 28 呈阶梯状设置，所述第一液晶面板定位部 26 位于所述触摸屏定位部 28 的下方。所述第二治具 40 包括：第二底板 42、以及分别与所述第二底板 42 四个角连接的四个第二定位块 44，所述第二定位块 44 与所述第二底板 42 连接处设有第二液晶面板定位部 46 以及背光模组定位部 48。在所述第二定位块 44 中，所述第二液晶面板定位部 46 与背光模组定位部 48 呈阶梯状设置，所述背光模组定位部 48 位于所述第二液晶面板定位部 46 的下方。

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[0025] 进一步地，任一所述第一定位块 24 上还设有第一凹槽 25，所述第一凹槽 25 与触摸屏定位部 28 连接，利用该第一凹槽 25，可以辅助将液晶面板与触摸屏贴合后的整体，从第一治具 20 上快速拆卸下来，提升工作效率。任一所述第二定位块 44 上还设有第二凹槽 45，所述第二凹槽 45 与第二液晶面板定位部 46 连接，另一所述第二定位块 44 上还设有第三凹槽 47，所述第三凹槽 47 均与第二液晶面板定位部 46 及背光模组定位部 48 连接，利用该第二与第三凹槽 45、47，可以辅助将液晶面板、触摸屏及背光模组贴合后的整体，从第二治具 40 上快速拆卸下来，提升工作效率。

[0026] 所述第一定位块 24 与第一底板 22 一体成型，所述第二定位块 44 与第二底板 42 一体成型，生产效率高，便于降低治具组的生产成本。

[0027] 具体贴合原理是：将液晶面板放置于四个第一定位块 24 的第一液晶面板定位部 26 与第一底板 22 形成的收容空间中，将触摸屏放置于四个第一定位块 24 的触摸屏定位部 28 与第一底板 22 形成的收容空间中，利用第一治具 20 分别捕抓触摸屏外形边框与液晶面板外形边框，完成对位，并将触摸屏与液晶面板贴合在一起，采用还没组装背光模组的液晶面板与触摸板贴合在一起，并采用外形边框的对位方式进行对位，可以很好地保证显示区域四周边框的一致性。之后，再将背光模组放置于四个第二定位块 44 的背光模组定位部 48 与第二底板 42 形成的收容空间中，将触摸屏与液晶面板贴合在一起后形成的整体放置于四个第二定位块 44 的第二液晶面板定位部 46 与第二底板 22 形成的收容空间中，利用第二治具 40 分别捕抓触摸屏与液晶面板贴合在一起后形成的整体的外形边框、以及背光模组的外形边框，完成对位，并将液晶面板与背光模组贴合在一起，以完成触摸屏与液晶模组的贴合，这样可以保证贴合后的外形尺寸。

[0028] 综上所述，本实用新型提供一种触摸屏与液晶模组贴合治具组，应用该治具组先采用外形边框对位方式将液晶面板与触摸板贴合在一起，保证了产品显示区域四周边框的一致性，之后再采用外形边框对位方式与背光模组贴合在一起，可以很好地保证背光模组的外形尺寸，本实用新型还能够很好地降低背光损耗。

[0029] 以上仅为本实用新型的较佳实施例而已，并不用于限制本实用新型，凡在本实用新型的精神和原则之内所作的任何修改、等同替换和改进等，均应包含在本实用新型的保护范围之内。

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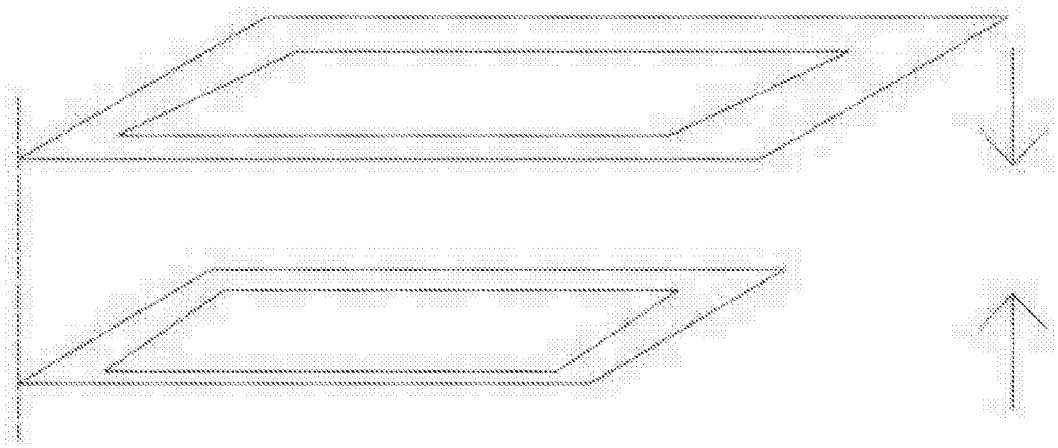


图 1

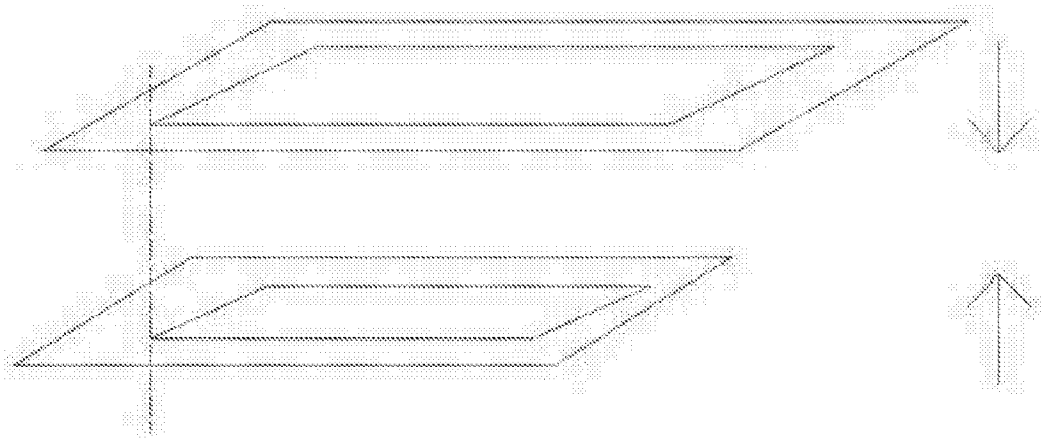


图 2

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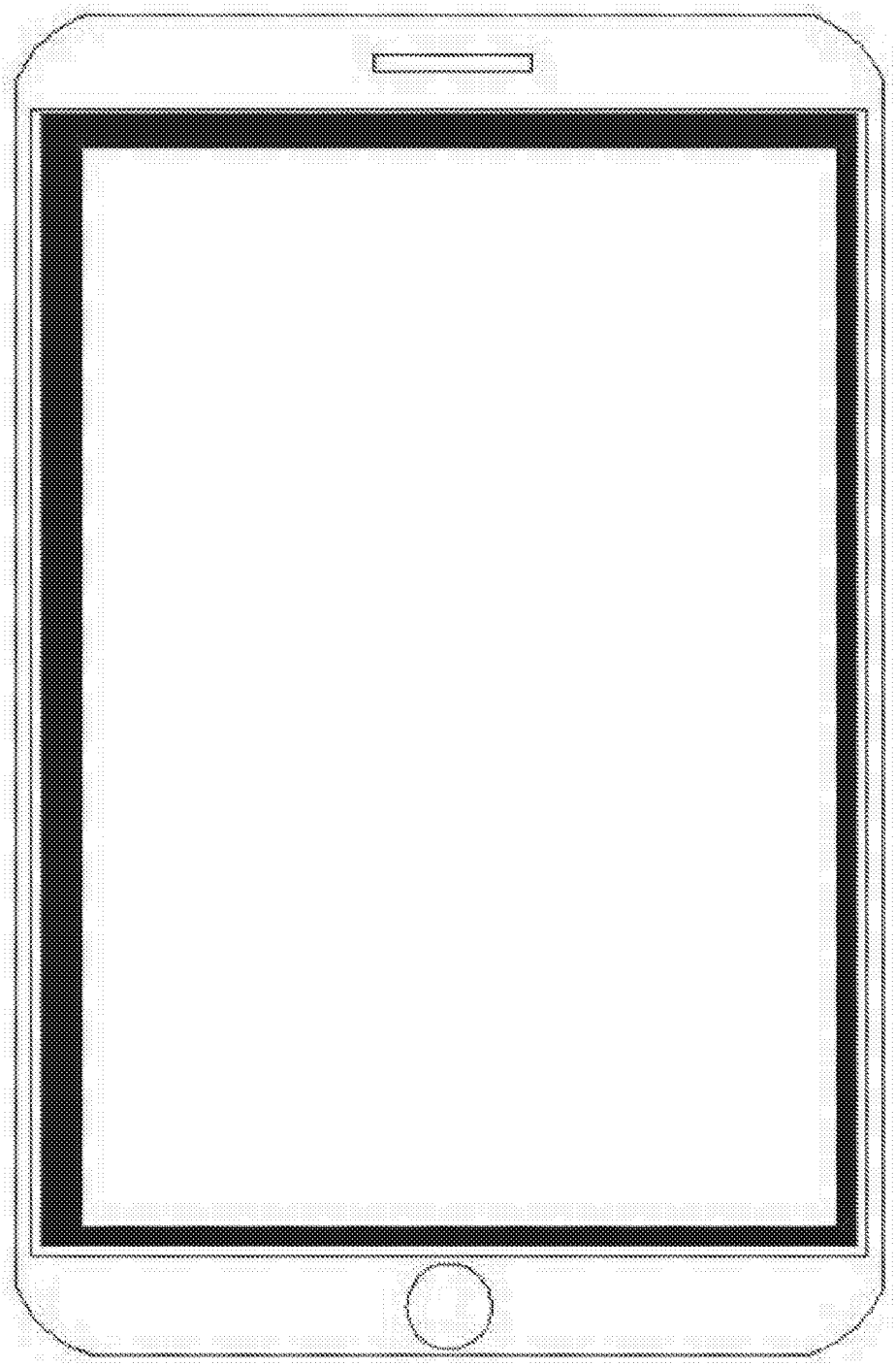


图 3

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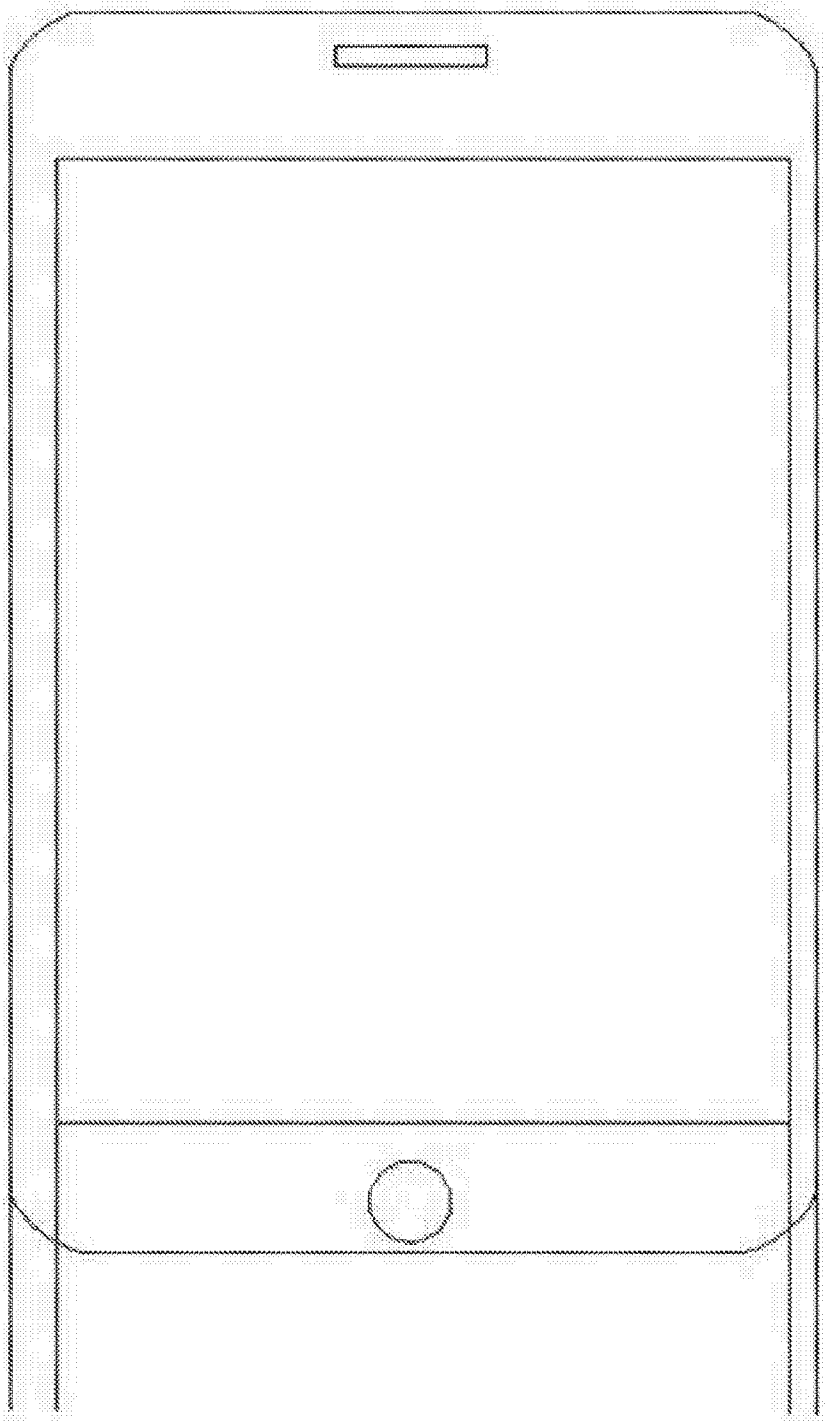


图 4

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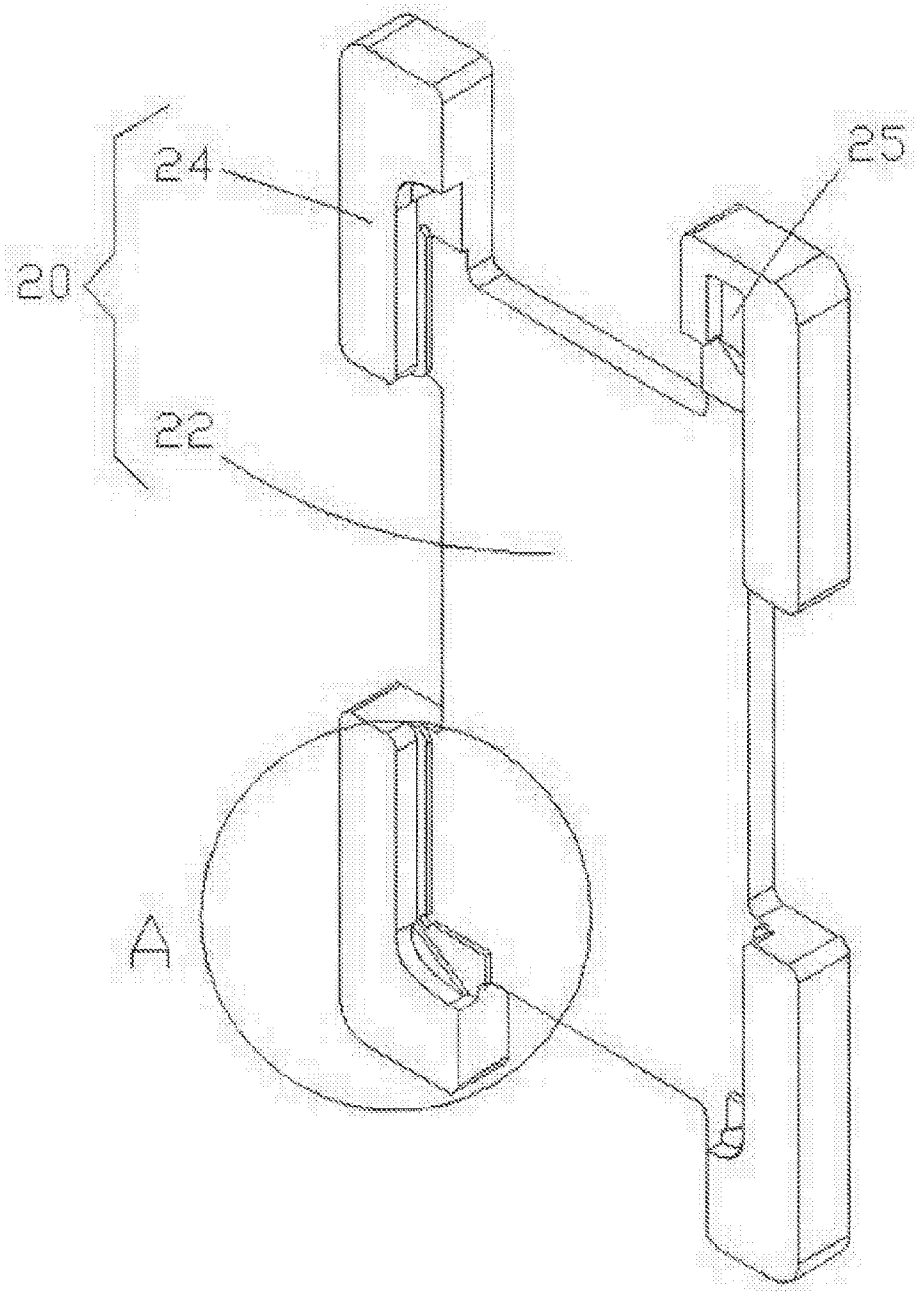


图 5

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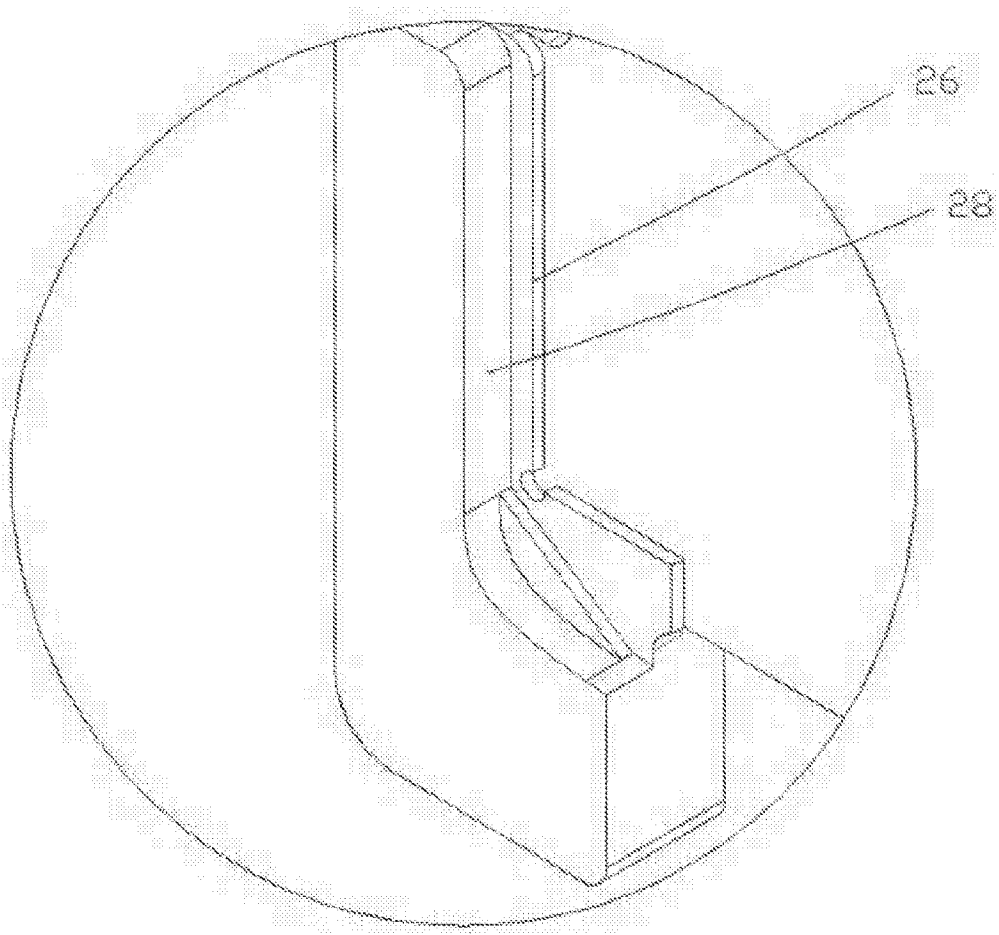


图 6

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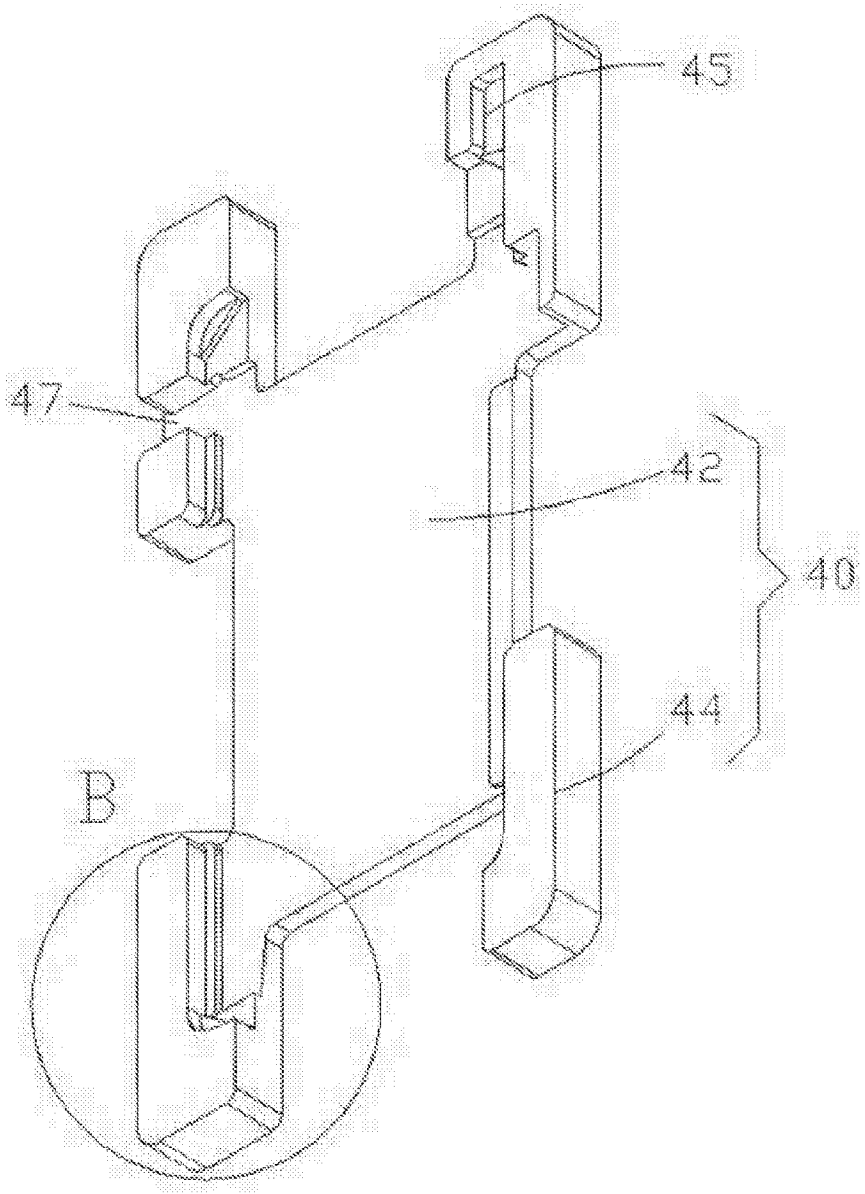


图 7

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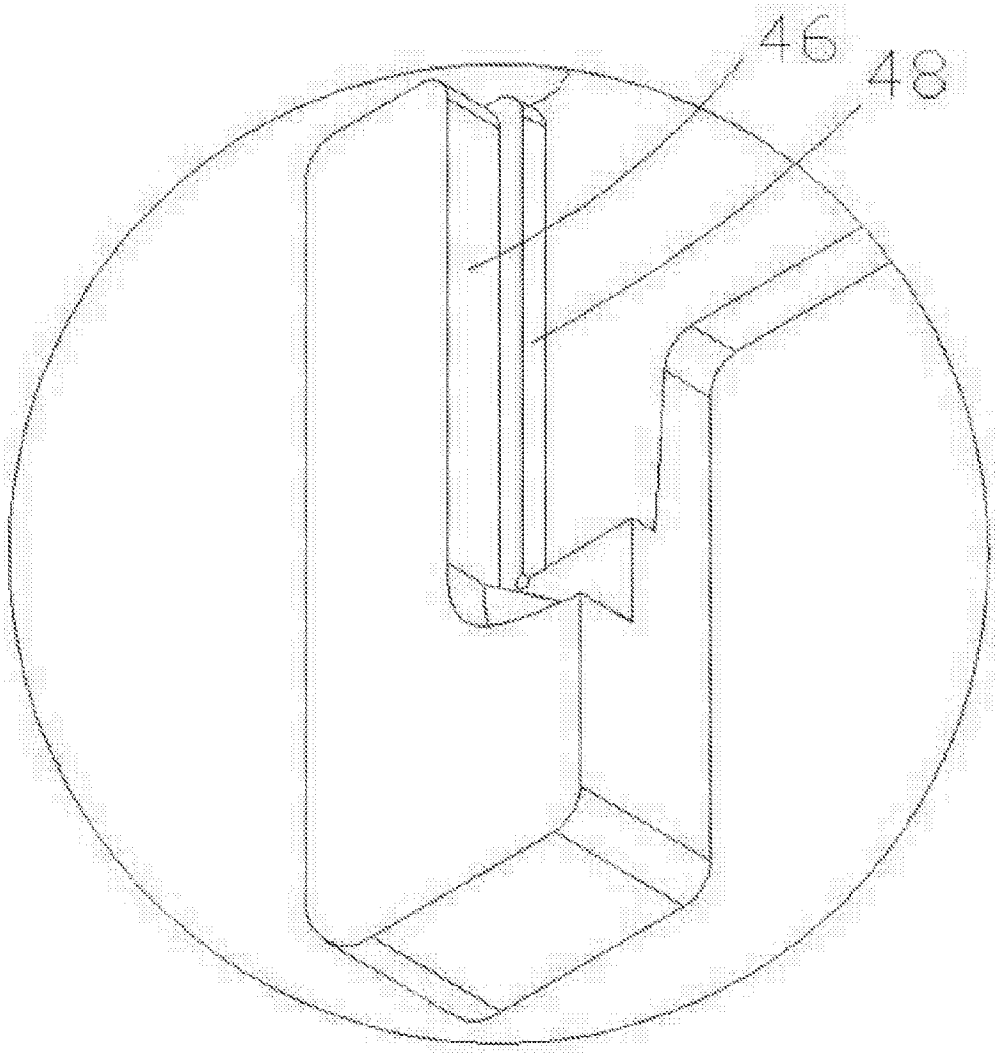


图 8

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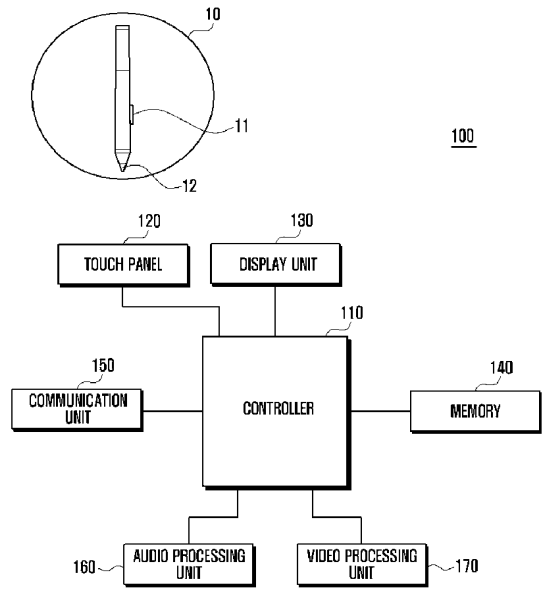
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(54) A portable apparatus and an input method of a portable apparatus

(57) A portable apparatus comprising a portable terminal and a pen. The pen includes a button arranged to set the pen to a first input state in which the pen generates a first level of electricity or to a second input state in which the pen generates a second level of electricity. A touch sensor changes electricity according to the level of electricity generated by the pen when touched by the pen, to generate a first input signal or a second input signal accordingly. A controller analyses the first or second input signal, to determine a first input or second input, and performs a corresponding pre-set function for the first input in an executed application and calls a pre-set application or performs a pre-set command for the second input. A display unit displays a screen processed according to at least one of the first input and the second input.

FIG. 1



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Description

Field of the Invention

[0001] The present invention relates to a portable apparatus and an input method of a portable apparatus. In particular, the portable apparatus comprises a portable terminal and a pen. More particularly, although not exclusively, the present invention relates to a pen input device and a method of a combination of a portable terminal and a pen, the portable terminal having a touch panel.

Description of the Related Art

[0002] A portable terminal may often include a touch device, and the touch device may sense touched points within a touch panel and to control the operation of the portable terminal. Such a touch device often uses an electrostatic capacitive sensing method in which the touch panel comprises an array of electrostatic capacitive sensors. Such a portable terminal provides for finger touch interaction. However, a finger touch method is not appropriate for performing precise work due to the large size of the touch contact area of a finger on a touch panel.

[0003] Therefore, there is an increasing need for another input method in addition to or instead of using fingers in a portable terminal including a touch device. In particular, in case a precise and detailed input is needed, such as when taking a memo or drawing a picture, using a pen in accordance with embodiments of the present invention may be advantageous.

Summary of the Invention

[0004] Embodiments of the present invention aim to address at least some of the above problems, and provide a portable apparatus comprising a portable terminal and a pen and an input method of a portable terminal including a touch panel. In an exemplary embodiment of the present invention, the experience of actually using a pen is applied in a touch mobile device, thereby providing a new experience allowing different input options such as pen gesture and pen handwriting, etc. which are not possible with only a finger touch.

[0005] To this end according to certain embodiments of the invention, the pen and the touch panel are arranged such that when the pen is set to a first input state an operation of an application can be performed using the a pen, and when set to a second input state an application can be called or a certain command can be performed. The portable terminal can be arranged to perform a function or command which is respectively set according to the first pen input state and the second pen input state.

[0006] Embodiments of the present invention provide an input device in the form of a portable apparatus comprising a portable terminal and a pen, and an input method of such a portable apparatus capable of controlling operations of an application executed according to user input with the pen. Such user input may relate to inputting letters by handwriting and drawing an image in various applications. Further, embodiments of the present invention provide a device and method for generating various inputs to a portable terminal capable of calling a certain application of a portable terminal independently of the operational control of an application executed in the portable terminal and generating a certain command by adding a button to a pen.

[0007] In accordance with a first aspect of the present invention there is provided a portable apparatus comprising a portable terminal and a pen, the portable terminal comprising a controller, a touch panel, and a display unit: wherein the pen includes a button and the pen is arranged to be set to a first input state in which the pen generates a first level of electricity or to a second input state in which the pen generates a second level of electricity depending on whether or not the button has been pressed; wherein the touch panel includes a touch sensor arranged to change electricity in response to being touched by the pen or the pen approaching the touch panel and according to the level of electricity generated by the pen, the touch panel being arranged to generate a first input signal or a second input signal depending upon the change in electricity; wherein the controller is arranged to analyse the first or second input signal, to determine a first input or second input depending upon the first or second input signal, to perform a pre-set function corresponding to the first input in an executed application, and to call a pre-set application or perform a pre-set command corresponding to the second input; wherein the display unit is arranged to display a screen processed according to at least one of the first input and the second input under the control of the controller; and wherein the first input includes at least one of a general input that controls operation of the executed application, a handwritten letter and a drawing, and the second input is a command that calls a predetermined application and/or a command for execution of a predetermined operation.

[0008] In accordance with a second aspect of the present invention there is provided an input method of a portable apparatus comprising a portable terminal and a pen, the portable terminal comprising a touch panel, the input method comprising: generating by the pen a first level electricity in a first input state and a second level of electricity in a second input state depending on whether or not a button of the pen has been pressed; generating by the touch panel a first input signal or a second input signal according to a sensed change in capacitance of a touch sensor in response to the touch panel being touched by the pen or the pen approaching the touch panel and according to the level of electricity generated at the pen; analysing the first or second input signal to determine a first input or a second input depending upon the first or second input signal; performing a pre-set function corresponding to the first input in an application being executed; calling a pre-set application or performing a pre-set command corresponding to the second input; and

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displaying, on a display unit, a screen processed according to at least one of the first input and the second input under the control of the controller; wherein the first input includes at least one of a general input that controls operation of the executed application, a handwritten letter and a drawing, and the second input is a command that calls a predetermined application and/or a command for execution of a predetermined operation.

[0009] According to embodiments of the present invention, by performing a touch function of a touch device using a pen in a portable terminal, a specialized experience can be provided, and precise operational control is possible. Further, because letters can be inputted by handwriting, user convenience can be improved, and because drawing images can be included in various applications, various effects of a portable terminal can be implemented. In addition, by adding a button in a pen, various inputs of a portable terminal are capable of calling a certain application and generating a certain command of the portable terminal independently of operational control of an application executed in the portable terminal. Therefore, by performing an input function using a pen in a portable terminal, a pen-specialized handwriting experience is extended to general mobile use, through which a specialized experience using a pen can be provided, which has not been possible before.

[0010] Another aspect of the invention provides a computer program comprising instructions arranged, when executed, to implement a method and/or apparatus in accordance with any one of the above-described aspects. A further aspect provides machine-readable storage storing such a program.

Brief Description of the Drawings

[0011] The objects, features and advantages of the present invention will be more apparent from the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates an implementation of a portable terminal according to an exemplary embodiment of the present invention;

FIG. 2 illustrates a pen setting procedure according to the exemplary embodiment of the present invention;

FIGS. 3A and 3B illustrate screens displayed in a display unit in the process of performing a pen setting procedure as in FIG. 2;

FIG. 4 is a flowchart illustrating a procedure for controlling an operation of an application executed in a portable terminal using a pen according to the exemplary embodiment of the present invention;

FIG. 5A illustrates an example of a form for a general input of a first input according to the exemplary embodiment of the present invention, and FIG. 5B illustrates an example of a form of a second input according to the exemplary embodiment of the present invention;

FIG. 6 is a flowchart illustrating a procedure for processing a first input performed in FIG. 4;

FIG. 7 illustrates a procedure for processing a general input of a first input processed in FIG. 6;

FIG. 8 illustrates a procedure for writing a document using a pen according to the exemplary embodiment of the present invention;

FIG. 9A illustrates a handwriting pad as a handwriting input method editor (IME) displayed in a letter writing application, and FIG. 9B illustrates a method for correcting handwritten letters and documents in a document writing application;

FIG. 10 illustrates a procedure for processing a drawing input in the exemplary embodiment of the present invention;

FIGS. 11A to 11G illustrate an example of performing a drawing mode as in FIG. 10;

FIG. 12 is a flowchart illustrating a procedure for processing a second input according to the exemplary embodiment of the present invention;

FIGS. 13A and 13B illustrate an example processed while performing a procedure as in FIG. 12;

FIGS. 14A to 14C illustrate a rich memo list of a portable terminal and a procedure for controlling the list according to the exemplary embodiment of the present invention;

FIG. 15A illustrates an example of a rich memo according to the exemplary embodiment of the present invention, and FIG. 15B illustrates an example of a drawing pad used in a rich memo;

FIG. 16 illustrates a quick memo list included in a rich memo according to the exemplary embodiment of the present invention;

FIG. 17 illustrates an exemplary embodiment of a pad for generating a quick memo in a quick memo list of FIG. 16; and

FIG. 18 illustrates a method for selecting a quick memo application according to the exemplary embodiment of the present invention.

Detailed Description of the Invention

[0012] Preferred embodiments of the present invention are described with reference to the accompanying drawings in detail. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. The same reference numbers are used throughout the drawings to refer to the same or like parts. Detailed descriptions of well-known functions and structures incorporated herein may be omitted to avoid obscuring the subject matter of the present invention. Also, terms described herein, which are defined considering the functions of the present invention, may be implemented differently depending on user and operator's intention and practice. Therefore, the terms should be understood on the basis of the disclosure throughout the specification.

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The principles and features of this invention may be employed in varied and numerous embodiments without departing from the scope of the invention.

[0013] Furthermore, although the drawings represent exemplary embodiments of the invention, the drawings are not necessarily to scale and certain features may be exaggerated or omitted in order to more clearly illustrate and explain the present invention.

[0014] Among the terms set forth herein, a terminal or portable terminal refers to any kind of device capable of processing data which is transmitted to or received from any external entity. The terminal may display icons or menus on a screen to which stored data and various executable functions are assigned or mapped. The terminal may include a computer, a notebook, a tablet PC, a mobile device, and the like.

[0015] Among the terms set forth herein, a pen refers to a pointer device for interacting with a touch screen, touch panel or other form of touch input within a portable terminal. Preferably such a pen has provides for finer control of the touch panel than is possible with a finger, by ensuring that the pen has a smaller tip for touching the touch panel than a fingertip. As will be explained below, certain embodiments of the invention include a pen having a button arranged to set the pen into either a first input state or a second input state. The input states may relate to first and second levels of electricity within the pen, which may be provided proximal to the pen tip. In certain embodiments the portable terminal touch panel may include an array of sensors arranged firstly to detect the presence of a pen touching the touch panel and secondly to distinguish between the electricity levels of the first and second input states in order to generate first and second input signals to be supplied to a portable terminal controller.

[0016] Among the terms set forth herein, a portable apparatus refers to a combination of a portable terminal including a touch panel and a pen as described above. Alternatively, the pen may be viewed as part of the portable terminal itself, in which case reference may be made solely to a terminal or portable terminal including a pen and a touch panel.

[0017] Among the terms set forth herein, a screen refers to a display or other output device which visually displays information to the user, and which optionally is capable of receiving and electronically processing tactile inputs from a user using a pen, a stylus, a finger of the user, or other techniques for conveying a user selection from the user to the output devices.

[0018] Among the terms set forth herein, an icon refers to a graphical element such as a figure or a symbol displayed on the screen of the device such that a user can easily select a desired function or data. In particular, each icon has a mapping relation with any function being executable in the device or with any data stored in the device and is used for processing functions or selecting data in the device. When a user selects one of the displayed icons, the device identifies a particular function or data associated with the selected icon. Then the device executes the identified function or displays the identified data.

[0019] Among terms set forth herein, data refers to any kind of information processed by the device, including text and/or images received from any external entities, messages transmitted or received, and information created when a specific function is executed by the device.

[0020] Among the terms set forth herein, first and second input states refer to an input state selected at the pen according to whether the pen button is pressed (second input state) or not pressed (first input state). A touch input refers to physical contact being made between the pen and the touch panel (pen touch) or between a hand or finger and the touch panel (hand touch or finger touch). Alternatively, a touch input may refer to the pen, hand, finger etc. approaching the touch panel without physical contact being made. First and second input signals refer to signals generated by the touch panel and supplied to a portable terminal controller in response to a pen touch according to whether the first or second input state is selected through the pen button. First and second input refers to a final user input determined by the processor in response to first and second input signals supplied by the touch panel and taking into account properties of the first and second input signals relating to movement of the pen relative to the touch panel.

[0021] The present invention discloses a device and method for performing a certain function or command according to a pen touch in a portable apparatus comprising a pen and a portable terminal having a touch device (for instance, a touch screen which may also be described as a touch display or a touch panel). Here, the portable terminal can include a mobile phone, a multimedia device like an MP3 player, and a tablet PC, etc. As noted above, in certain embodiments of the invention there may be provided a portable terminal which includes a pen. The pen may be a separable or detachable component of the portable terminal. However, in the present specification reference will be made to a portable apparatus comprising a portable terminal and a pen. Further, in an exemplary embodiment of the present invention, a pen can generate different kinds of input signals by having a button or a means and/or any other known devices, components, and methods having a function similar to that of a button. In the explanation below, a first input is determined by a portable terminal controller in response to a first input signal generated by a touch panel when a pen is in a first input state, and a second input is determined by the portable terminal controller in response to a second input signal generated by the touch panel when the pen is in a second input state where a button is pushed. It will be understood that the pen button may be pressed and released to transition between the first and second input states or the second input state may relate to the pen button being pressed and held pressed. Further, in the explanation below, a document writing mode refers to a mode for converting a user's handwritten letter

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inputs into letter data, and a drawing mode refers to a mode for converting a user's handwritten drawing inputs into an image. At this time, letters handwritten in the drawing mode can be converted into letter data when a recognition command is generated.

[0022] FIG. 1 illustrates an implementation of a portable apparatus comprising a portable terminal 100 and a pen 10 according to the exemplary embodiment of the present invention.

[0023] Referring to FIG. 1, the portable apparatus includes a pen 10 according to the exemplary embodiment of the present invention which comprises a button 11, a head 12, and a body made of, for example, aluminium, etc. Here, the head 12 is made of insulating material (e.g., silicone rubber or any known conductive material), and can contain a component known in the art that can generate an electrical field of different magnitudes depending on whether the button 11 has been pushed. Specifically, the pen 10 has a first input state in which the button 11 is not pressed in which at least part of the pen has a first level of electricity and a second input state in which the button 11 is pressed in which at least part of the pen has a second level of electricity. By "level of electricity" it is meant that the component within the pen 10 carries different levels of electrical charge according to whether the button 11 is pressed. Consequently, at least part of the pen 10 can be charged to a different electrical potential in the first and second input states. This difference in electrical potential can be detected by a sensor within a touch panel 120 of the portable terminal, and used to generate a first or second input signal accordingly. As will be described below, the first and second input signals are characterised by further properties relating to movement of the pen 10 relative to the touch panel 120.

[0024] The portable terminal 100 includes a touch panel 120 which can be a touch device of a capacitive-sensor type and electromagnetic type known in the art, and can be implemented integrally with a display unit 130. In addition, the touch panel 120 can be comprised of an electromagnetic touch device and a capacitive touch device. In such case, the electromagnetic touch panel is to be operated as a touch panel for the pen and thus a current is applied on the touch panel causing resonance and thereby current induced by a touch (i.e. a contact) from the pen, can be measured. Then, the control unit 110 determines whether a touch has been detected and location of the touch, in case the touch is detected, according to a touch signal of the pen from the touch panel 120. Moreover, the control unit 110 can detect a contact (i.e. a touch) from a finger of the user via the capacitive touch panel. Thus, the control unit 200 detects the touch input from the finger and the pen via independently operating touch panels. As a result, the control unit 200 can simultaneously receive the two touch inputs. In the following descriptions, the touch panel 120 can either be the capacitive touch panel or the electromagnetic touch panel.

[0025] The touch panel 120 according to the exemplary embodiment of the present invention should be able to distinguish and sense touch inputs of the pen 10 and a user's finger, etc. The touch panel 120 is able to distinguish between a pen touch when the pen is in the first input state and a pen touch when the pen is in the second input state, and generate first and second input signals accordingly, by sensing the electrical potential of the component within the pen through its interaction with the sensors within the touch panel. In certain embodiments the touch panel may be able to distinguish between a pen touch and a finger touch through changes at the sensors. The display unit 130 displays operation screens of applications executed in the portable terminal 100.

[0026] A memory 140 stores an operation program of the portable terminal 100 and programs according to the exemplary embodiment of the present invention for implementing the present invention as described herein, and stores functions or commands that should be operated according to the input state of the pen 10 in the exemplary embodiment of the present invention. A controller 110 controls general operation of the portable terminal 100 and analyses different types of input signals received from the touch panel 120 according to the exemplary embodiment of the present invention and processes a corresponding function or command. Further, the controller 110 includes a letter recognition processing unit, recognizes handwritten letters written in the document writing mode, and recognizes handwritten letters when a handwritten letter recognition command is generated in the screen of the display unit 130 and/or touch panel 120. Further, the controller 110 includes an image processing unit, and generates a new image by combining a drawn or handwritten image with a screen image being displayed. Further, the controller 110 includes a crop processing unit, and if the user draws a closed curved line and generates a crop command, the image in the closed curved line is cropped and processed.

[0027] The communication unit 150 performs a communication function of the portable terminal 100. Here, the communication unit 150 can be a CDMA, WCDMA or LTE type communication unit which wirelessly communicates with a public switched telephone network (PSTN), can be a communication unit of WiFi, WiMax WiBro type connected to a wireless Internet network, and/or can be a Bluetooth compatible device which can perform wireless communications with a short range device, and a communication unit of a near field communication (NFC) or RFID type. The communication unit 150 can include at least one of the above example communication units, and can also include any other known types of communication units. The audio processing unit 160 processes audio signals of the portable terminal 100, and processes video signals of the portable terminal 100. Alternatively, a video processing unit 170 may be included and connected to the portable terminal 100 for processing any video signals.

[0028] The pen 10 includes a body which may be composed, for example, of aluminium, which allows an electric current flowing in a human's body to reach the surface

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of a device, a head 12 made of any known insulating material, such as silicone or silicone rubber, which spreads; that is, capable of being deformed, so that electricity can be detected in an area larger than a certain predetermined minimum area. Further, the pen 10 includes a button 11, and can have a configuration which can generate electricity of different magnitudes depending on whether the button 11 has been pushed. That is, in the state where a person is in contact with the pen; for example, the state where a person is holding the pen 10, the pen 10 can generate electricity, and at this time, the pen 10 can be implemented with known components to generate electricity of a first magnitude in the state where the button 11 has not been pushed, and the pen 11 can be implemented with known components to generate electricity of a second magnitude in the state where the button 11 has been pushed.

[0029] In the portable terminal 100 having the above configurations and implementations, the touch panel 120 includes a touch sensor, and if electricity is sensed in an area larger than a certain predetermined minimum area, the touch sensor recognizes the contact with the touch panel 120 as a touch. For example, the "GALAXY S series", "GALAXY note" and "GALAXY NEXUS" devices, which are electronic devices with touch screens, commercially available from "SAMSUNG", recognize a touch when the sensed area is larger than 2.5mm (length) X 2.5mm (breadth), the "IPHONE", an electronic device commercially available from "APPLE CORPORATION", recognizes a touch when the sensed area is larger than 3mm X 3mm, and the "VEGA X", an electronic device commercially available from "PANTECH", recognizes a touch when the sensed area is larger than 5mm X 5mm. Further, in the case of the touch panel 120, the pen's head-contacting area is different from the finger-contacting area. That is, the contacting area of the pen 10 is relatively smaller than a typical finger-contacting area of most users of the portable terminal 100, and thus the controller 110 can sense and distinguish the input signal received from the touch panel 120 as a pen touch input or a finger touch input depending on the size of the contact area. Further, the pen 10 can generate electricity of different magnitudes depending on whether the button 11 has been pushed. Hence, changes of electricity sensed through the touch panel 120 can be different, and the controller 110 can sense a pen input depending on whether the button 11 has been pushed according to the changes of electricity.

[0030] Further, when constituting the touch panel 120, a touch sensor for sensing a finger touch and a touch sensor for sensing a touch of a pen 10 can be independently implemented. The contact area and/or magnitude of the electricity according to a touch by a finger and a pen can be different, and thus the controller 110 can sense a change of electricity generated from each touch sensor, and sense and distinguish a touch of the finger or the pen 10.

[0031] In the explanation below, a signal generated by the touch panel 120 in the state where the button 11 of a pen 10 has not been pushed (button off state) is called a first input signal, and a signal generated in the state where the button 11 has been pushed (button on state) is called a second input signal. In the exemplary embodiment of the present invention, the first input signal can be processed by the controller based upon properties of how the pen 10 moves relative to the touch panel 120 into a general first input such as a tap, a long press and a flick, handwriting, drawing and a crop, and there can be an input which performs a function that is set for the corresponding application. Further, the second input signal can be processed by the controller to determine a second input of a command which performs a certain function in the portable terminal 100, and can be generated by a hand gesture in the state where the button 11 of the pen 10 has been pushed. That is, the second input can be a long press in the state where the button 11 of the pen 10 has been pushed, a double tap (click), a flick (horizontal, vertical), and a certain form of a gesture (e.g., a movement which approximates the shape of a circle and a quadrangle, etc.). The second input may overlap a general input of the first input. The memory 140 can include a mapping table for functions and commands according to the first input and the second input, and the controller 110 can perform a function or command according to the first or second input in an application currently in operation with reference to the memory 140 when generating the first or second inputs.

[0032] In order to efficiently process an input signal resulting from use of the above pen 10, the controller 110 can perform a pen input setting operation. FIG. 2 illustrates a pen setting procedure according to the exemplary embodiment of the present invention. Further, FIGS. 3A and 3B illustrate screens displayed in the display unit 130 in the process of performing a pen setting procedure as in FIG. 2.

[0033] Referring to FIGS. 2, 3A and 3B, in the state where a screen 311 as shown in FIG. 3A is displayed, if a pen setting mode is selected, the controller 110 senses the pen setting mode in step 211. If no pen setting mode is detected in step 211, the method proceeds to step 250 to perform a corresponding function. However, if a pen setting mode is detected in step 211, the method displays a screen 313 as shown in FIG. 3A in step 213. The function, which can be set for the pen setting mode, can set a shortcut, a user touch area and a handwriting pad. First, the shortcut is defined as a function for quickly executing a certain application, the preferred hand side is defined as an area of the touch panel 120 where pen touches mainly occur, and the pen detection is for setting whether to turn on the handwriting when executing an application for performing a letter input.

[0034] At this time, if the user selects shortcut settings, the controller 110 senses the selection in step 215, and displays a menu of application items which can perform a shortcut function 315 as shown in FIG. 3A in step 217. FIG. 3A displays examples of memo items; for example,

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an "S memo" function is a rich memo function capable of writing various memos using the pen 10 in the portable terminal 100, with a rich memo being an electronic memo which can combine a handwriting, a drawing, an audio file, and an image, etc., and a "quick memo" function is a handwriting memo function. Hence, a user of the portable terminal 100 of the present invention can select one of the items or functions displayed in the menu 315, and if an item is selected, the controller 110 senses the selection in step 219, and registers the selected item as a shortcut in step 221; otherwise, in step 219, if no item is selected, the method loops back to continue to display items or functions to be selected in step 217. The shortcut function can be mapped with one of the second inputs determined by the controller 110 when the pen 10 is in the second input state as described above. The actions 317 shown in FIG. 3A may include the double click second input, and an example of the case of being set to a quick memo has been used as the default value of the shortcut. After step 221, the method checks in step 235 if a terminate command is entered. If so, the method ends; otherwise, the method loops back to continue displaying a setting item in step 213.

[0035] Further, if no shortcut is detected in step 215 to have been set, the method checks for the selection of a touch area setting, and if a user selects a touch area setting to be a preferred hand side instead of a touch area mode, the controller 110 senses the selection in step 223, and displays a touch area item in step 225. This is a function that is applied to the entire portable terminal 100, and is for separately recognizing touch areas for right-hand users and left-hand users according to the gradient of a pen 10 when the user uses the pen 10. At this time, if the user selects a touch area item to be right-handed or left-handed, the controller 110 senses the selection in step 227, and determines the touch area of the touch panel 120 according to the selected item in step 229. That is, the controller 110 checks whether the user is right-handed or left-handed, and then sets the touch area in the touch panel 120 according to the result of the selection, and the recognition ability for the set touch area is enhanced than that for other areas. After step 229, the method proceeds to step 235. However, if no touch area item is selected in step 227, the method loops back and continues to display the touch area item in step 225.

[0036] Further, if the user has set the touch area mode in step 223, the method checks if a pen detection mode has been set in step 231. If so, the method proceeds to step 235. Otherwise, if a user is to select a pen detection mode, the controller 110 senses the selection in step 231, and displays a message to set the on or off state of the pen detection mode and to determine whether or not to display a handwriting pad based on the on or off state, in step 233. Further, if the user selects the pen-off state at step 233, the portable terminal 100 is set to display an IME, such as a last IME screen which has been used before in the text input mode of the portable terminal 100, and if the user selects the pen-on state at step 233, the portable terminal 100 is set to display the handwriting pad at the text input mode of the portable terminal 100. Here, the text input mode of the portable terminal 100 can be a mode for executing an SMS or other text message application, an e-mail application, or a messenger application, etc. At this time, in case the text input mode is performed in the state where the pen detection mode is off, the controller 110 displays the previous IME in the display unit 130. If a hand touch is sensed as shown in the screen 331 in FIG. 3B, in the state where the pen detection mode is on, the controller 110 analyses the previous IME, and if the mode is a QWERTY mode, the screen 333 is displayed by the display unit 130, but if the mode is a 3*4 keypad mode, the screen 335 is displayed by the display unit 130, as shown in FIG. 3B. If the touch of the pen 10 is sensed on the screen 341 shown in FIG. 3B, the controller 110 displays a handwriting pad 343. In the handwriting pad, the user writes letters using the pen 10 in the area 355, and the written letters are recognized and are displayed in the area 351. Further, the user can write sentences using items such as soft keys, displayed in the area 353 while performing a handwriting operation.

[0037] After performing the pen setting mode as in FIG. 2, if the user terminates the pen setting mode, the controller 110 senses the action and terminates the pen setting mode in step 235 of FIG. 2.

[0038] After performing the pen setting mode, the user can perform or control operation of the portable terminal 100 using the pen 10. FIG. 4 is a flowchart illustrating a procedure for performing or controlling an operation of the portable terminal 100 using the pen 10 according to the exemplary embodiment of the present invention.

[0039] Referring to FIG. 4, an input signal can be generated by the touch panel 120 of the portable terminal 100 in response to a touch input by touching the touch panel with the pen 10 or using a finger. At this time, if the touch input is by the pen 10 (a pen touch), the touch panel 120 generates an input signal, which is supplied to the controller 110 to determine the input in step 411. If no touch input is sensed by the touch panel 120, the method loops back to step 411 to continue checking for touch inputs. Once a touch input is sensed, the controller 110 checks in step 413 whether the input is a pen input. If not, the method determines that the touch input is not a pen input, and processes the inputs as hand or finger touches. Otherwise, the controller determines in step 413 that the input is a pen input, and checks whether the input is the first input of the pen 10 or the second input of the pen 10, as defined herein, in step 415. Here, the first input is determined by the controller 110 when the touch panel 120 generates a first input signal in response to a touch input in the state where the button 11 of the pen 10 has not been pushed. The second input is determined by the controller 110 when the touch panel 120 generates a second input signal in response to a touch input in the state where the button 11 of the pen 10 has been pushed. At this time, if the input is the first input, the controller 110

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analyses a first input signal from the touch panel in step 417 and performs a corresponding operation according to the analysed result in step 419. The method then loops back to step 411. If the input is the second input in step 415, the controller 110 analyses the second input signal from the touch panel in step 421, and performs a corresponding command according to the analysed result in step 423. The method then loops back to step 411.

[0040] FIG. 5A illustrates an example of a form for a general input of a first input according to the exemplary embodiment of the present invention, and FIG. 5B illustrates an example of a form of a second input according to the exemplary embodiment of the present invention.

[0041] As shown in FIG. 5A, the first input can be a general input as in FIG. 5A, and a handwriting, a drawing and a crop, etc. A tap in the general input of the first input is a function for selecting an item in the application in operation, a long press is a function for displaying a contextual pop-up, and a flick is a function for moving to a next page or a previous page or scrolling up or down according to a right or a left direction, or an upward or a downward direction.

[0042] As shown in FIG. 5B, the second input is a hand gesture according to a touch of the pen 10 in the state where the button 11 has been pushed, and can be set to a command for performing a certain function of the portable terminal 100. That is, as illustrated in FIG. 5B, in the second input, a double click is moved to a memo mode. In the pen setting mode of FIG. 2, in the case where a quick memo is set as a shortcut function, the double click of the second input is set as a command for performing the shortcut. The double click is used as a command for performing the memo function. Further, in the above second input, the long press can be used as a screen capture command in the image processing mode, e.g., a mode for displaying moving pictures, such as a camera mode and an image display mode, etc. A flick can be used as a back or menu call command according to the horizontal or vertical direction of the movement of the user's hand performing the flick, and a round form input approximating a circle can be used as a command for moving to a home screen. That is, the second input can be used as an input for a command to perform a certain function in the state where an arbitrary application is performed in the portable terminal 100, and can be used as a command for directing the portable terminal 100 to perform a pre-set operation e.g., a screen capture, while a certain application is performed.

[0043] Here, the general input of the first input and the second input can use the same format. For example, the format can be a long press and a flick, etc.

[0044] FIG. 6 is a flowchart illustrating a procedure for processing a first input performed at step 417 of FIG. 4.

[0045] Referring to FIG. 6, if the first input of the pen 10 is sensed by the touch panel 120, the controller 110 analyses the first input signal generated by the touch panel 120 in step 611 to determine the first input. The first input according to the exemplary embodiment of the present invention can be a general input as in FIG. 5A, a handwriting letter in the document writing mode, a drawing in the drawing mode, and a crop in the image-displaying mode, etc. However, the first input of the pen 10 can be further extended in addition to the above input. In the explanation below, a general input, a first input in the document writing mode, a drawing input and a crop input, etc. will be considered in order.

[0046] First, if the first input is a general input as in FIG. 5A, the controller 110 senses the general input in step 613, and processes the general input in step 615. The method then returns to complete step 419 in FIG. 4. FIG. 7 illustrates a procedure in greater detail for processing a general input of a first input processed in FIG. 6.

[0047] Referring to FIG. 7, if a tap input is generated, the controller 110 selects an item touched in the currently executed application by checking if the item is touched with a tap input in step 711, and if so, processing the function of the selected item in step 713, and the method returns to step 615 in FIG. 6. Further, if a tap is not input in step 711, if a long press is sensed as determined in step 715, the controller 110 calls a pre-set menu to be displayed as a contextual pop-up for a related function in the corresponding application in step 717, and the method returns to step 615 in FIG. 6. Further, if no long press is detected in step 715, if a flick is generated, the controller 110 senses the flick generation in step 719, and performs a function which is set according to the flick direction in step 721, and the method returns to step 615 in FIG. 6. Otherwise, in step 719, if no flick is detected, the method returns to step 615, in FIG. 6. At this time, if the flick is sensed as a horizontal direction, the controller 110 moves from the current page to the previous or next page, and if the flick is sensed as vertical direction, the controller 110 scrolls up or down the screen. FIG. 7 assumes the case where a general input of the first input is set as in FIG. 5A, but a different function can be performed according to the result of the mapping between the general input and the input type. Further, the case where the form of a general input is a tap, a long press and a flick has been described as an example, but a different form of a general input can be further added.

[0048] Secondly, referring back to FIG. 6, if no general input is detected in step 613, if the first input is a handwriting and the current application is in the document writing mode, the controller 110 senses the mode in step 617, and recognizes and processes handwritten letters in step 619. FIG. 8 illustrates a procedure for writing a document using the pen 10 according to the exemplary embodiment of the present invention. FIG. 8 illustrates an operation performed at step 619 of FIG. 6.

[0049] Referring to FIG. 8, the document writing mode can be performed in an application such as an SMS, an e-mail and a messenger application, etc. as explained above. In such a case, if the controller 110 senses that the pen 10 is touched or approaches the touch panel 120 within a certain distance, the controller 110 displays, in step 811, the handwriting pad as in FIG. 9A in the display

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unit 130. As shown in FIG. 9A, the handwriting pad comprises a second display area 355 that displays letters written by the pen 10, a first display area 351 that recognizes written letters and displays the letters, and an area that displays soft keys which are necessary for handwriting.

[0050] Here, the area 911 labelled "Symbol" is a functional key for calling special letters, and displays a combination of letters such as Roman characters, mathematical symbols, and special symbols, etc. The area 913 labelled "Voice" performs a function for inserting a voice or other audible sounds in the document writing mode, and the area 915 which displays, for example, a compass or gear symbol, is an area where a setting function is performed to specify and save user-customized settings of the portable terminal 100. Further, the area 917 labelled, for example, "English", is an area for selecting a language, and if the user long-presses or clicks on the area 917, available languages are displayed in a contextual pop-up. At this time, the pop-up screen displays items of available languages such as English, French and Korean, etc. Further, the IME area 919 labelled "IME" is an area that changes the document writing pad, and in the state where the handwriting pad as in FIG. 9A is displayed, if the IME is selected, a QWERTY keypad or 3*4 keypad is displayed as shown in the area 335 of FIG. 3B. Further, the area 921 with the backspace or delete symbol is an area for performing a back space function, and if the area is selected, the controller 110 moves the current position of the cursor, for example, in a horizontal backward direction. The area 923 with the Enter or Return symbol is an enter key area, and performs an enter key function of a document being written. At this time, in case the enter key area is touched, the controller 110 performs an inserting operation if there is a text in the second display area 355, and in case there is no text in the second display area 355 and the area is multi-lined, an enter key operation is performed, while in case there is no text and the area is not multi-lined, a "done" function is performed, and in the case of an e-mail, if there is no text in the URL input window, a "go" function is performed.

[0051] In the state where the handwriting pad is displayed as in FIG. 9A, the method in FIG. 8 performs step 813 after step 811, in which the controller 110 displays handwriting letters in the second display area 815, when the user can generate handwritten letters in the second display area 355. Then the controller 110 senses the handwritten letters generated according to the movement track of the pen 10 through the touch panel 120, displays the letters in the second display area 355, recognizes handwritten letters displayed in the second display area 353 and displays the letters in the first display area 351 in step 815. At this time, the recognition method can use a completed recognition method known in the art, in which entered symbols are recognized in word units, or a stroke recognition method known in the art. Further, in case a wrong recognition occurs in the process of writing and recognizing a document as explained above, the controller 110 can display a recommended letter on the bottom of the first display area 315, or alternatively in an area which is set in a certain position of the handwriting pad, and if the user selects the displayed letter, the controller can insert the selected letter in the position of the corresponding letter of the first display area 351.

[0052] However, in case a wrong input of the user occurs or a wrong recognition occurs in the process of recognizing a letter, a user's correction is necessary. At this time, referring again to FIG. 8, after step 815, if there is a user's request for correction, the controller 110 senses the request in step 817, re-recognizes and corrects the handwritten letters inputted according to the user's document correction request in step 819, and loops back to step 813. At this time, it is desirable for the above amendment of the letters to be directly corrected by the user's handwriting in the second display area 355. FIG. 9B illustrates a method for correcting letters according to the exemplary embodiment of the present invention. Further, the document correction is performed by the user handwriting general document correction letters.

[0053] Referring to FIG. 9B, letters incorrectly inputted by the user are corrected by overwriting the incorrectly inputted letters displayed in the second display area 355. For example, in case "US" is intended to be corrected to "UK" as shown in the area 931 of FIG. 9B, which is displayed in the second display area 355, the letter "K" is handwritten over the letter "S" as displayed in the second display area 355. In such a case, the controller 110 recognizes the overwritten letter in the second display area 355 as a letter correction, and thus changes the previously written letter to the later written letter and displays the corrected letters in the first display area 351. Further, when writing a document, in case a line or a word is intended to be deleted, as shown in the area 933 of FIG. 9B, the user can draw a line, for example, from right to left on the corresponding letters displayed in the second display area 355. In such a case, if the controller 110 recognizes a line drawn from right to left, the controller 110 deletes the letters positioned in the line and displays the result in the first display area 351. In the method as described above, if line drawing from right to left on the written letters is sensed in the area 935 of FIG. 9B, the controller 110 makes a space between the previous letter and the corresponding letter, and if the written letter is connected to the letter as shown in the area 937 of FIG. 9B, the controller 110 removes the space between the letters. If line drawing of an entered shape is sensed as shown in the area 939 of FIG. 9B, the controller 110 performs a line changing function in the corresponding position, and if a gull-type touch occurs as shown in the area 941 of FIG. 9B, the controller 110 deletes letters written in the position of the gull-type touch. Further, if a long press occurs on the written letters as shown in the area 943 of FIG. 9B, the controller 110 displays words for correcting the letters on the pressed position, and if the user selects a displayed word, the word is selected.

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For example, if the letters displayed in the second display area 355 are "cook" and a long press of a pen 10 is sensed on the letters, the controller 110 displays words that can be substituted (e.g., "cook", "book" and "cool", etc.) in the pre-set position of the handwriting pad (e.g., the lower area of the first display area 351). Further, if a user-desired word is clicked on (tapped), the controller 110 substitutes the user-selected word with the long-pressed word.

[0054] As described above, letters handwritten in the second display area 355 of FIG. 9A are recognized and are displayed in the first display area 351. At this time, referring back to FIG. 8, if a correction as in FIG. 9B occurs, the controller 110 senses the correction in step 817, and corrects written letters or documents according to the correction request (letter correction, sentence or word deletion, space addition, space deletion, line change, letter deletion, and letter change selection, etc.). At this time, the above amendment can be directly done on the letters displayed in the second display area 355, and the controller 110 can sense the input of the pen 10 according to the user's correction request and perform a document correction procedure. Hence, it is seen that the document correction procedure can be conveniently performed by a user using the portable terminal 100 with the touch panel 120 and the components and methods of the present invention.

[0055] If the above handwriting letter input and correction are performed, the controller 110 recognizes the input and correction, and displays the result in the first display area 351. Further, in the state where the above document writing mode is performed, if a termination command occurs, the controller 110 senses the generation of the termination command in step 821, and processes the written letters in step 823. At this time, the method of processing the above written letters varies depending on the document writing mode. That is, in the case of an SMS, the written document is transmitted to a pre-set phone number subscriber and at the same time, is stored in the memory 140. In the case of a memo, a corresponding memo (an alarm and schedule, etc.) can be stored in the memory 140 according to the user's designation. After step 823, the method returns to complete step 619 in FIG. 6, to return to complete step 419 in FIG. 4.

[0056] FIG. 8 illustrates a method of processing written letters of the first input in the state where a handwriting pad is displayed in the document writing mode, but even in the state where the handwriting pad is not displayed, it is possible to recognize handwritten letters as a document. In such a case, the controller 110 displays the handwritten letters in the display unit 130, and if the user generates a recognition command, handwritten letters being displayed can be recognized and be converted into a document.

[0057] Third, referring back to FIG. 6, in step 617, if a document writing mode is not detected, if a drawing of a first input through the pen 10 is sensed, the controller 110 senses the drawing at step 621 of FIG. 6, and senses and processes the drawing inputted through the pen 10 at step 623. FIG. 10 illustrates a procedure for processing a drawing input in the exemplary embodiment of the present invention, and illustrates the operation procedure of step 623 of FIG. 6. FIGS. 11A to 11G illustrate an example of performing a drawing mode as in FIG. 10.

[0058] Referring to FIG. 10, in the case of drawing, the user can select the drawing mode and perform a drawing operation, and can perform handwriting or drawing in a currently operated application. That is, as illustrated in FIG. 11A, in case the user intends to insert or add a drawing in a document written in the document writing mode, and then transmit the document, the user can enter the drawing mode in the application and can perform the drawing operation, and then insert or add the drawing in the document. Further, by performing a drawing operation in the image in the currently operated application, the drawing can be overwritten.

[0059] If the user selects an indication of a drawing pad to be used in the drawing mode, the controller 110 senses the selection in step 1011, the controller 110 temporarily stops the current application and displays the drawing pad in step 1013. For example, as shown in the screen 1111 of FIG. 11A, if a tap function is performed while writing an e-mail document, selectable items are displayed as shown in the screen 1113, and here, if the drawing is tapped (clicked) as a first input using the pen 10, the controller 110 displays the drawing pad as shown in the screen 1115. Thereafter, if the user draws on the drawing pad using the pen 10, the controller 110 senses the drawing through the touch panel 120 and displays the drawing in the display unit 130 as shown in the screen 1117 in step 1015. Thereafter, if the user terminates drawing (i.e., touches "done" on the screen 1117), the controller 110 senses the touch in step 1017, generates a drawing image as shown in the screen 1119 in step 1019, and process the image in step 1021. After step 1021, the method returns to complete step 623 in FIG. 6, to return to complete step 419 in FIG. 4.

[0060] That is, in case a drawing mode is selected while writing an e-mail as in FIG. 11A, the controller 110 displays the drawing pad as shown in the example screen 1115, and displays the user's drawing on the drawing pad. Thereafter, if the drawing is terminated, the controller 110 inserts the generated drawing in the e-mail message, and if the user selects a function such as a transmission function, a message including the drawing image is transmitted to the other person; that is, the e-mail recipient, and at the same time, is stored in the memory 140 of the sending user's portable terminal 100. As explained above, among applications that perform a drawing function using a drawing pad, as shown in FIG. 11C, a document writing application (a message application such as a message and an e-mail, etc.) provides a drawing pad which allows for drawing a picture while writing a message, and thus it is possible to transmit a picture along with a message. Further, as shown in FIG. 11D, an application which provides a handwriting pad (i.e., ap-

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plications where a text input is possible) can perform a drawing function where the user can directly handwrite on the touch panel 120 and display unit 130 displaying the screen in FIG. 11D.

[0061] Further, referring back to FIG. 10, in the case of applications which can perform drawing without using the drawing pad, in case that the user generates a drawing of a first input using the pen 10, the controller 110 senses generation of such a drawing without a drawing pad in step 1011, and proceeds to step 1023 to display the drawing generated from the user on the current screen. Thereafter, if the user terminates drawing, the controller 110 senses the termination in step 1025, generates a drawing image in step 1019, and processes the generated image according to the user's command in step 1021, and then the method returns to complete step 623 in FIG. 6, to return to complete step 419 in FIG. 4. However, in step 1021, if the drawing operation is not terminated, the method loops back to step 1023 to continue processing an input drawing.

[0062] There are some applications where drawing can be performed without using a drawing pad as explained above. For example, in the case of a currently executed multimedia application (e.g., a photo editor, a video maker and a gallery application, etc.), as shown in the example screens in FIG. 11B, the user can directly draw on a multimedia image displayed by the display unit 130, and generate an image to which the user's drawing has been added. Further, in the case of a memo application that provides a handwriting function (e.g., a quick memo and a rich memo application, etc.), as shown in the example screens in FIG. 11E, the user can generate a handwritten memo as an image and process the image. That is, handwritten letters written in the memo application can be generated as an image as in the drawing. Further, in an application displayed as an image (e.g., an e-book application), the user can directly perform handwriting and drawing such as writing notes and highlighting, etc. on the displayed image, as shown in the circled image and crossed-out text in the example screen shown in FIG. 11F, to generate a drawing image. Further, in an editable application (e.g., an editable screen capture application, etc.), as shown in the example screens in FIG. 11G, the user can generate a drawing image by directly writing on the screen, such as the annotation "Cool-!" and other markings shown in FIG. 11G. In such a case, a handwriting-editing-possible screen capture function can be provided, and the corresponding drawing function can be performed in all screens displayed in the portable terminal 100. For example, in applications which display an Internet-based surfing magazine screen and document screen, etc., the drawing can be performed in the screen, and the screen can be edited.

[0063] Fourth, referring back to FIG. 6, after no drawing mode is detected in step 621, in the state where an image is displayed in the screen, if the user draws on a certain location of a displayed image using a pen (drawing a circular or polygonal closed curved line) and selects a crop function, the controller 110 senses the selection in step 625, and crops the screen and processes the cropped screen in step 627. For example, in the state where an image such as a photograph is displayed in the display unit 130, if the user draws a closed curved line, selects a crop item and touches (tap or click) the item, the controller 110 recognizes an image crop, and captures and processes the image inside the closed curve. Further, the cropped screen can be stored in the memory 140, and can also be generated as a new image by inserting the image into or adding to another screen. After step 627, the method returns to complete step 419 in FIG. 4. However, referring back to step 625, if crop mode is not selected, the method performs a corresponding function in step 629 and returns to complete step 419 in FIG. 4.

[0064] As described above, in case a touch input is sensed by the touch panel 120 in the first input state where the button 11 of the pen 10 is not pushed, the touch panel 120 generates a first input signal which is received by the controller 110. The controller 110 determines that the input is the first input at step 415 of FIG. 4, and if the first input is determined, the controller 110 recognizes a general input, handwriting, drawing or crop operation according to the inputted form, and processes the corresponding application at steps 417 and 419. However, in case a touch input is sensed by the touch panel 120 in the second input state where the button 11 of the pen 10 is pushed, the touch panel 120 generates a second input signal which is received by the controller 110. The controller 110 determines that the input is the second input at step 415 of FIG. 4, and if the second input is sensed, the controller 110 processes the command according to the hand gesture of the second input in steps 421 and 423. Here, the other second inputs except a certain input (e.g., a long press) perform applications corresponding to the command regardless of the currently executed application.

[0065] As described above, the first input of the present invention is inputted without pushing the button 11 of the pen 10. The first input can provide all interactions done by fingers in the same manner with the pen 10. At this time, the first input can perform a pen-specialized function in the application.

[0066] FIG. 12 is a flowchart illustrating a procedure for processing a second input according to the exemplary embodiment of the present invention, and FIGS. 13A and 13B illustrate an example processed while performing a procedure as in FIG. 12.

[0067] Referring to FIGS. 4 and 12, if the second input is determined by the controller 110 in step 415, the controller 110 checks the second input and then analyses the form of the second input in step 421, and proceeds to step 1211. At this time, if the second input is a double click, the click is sensed in step 1213, and a pre-set application is called and processed in step 1215. At this time, the setting of the application can be a shortcut application which is set in the pen setting procedure as in

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FIG. 2. For example, in case the shortcut application is set to the quick memo, if a double click occurs in the state where the button 11 of the pen 10 is clicked as shown in the representation 1311 of the pen 10 followed by the double click operation 1321 of FIG. 13A, the controller 110 displays a quick memo, which is set as a shortcut 1323, shown in the display unit 130. The method then returns to complete step 421 and process the input command in step 423 in FIG. 4.

[0068] Further, referring to FIG. 12, if no double click is detected in step 1213, if the second input is a long press, the controller 110 senses the input in step 1217, and captures a screen displayed in the application currently in operation in step 1219. At this time, the application can perform additional applications for displaying the screen image. For example, as shown in the representation 1311 of the pen 10 followed by the long press operation 1321 of FIG. 13A, if a long press occurs in the state where the button 11 of the pen 10 is clicked on, the controller 110 captures the displayed image and displays the captured image 1323 in the display unit 130. The method then returns to complete step 421 and process the input command in step 423 in FIG. 4.

[0069] Further, referring to FIG. 12, if no long press is detected in step 1271, if the second input is a horizontal flick, the controller 110 senses the input in step 1221, and performs a command which has been set for the horizontal flick in step 1223. Here, in an exemplary embodiment of step 1223, the horizontal flick is performed from right to left, and the pre-set command has been set to perform a back function. In such a case, as shown in the representation 1311 of the pen 10 followed by the horizontal flick operation 1331 of FIG. 13B, if a flick is sensed from right to left in the state where the button 11 of the pen 10 has been clicked on, the controller 110 performs a "back" function represented by the operation 1333. The method then returns to complete step 421 and process the input command in step 423 in FIG. 4.

[0070] Further, referring to FIG. 12, if no horizontal flick is detected in step 1221, if the second input is a vertical flick, the controller 110 senses the input in step 1225, and performs a command which has been set for the vertical flick in step 1227. Here, in an exemplary embodiment, the vertical flick is performed from bottom to top, and the pre-set command is set to perform a menu call function. In such a case, as shown in the representation 1311 of the pen 10 followed by the vertical flick operation 1341 of FIG. 13B, if a flick is sensed from bottom to top in the state where the button 11 of the pen 10 has been clicked on, the controller 110 performs a "menu" call function represented by the operation 1343. The method then returns to complete step 421 and process the input command in step 423 in FIG. 4.

[0071] Further, referring to FIG. 12, if no vertical flick is detected in step 1225, if the second input is circle-shaped, the controller 110 senses the input in step 1229, and performs a command which is indicated within the circle on the touch panel 120 in step 1231. In an exemplary embodiment, the command, which is indicated within the circle-shaped second input, is a home screen call. The method then returns to complete step 421 and process the input command in step 423 in FIG. 4. However, in step 1229, of no circle shape is detected, the method proceeds to step 1234 to perform a corresponding command, and the method then returns to complete step 421 and process the input command in step 423 in FIG. 4.

[0072] As described above, the second input can be a hand gesture which is inputted in the state where the button 11 of the pen 10 has been clicked on, and the controller 110 analyses the sensed second input and performs each corresponding command. At this time, the second input can comprise an application call gesture such as a double tap and a long press, and a certain command execution gesture such as a right-to-left flick and a bottom-to-top flick, etc. The second input is a gesture input which is pre-set in the state where the button 11 of the pen 10 is pushed, and can improve the general usability of the pen 10, call applications such as a screen capture and a memo, etc. and perform a certain command such as "Back" and "Menu" by mapping the function of the hard key with the gesture of the pen 10 so that the use experience of the pen 10 can be continued.

[0073] Further, in the exemplary embodiment of the present invention, as described above, the first input and the second input are determined by the controller 110 in response to first and second input signals generated by the touch panel 120 in response to sensed pen touch inputs according to whether the button 11 has been pressed (and therefore whether the pen is in the first or second input state). The input state of the pen 10 is sensed by the touched panel through different magnitudes of changes of electricity of the touch panel 120 when the pen 10 touches the touch panel 120. That is, in the pen 10, the magnitude of generated electricity can be different depending on whether the button 11 is clicked or not, and such different magnitudes of electricity cause correspondingly different changes in electricity. In such a case, when the pen 10 is touched on the touch panel 120, different electricity changes are caused. Here, in the exemplary embodiment, the first input signal is generated by the touch panel 120 in the state where the button 11 of the pen 10 is not clicked on, and the second input signal is generated by the touch panel 120 in the state where the button 11 of the pen 10 is clicked on. However, even if the input signal generated by the touch panel 120 in the state where the button 11 of the pen is not clicked on is set to the second input, and the input signal generated by the touch panel 120 in the state where the button 11 of the pen is clicked on is set to the first input, the same operation can be performed.

[0074] In addition, in a portable terminal having a touch device, if a pen input function is used, various specialized services can be efficiently performed. One of such services is a memo function. The memo function of the portable terminal 100 of the present invention provides an

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integrated memo (a rich memo also called an s-memo) function which combines a letter, an image, a video and audio file, etc. Further, a portable terminal can used as a scheduler, and thus it is preferable that a quick memo function, capable of quickly performing a memo function, is added. Accordingly, the portable terminal 100 of the present invention, using the components and methods described herein, includes such a quick memo function.

[0075] FIGS. 14A to 14C illustrate a rich memo list of the portable terminal 100 and a procedure for controlling the list according to the exemplary embodiment of the present invention.

[0076] Referring to FIGS. 14A to 14C, FIG. 14A illustrates the rich memo as a list arranged by thumbnails, and FIG. 14B illustrates the rich memo as a list arranged by lists. Referring to FIG. 14A, the rich memo list 1411 illustrates the thumbnail items of the quick memo and rich memo as a list, and the feature of each item of the list can be defined by the settings as shown in the table 1413. Here, the quick memo button displays quick memos as one thumbnail, and rich memos are constituted respectively as corresponding thumbnails to constitute a list. In the state where thumbnail lists of the rich memo are displayed as a list 1411 of FIG. 14A, if a user menu is called, a menu 1421 of FIG. 14A is called, which may be a second input processed by steps 421-423 of FIG. 4. Here, the menu calling can be performed in response to a second input as described above, and as shown in FIG. 5B which shows different types of second input, in the state where the thumbnail list is displayed as the list 1411 of FIG. 14A, if the button 11 of the pen 10 is clicked on and is flicked from bottom to top, the controller 110 senses the flick as a menu call. Further, in the displayed menu 1421, if a corresponding item is clicked on (tap of the first input), the lists 1423, 1425, 1427 of the selected items is displayed.

[0077] The rich memo list of FIG. 14B has a form which is different from the form of the thumbnail list of FIG. 14A, and so the items 1451, 1453, 1461, 1463, 1465, 1467 of the rich memo list respectively correspond to the items 1411, 1413, 1421, 1423, 1425, 1427 of the thumbnail list shown in FIG. 14A.

[0078] FIG. 14C illustrates a procedure for selecting the rich memo and the quick memo according to the exemplary embodiment of the present invention. As shown in the thumbnail list 1481, if a quick memo button is clicked on (tap) in the thumbnail list screen 1481, a quick memo list 1491 is displayed. Further, as shown in the quick memo list 1491, in the state where such a quick memo list 1491 is displayed, if a second input of the horizontal flick (right to left) is generated using the pen 10, the controller 110 displays the thumbnail list 1481 of the rich memo. Further, in the state where the thumbnail list 1481 of the rich memo is displayed, if a second input of the vertical flick (bottom to top) is generated using the pen 10, the controller 110 calls a menu, and can display the list 1483 of the rich memo by the user's selection.

[0079] Further, in the state where either of a rich memo list 1481, 1483 is displayed, if the user clicks on the generation button using the pen 10, an example of a drawing pad 1485 is generated, and the user can write a rich memo through the drawing pad 1485. Further, for the quick memo list 1491, in the state where the quick memo list 1491 is displayed, if the user clicks on the quick memo (tap of the first input), the drawing pad 1493 or the text pad 1495 is generated, and the user can generate the quick memo as the drawing or text using the drawing pad 1493 or the text pad 1495.

[0080] FIG. 15A illustrates an example of a rich memo according to the exemplary embodiment of the present invention, and FIG. 15B illustrates an example of a drawing pad used in a rich memo.

[0081] Referring to FIGS. 15A and 15B, in the state where the list of the rich memo is displayed, if the user selects a certain rich memo thumbnail (or an item on the list), corresponding rich memos 1511 are displayed as shown in FIG. 15A. At this time, the rich memo has a structure 1513. Further, in the state of the rich memo 1511, if a menu is called by the second input as described above, a menu 1521 is called, and sub-menus 1523-1527 can be selected from the called menu 1521.

[0082] Further, in the state where a certain rich memo is displayed, if the user pushes a generation button, a drawing pad 1551 of FIG. 15B is displayed. Here, the drawing pad 1551 can have menu 1553 and various settings 1555. Using the menu 1553 and settings 1555, the user can add a title to the drawing which is drawn or to be drawn in the drawing pad 1551, such that the added title appears, for example, near the top of an updated drawing pad 1557 on the touch panel 120. Further, using the menu 1553 and settings 1555, the user can add a tag identifying the drawing which is drawn or to be drawn, such that the tag appears, for example, near the bottom of an update drawing pad 1559. In addition, the rich memo can perform an image generation in response to the drawing operation by the user, as well as performing an image insertion and an audio sound, etc. as well as a text memo. At this time, the method of writing the rich memo can be performed using the pen 10. Here, methods such as text writing, drawing and cropping of the first input can be used, and an operation of the rich memo application by the generation input can be controlled. Here, the handwriting of the rich memo can be performed in the drawing pad 1551, the handwritten letters can be processed as an image, and a recognition command can be generated and recognized through the menu. That is, the rich memo can be written through drawing and handwriting, etc. using the pen 10, and a video and/or audio file can be inserted into the written rich memo. Further, the handwritten letters can be converted into data by a recognition command and can be stored when necessary. Further, the written rich memo can be stored in the memory 140, and can be transmitted to an external device or an external subscriber through the communication unit 150.

[0083] FIG. 16 illustrates a quick memo list included in

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a rich memo according to the exemplary embodiment of the present invention. Quick memos are displayed as a thumbnail list, such as the example thumbnail list 1611, and when a second input of the menu call is generated, a menu 1613 is displayed and sub-menus 1615-1621 can be selected for performing functions on the thumbnail list 1611.

[0084] FIG. 17 illustrates an exemplary embodiment of a pad for generating a quick memo in a quick memo list of FIG. 16. Referring to FIG. 17, in a quick memo application, the user can write a quick memo using a drawing pad 1711 or a text pad 1723. Further, the user can call a menu through use of the pen 10, and the menu can be any of the menus 1725, 1727, 1729, 1731 providing various menu selections, functions, and settings.

[0085] Further, the quick memo application can be selected when performing a rich memo application, and a quick memo can be selected through the second input. That is, as described herein with reference to FIGS. 2 and 3A, the user can set an application which can perform as a shortcut function in the setting process. At this time, in case the quick memo is set by the shortcut application, the quick memo application can be selected as shown in FIG. 18. FIG. 18 illustrates a method for selecting a quick memo application according to the exemplary embodiment of the present invention. Referring to FIG. 18, in case the quick memo is set by a shortcut application, if a second input for selecting a quick memo, which set as a shortcut function, is determined in the state in which an arbitrary application is being executed using the screen 1811 (a double click in the state where the button 11 of the pen 10 is clicked on), the controller 110 displays a drawing pad 1813 for executing the quick memo application. Further, if the user writes a quick memo (drawing and/or handwriting) on the drawing pad 1813, the controller 110 displays the written quick memo in the drawing pad 1813. Further, the written quick memo is registered in the quick memo thumbnail list 1611 of FIG. 16.

[0086] The above-described apparatus and methods according to the present invention can be implemented in hardware, firmware or as software or computer code that can be stored in a recording medium such as a CD ROM, a RAM, a ROM, a floppy disk, DVDs, a hard disk, a magnetic storage media, an optical recording media, or a magnetooptical disk or computer code downloaded over a network originally stored on a remote recording medium, a computer readable recording medium, or a non-transitory machine readable medium and to be stored on a local recording medium, so that the methods described herein can be rendered in such software that is stored on the recording medium using a general purpose computer, a digital computer, or a special processor or in programmable or dedicated hardware, such as an ASIC or FPGA. As would be understood in the art, the computer, the processor, microprocessor controller or the programmable hardware include memory components, e.g., RAM, ROM, Flash, etc. that may store or receive software or computer code that when accessed and executed by the computer, processor or hardware implement the processing methods described herein. In addition, it would be recognized that when a general purpose computer accesses code for implementing the processing shown herein, the execution of the code transforms the general purpose computer into a special purpose computer for executing the processing shown herein.

[0087] Accordingly, embodiments provide a program comprising code for implementing apparatus or a method as claimed in any one of the claims of this specification and a machine-readable storage storing such a program. Still further, such programs may be conveyed electronically via any medium such as a communication signal carried over a wired or wireless connection and embodiments suitably encompass the same.

[0088] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

[0089] Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0090] Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

[0091] It will be also be appreciated that, throughout the description and claims of this specification, language in the general form of "X for Y" (where Y is some action, activity or step and X is some means for carrying out that action, activity or step) encompasses means X adapted or arranged specifically, but not exclusively, to do Y.

[0092] Although exemplary embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the scope of the present invention, as defined in the appended claims.

Claims

1. A portable apparatus comprising a portable terminal and a pen, the portable terminal comprising a controller, a touch panel, and a display unit:

   wherein the pen includes a button and the pen is arranged to be set to a first input state in which the pen generates a first level of electricity or to

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a second input state in which the pen generates a second level of electricity depending on whether or not the button has been pressed;
wherein the touch panel includes a touch sensor arranged to change electricity in response to being touched by the pen or the pen approaching the touch panel and according to the level of electricity generated by the pen, the touch panel being arranged to generate a first input signal or a second input signal depending upon the change in electricity;
wherein the controller is arranged to analyse the first or second input signal, to determine a first input or second input depending upon the first or second input signal, to perform a pre-set function corresponding to the first input in an executed application, and to call a pre-set application or perform a pre-set command corresponding to the second input;
wherein the display unit is arranged to display a screen processed according to at least one of the first input and the second input under the control of the controller; and
wherein the first input includes at least one of a general input that controls operation of the executed application, a handwritten letter and a drawing, and the second input is a command that calls a predetermined application and/or a command for execution of a predetermined operation.

2. The portable apparatus of claim 1, wherein in response to determining a first input the controller is further arranged to operate a drawing function to cause the display unit to display a handwriting pad when executing a document writing application, and to display a handwritten letter inputted in the handwriting pad, and recognizes and processes the handwritten letter.

3. The portable apparatus of claim 1 or claim 2, wherein in response to determining a first input the controller is further arranged to operate a drawing function to cause the display unit to display a drawing pad when selecting a drawing application, and to display the drawing of the first input in the drawing pad, to include the drawing image in the currently executed application, and process the drawing image when the drawing function is terminated.

4. The portable apparatus of claim 3, wherein in response to determining a first input the controller is further arranged to display a drawing in the current screen in response to the first input when the drawing occurs in an application which displays an image on the display unit, and when the drawing function is terminated the controller is further arranged to display an image including the drawing in the screen image.

5. The portable apparatus of any one of the preceding claims, wherein the controller is further arranged to analyse an input type in response to determining a second input, if the input type is an application call, to call and display an application corresponding to the application call, which is set for the corresponding second input, is called and displayed, and if the input type is a command, to perform the command, which is set for the corresponding second input.

6. An input method of a portable apparatus comprising a portable terminal and a pen, the portable terminal comprising a touch panel, the input method comprising:

generating by the pen a first level electricity in a first input state and a second level of electricity in a second input state depending on whether or not a button of the pen has been pressed;
generating by the touch panel a first input signal or a second input signal according to a sensed change in electricity of a touch sensor in response to the touch panel being touched by the pen or the pen approaching the touch panel and according to the level of electricity generated at the pen;
analysing the first or second input signal to determine a first input or a second input depending upon the first or second input signal;
performing a pre-set function corresponding to the first input in an application being executed;
calling a pre-set application or performing a pre-set command corresponding to the second input; and
displaying, on a display unit, a screen processed according to at least one of the first input and the second input under the control of the controller;
wherein the first input includes at least one of a general input that controls operation of the executed application, a handwritten letter and a drawing, and the second input is a command that calls a predetermined application and/or a command for execution of a predetermined operation.

7. The input method of claim 6, wherein performing a pre-set function corresponding to the first input comprises:

displaying, on a display unit, a handwriting pad when executing a document writing application;
displaying, on the display unit, a handwritten letter inputted in the handwriting pad; and
recognizing and processing the handwritten letter.

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8. The input method of claim 7, wherein recognizing the handwritten letter further comprises:

correcting the letter using a corresponding function if a first input for correcting a handwritten letter is generated.

9. The input method of claim 7 or claim 8, wherein the document writing mode is at least one of a text message, e-mail or messenger application.

10. The input method of any one of claims 6 to 9, wherein performing of a pre-set function corresponding to the first input further comprises:

performing a drawing function using the controller;
displaying, on the display unit, a drawing pad when selecting a drawing mode application;
displaying, on the display unit, the drawing of the first input in the drawing pad; and
including the drawing image in the currently executed application and processing the drawing image when the drawing function is terminated.

11. The input method of claim 10, wherein the application being executed is a letter writing application, and the generated drawing image is included in the written text message.

12. The input method of claim 10 or claim 11, wherein performing the pre-set function corresponding to the first input further comprises:

displaying the drawing of the first input inputted in the current screen image when the drawing occurs in the application which displays an image; and
generating an image including the drawing in the screen image when the drawing function is terminated.

13. The input method of any one of claims 6 to 12, wherein a general input of the first input includes at least one of a tap, a long press, a horizontal flick and a vertical flick, and when the general input occurs, the application being executed performs a function corresponding to the general input.

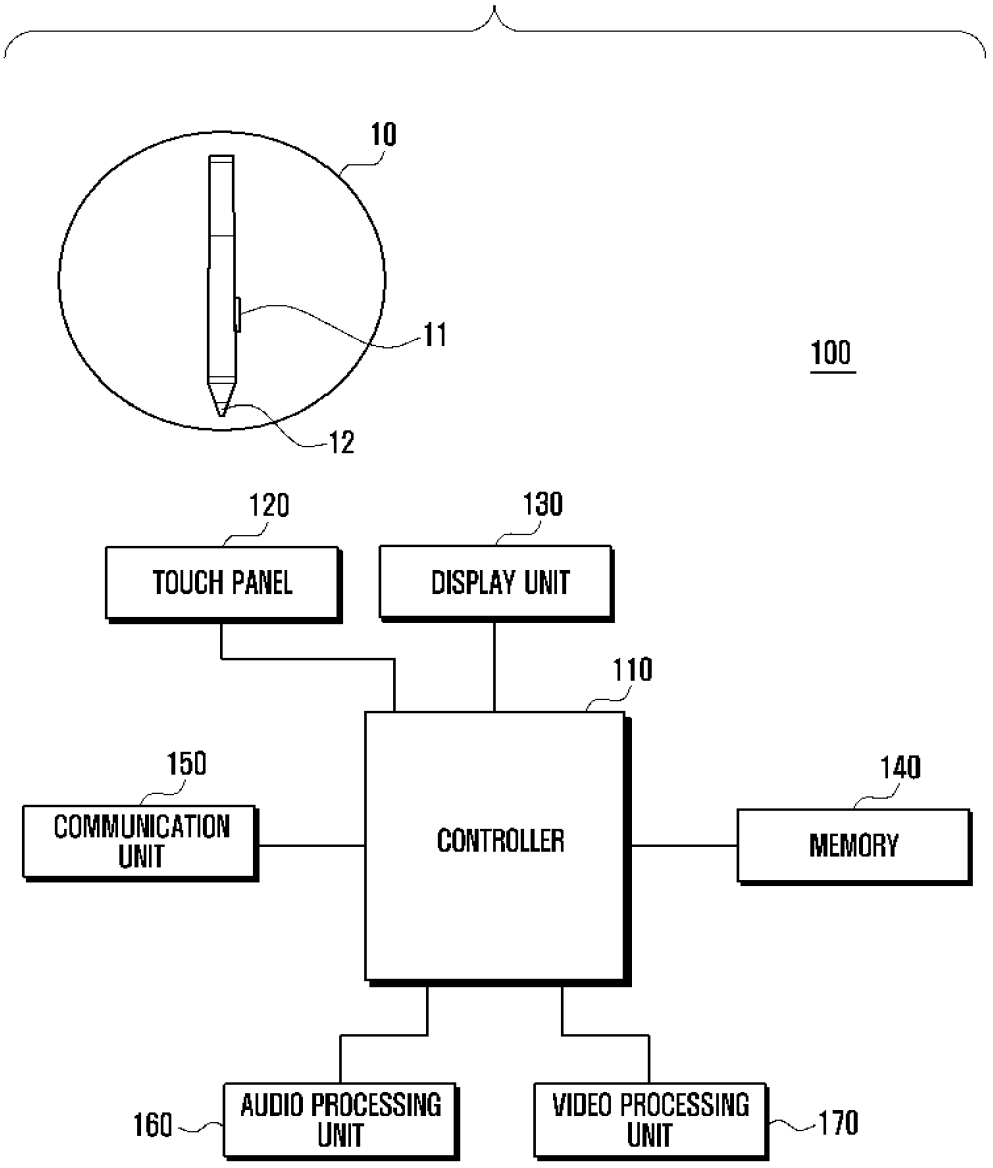
14. The input method of any one of claims 6 to 13, calling the pre-set application or performing a pre-set command corresponding to the second input comprises:

analysing an input type of the second input;
calling and displaying the pre-set application which is set for the second input if the input is an application call for the pre-set application; and
performing the pre-set command which is set for the corresponding second input if the input is the pre-set command.

15. The input method of claim 14, wherein a second input for the application call includes at least one of a double click and a long press, and a second input for command execution is a flick.

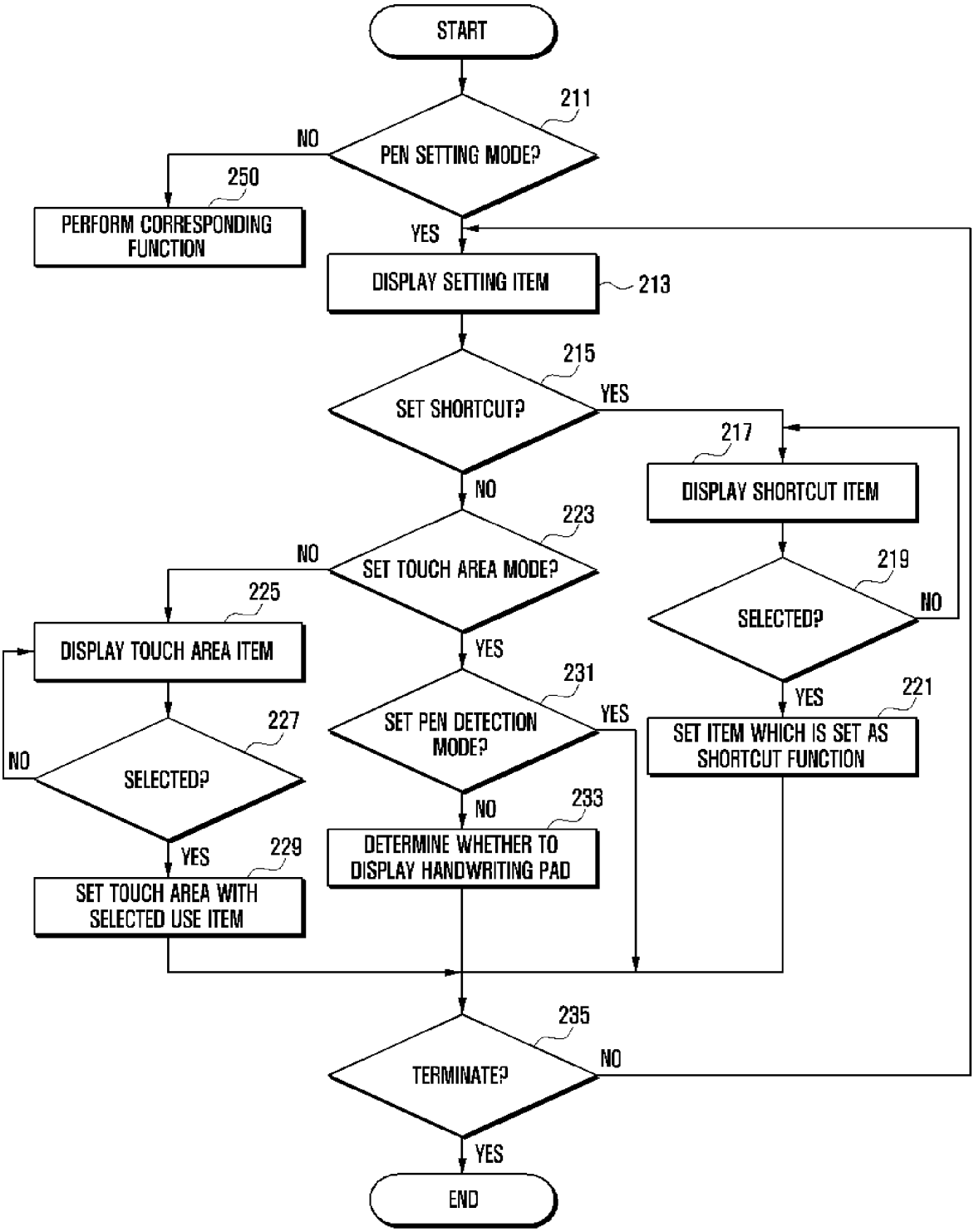
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FIG. 1



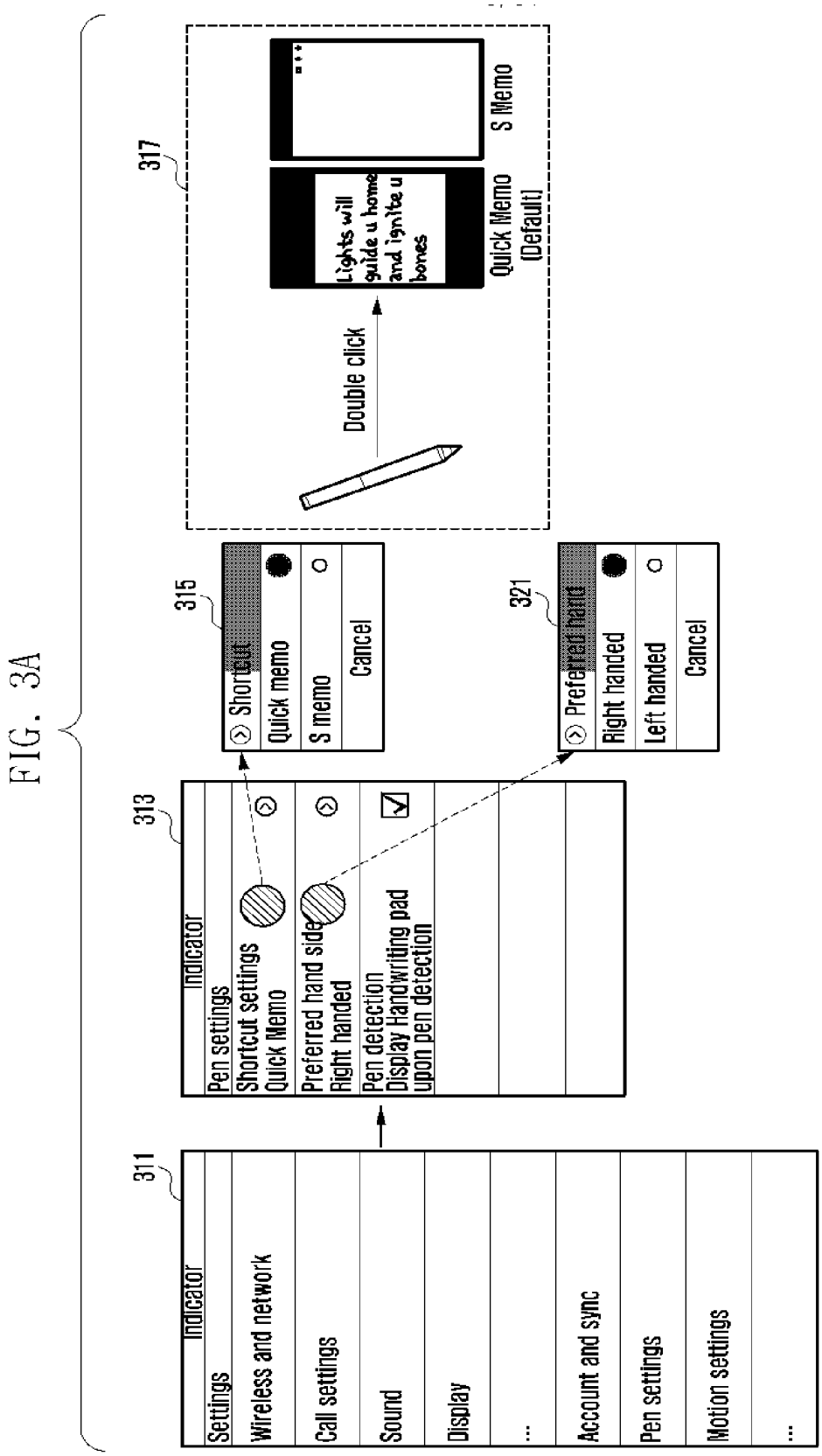
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FIG. 2



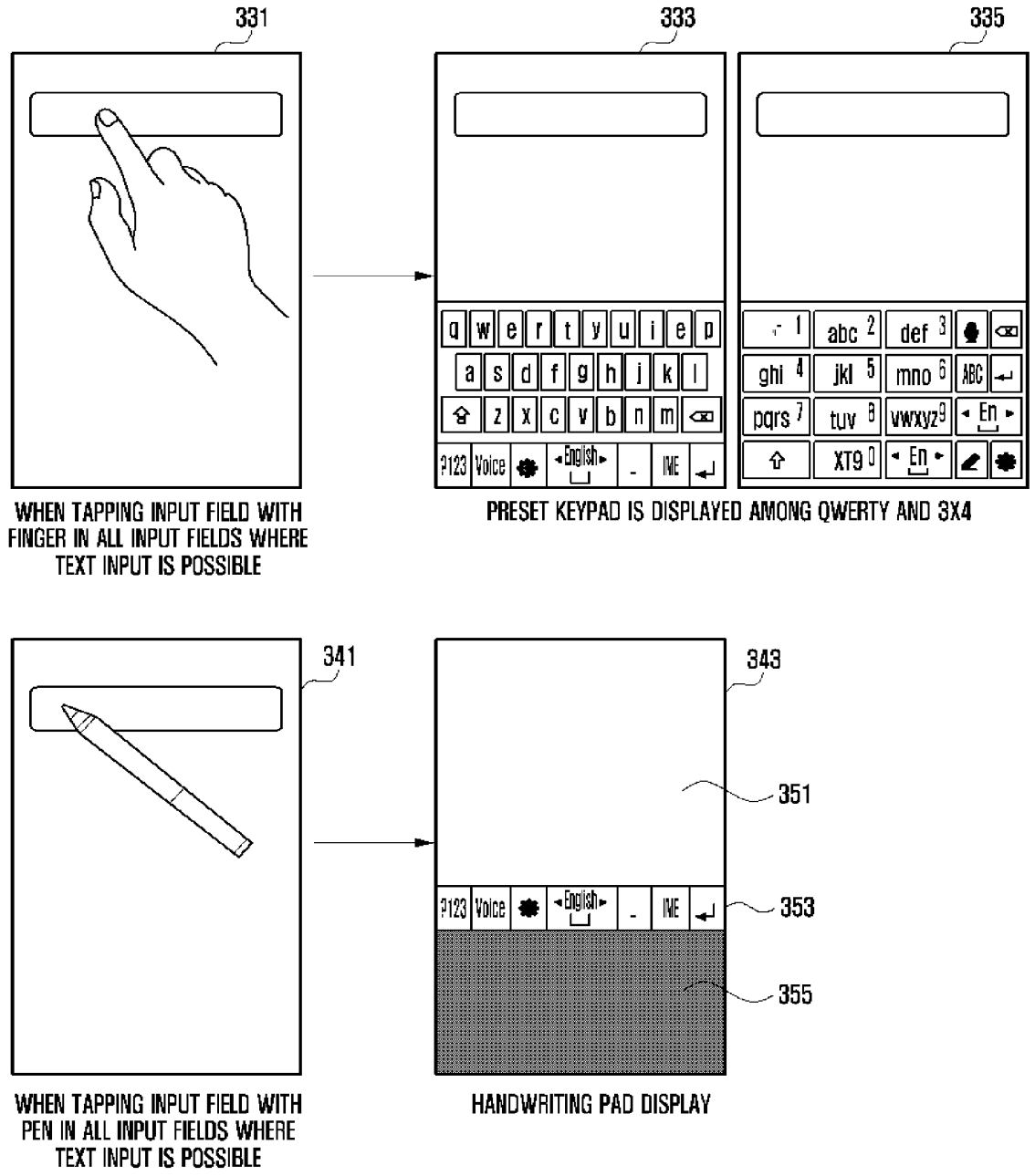
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FIG. 3A



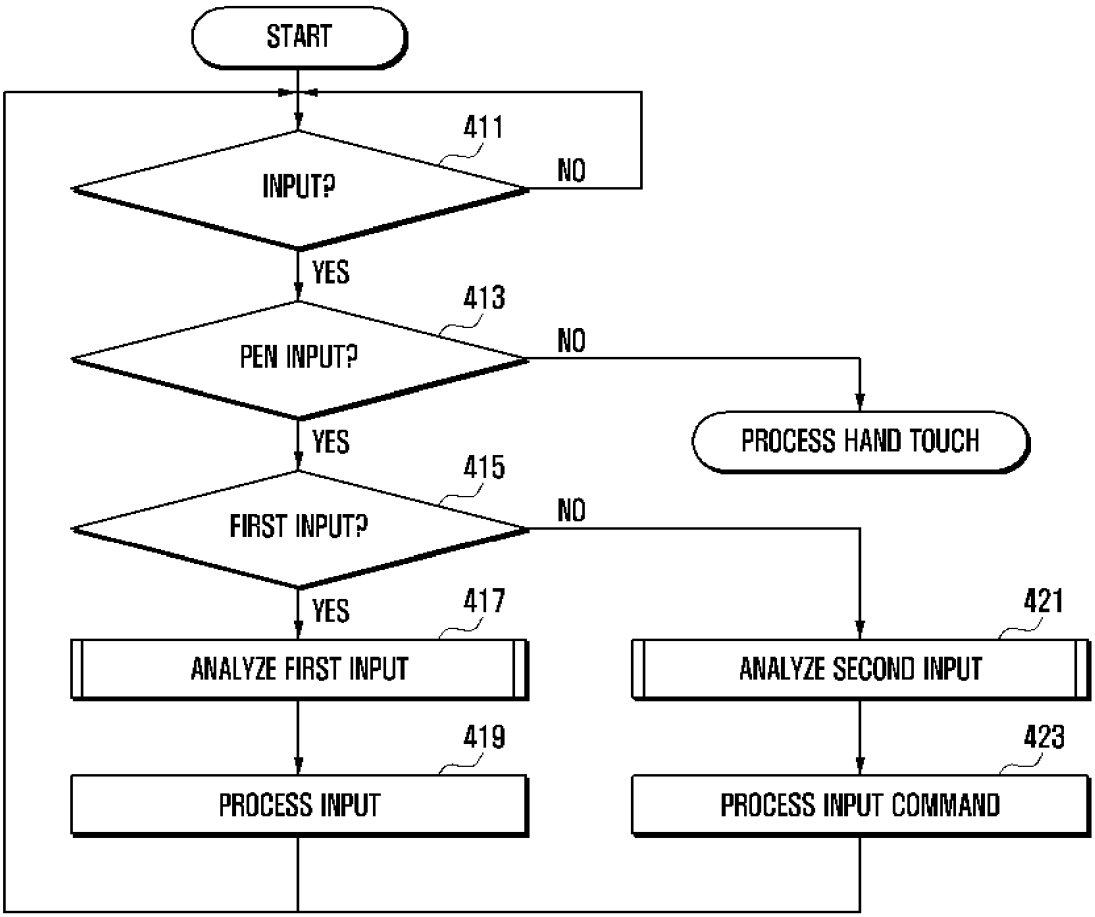
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FIG. 3B



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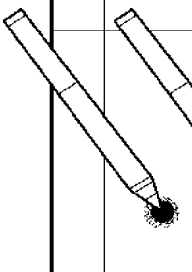
FIG. 4



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FIG. 5A

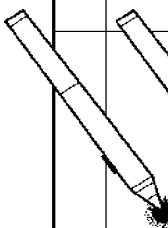
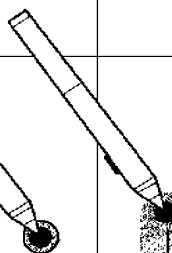
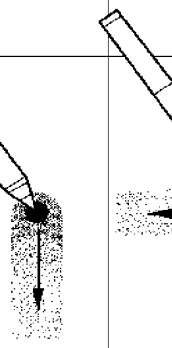
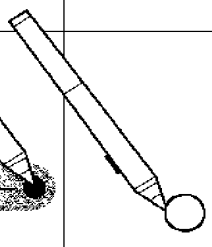
WHEN PERFORMING OPERATION WITHOUT CLICKING ON PEN SIDE BUTTON

	Type	Operation	Visual effect
	Tap	* Select Item	○
	Long press	* Display contextual pop-up	○
	Flick	* Move to next page * Scroll up, down	○ (NATURAL FEEDBACK IS PROVIDED WHEN FLICKS CONSECUTIVELY OCCUR)

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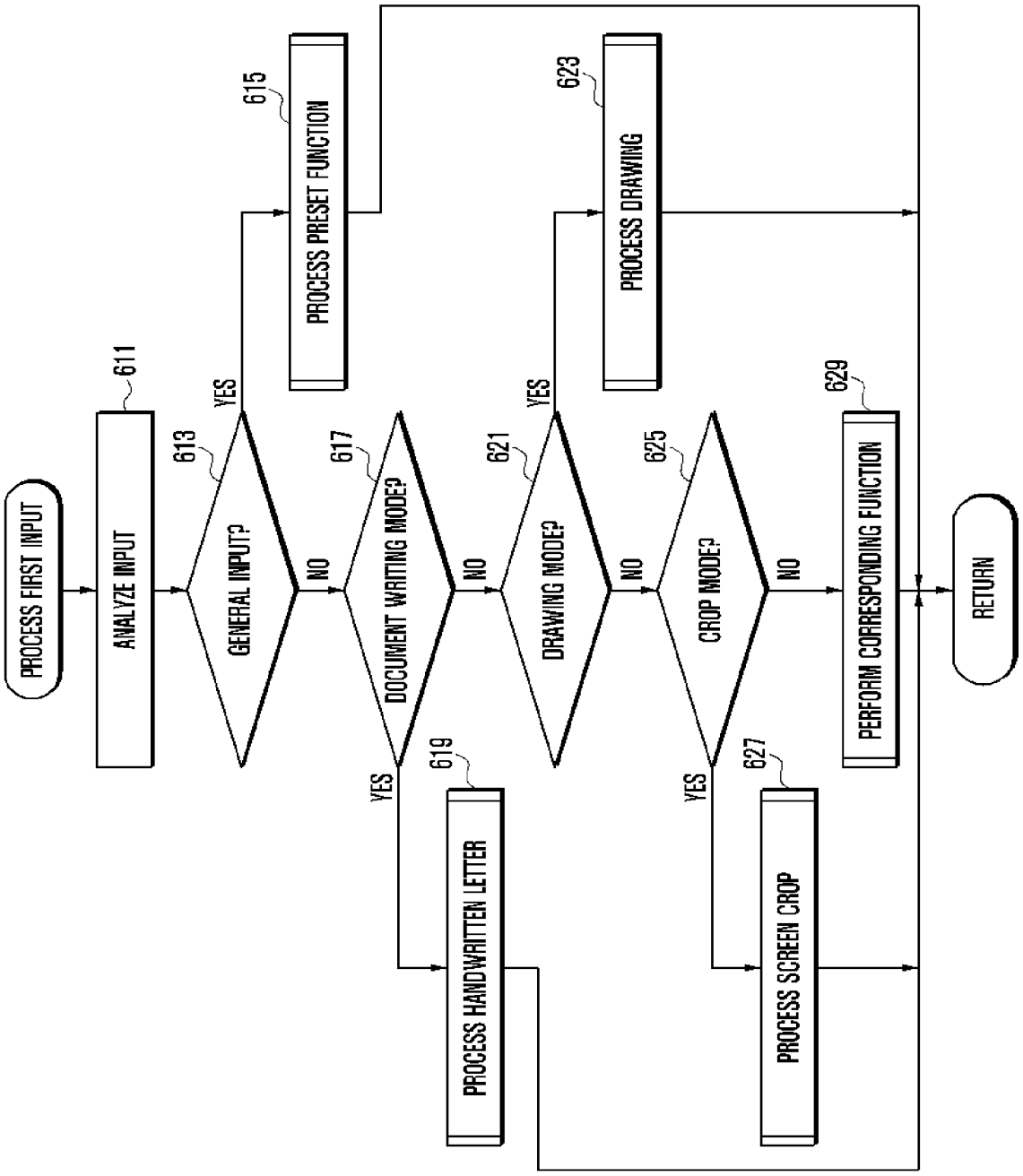
FIG. 5B

WHEN PERFORMING OPERATION BELOW AFTER CLICKING ON PEN SIDE BUTTON

	Type	Operation	Visual effect
	Double click	* Memo Application CALL	X
	Long press	* Screen capture	X
	Flick (RIGHT→LEFT)	" Back" OPERATION	X
	Flick (BOTTOM →TOP)	" Menu" CALL	X
	Circle	"Home" OPERATION	X

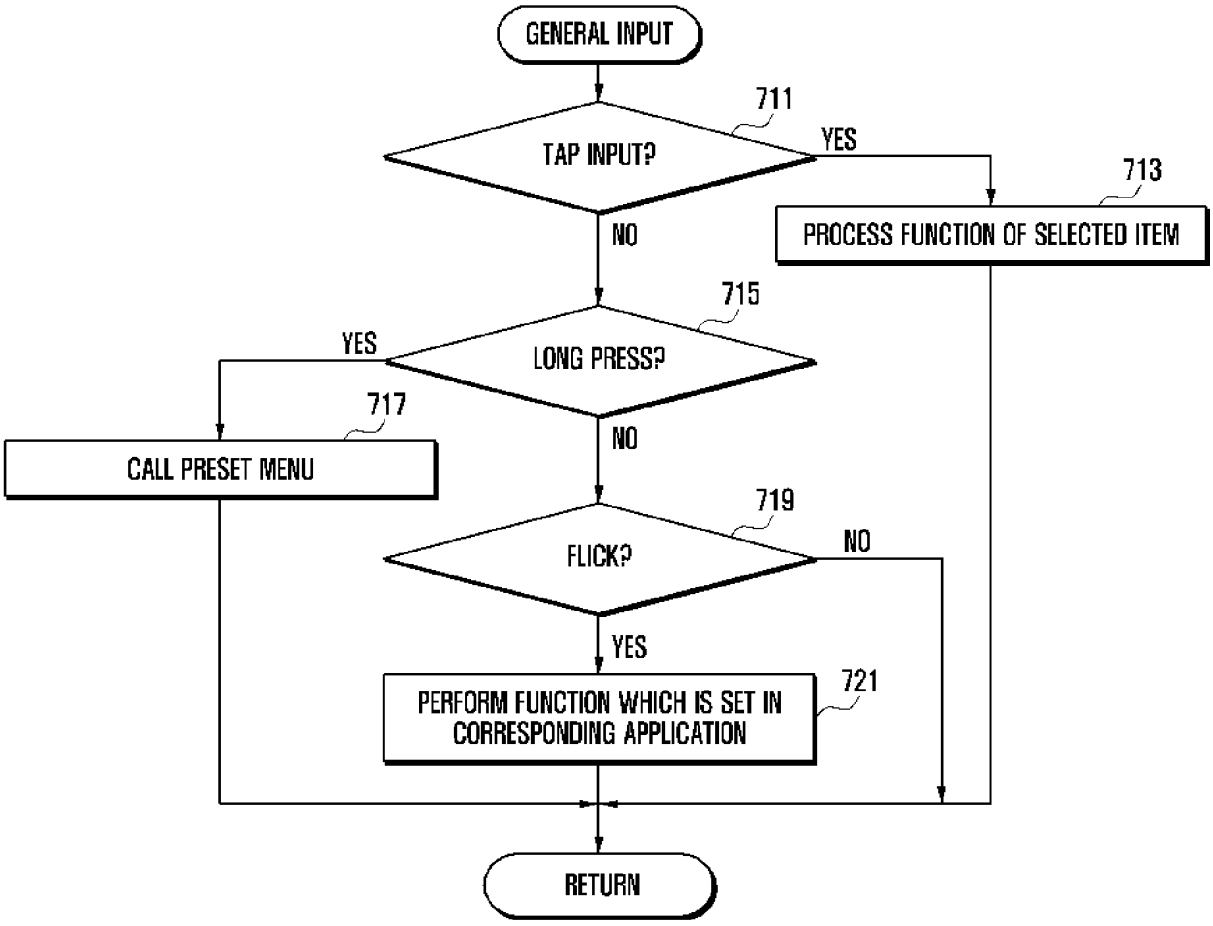
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FIG. 6



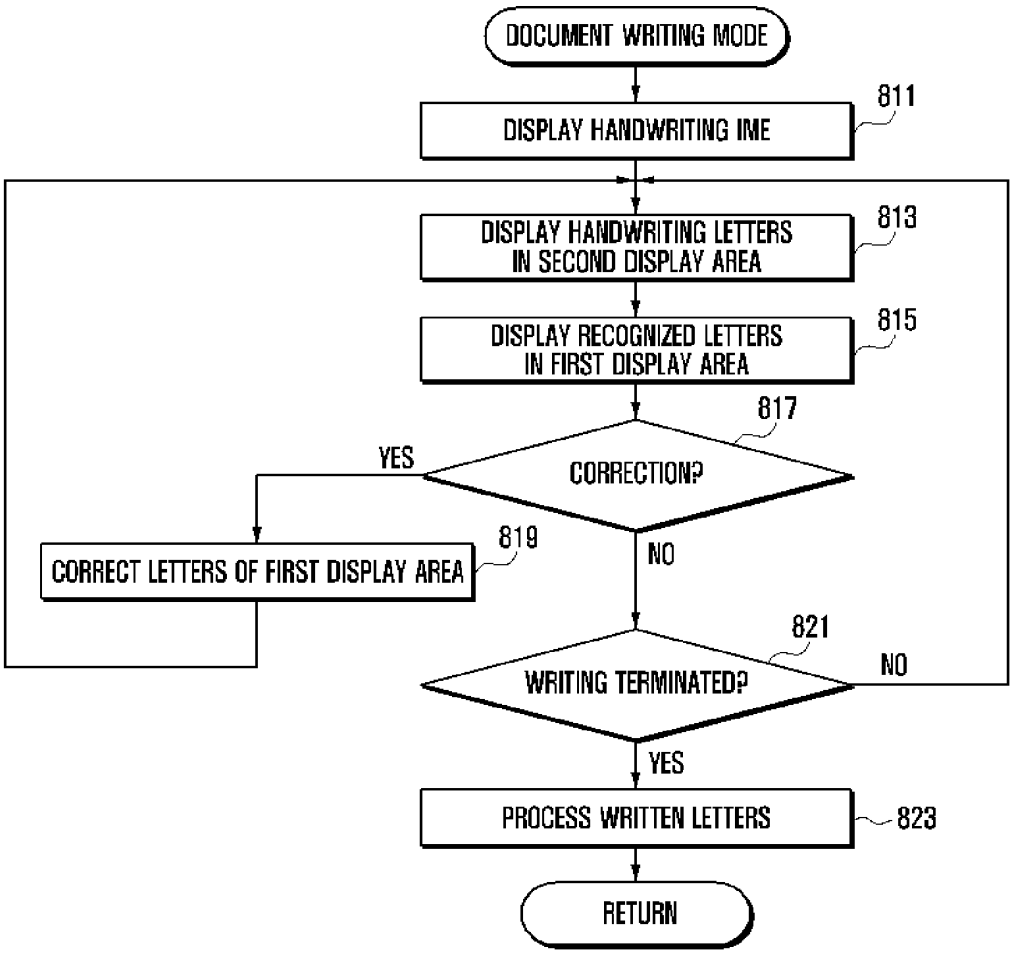
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FIG. 7



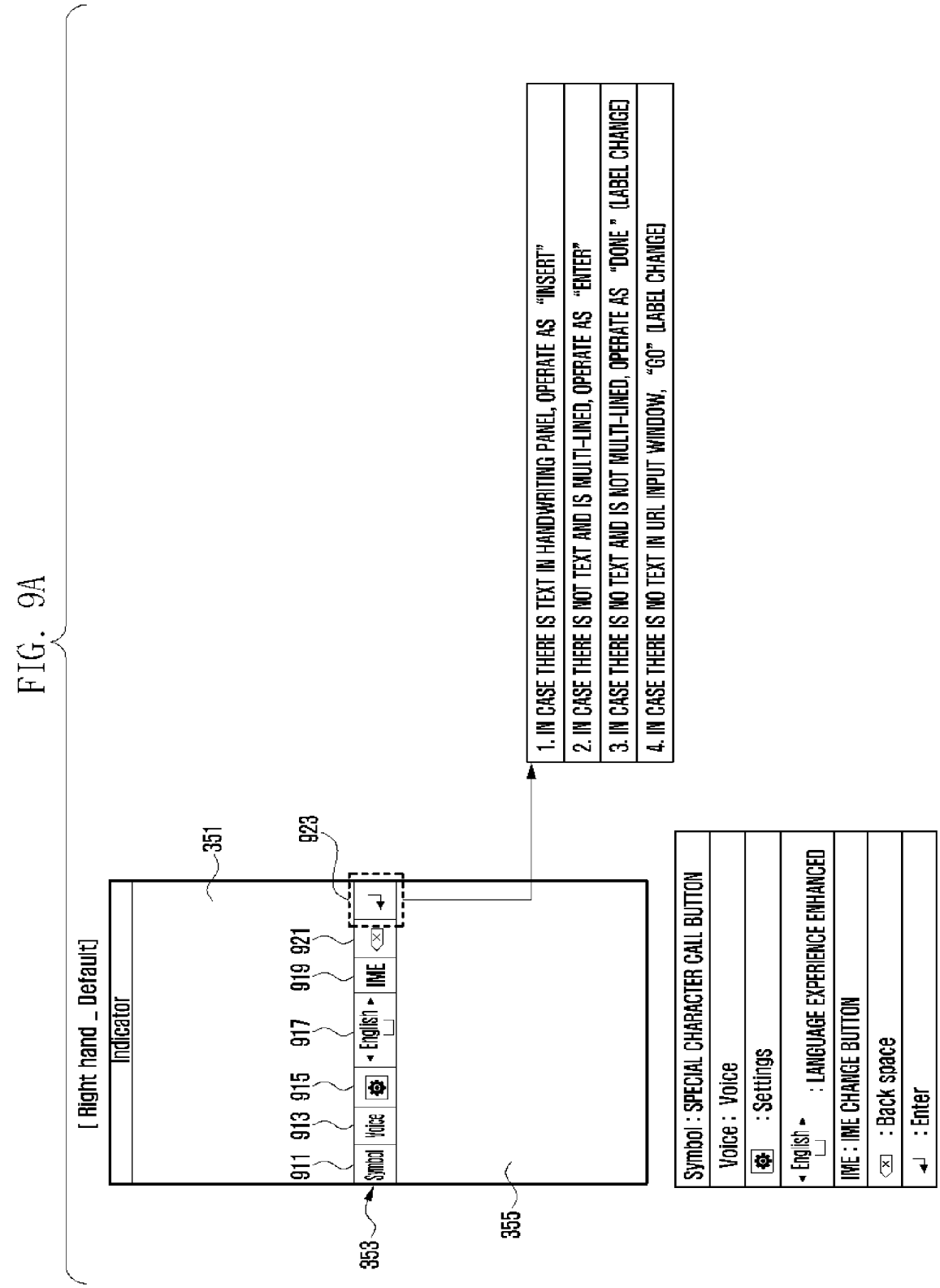
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FIG. 8



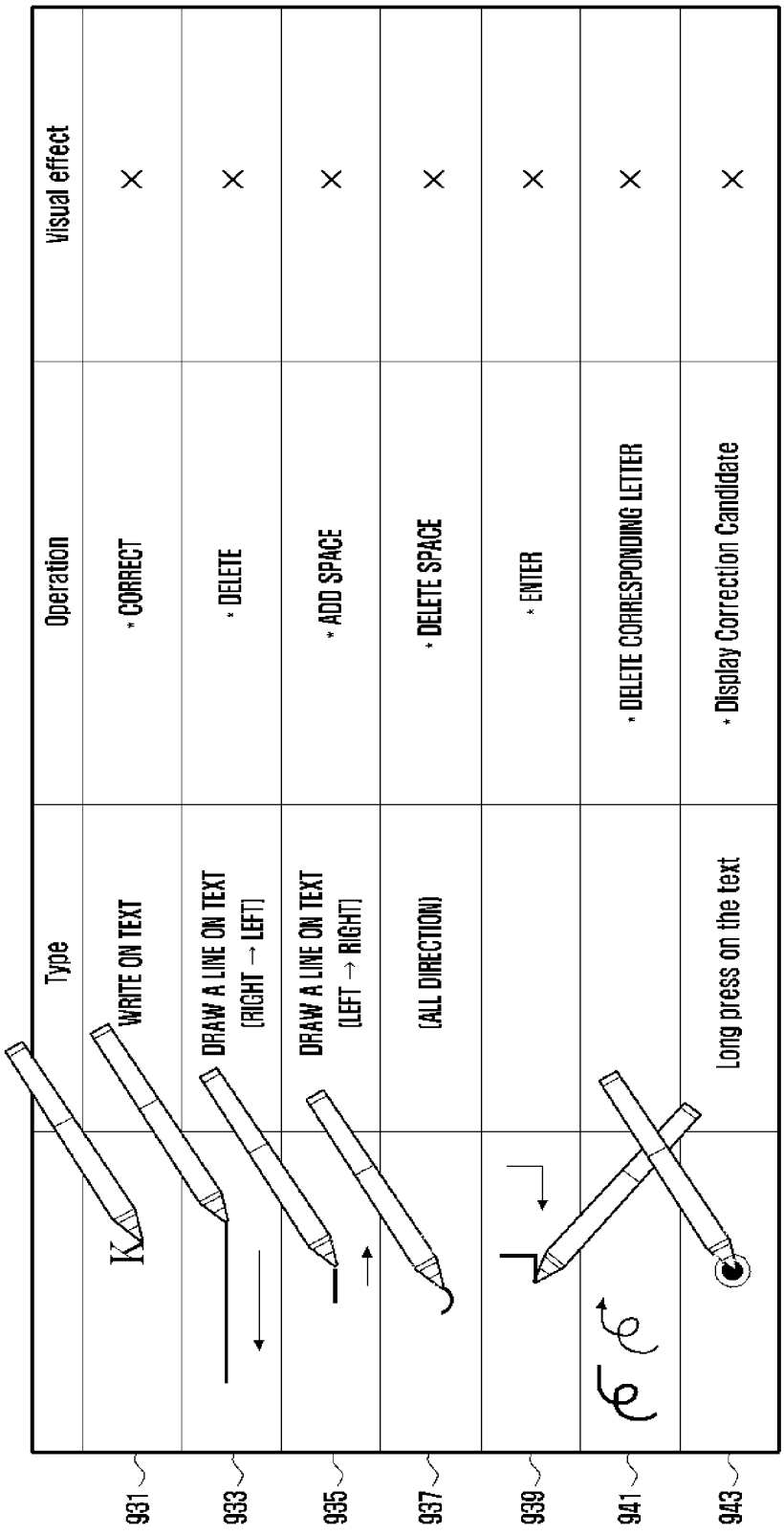
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FIG. 9A



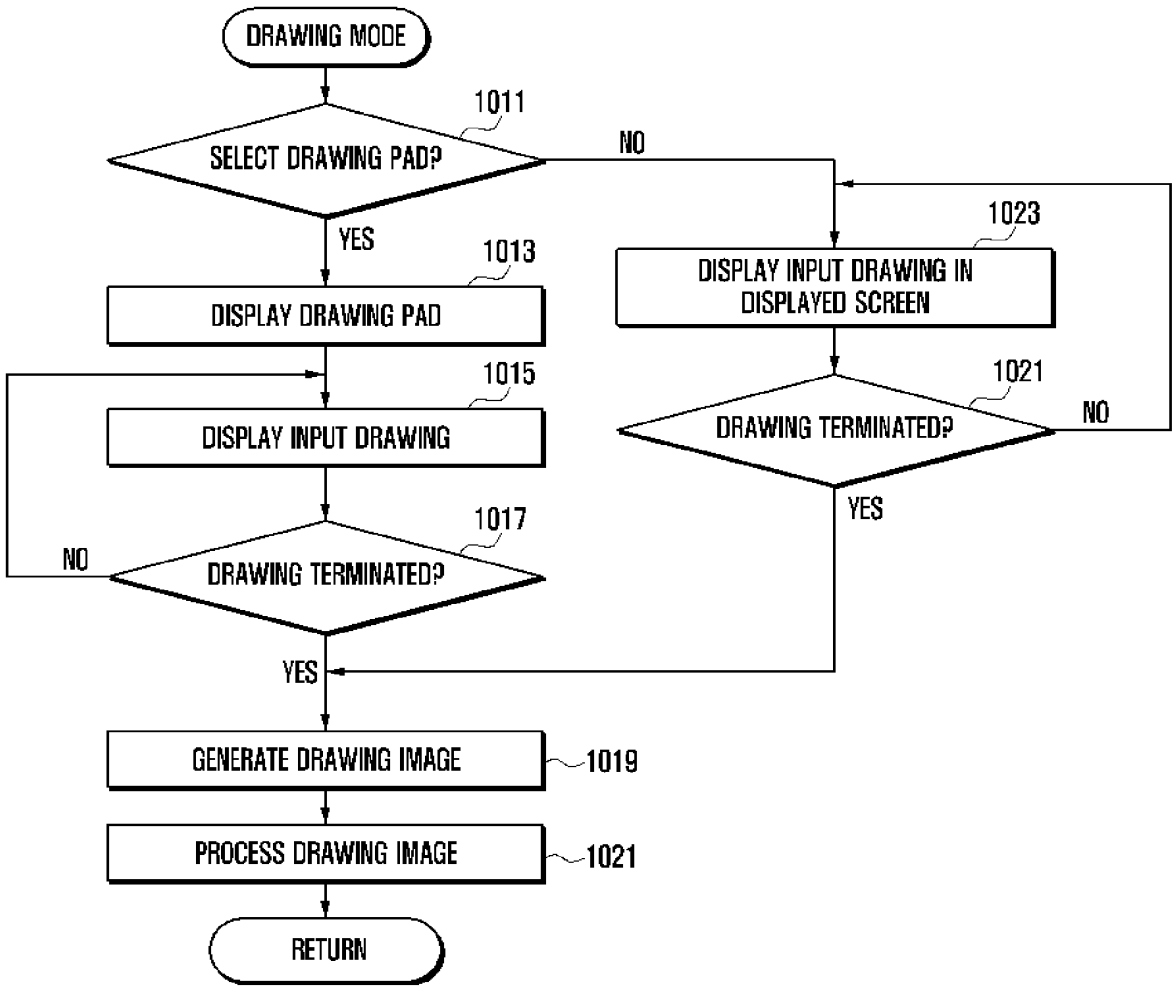
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FIG. 9B



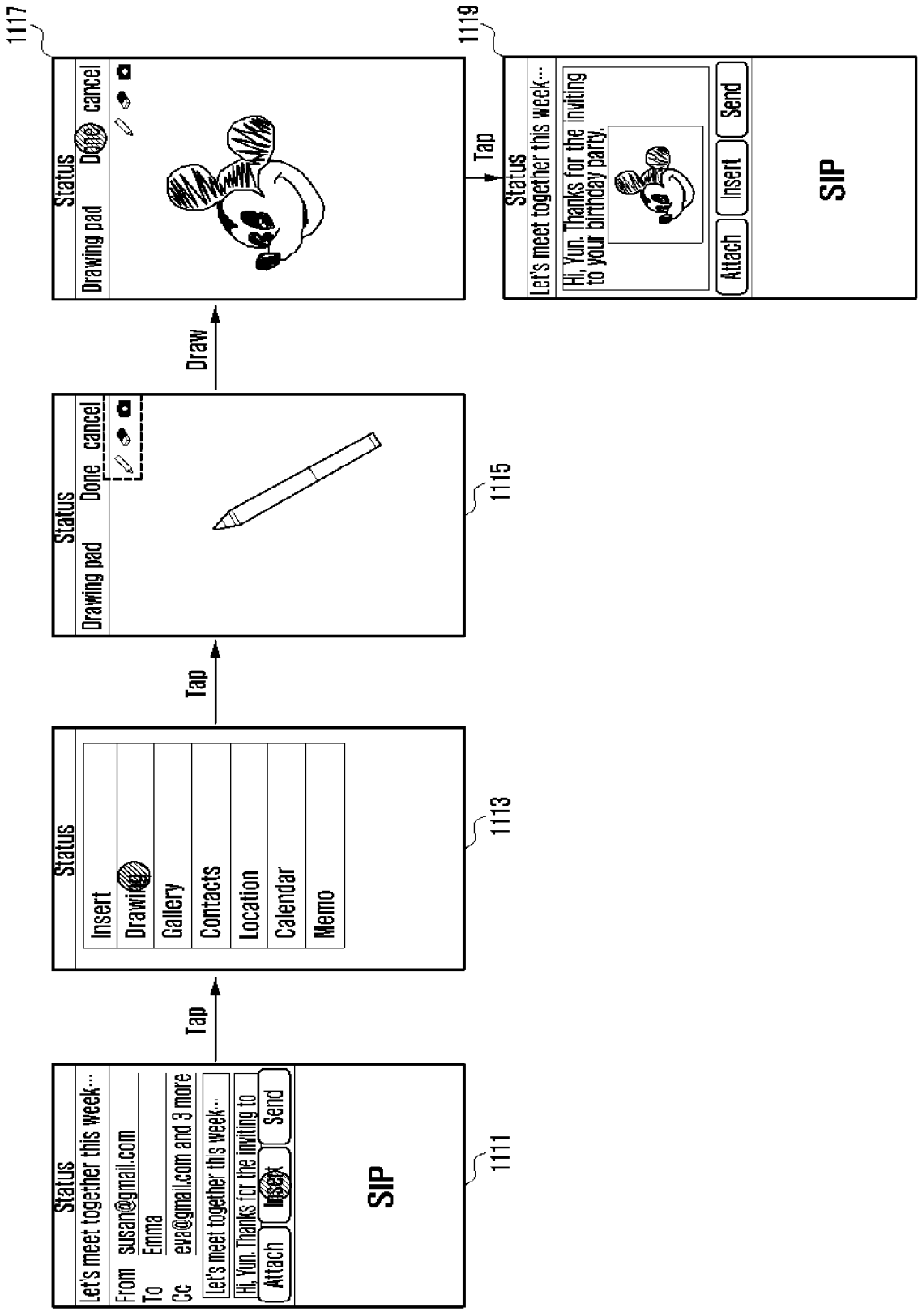
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FIG. 10



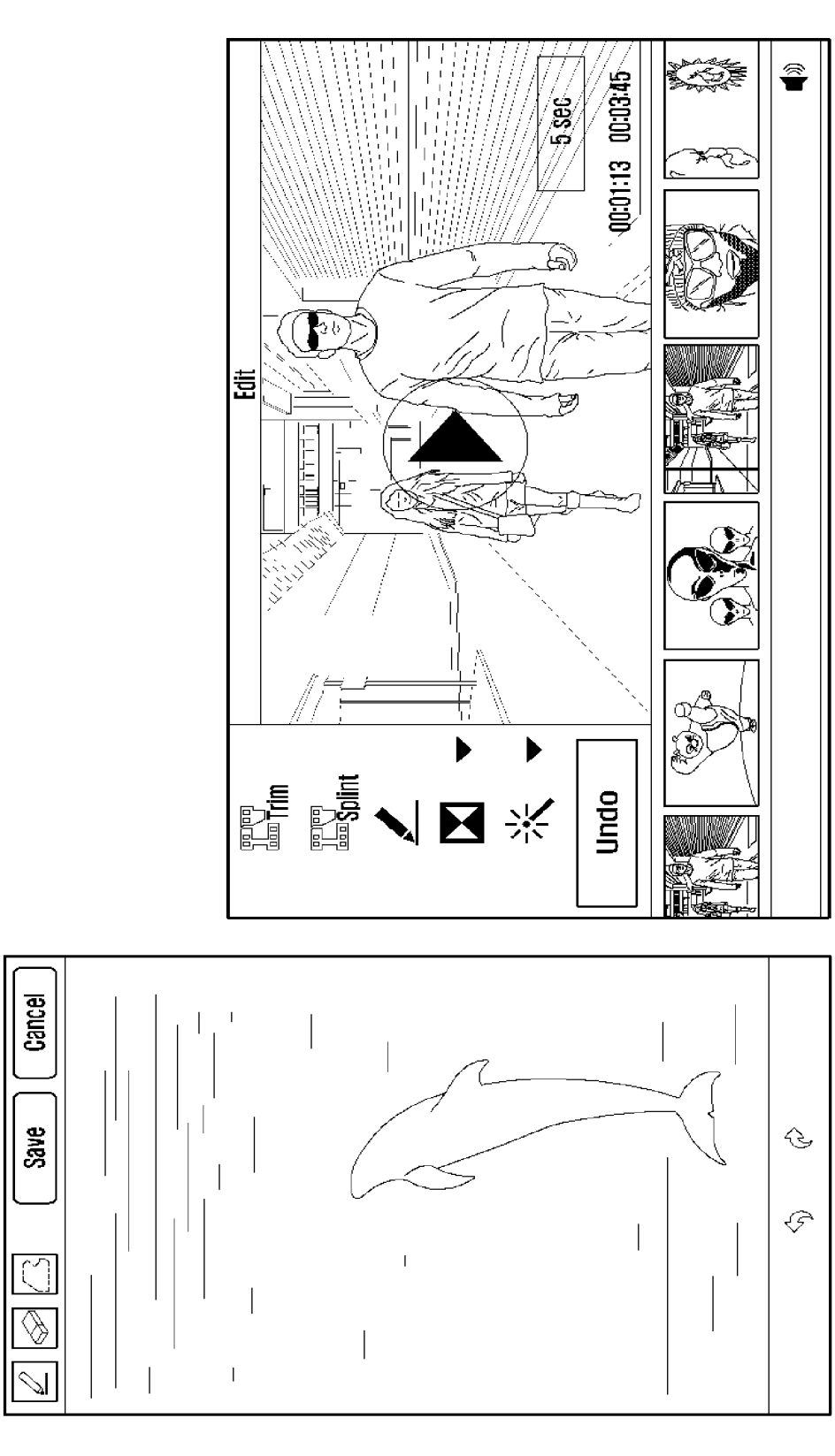
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FIG. 11A



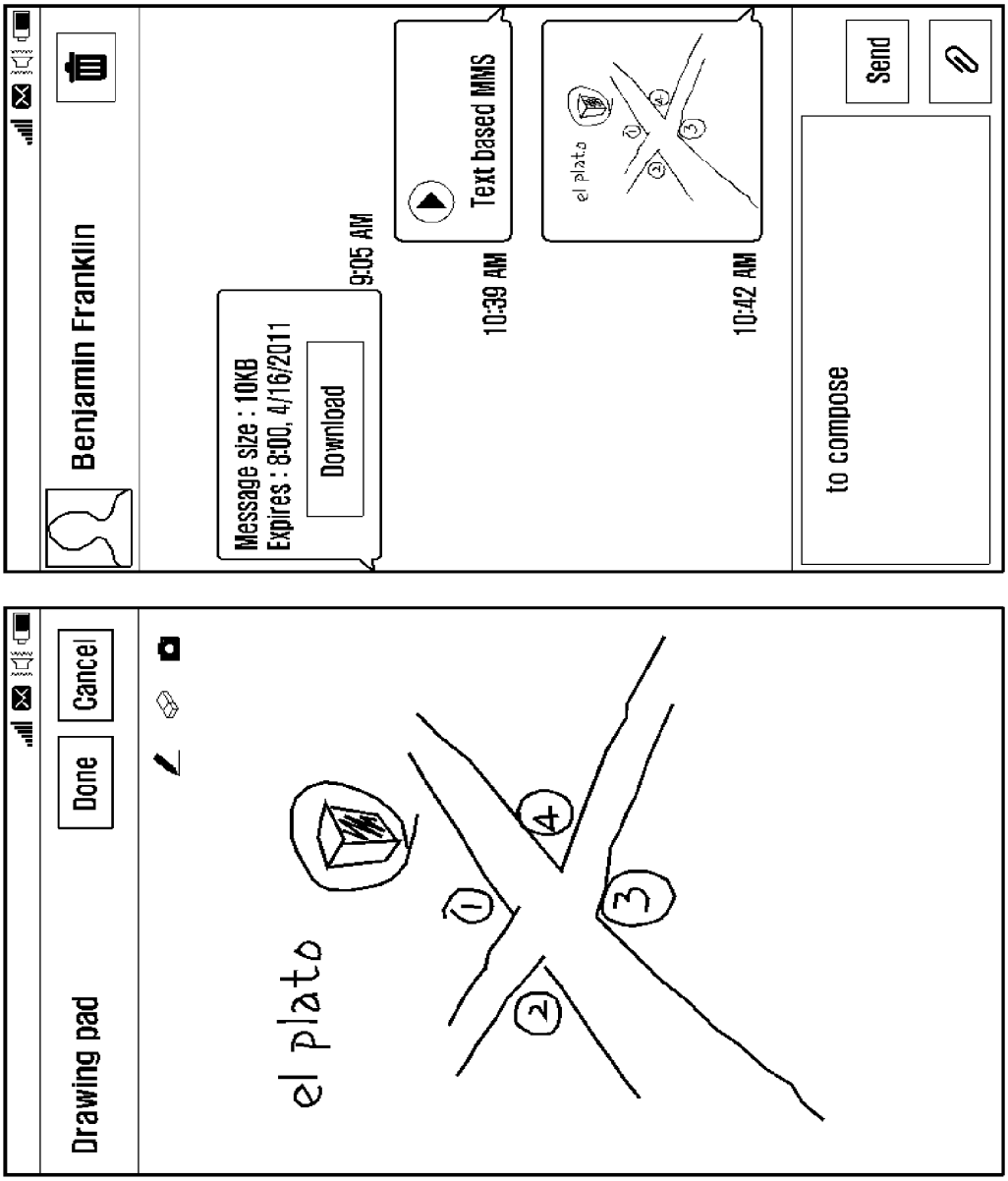
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FIG. 11B



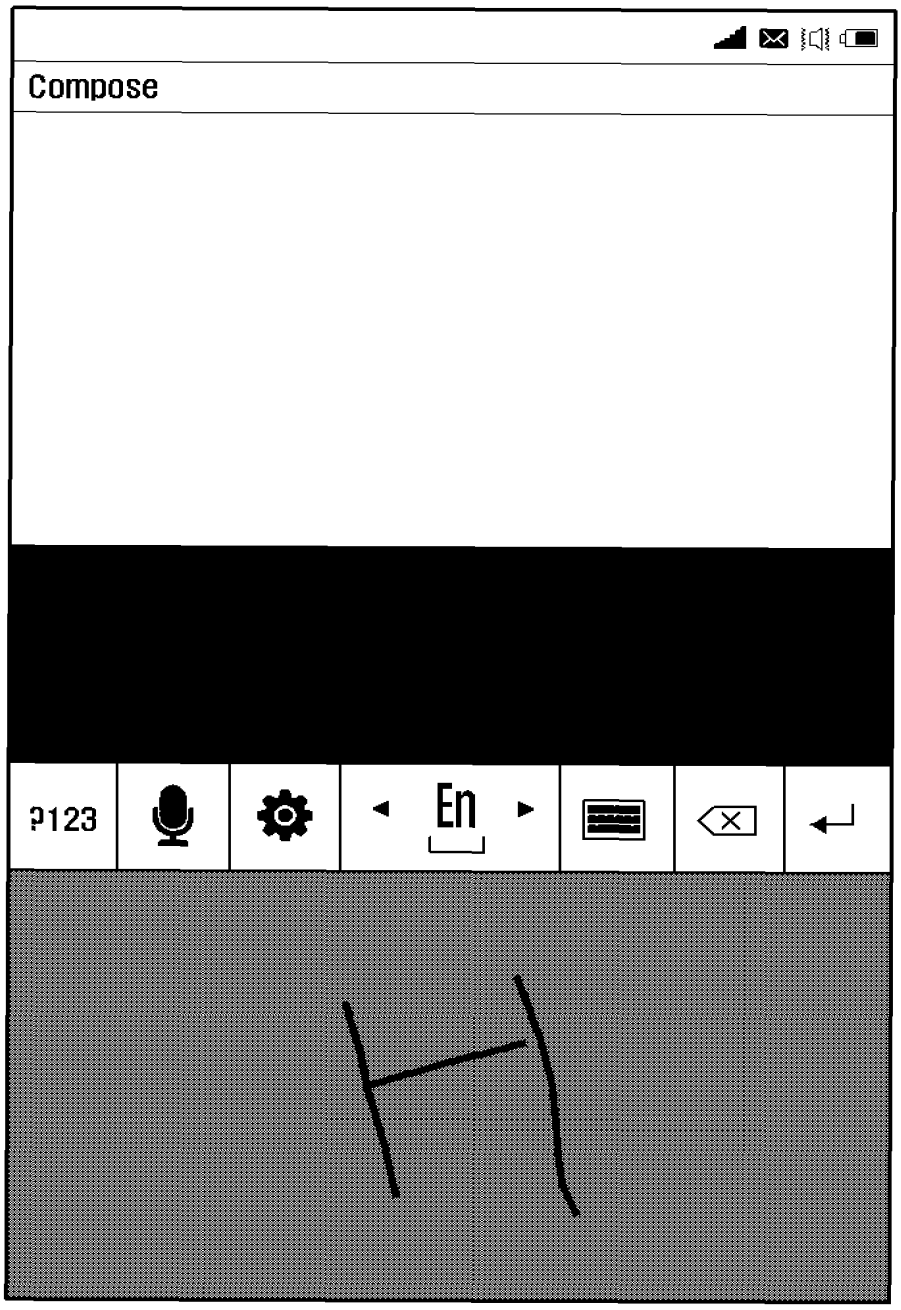
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FIG. 11C



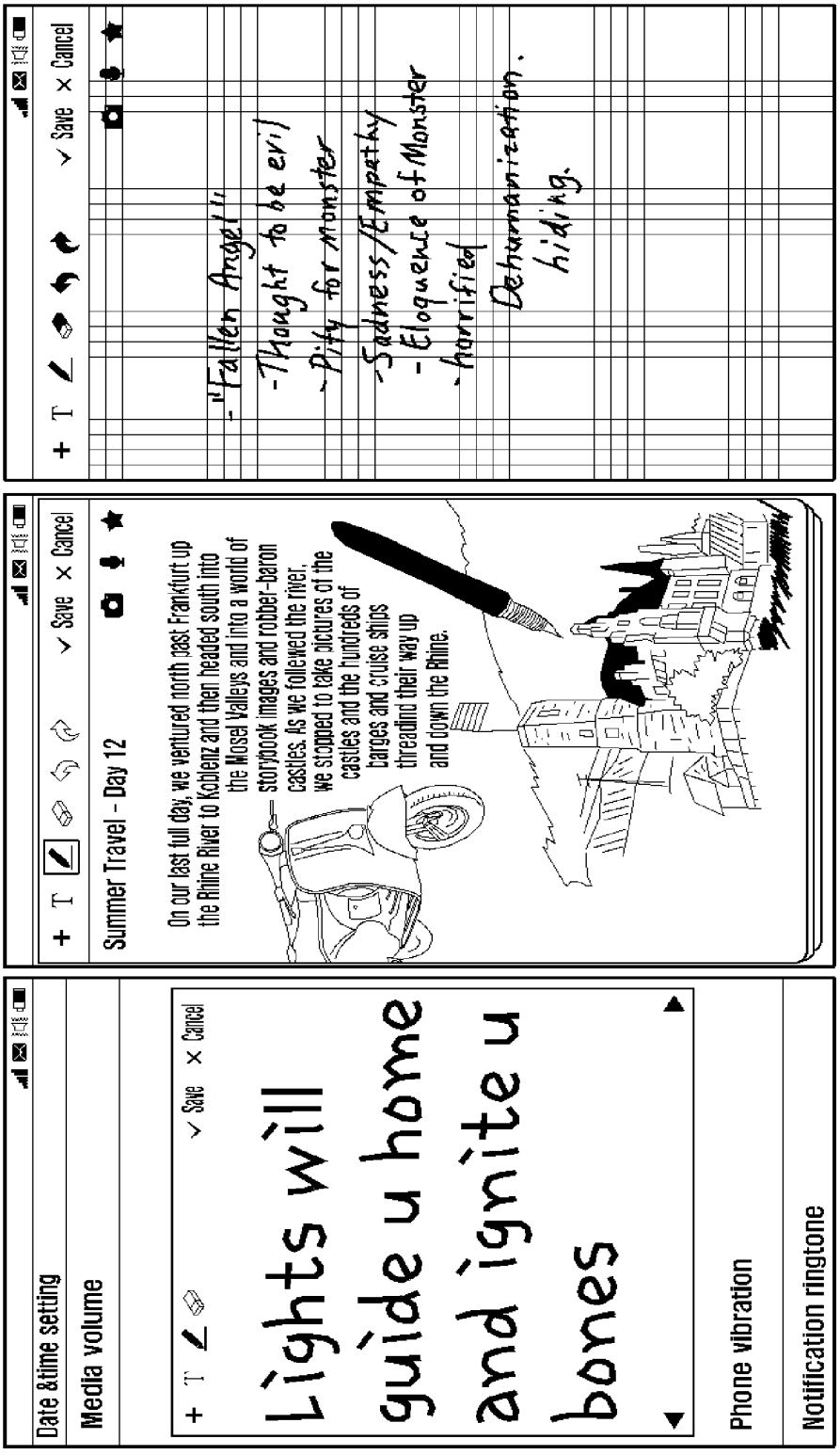
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FIG. 11D



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FIG. 11E



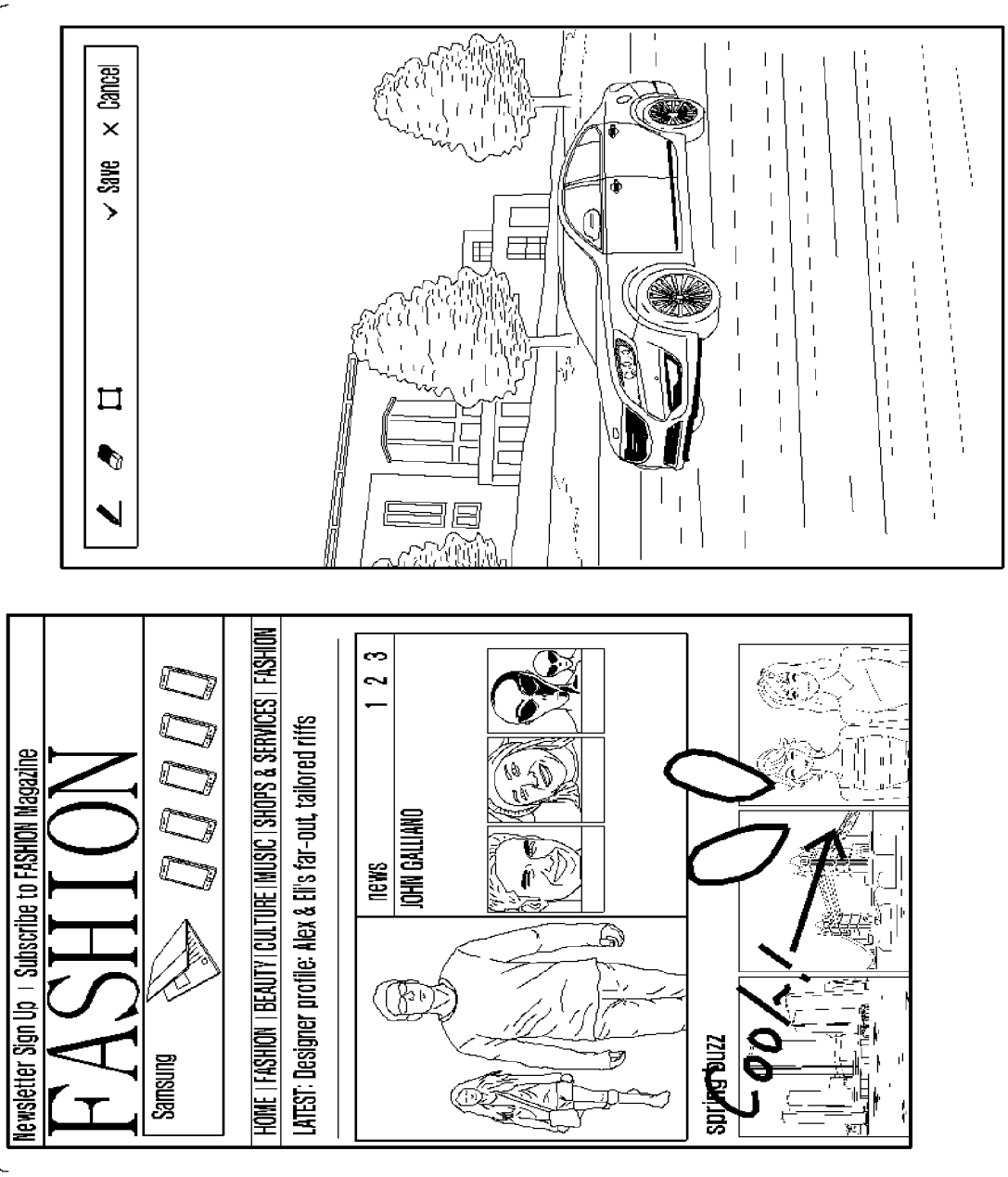
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FIG. 11F



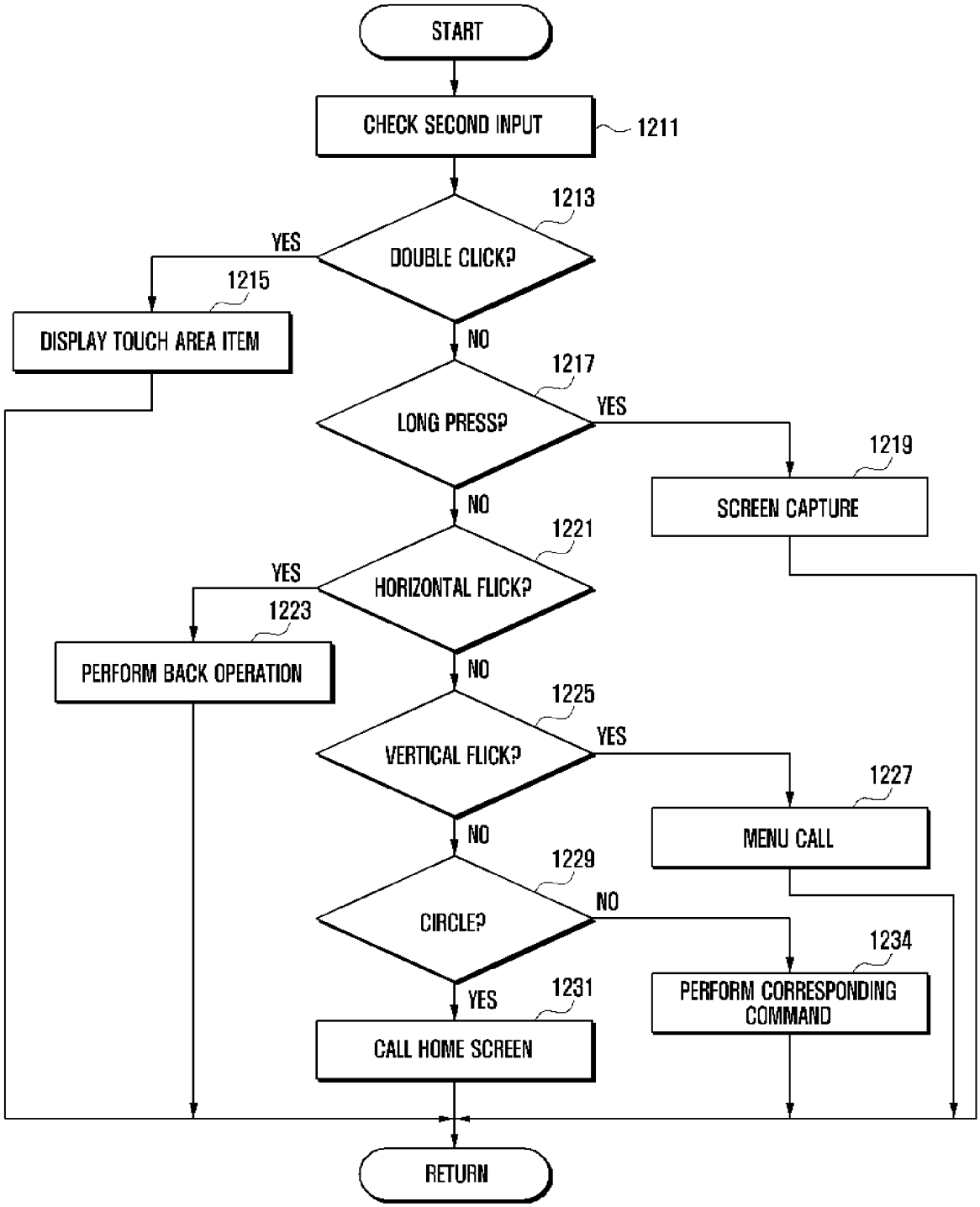
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FIG. 11G



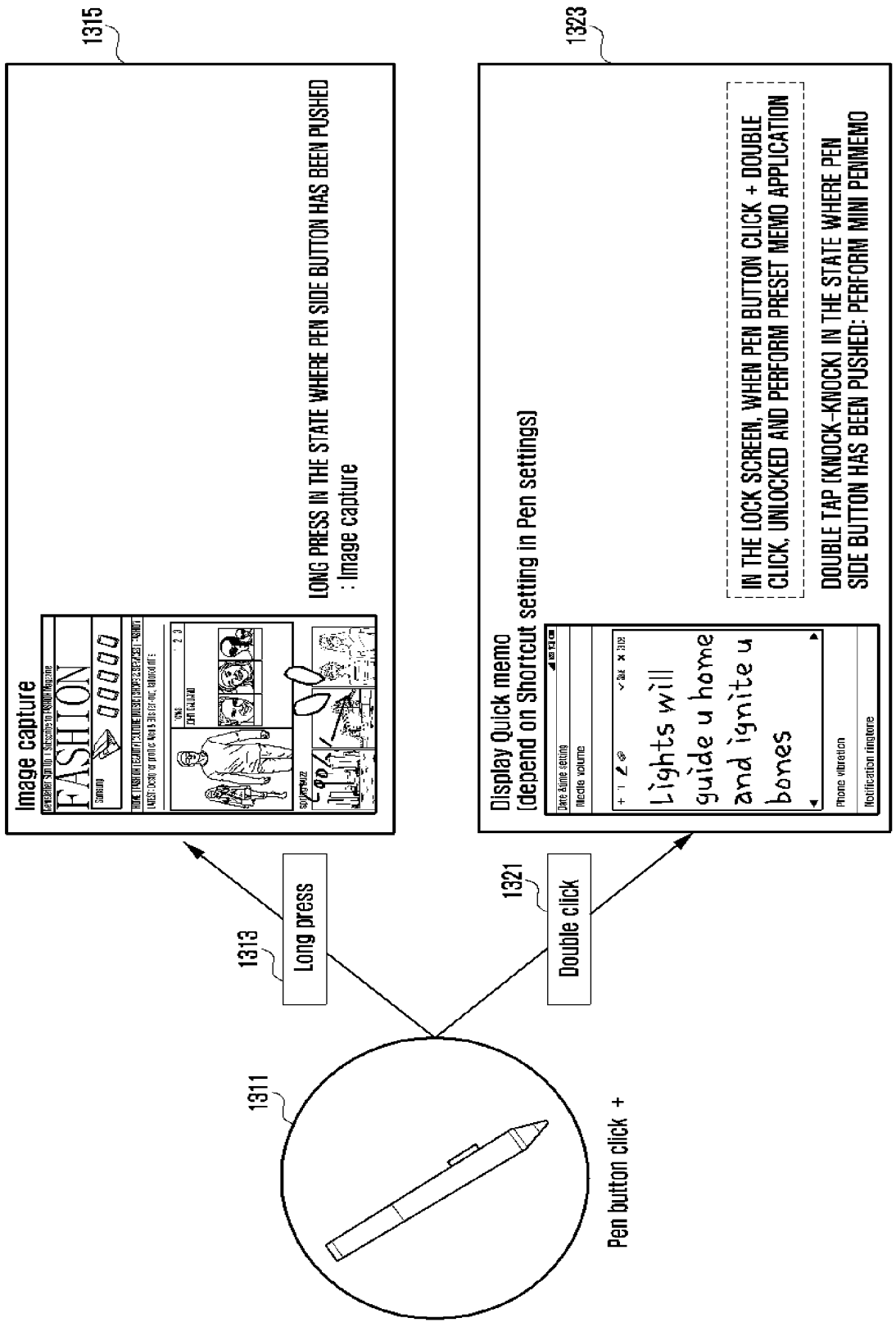
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FIG. 12



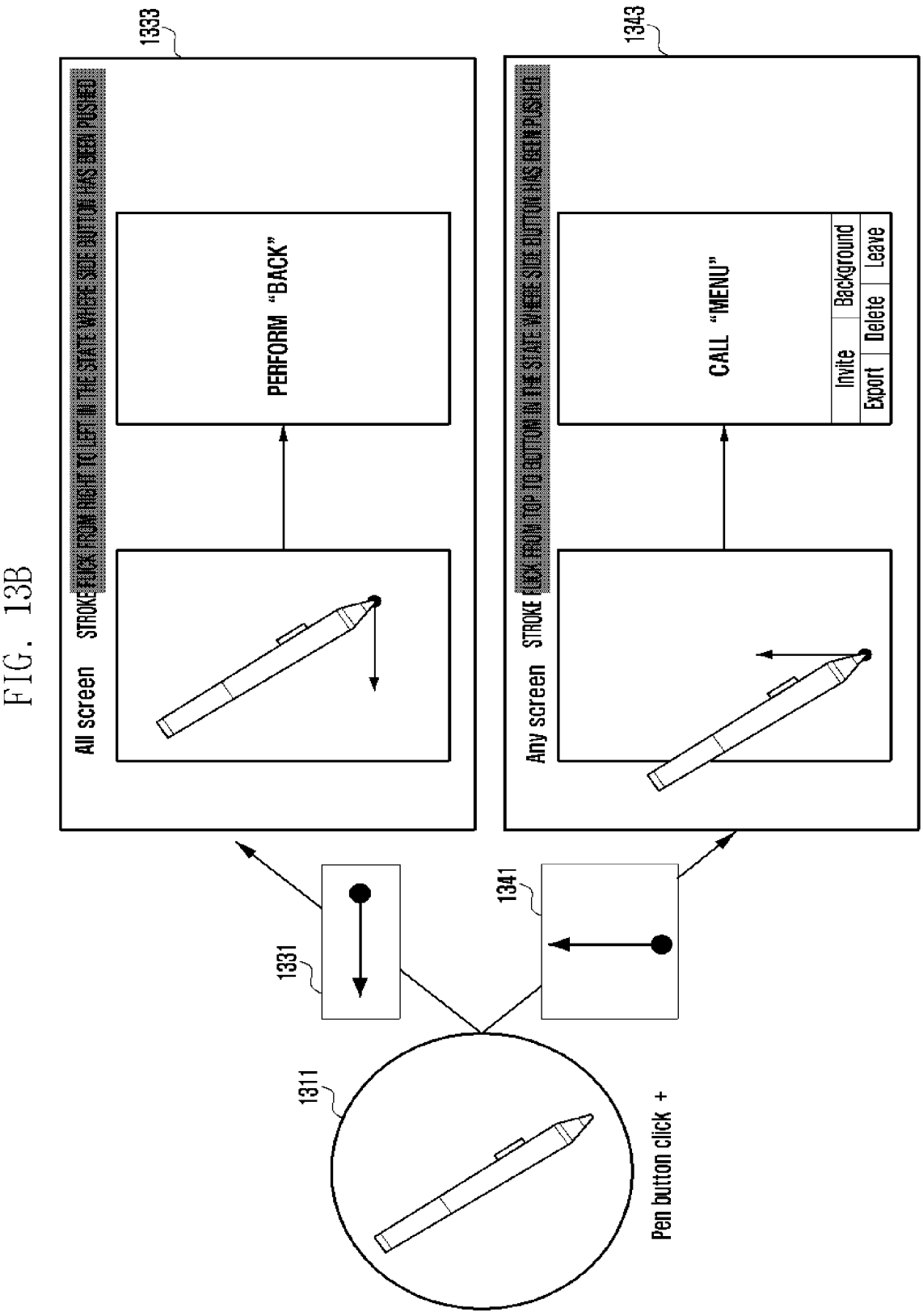
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FIG. 13A



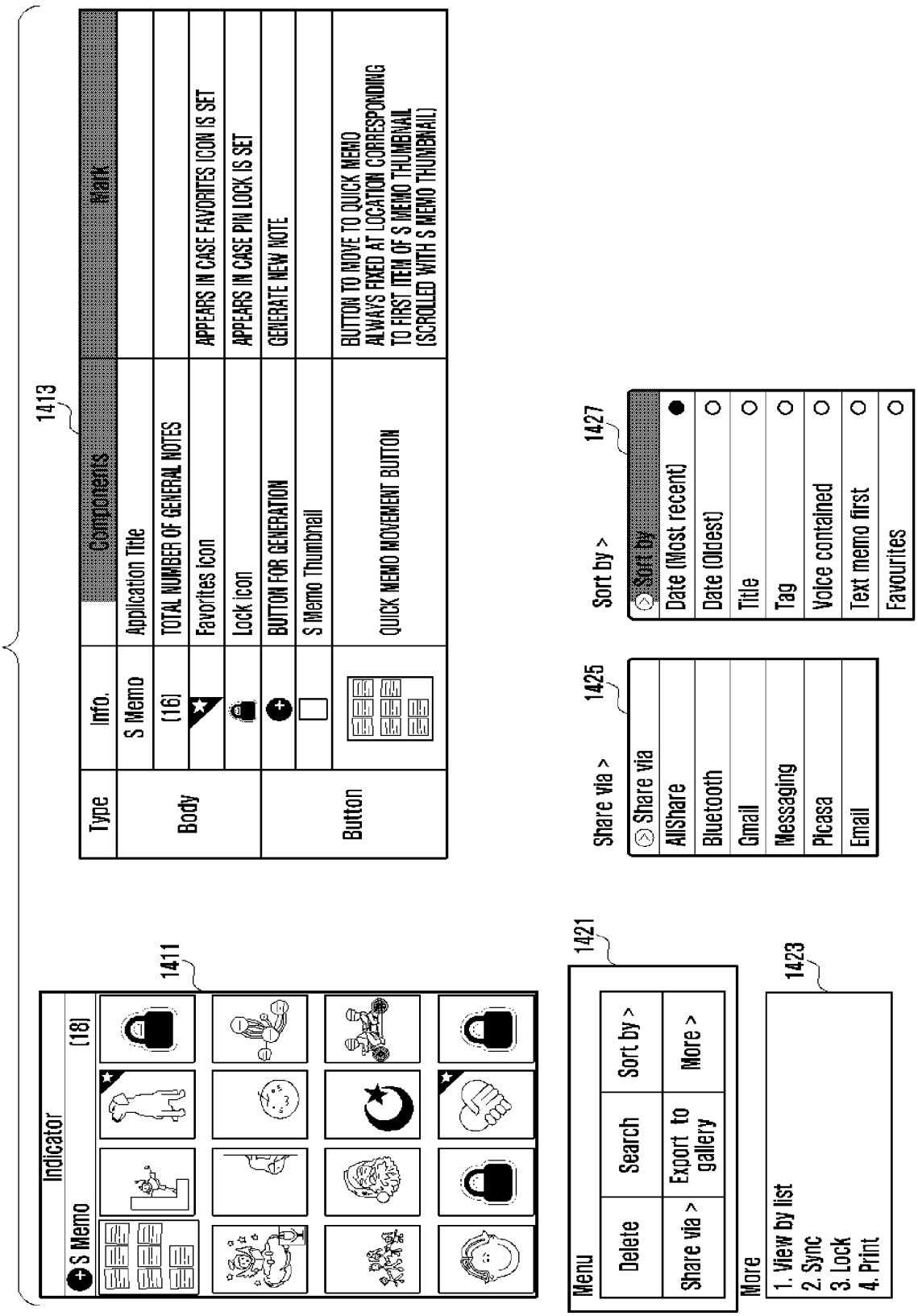
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FIG. 13B



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FIG. 14A

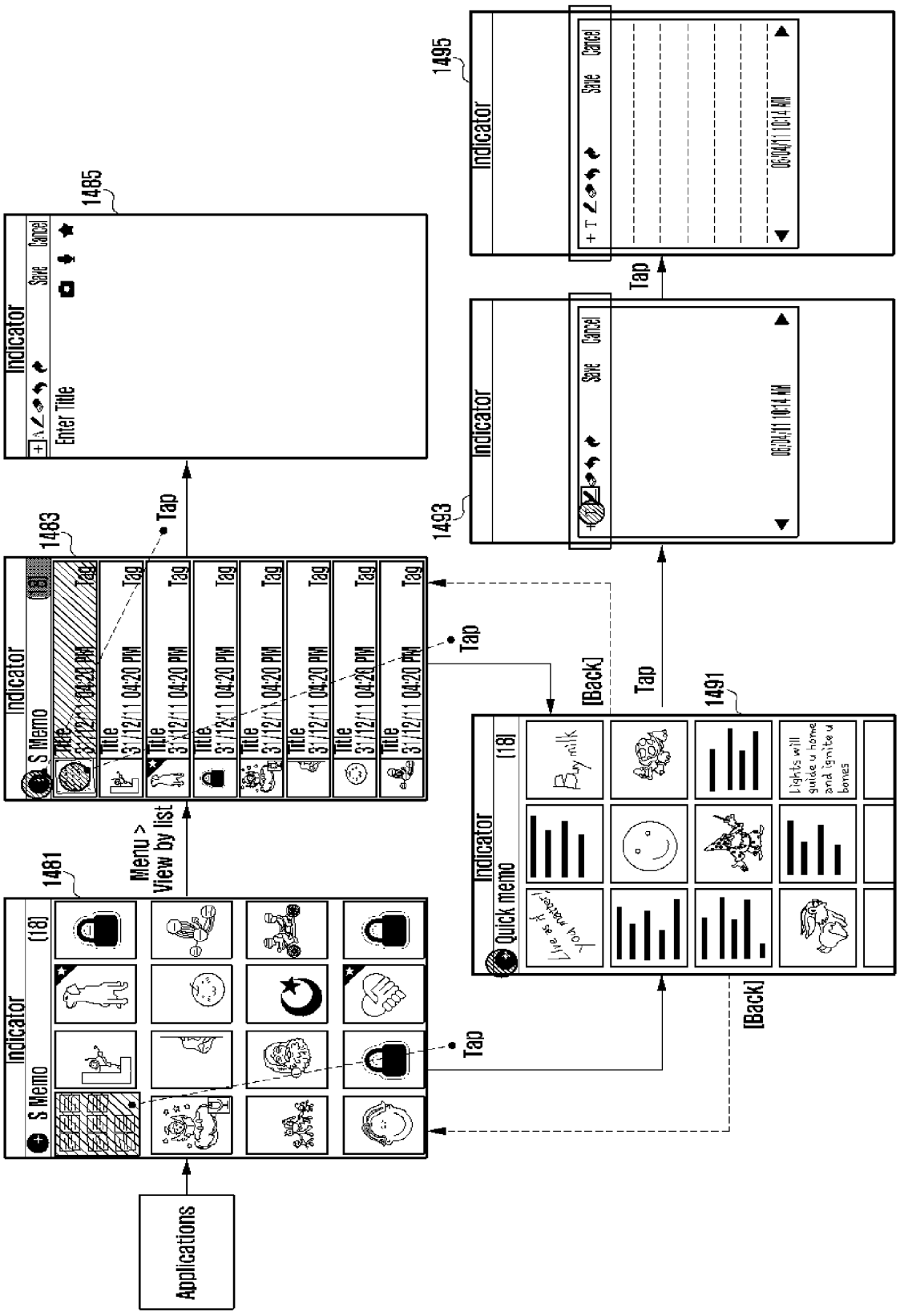


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FIG. 14B

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FIG. 14C

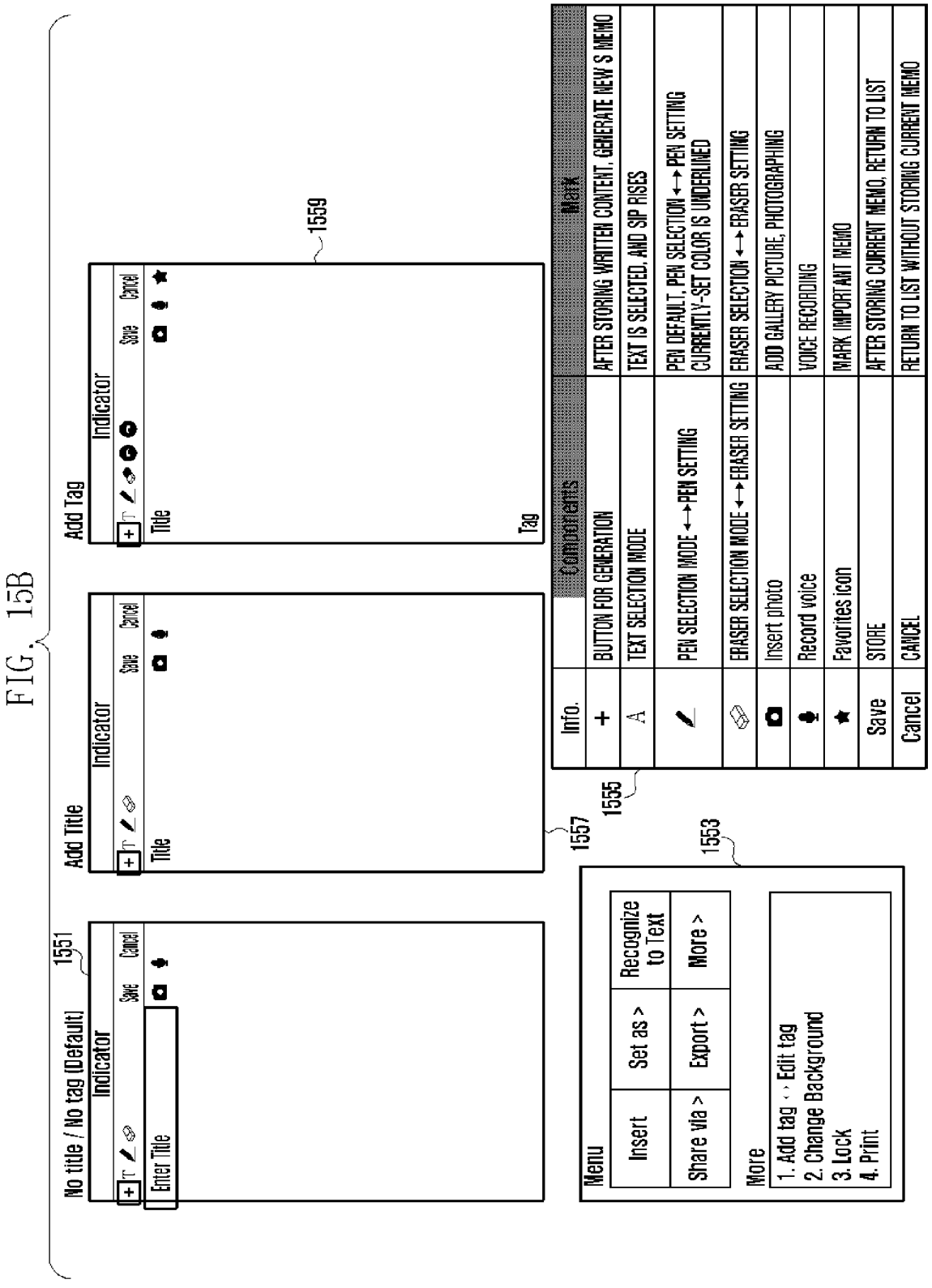


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FIG. 15A

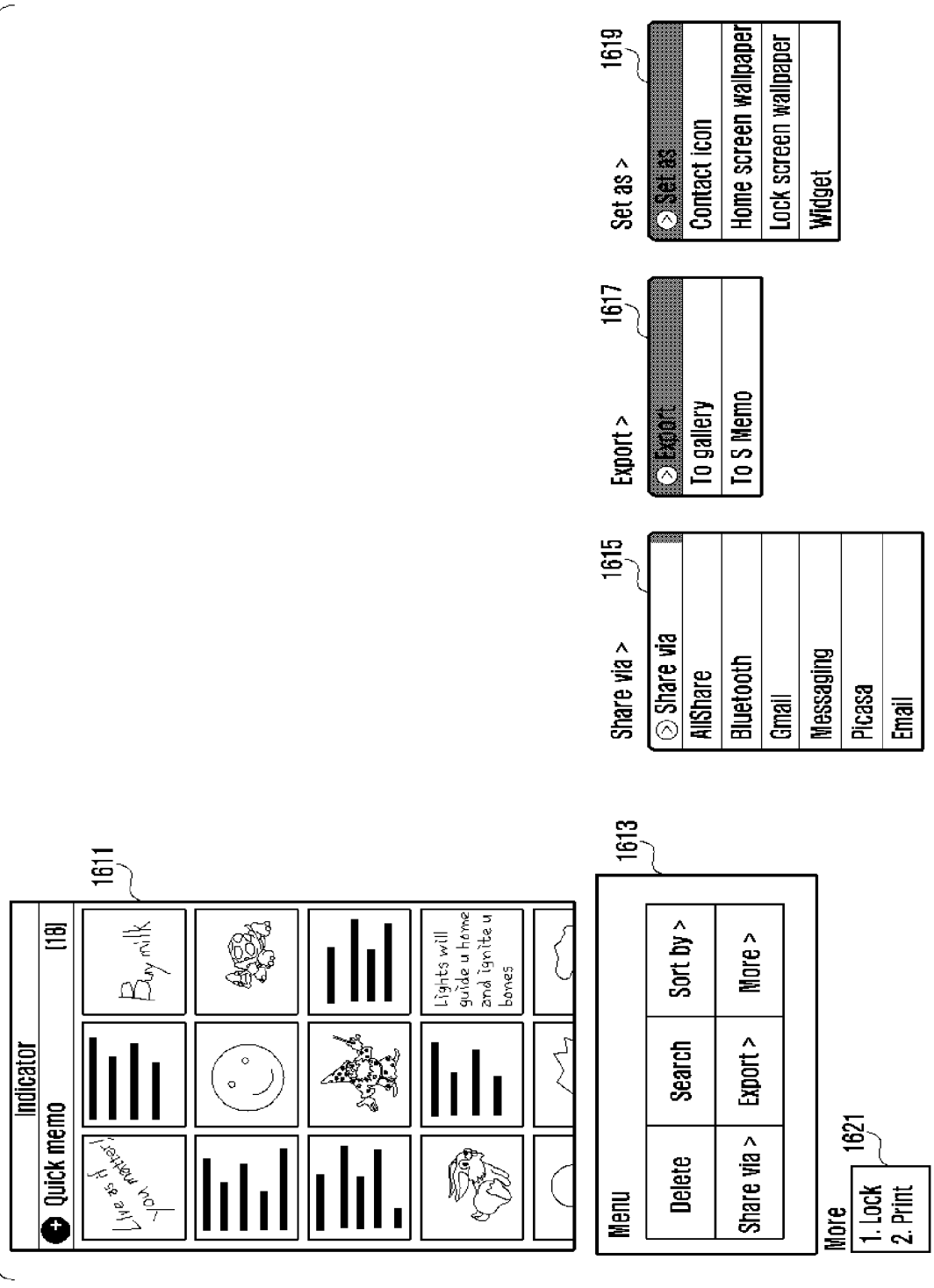
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FIG. 15B



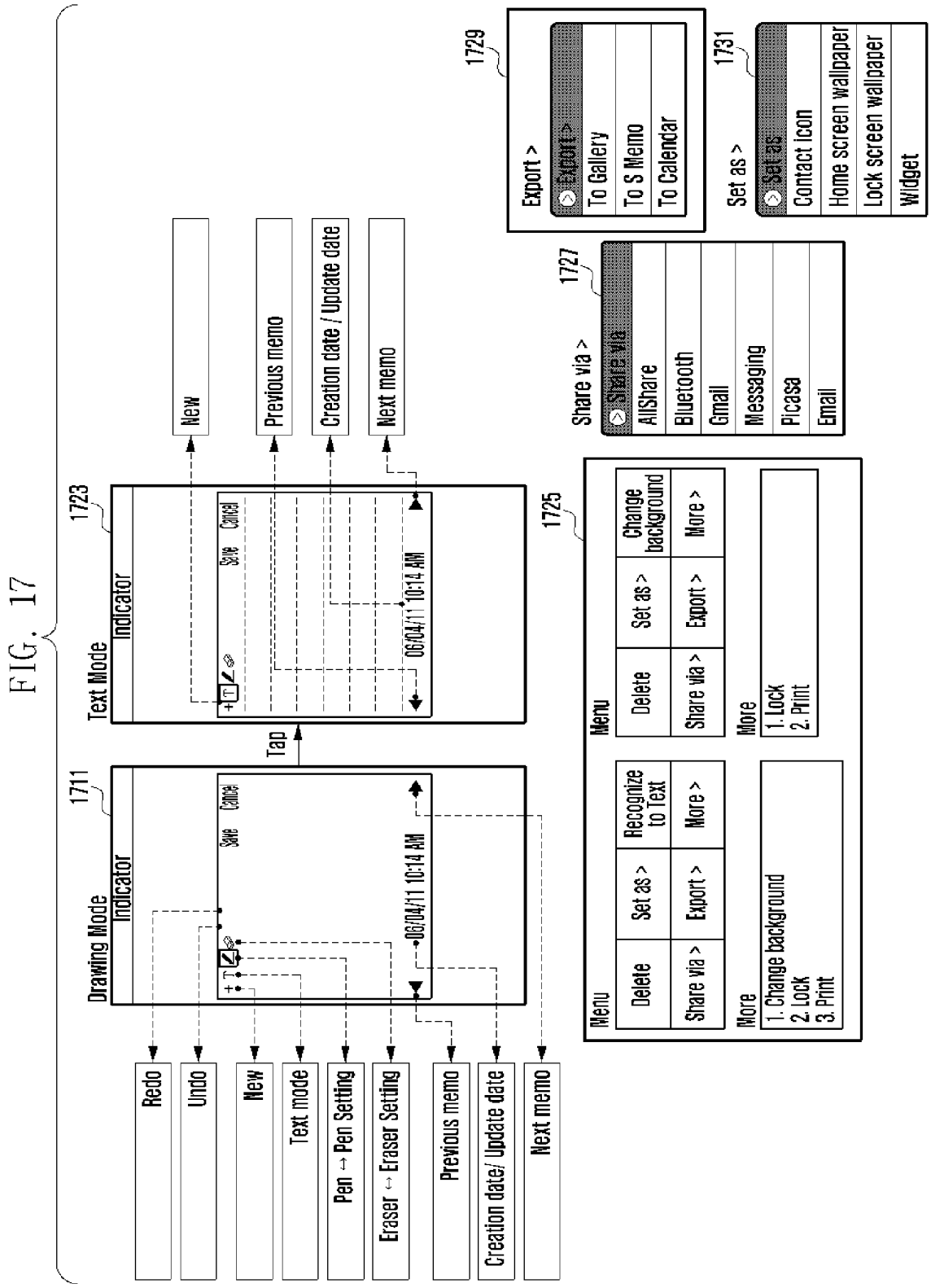
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FIG. 16



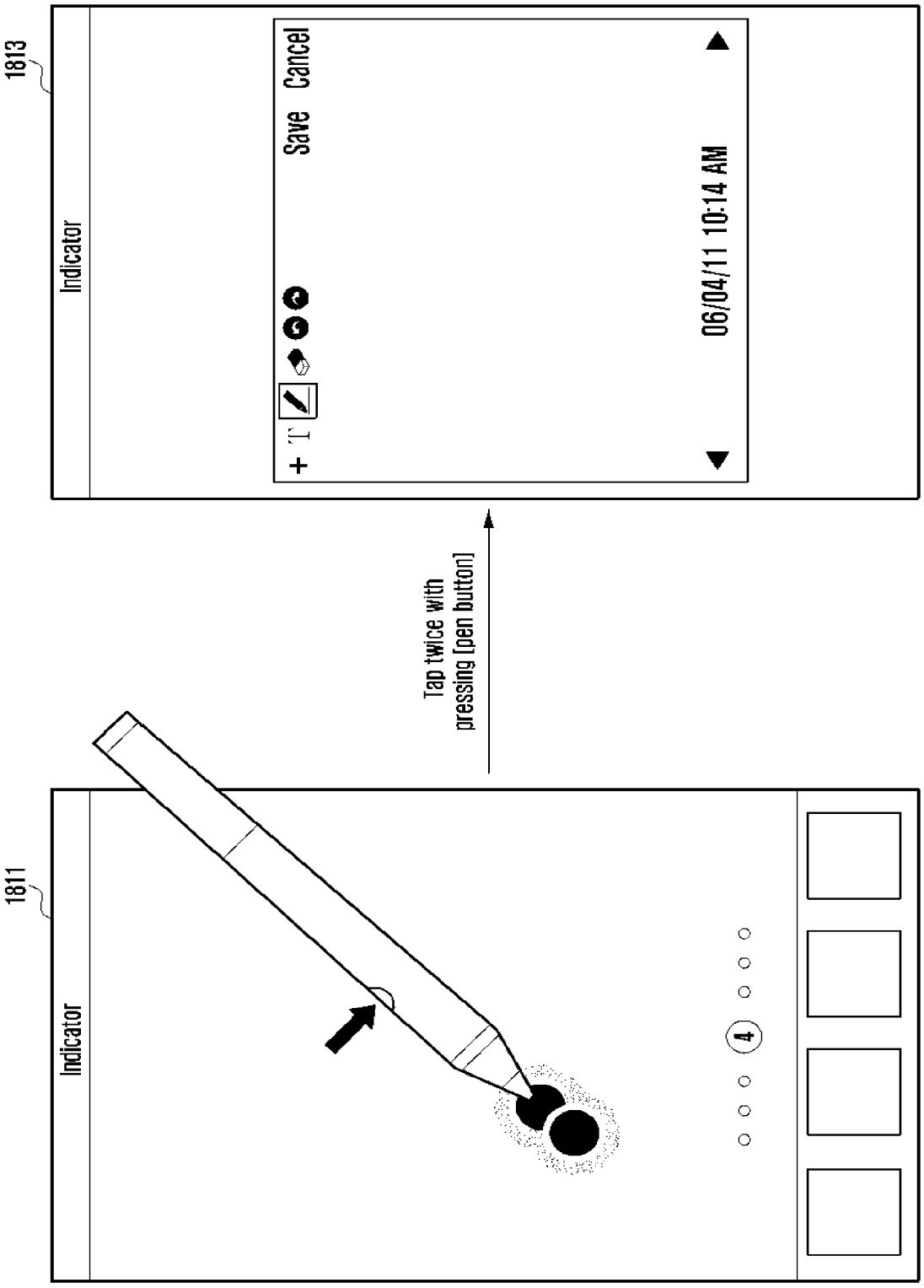
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FIG. 17



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FIG. 18



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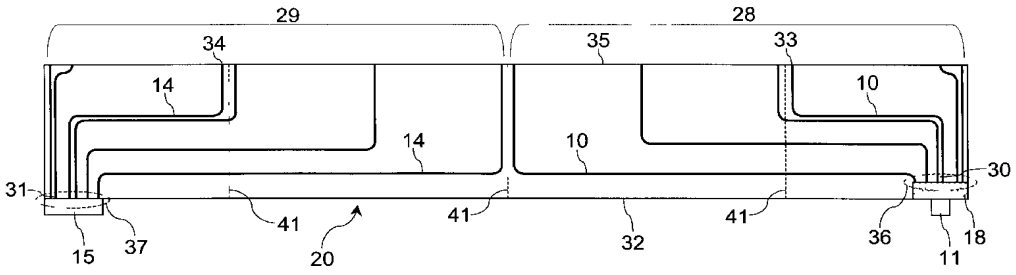
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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, **DK,** EE, ES, FI, FR, GB, GR, HU, IE, **IS, IT,** LT, LU, LV, MC, MT, NL, PL, PT, **RO,** SE, **SI,** SK, TR), OAPI (BF, **BJ,** CF, CG, CI, CM, GA, GN, GQ, GW, ML, **MR,** NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report*

(54) **Title:** WAVEGUIDE CONFIGURATIONS FOR OPTICAL TOUCH SYSTEMS



(57) **Abstract:** The present invention relates to waveguide structures and optical elements for use in an optical touch input device. The waveguide structures and optical elements allow for reduced bezel width and simplified assembly of optical touch input devices, and relaxed component tolerances.

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WAVEGUIDE CONFIGURATIONS FOR OPTICAL TOUCH SYSTEMS

FIELD OF THE INVENTION

The present invention relates to input systems, and in particular, optical touch systems having relatively reduced bezel dimensions. However, it will be appreciated that the invention is not limited to this particular field of use.

BACKGROUND OF THE INVENTION

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of the common general knowledge in the field.

Touch input devices or sensors for computers and other consumer electronics devices such as mobile phones, personal digital assistants (PDAs) and hand-held games are highly desirable due to their extreme ease of use. In the past, a variety of approaches have been used to provide touch input devices. The most common approach uses a flexible resistive overlay, although the overlay is easily damaged, can cause glare problems, and tends to dim an underlying display, requiring excess power usage to compensate for such dimming. Resistive devices can also be sensitive to humidity, and the cost of the resistive overlay scales quadratically with perimeter. Another approach is capacitive touch, which also requires an overlay. In this case the overlay is generally more durable, but the glare and dimming problems remain.

In yet another common approach, a matrix of infrared light beams is established in front of a display, with a touch detected by the interruption of one or more of the beams. Such 'optical' touch input devices have long been known (US 3,478,220; US 3,673,327), with the beams generated by arrays of optical sources such as light emitting diodes (LEDs) and detected by corresponding arrays of detectors (such as

phototransistors). They have the advantage of being overlay-free and can function in a variety of ambient light conditions (US 4,988,983), but have a significant cost problem in that they require a large number of source and detector components, as well as supporting electronics. Since the spatial resolution of such systems depends on the number of sources and detectors, this component cost increases with display size and resolution.

An alternative optical touch input technology, based on integrated optical waveguides, is disclosed in US 6,351,260, US 6,181,842 and US 5,914,709, and in US Patent Application Nos. 2002/0088930 and 2004/0201579. The basic principle of such a device is shown in Figure 1. In this optical touch input device, integrated optical waveguides ('transmit' waveguides) 10 conduct light from a single optical source 11 to integrated in-plane lenses 16 that collimate the light in the plane of a display and/or input area 13 and launch an array of light beams 12 across that display and/or input area 13. The light is collected by a second set of integrated in-plane lenses 16 and integrated optical waveguides ('receive' waveguides) 14 at the other side of the screen and/or input area, and conducted to a position-sensitive (i.e. multi-element) detector 15. A touch event (e.g. by a finger or stylus) cuts one or more of the beams of light and is detected as a shadow, with position determined from the particular beam(s) blocked by the touching object. That is, the position of any physical blockage can be identified in each dimension, enabling user feedback to be entered into the device. Preferably, the device also includes external vertical collimating lenses (VCLs) 17 adjacent to the integrated in-plane lenses 16 on both sides of the input area 13, to collimate the light beams 12 in the direction perpendicular to the plane of the input area.

The touch input devices are usually two dimensional and rectangular, with two arrays (X, Y) of transmit waveguides 10 along adjacent sides of the input area, and two

corresponding arrays of receive waveguides 14 along the other two sides. As part of the transmit side, in one embodiment a single optical source 11 (such as an LED or a vertical cavity surface emitting laser (VCSEL)) launches light via some form of optical power splitter 18 into a plurality of waveguides that form both the X and Y transmit arrays. The X and Y transmit waveguides are usually fabricated on an L shaped substrate 19, and likewise for the X and Y receive waveguides, so that a single source and a single position-sensitive detector can be used to cover both X and Y dimensions. However in alternative embodiments, a separate source and/or detector may be used for each of the X and Y dimensions. For simplicity, Figure 1 only shows four waveguides per side of the input area 13; in actual touch input devices there will generally be sufficient waveguides for substantial coverage of the input area.

These prior art devices house the waveguide structures that form the X and Y transmit arrays within a protective bezel that surrounds the input area. Typically, the input area will coincide with a display, in which case the touch input device may be referred to as a 'touch screen'. Other touch input devices, sometimes referred to as 'touch panels', do not have a display. The present invention applies to both types of input device. As will be appreciated, the bezel width necessarily limits the display size within a given touch screen device, which may be a significant limitation for small devices such as mobile phones. A further problem is that, to minimise the bezel width, the distance between the in-plane lenses and the external VCLs should be minimised, leading to a high magnification optical system that is extremely susceptible to errors in the design, fabrication and placement of the external VCLs.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

DISCLOSURE OF THE INVENTION

According to a first aspect the present invention provides a waveguide structure for an input device having an input area defining a plane, said waveguide structure having at least one optical waveguide adapted to carry a signal for said input device, said waveguide structure being configured such that, in use, said at least one optical waveguide extends entirely below said plane.

The input device typically includes a substantially planar input surface for receiving user input, and in the preferred embodiment, the input surface defines the plane of the input area. The input device also includes a periphery defined by one or more sides, and is preferably substantially rectangular in shape.

The signal may comprise an input signal or an output signal and is preferably light having a predetermined wavelength. The wavelength may be in the visible region of the spectrum or the infrared region of the spectrum. Desirably the wavelength is between 700 and 1000 nm.

The waveguide structure preferably includes a plurality of optical waveguides, wherein each optical waveguide extends entirely below the plane.

Preferably the waveguide structure is substantially flexible and formed from polymeric materials. Optimally, the waveguide structure is bendable through at least 90° without suffering mechanical damage. In a particularly preferred embodiment, the waveguide structure comprises a plurality of polymer optical waveguides fabricated on a flexible polymer substrate.

Preferably the waveguide structure extends around at least a portion of the periphery. Optionally the waveguide structure extends around adjacent sides of the periphery. However, in preferred embodiments the waveguide structure extends around the entire periphery.

In preferred embodiments, the waveguide structure is disposed substantially perpendicularly to the plane of the input device. However, in other embodiments the waveguide structure extends underneath and substantially parallel to the plane of the input device, and preferably lies substantially within the periphery.

The waveguide structure is preferably configured such that, in use, the at least one optical waveguide passes through a maximum of two mutually perpendicular planes.

The waveguide structure may be formed as a substantially rectangular two-dimensional sheet. However, in other embodiments, the waveguide structure is formed as a substantially L-shaped two-dimensional sheet.

In a particular embodiment of the invention the waveguide structure comprises a plurality of input waveguides adapted to carry an input signal and a plurality of output waveguides adapted to carry an output signal. Preferably the input waveguides are grouped on the waveguide structure to define a transmit section, and the output waveguides are grouped on the waveguide structure to define a receive section. Typically, the input waveguides are referred to as transmit waveguides and the output waveguides referred to as receive waveguides. Each waveguide includes an input portion for receiving an input signal and an output portion for transmitting an output signal. Typically the waveguides are positioned such that the input portions of the transmit waveguides and the output portions of the receive waveguides are disposed on or proximate to a first side of the waveguide structure, and the output portions of the transmit waveguides and the input portions of the receive waveguides are disposed on or proximate to a second side of the waveguide structure, wherein the first and second sides are substantially mutually opposed. In this embodiment, the input portions of the transmit waveguides are grouped into an input array, and the output portions of the receive waveguides are grouped into an output array, each array extending along a

portion of the first side. However, the output portions of the transmit waveguides and the input portions of the receive waveguides are spaced, preferably substantially evenly spaced, along substantially the entire length of the second side.

In other embodiments, the waveguides are positioned such that the input portions of the transmit waveguides and the output portions of the receive waveguides are disposed on or proximate to opposite sides of the waveguide structure, and the output portions of the transmit waveguides and the input portions of the receive waveguides are disposed on or proximate to a common side of the waveguide structure. Preferably the output portions of the transmit waveguides and the input portions of the receive waveguides are spaced, preferably substantially evenly spaced, along substantially the entire length of the common side.

The input array is suitably optically coupleable with a light source and the output array is optically coupleable with a light detector, which is preferably a position-sensitive detector.

In preferred embodiments the output portions of the transmit waveguides and the input portions of the receive waveguides include an integral structure, such as a planar lens. In other embodiments the integral structure may be a planar internally reflective mirror.

Preferably the waveguide structure includes at least one fold line defined by a line of weakness to assist in folding the waveguide structure about the periphery of an input device. In alternative embodiments, the fold line is a printed mark to assist in manual assembly with an input device and/or with an optical element. Alternatively, the printed mark is visible to a machine vision system when the waveguide structure is machine assembled with an input device.

According to a second aspect the present invention provides an optical element for an input device having an input area defining a plane, said optical element comprising: a first reflective surface; and a connect portion adapted for connection to a waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device, said optical element being configured for use with said input device such that, in use, said first reflective surface is positioned above said plane to re-direct said signal to or from said optical waveguide, said connect portion being at least partially below said plane whereby said at least one optical waveguide extends entirely below said plane. The reflective surface may be a mirror adapted for optical communication with the connect portion. The mirror may be plane or arcuate in cross-section and is optionally metallised. However, in a preferred embodiment the first reflective surface is an internally reflective surface.

Preferably, the optical element further includes a body of light transmissive material for transmission of the signal between the connect portion and the first reflective surface, in which case the first reflective surface is an internally reflective surface. More preferably, the internally reflective surface is a totally internally reflective surface. Preferably the first reflective surface is curved thereby to focus the signal in a direction substantially perpendicular to the plane of the input device. Alternatively, the first reflective surface may be planar so that it does not focus the signal.

In further aspects, the optical element includes a second reflective surface that, in use, is positioned below the plane of the input device. An optical element having a second reflective surface is particularly useful when the waveguide structure extends underneath and substantially parallel to the plane of the input device. Preferably, the second reflective surface is an internally reflective surface, more preferably a totally internally reflective surface. The second reflective surface may be curved so as to focus

the signal in a direction substantially perpendicular to the plane of the input device. Preferably, the second reflective surface is curved in a cylindrical fashion so as to focus a plurality of signals associated with a plurality of optical waveguides. Alternatively, the second reflective surface may be planar.

In preferred embodiments, the optical element is formed as a strip of plastics material substantially transparent to the signal light (e.g. in the infrared region of the spectrum) and opaque to light at other wavelengths (e.g. ambient visible light). The optical element is preferably injection moulded or extruded. Additionally, in a preferred form the optical element is substantially rigid.

When formed as a strip of plastics material, the first reflective surface of the optical element is preferably arcuate in cross section thereby to focus a plurality of signals associated with a plurality of optical waveguides.

In the preferred embodiments where the optical element further includes a body of light transmissive material between the connect portion and the first reflective surface, the optical element includes an optical surface through which light passes as it transits the input area. In some embodiments, this optical surface will be planar. Alternatively, it may be arcuate in cross section to form a lens portion thereby to focus the signal in a direction substantially perpendicular to the plane of the input device. Preferably, the optical surface is curved in a cylindrical fashion so as to focus a plurality of signals associated with a plurality of optical waveguides. Irrespective of the precise shape of the optical surface, the optical element is preferably shaped such that, in use, the exterior angle between the input device and the optical surface is greater than 90°. In related aspects, the optical element includes a recess such that the optical element is releasably attachable with the input device. Further, the waveguide structure may be fixedly attached to the optical element by, for example, gluing.

According to a third aspect the present invention provides an apparatus comprising: an input device having an input area defining a plane and having a periphery; a waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device; and one or more optical elements extending along at least a portion of said periphery and in optical communication with said at least one waveguide, each optical element extending from a position below said plane to a position above said plane such that, in use, each said optical element transmits said input signal or said output signal to or from said input area to said at least one waveguide extending entirely below said plane.

According to a fourth aspect the present invention provides a method of transmitting input and output signals for an input device, said input device having an input area defining a plane and having a periphery, said method comprising: providing at least one waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device, said at least one optical waveguide extending entirely below said plane; providing one or more optical elements along at least a portion of said periphery; and optically coupling said waveguide structure with a respective optical element such that, in use, each said optical element transmits said input signal or said output signal to or from said input area to a respective waveguide extending entirely below said plane.

According to a fifth aspect the present invention provides a method of reducing bezel width in an input device, said input device having an input area defining a plane and having a periphery, said method comprising: providing at least one waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device; providing one or more optical elements along at least a portion of said periphery; and optically coupling said at least one optical waveguide

with a respective optical element such that, in use, each said optical element transmits said input signal or said output signal to or from said at least one optical waveguide; wherein said at least one optical waveguide is terminated at a position below said plane, and wherein said optical elements extend from above said plane to a position below said plane.

Unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of 'including, but not limited to'.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates a typical prior art waveguide-based optical touch screen sensor;

Figure 2 is a plan view of one embodiment of a waveguide structure according to the present invention;

Figure 3 is a plan view of another embodiment of a waveguide structure according to the present invention;

Figure 4 is a plan view of yet a further embodiment of a waveguide structure according to the present invention, wherein the waveguide includes a recess to accommodate electrical connections to a display that the waveguide structure surrounds;

Figure 5 is a perspective view of one half of the waveguide structure embodiment shown in Figure 2, shown folded into an L-configuration and ready to be engaged to a display;

Figure 6 is a perspective view of the waveguide structure embodiment shown in Figure 2 engaged to a display;

Figure 7 is a top view of the waveguide structure embodiment shown in Figure 3 engaged to a display;

Figure 8 is a plan view of another embodiment a waveguide structure according to the invention;

Figure 9 is an underside view of a display showing a pair of the waveguide structure embodiments shown in Figure 8 engaged thereto;

Figure 10 is a sectional side view of one embodiment of an optical element according to the present invention shown engaged to a display and having a waveguide structure optically engaged thereto, and directing light from the waveguide across the upper surface of the display;

Figure 11 is a view similar to Figure 10 but showing another embodiment of an optical element according to the present invention;

Figure 12 is a view similar to Figure 10 but showing a further embodiment of an optical element according to the present invention;

Figure 13 is a view similar to Figure 10 but showing yet another embodiment of an optical element according to the present invention;

Figure 14 is a sectional side view of another embodiment of an optical element according to the present invention shown engaged to a display and having a waveguide structure optically engaged thereto, wherein the waveguide structure is positioned beneath and parallel to the display;

Figure 15 is a view similar to Figure 14 but showing another embodiment of an optical element according to the present invention;

Figure 16 is an exploded perspective view of a display, a waveguide structure according to the invention and an optical element according to the invention;

Figure 17 is a sectional side view of a prior art waveguide-based optical touch input device showing the relatively wide bezel dimension required to accommodate the waveguide structure and associated optics;

Figure 18 is a sectional side view of the combined waveguide structure and optical element of one embodiment of the present invention engaged to a display showing the relatively reduced bezel dimensions required; and

Figures 19(a) and 19(b) show plan and side views of a typical prior art assembly of a transmit waveguide and an external vertical collimating lens.

PREFERRED EMBODIMENT OF THE INVENTION

Referring initially to Figures 2 to 9, a waveguide structure 20 for an input device in the form of a touch screen 21 is formed as a substantially two-dimensional sheet comprising a plurality of waveguides adapted to carry input signals or output signals for the touch screen 21. The touch screen 21 is substantially rectangular in shape and includes a substantially planar input surface 23 for receiving user input, such as the touch of a finger or a stylus. In this embodiment the input surface 23 coincides with the outer surface of a display 24 (such as a liquid crystal display (LCD)). In other embodiments the input surface may coincide with the outer surface of a transparent protective cover in front of a display.

In the various embodiments as shown in Figures 2 to 4, the substantially rectangular waveguide structure 20 is formed from a resilient plastics material that is substantially flexible. Preferably the waveguide structure 20 is repeatably and reversibly bendable through at least 90° without being mechanically damaged. For example,

Figure 5 shows one half of the waveguide structure 20 shown in Figure 2 folded into an L-configuration and ready to be engaged to a display. Figure 6 shows the entire waveguide structure 20 of Figure 2 engaged to the periphery 25 of a display 24, and Figure 7 shows waveguide structure 20 of Figure 3 or Figure 4 engaged to the periphery 25 of a display 24. In the embodiment shown in Figure 8, the waveguide structure 20 is configured as an 'L', rather than a substantially rectangular sheet as shown in Figures 2 to 4. This embodiment is particularly useful when, as shown in Figure 9, the waveguide structure is engaged to the underside of a display 24.

The waveguide structure 20 preferably comprises a plurality of optical waveguides comprising a photo-curable polymer material fabricated on a flexible polymer substrate, for example by a method disclosed in US Patent Application No 11/742,194 entitled 'Methods for fabricating polymer optical waveguides on large area panels'. Briefly, this document describes methods for fabricating polymer optical waveguides comprising a three layer structure, wherein at least one of the optical layers is deposited by a two-stage deposition process whereby the second step is a spinning process. The invention disclosed in US 11/742,194 is of particular relevance to the volume production of polymer optical waveguides on large area substrates.

As shown in Figure 6, the waveguide structure 20 is configured such that, in use, the waveguide structure 20 extends around at least a portion of the periphery 25 of a display 24. Preferably the waveguide structure 20 extends around the entire periphery 25 and is disposed substantially perpendicularly to the input surface 23 of a touch screen 21. Importantly, the waveguide structure 20 is engaged to a touch screen 21 such that each of the waveguides 10, 14 extends entirely below the input surface 23 of the touch screen.

In other waveguide substrate configurations, the waveguide structure 20 is a two-dimensional sheet that extends underneath and substantially parallel to the input surface 23 of a touch screen 21. One such configuration comprises four waveguide structures 20, each extending along an edge of the touch screen 21. However, in preferred configurations as shown in Figures 8 and 9, the waveguide structure 20 is formed on a pair of L-shaped substrates 26 that extend underneath and substantially parallel to the input surface 23 of a touch screen 21. It will be appreciated that preferably the L-shaped substrates 26 lie substantially within the periphery 25 of the touch screen. However, the L-shaped substrates could also exceed the periphery 25 of the touch screen. In other embodiments, the waveguide structures 20 may lie underneath as well as extend along at least a portion of the periphery 25 of a touch screen 21, however, not extend above the input surface 23 of the touch screen. Irrespective of the particular embodiment, it will be understood that the waveguide structures 20 of the present invention are configured such that, in use, the waveguides pass through a maximum of two mutually perpendicular planes.

Referring again to the embodiment as shown in Figure 2, the waveguide structure 20 comprises a plurality of transmit waveguides 10 adapted to carry a plurality of light signals from a light source 11, and a plurality of receive waveguides 14 adapted to carry a plurality of output signals to a multi-element detector 15. The transmit waveguides 10 are grouped on the waveguide structure 20 to define a transmit section 28, and the receive waveguides 14 are grouped to define a receive section 29. Each of the waveguides 10 and 14 includes an input portion for receiving an input signal and an output portion for transmitting an output signal. The transmit and receive waveguides 10 and 14 are positioned on the waveguide structure 20 such that the input portions 30 of the transmit waveguides 10 and the output portions 31 of the receive waveguides 14 are

disposed on or proximate to a first side 32 of the waveguide structure 20, and the output portions 33 of the transmit waveguides 10 and the input portions 34 of the receive waveguides 14 are disposed on or proximate to a second side 35 of the waveguide structure 20, the first and second sides 32 and 35 being mutually opposed. Further, the input portions 30 of the transmit waveguides 10 are grouped into an input array 36, and the output portions 31 of the receive waveguides 14 are grouped together into an output array 37, with each array 36 and 37 extending along only a portion of the first side 32 for coupling with a source 11 or detector 15 respectively. It should be understood that the input array 36 of transmit waveguides 10 may include a splitter 18 for distribution of optical power to the transmit waveguides 10. In contrast, the output portions 33 of the transmit waveguides 10 and the input portions 34 of the receive waveguides 14 are spaced, preferably substantially evenly spaced, along substantially the entire length of the second side 35. However, it will be appreciated that the spacing may be selected for the particular application. It will be further appreciated that for clarity, only a few transmit waveguides 10 or receive waveguides 14 are shown in each of Figures 2 to 6 and 8 to 9.

Referring again to the embodiments as shown in Figures 3 and 4, the waveguides are positioned such that the input portions 30 of the transmit waveguides 10 and the output portions 31 of the receive waveguides 14 are disposed on or proximate to opposite sides of the waveguide structure 20. The output portions 33 of the transmit waveguides 10 and the input portions 34 of the receive waveguides 14 are disposed on or proximate to a common side 35 of the waveguide structure 20 and spaced along substantially the entire length of the common side. Preferably the waveguides are substantially evenly spaced, however it will be appreciated that the spacing may be selected for the particular application.

As shown in Figures 2 to 4, the input array 36 is optically coupleable with a light source 11 for supplying a light signal and the output array 37 is optically coupleable with a suitable multi-element light detector 15. The light has a predetermined wavelength that may, for example, be in the infrared region of the spectrum, preferably between 700 and 1000 nm. Alternatively, the predetermined wavelength may be in the visible region of the spectrum.

Referring in particular to the embodiment as shown in Figure 8, the output array 37 is disposed at the terminus of one leg of the L-shaped waveguide structure 20, and the input portions 34 of the receive waveguides 14 are substantially evenly spaced along substantially the entire length of the two outer edges 39 of the L-shaped substrate 26, thereby to define an L-shaped receive section. It will be appreciated that, apart from the inclusion of an optical splitter 18, an essentially identical arrangement to that shown in Figure 8 would function as a transmit L-shaped waveguide structure.

Additionally, waveguide structures can be overlapped to ensure that the entire periphery 25 of a touch screen 21 is accessible to either the transmit section 28 or receive section 29 of a waveguide structure 20. For example, the waveguide structures shown in Figure 3 and Figure 4 can be folded around the periphery 25 of the touch screen 21 with a source 11 and a detector 15 overlapped in one corner, as clearly shown in Figure 7. A source 11 and detector 15 could be located on a single chip. It should be noted that the waveguide structure shown in Figure 2 requires a source 11 and a detector 15 to be located below the touch screen 21, whereas the waveguide structures shown in Figures 3 and 4 allow a source 11 and a detector 15 to be located beside the touch screen 21. The latter two waveguide structures may be preferable if it is important to minimise the depth of the device as a whole. In yet another configuration, the receive-side waveguide structure shown in Figure 8 and a similar transmit-side waveguide structure

can be engaged in overlapping fashion to the underside of a display 24, as shown in Figure 9. It will be appreciated that this overlapping arrangement may require a degree of flexibility in each waveguide structure for out-of-plane bending, but this will be trivial if, as preferred, the substrates 26 are composed of plastics materials.

For clarity, the waveguide structures 20 illustrated in Figures 2 to 6 and 8 to 9 show the output portions 33 of the transmit waveguides 10 and the input portions 34 of the receive waveguides 14 extending to edge(s) 35 or 39 of each structure. In some embodiments this will indeed be the case. In other embodiments, the output portions 33 or the input portions 34 (or both) each include an integral structure for collimating the light beams in the plane of the input surface 23. Generally the integral structure is in the form of a planar lens 16, as shown in Figure 1 and Figure 16. Alternatively, the integral structure may be a planar internally reflective mirror, as disclosed in US patent publication No 2006/0188196, entitled 'Waveguide design incorporating reflective optics'.

In the waveguide structures 20 shown in Figures 2 to 4, the transmit waveguides 10 and receive waveguides 14 are provided on a single substantially rectangular strip designed to be folded around the entire periphery of the touch screen. It will be appreciated that the larger the touch screen, the longer the rectangular strip needs to be, however this will be limited by the size of the substrate used for waveguide fabrication. The waveguide fabrication techniques disclosed in US Patent Application No 11/742,194 will clearly be applicable to this situation. If substrate size is a limitation it is of course possible to fabricate the transmit waveguides and receive waveguides on separate substantially rectangular strips, each of which would be folded around two sides of the periphery, for example as shown in Figure 5.

Irrespective of whether the transmit waveguides and receive waveguides are fabricated on separate strips or a single strip, a key advantage of fabricating the waveguides on rectangular strips, as shown in Figures 2 and 3, compared to the prior art L-shaped waveguide structures as shown in Figure 1, is that it is significantly easier to singulate rectangular structures than L-shaped structures with a dicing saw. In particular, the interior sides of an L-shaped structure are difficult to cut with a dicing saw. It will be noted that the waveguide structure shown in Figure 4 has a recess 61, designed to facilitate electrical connections to the touch screen 21. The recess 61 will complicate the singulation process, but since there are no transmit waveguide outputs 33 or receive waveguide inputs 34 along the side 62 incorporating the recess 61, that side can be shaped with a cruder stamping process while the straight sides are diced. Similarly, an advantage of the L-shaped configuration shown in Figure 8 compared to the prior art L-shaped configuration shown in Figure 1 is that the inner edges 38 of the L-shaped waveguide structure of the invention, having no receive waveguide inputs 34, can be shaped with a cruder stamping process while the outer edges 39 can be diced with a dicing saw. It will be appreciated that even if the transmit waveguides 10 and receive waveguides 14 terminate in an integral structure such as a planar lens 16 with a curved optical interface (as shown in Figure 1), it is desirable to cut the substrate as close as possible to the optical interface; this requires the precision of a dicing saw and is not suited to a stamping process.

As discussed above with regard to Figures 5 to 7, the waveguide structures 20 are preferably substantially flexible for assisting in folding around the periphery 25 of a touch screen 21. In the embodiments shown in Figures 2 to 4, a waveguide structure 20 includes at least one fold line 41 defined by a line of weakness to assist in the installation around a touch screen 21. In alternative embodiments, the fold line 41 is a

printed mark visible to a machine vision system when the waveguide structure 20 is machine assembled with a touch screen 21. Alternatively the printed mark may assist with manual assembly of the waveguide structure 20 with a touch screen 21.

Turning now to Figures 10 to 15, an optical element 42 for a touch screen 21 is shown comprising a first reflective surface 43 for reflecting a light signal 44 in a direction substantially parallel to the input surface 23, coincident with the outer surface of a display 24, and a connect portion 45 adapted for connection to the waveguide structure 20. The optical element 42 is configured for use with a touch screen 21 such that, in use, the first reflective surface 43 is positioned above the input surface 23 of a touch screen 21 to re-direct a light signal 44 to or from the waveguide structure 20. Preferably the connect portion 45 is at least partially below the input surface 23.

The optical element 42 further includes a body of light transmissive material 46 for transmission of a light signal 44 between the connect portion 45 and the first reflective surface 43.

In other embodiments, as shown in Figures 14 and 15, the optical element 42 further includes a second reflective surface 47 that, in use, is positioned below the input surface 23, and where the waveguide structure 20 extends underneath and substantially parallel to the input surface.

It will be appreciated that an optical element 42 could be constructed such that one or both of the reflective surfaces are externally reflective (i.e. conventional) mirrors rather than internally reflective surfaces. However a construction where an optical element 42 has internally reflective surfaces, as shown for example in Figures 10 to 15, is preferred for robustness and ease of manufacture (by injection moulding for example). Further, an externally reflective mirror would need to be metallised, whereas the internally reflective surfaces may not need to be metallised if the condition for total

internal reflection is met. Those skilled in the art will understand that this can be ensured by appropriate design of the optical element.

As shown in Figure 16, an optical element 42 is preferably formed as an elongate strip of plastics material substantially transparent to the signal light (e.g. infrared light). Desirably, the optical element 42 is opaque to light of other wavelengths (e.g. ambient visible light if the signal comprises infrared light). The optical element 42 may be injection moulded or extruded and is preferably substantially rigid.

The first internally reflective surface 43 may be curved thereby to focus a light signal 44 in a direction substantially perpendicular to the plane of the input surface 23, as shown for example in Figures 10 to 12 and 15. Alternatively, the first reflective surface 43 may be planar, as shown for example in Figures 13 and 14. The second reflective surface 47, where present, may likewise be curved or planar. If either the first or second reflective surfaces are curved, they are preferably curved in a cylindrical fashion so as to focus a plurality of signals associated with a plurality of waveguides.

As shown in Figures 10 to 15, the optical element 42 has an optical surface 48 through which light 44 passes as it transits a touch screen 21. In some embodiments, for example as shown in Figures 10, 12 and 15, this optical surface 48 may be planar. Alternatively, as shown for example in Figures 11, 13 and 14, it may be curved to form a lens portion 49 so as to focus a light signal 44 in a direction substantially perpendicular to the plane of the input surface 23. Preferably, the lens portion 49 is curved in a cylindrical fashion so as to focus a plurality of signals associated with a plurality of waveguides. Irrespective of the precise shape of the optical surface 48, the optical element 42 is preferably shaped such that, in use, the exterior angle between the input surface 23 and the optical surface 48 is greater than or equal to 90° (as shown in Figures 10, 12, 13 and 15 for example), to minimise the build-up of dirt over time which could

potentially obscure the optical surface 48. In other embodiments, optical elements engaged to the transmit and receive sections of the waveguide structure have different optical surfaces. For example, the transmit-side optical elements may have a planar optical surface 48 and the receive-side optical elements may have an optical surface in the form of a lens 49.

Preferably the optical element 42 includes a recess 50 such that the optical element 42 is releasably attachable to a display 24. In certain embodiments the optical element 42 is configured as a single piece having physical dimensions matching the periphery 25 of a display 24 such that the optical element 42 is adapted to 'clip' onto the display. Alternatively, the optical element 42 can be glued onto a display 24. In other embodiments the optical element 42 may be configured as two L-shaped pieces each adapted to clip around two adjacent sides of a display, or as four straight pieces each adapted to be attached to one side of a display 24 (as shown in Figure 16).

The waveguide structure 20 may be fixedly attached to the optical element 42 by gluing. However, it will be appreciated that any method of attachment that provides sufficient and stable optical communication between the waveguides 10, 14 and the optical element 42 will be suitable.

A particularly preferred design for an optical element 42 is shown in Figure 13, with an internally reflective surface 43, a recess 50 and an optical surface 48 comprising a lens portion 49. In this particular design, the internally reflective surface 43 is a plane surface inclined at an angle 61 of 49° to the horizontal, and the lens portion 49 forms an exterior angle of approximately 90° with the input surface 23 such that there is no re¬entrant cavity between the two where dirt may collect. Because the internally reflective surface 43 is angled at 49° to the horizontal, instead of 45°, the lens portion 49 is still able to collimate the signal light 44 parallel to the input surface 23. By way of specific

example, the dimensions 62, 63, 64, 65, 66, 67 and 68 of the optical element 42 are 3.9mm, 10mm, 4.4mm, 30mm, 6mm, 6.4mm and 3.6mm respectively, and the lens portion 49 has a radius of curvature of 7.2mm. Furthermore, the waveguide structure 20 is oriented such that its waveguides are on the surface adjacent to the connect portion 45.

Referring now to Figure 16, an apparatus for use in an input device is shown comprising a touch screen 21, a pair of waveguide structures 20, and four optical elements 42. The pair of waveguide structures 20 correspond to a transmit waveguide structure and a receive waveguide structure which, together, extend along substantially the entire periphery 25 of a display 24. The four optical elements 42 are engaged to the waveguide structures 20 in use and are in optical communication with respective waveguides of the waveguide structures 20. However, it will be appreciated that a pair of L-shaped optical elements, or a one-piece optical element would also be suitable. It will be appreciated that each of the optical elements 42 extends from a position below the input surface 23 to a position above the input surface 23 such that each optical element 42 transmits input or output signals to or from the input area 13 of a touch screen 21 between respective waveguides of the waveguide structures 20, which extend entirely below the input surface 23. The planar lenses 16 of each waveguide can be seen in Figure 16. These lenses 16 collimate light into and from the optical elements 42, such that signal beams passing across the input surface 23 of a touch screen 21 are focused in the plane of the input surface. It will be noted that in this particular configuration, unlike the configuration shown in Figure 13, the waveguide structures 20 are positioned between the display 24 and the optical elements 42.

In one example, the present invention includes a method of transmitting input and output signals for a touch screen device. The method comprises providing a waveguide structure 20, providing one or more optical elements 42, and then optically

coupling the waveguide structure 20 with a respective optical element 42 such that, in use, each optical element 42 transmits input or output signals to or from the input area 13 of a touch screen 21 to a respective waveguide of a waveguide structure 20 extending entirely below the input surface 23.

In a further example, referring to Figure 17 (prior art) and Figure 18, the present invention includes a method of reducing the width 54 of a bezel 51 in a touch screen 21. The method comprises providing a waveguide structure 20, providing one or more optical elements 42, and then optically coupling the waveguide structure 20 with a respective optical element 42 such that, in use, each said optical element 42 transmits an input or output signal 44 to or from the waveguide structure 20. The optical elements 42 extend from above the input surface 23 to a position below the input surface and the waveguides of each waveguide structure 20 are terminated at a position below the input surface.

It will be appreciated that the present invention provides a substantially reduced bezel dimension 54 (Figure 18) compared with prior art devices (Figure 17). The bezel requirements for the present invention (Figure 18) essentially comprise a thin raised 'lip' 52 surrounding a display 24. In contrast, the bezel requirements for prior art devices (Figure 17) comprise a relatively wide raised flange 53 surrounding a display 24.

In yet a further example, the present invention includes a method of reducing the tolerance required of an optical element used to provide focussing of optical signals in a direction substantially perpendicular to the plane of an input device. To illustrate, Figures 19(a) and 19(b) show plan and side views of a typical prior art assembly of an output portion 33 of a transmit waveguide 10 having an external vertical collimating lens (VCL) 17, wherein the transmit waveguide 10 and VCL 17 are mounted on a common base 71. An essentially identical arrangement is normally present on the receive side.

Typically, a transmit waveguide 10 comprises a substrate 72, a lower cladding layer 73, a core layer 74 and an upper cladding layer 75, with the core layer 74 terminating with an integrated planar lens 16 that collimates the light signal 44 in the plane of an adjoining input area. Note that for clarity the substrate 72, lower cladding layer 73 and upper cladding layer 75 have been omitted from Figure 19a. It will be appreciated that a light signal 44 launched from the end face 76 of a planar lens 16 will diverge in the direction perpendicular to the plane of the input area. As a consequence it is often desirable for the light signal 44 to be focussed in this direction as well. However, such 'out of plane' focussing requires a lens having curvature in that direction, which is difficult to shape reliably with photolithographic techniques. Consequently an external lens is employed for this task, for example a VCL 17. The VCL is generally curved in a cylindrical fashion so as to focus a plurality of signals associated with a plurality of waveguides.

It will be appreciated that the gap 77 between the end face 76 of the planar lens 16 and the curved face 78 of a VCL 17 contributes to the overall bezel width in a prior art device, and should ideally be minimised. However this requires the VCL to be a relatively powerful lens, i.e. to have a small radius of curvature. Those skilled in the art of micro-optics will understand that such a high magnification optical system is extremely susceptible to errors in the design and manufacture of a VCL, and in its placement with respect to the waveguides.

Certain embodiments of the present invention on the other hand provide such 'out of plane' focussing, via an optical element 42, as shown in Figures 10 to 15. For example, 'out of plane' focusing may be provided by a lens portion 49, a first reflective surface 43, a second reflective surface 47 or a combination of the above. Particularly notable are the embodiments shown in Figures 13 and 14, where 'out of plane' focussing

is provided by a lens portion 49, such that the distance between the waveguides in the waveguide structure 20 and the lens portion 49 is greatly increased compared to the gap 77 of the prior art device. An optical element 42 may be designed such that two or more of the lens portion 49, first reflective surface 43 and second reflective surface 47 provide the 'out of plane' focussing in combination, as shown for example in Figure 11. Such an arrangement may further relax the tolerances required for the optical element, since an optical system comprising two or more weaker focussing elements in series is generally more tolerant to alignment 'errors' than a system of equivalent magnification comprising a single relatively more powerful optical element.

It will be appreciated that the illustrated apparatus of the present invention provides many advantages over prior art devices, including but not limited to the following:

1.) Mounting the waveguide structure and the optical element of the present invention to a touch screen allows the bezel dimensions to be relatively reduced compared to prior art devices.

2.) The waveguide structures of the present invention provide a number of cost savings compared to prior art L-shaped waveguide structures. For example, from a manufacturing perspective it is relatively simpler to singulate a waveguide structure configured in rectangular strips than an L-shaped waveguide structure.

3.) Assembling an input device utilising the waveguide structures and optical elements of the present invention is relatively cheaper compared to prior art devices. Additionally, the present invention requires relatively fewer components than prior art devices.

4.) The configuration of the waveguide structure of the present invention means that the source and detector can be physically located adjacent to each other or,

preferably, on the same chip. This simplifies the layout of the internals of the input device and reduces production costs.

5.) From an aesthetics perspective, a thin bezel 'lip' surrounding the touch screen is more appealing than a relatively wide flange surrounding the touch screen.

6.) The optical element with the waveguide structure attached thereto can be fabricated as a single unit having physical dimensions matching the periphery of the touch screen. The optical element can then be simply clipped onto the touch screen thereby avoiding alignment issues and simplifying installation and reducing the installation costs.

7.) The apparatus and methods of the present invention enable a relatively larger touch screen to be provided on the device for the same overall dimensions because the bezel space requirements are now reduced. This satisfies the intent of many designers, which is to make the touch display of comparable width to the device itself. The advantage of this is that the user obtains the largest possible display size for a given device size, which is both practical and aesthetically pleasing.

8.) The apparatus and methods of the present invention relax the tolerances on the design, manufacture and placement of optical elements used to focus the optical signals in the direction perpendicular to the input area.

9.) The present invention may be used in conjunction with other transmit or receive optics. For example US Patent No 7,099,553 discloses a touch input device where the signal light is launched across the input area by an L-shaped light pipe with a plurality of reflective facets, instead of discrete transmit-side optical waveguides 10. In this sort of device the waveguide structures and optical elements of the present invention could still be used on the receive side.

In yet another alternative, the waveguide structures and optical elements of the present invention could be used on the transmit side of an optical input device, and with the receive waveguides 14 and multi-element detector 15 replaced by one or more arrays of discrete detectors.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:

1. A waveguide structure for an input device having an input area defining a plane, said waveguide structure having at least one optical waveguide adapted to carry a signal for said input device, said waveguide structure being configured such that, in use, said at least one optical waveguide extends entirely below said plane.

2. A waveguide structure according to claim 1 wherein said input device includes a substantially planar input surface for receiving user input.

3. A waveguide structure according to claim 2 wherein said plane is coincident with said input surface.

4. A waveguide structure according to any one of the preceding claims wherein said input device includes a periphery defined by one or more sides.

5. A waveguide structure according to any one of the preceding claims wherein said signal comprises an input signal or an output signal.

6. A waveguide structure according to any one of the preceding claims wherein said signal is light having a predetermined wavelength.

7. A waveguide structure according to any one of the preceding claims wherein each said at least one optical waveguide extends entirely below said plane.

8. A waveguide structure according to any one of the preceding claims wherein said waveguide structure is configured such that, in use, said at least one optical waveguide passes through a maximum of two mutually perpendicular planes.

9. A waveguide structure according to any one of the preceding claims wherein said waveguide structure is formed from polymeric materials.

10. A waveguide structure according to any one of the preceding claims wherein said waveguide structure is formed as a substantially rectangular sheet.

11. A waveguide structure according to any one of the preceding claims wherein said waveguide structure is substantially flexible.

12. A waveguide structure according to claim 11 wherein said waveguide structure is bendable through at least 90°.

13. A waveguide structure according to any one of claims 4-12 wherein said waveguide structure extends around adjacent sides of said periphery.

14. A waveguide structure according to any one of claims 4-13 wherein said waveguide structure extends around the entire said periphery.

15. A waveguide structure according to any one of the preceding claims wherein said waveguide structure is disposed substantially perpendicularly to said plane of said input device.

16. A waveguide structure according to any one of the preceding claims wherein said waveguide structure comprises a plurality of transmit waveguides adapted to carry an input signal to said input device or a plurality of receive waveguides adapted to carry an output signal from said input device, or both.

17. A waveguide structure according to claim 16 wherein said transmit waveguides are grouped on said waveguide structure to define a transmit section, and/or said receive waveguides are grouped on said waveguide structure to define a receive section.

18. A waveguide structure according to claim 16 or claim 17 wherein each said waveguide includes an input portion for receiving an input signal and an output portion for transmitting an output signal.

19. A waveguide structure according to claim 18 wherein said waveguides are positioned such that said input portions of said transmit waveguides and said output portions of said receive waveguides are disposed on or proximate to a first side of said waveguide structure, and said output portions of said transmit waveguides and said input

portions of said receive waveguides are disposed on or proximate to a second side of said waveguide structure.

20. A waveguide structure according to claim 19 wherein said first and second sides are substantially mutually opposed.

21. A waveguide structure according to claim 19 or claim 20 wherein said input portions of said transmit waveguides are grouped into an input array, and said output portions of said receive waveguides are grouped into an output array, each said array extending along a portion of said first side.

22. A waveguide structure according to any one of claims 19 to 21 wherein said output portions of said transmit waveguides and said input portions of said receive waveguides are substantially evenly spaced along substantially the entire length of said second side.

23. A waveguide structure according claim 18 wherein said waveguides are positioned such that said input portions of said transmit waveguides and said output portions of said receive waveguides are disposed on or proximate to opposite sides of said waveguide structure, and said output portions of said transmit waveguides and said input portions of said receive waveguides are disposed on or proximate to a common side of said waveguide structure.

24. A waveguide structure according claim 23 wherein said output portions of said transmit waveguides and said input portions of said receive waveguides are substantially evenly spaced along substantially the entire length of said common side.

25. A waveguide structure according to any one of the preceding claims wherein said waveguide structure includes at least one fold line defined by a line of weakness or a printed indicium.

26. A waveguide structure according to any one of claims 4 to 9 wherein said waveguide structure is formed as a substantially L-shaped sheet.

27. A waveguide structure according to claim 26 wherein said waveguide structure extends underneath and substantially parallel to said plane of said input device.

28. A waveguide structure according to claim 26 or claim 27 wherein said waveguide structure lies substantially within said periphery.

29. A waveguide structure according to any one of claims 26 to 28 wherein said waveguide structure comprises a plurality of transmit waveguides adapted to carry an input signal to said input device, or a plurality of receive waveguides adapted to carry an output signal from said input device.

30. A waveguide structure according to claim 29 wherein each said waveguide includes an input portion for receiving an input signal and an output portion for transmitting an output signal.

31. A waveguide structure according to claim 30 wherein said waveguides are positioned such that said input portions of said transmit waveguides or said output portions of said receive waveguides are disposed on or proximate to a first side of said waveguide structure.

32. A waveguide structure according to claim 31 wherein said first side is the terminus of a leg of said L-shaped sheet.

33. A waveguide structure according to any one of claims 30 to 32 wherein said output portions of said transmit waveguides or said input portions of said receive waveguides are substantially evenly spaced along substantially the entire outer edges of said L-shaped sheet.

34. A waveguide structure according to any one of claims 18 to 24 and 30 to 33 wherein said input portions of said transmit waveguides are grouped into an input array, or said output portions of said receive waveguides are grouped into an output array.

35. A waveguide structure according to claim 34 wherein said input array is optically coupleable with a light source.

36. A waveguide structure according to claim 34 wherein said output array is optically coupleable with a light detector.

37. A waveguide structure according to any one of claims 18 to 24 and 30 to 36 wherein said output portions of said transmit waveguides or said input portions of said receive waveguides include an integral structure.

38. A waveguide structure according to claim 37 wherein said integral structure is a planar lens.

39. A waveguide structure according to claim 37 wherein said integral structure is a planar internally reflective mirror.

40. An optical element for an input device having an input area defining a plane, said optical element comprising:

a first reflective surface; and

a connect portion adapted for connection to a waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device,

said optical element being configured for use with said input device such that, in use, said first reflective surface is positioned above said plane to re-direct said signal to or from said optical waveguide, said connect portion being at least partially below said plane whereby said at least one optical waveguide extends entirely below said plane.

41. An optical element according to claim 40 further including a body of light transmissive material for transmission of said signal between said connect portion and said first reflective surface.

42. An optical element according to claim 40 or claim 41 wherein said first reflective surface focuses said signal in a direction substantially perpendicular to said plane.

43. An optical element according to any one of claims 40 to 42 further including a second reflective surface, such that, in use, said second reflective surface is positioned below said plane.

44. An optical element according to claim 43 wherein said first and/or said second surface is an internally reflective surface.

45. An optical element according to any one of claims 40 to 44 wherein said optical element is formed as a strip of plastics material substantially transparent to light of the infrared or visible region of the spectrum.

46. An optical element according to any one of claims 40 to 45 wherein said optical element is substantially transparent to light of the infrared region of the spectrum and opaque to ambient visible light.

47. An optical element according to any one of claims 40 to 46 wherein said optical element is substantially rigid.

48. An optical element according to any one of claims 40 to 47 further including an optical surface.

49. An optical element according to claim 48 wherein said optical surface is a lens portion.

50. An optical element according to claim 49 wherein said lens portion is arcuate in cross-section.

51. An optical element according to any one of claims 40 to 50 further including a recess such that said optical element is attachable to said input device.

52. An optical element according to any one of claims 40 to 5 1 wherein said waveguide structure is fixedly attached to said optical element.

53. An apparatus comprising:

an input device having an input area defining a plane and having a periphery;

a waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device; and

one or more optical elements extending along at least a portion of said periphery and in optical communication with said at least one waveguide, each optical element extending from a position below said plane to a position above said plane such that, in use, each said optical element transmits said input signal or said output signal to or from said input area to said at least one waveguide extending entirely below said plane.

54. A method of transmitting input and output signals for an input device, said input device having an input area defining a plane and having a periphery, said method comprising:

providing at least one waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device, said at least one optical waveguide extending entirely below said plane;

providing one or more optical elements along at least a portion of said periphery; and

optically coupling said waveguide structure with a respective optical element such that, in use, each said optical element transmits said input signal or said output signal to or from said input area to a respective waveguide extending entirely below said plane.

55. A method according to claim 59 wherein each said optical waveguide extends entirely below said plane.

56. A method of reducing bezel width in an input device, said input device having an input area defining a plane and having a periphery, said method comprising:

providing at least one waveguide structure having at least one optical waveguide adapted to carry an input signal or an output signal for said input device;

providing one or more optical elements along at least a portion of said periphery; and

optically coupling said at least one optical waveguide with a respective optical element such that, in use, each said optical element transmits said input signal or said output signal to or from said at least one optical waveguide;

wherein said at least one optical waveguide is terminated at a position below said plane, and wherein said optical elements extend from above said plane to a position below said plane.

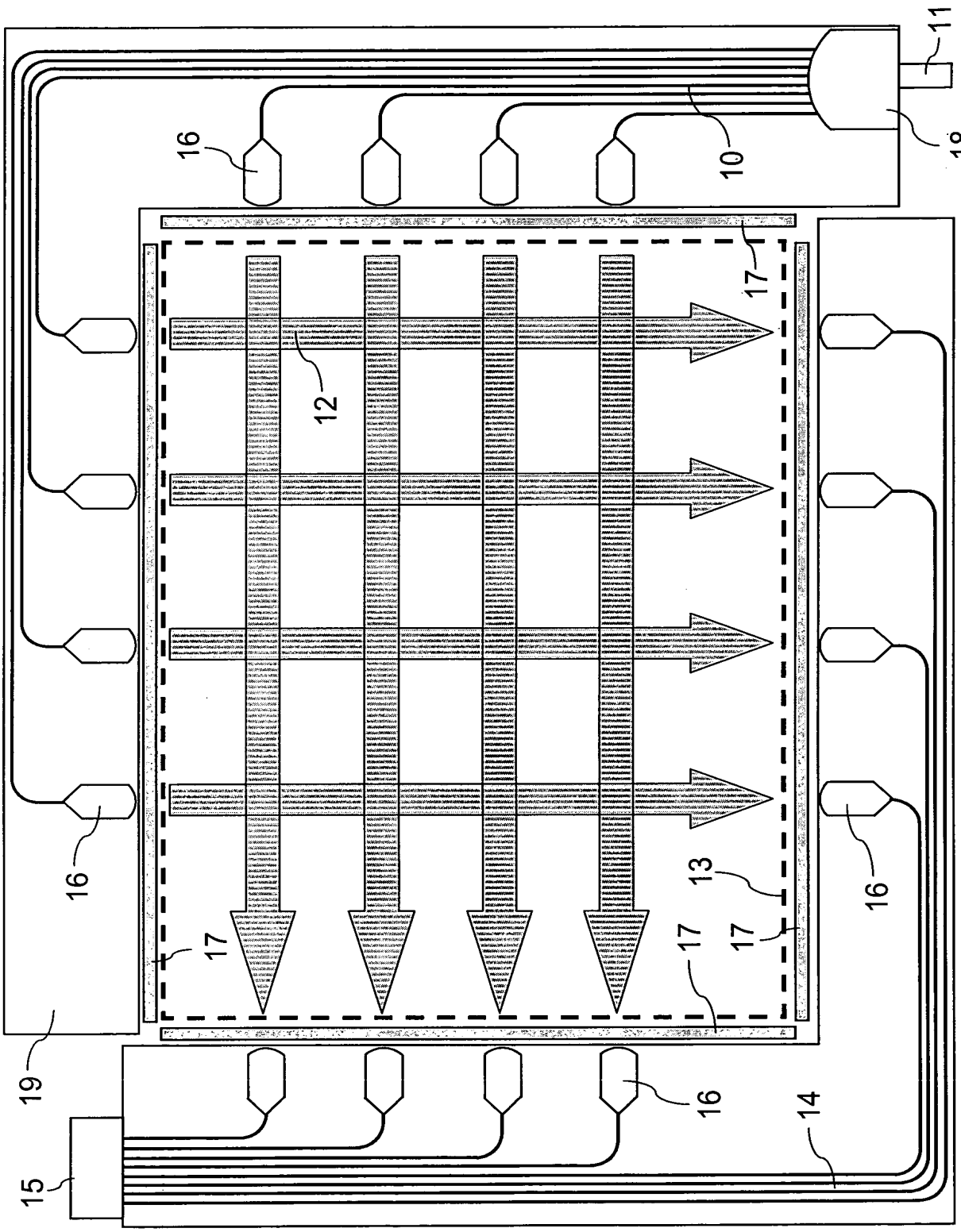


Fig. 1

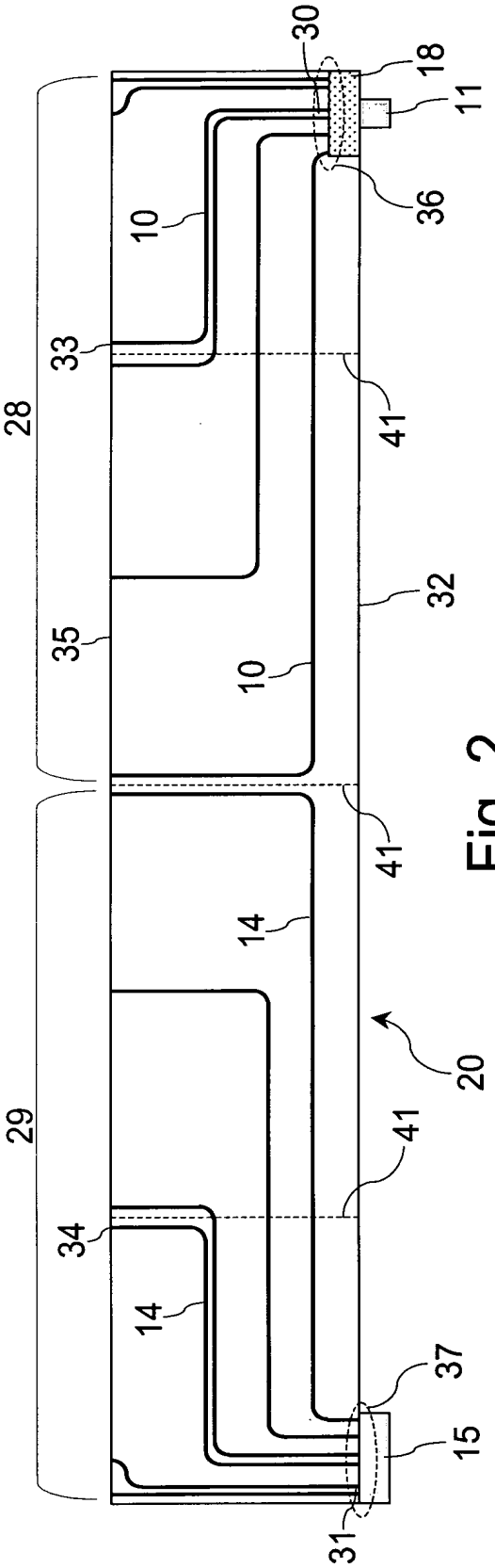

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Fig. 2

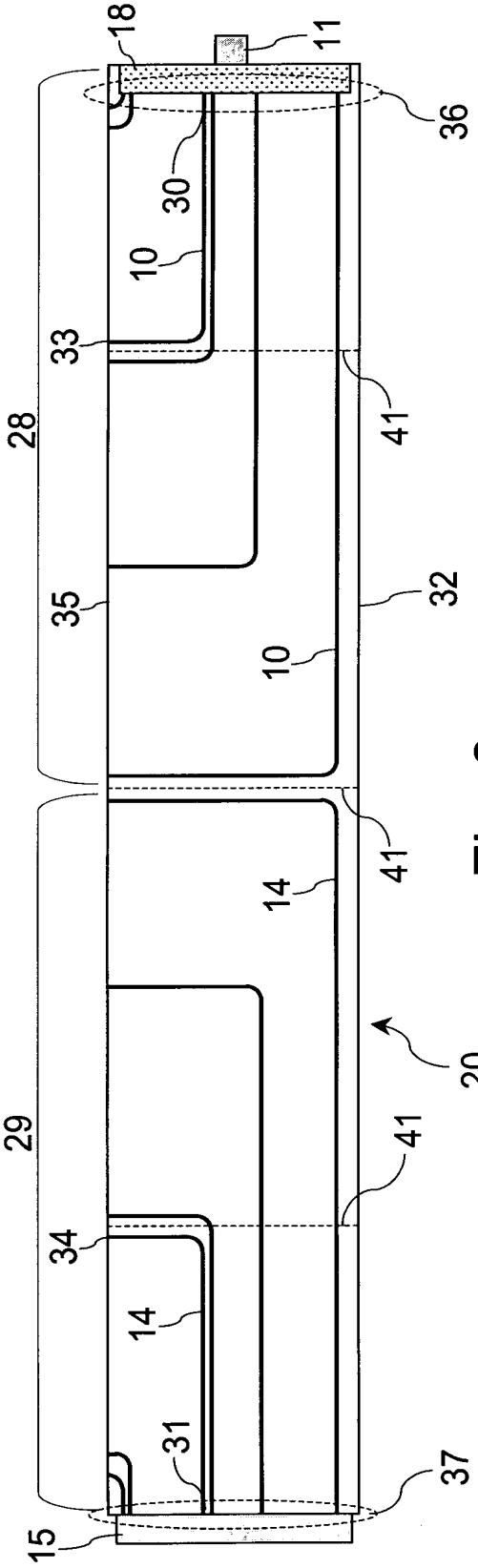

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Fig. 3

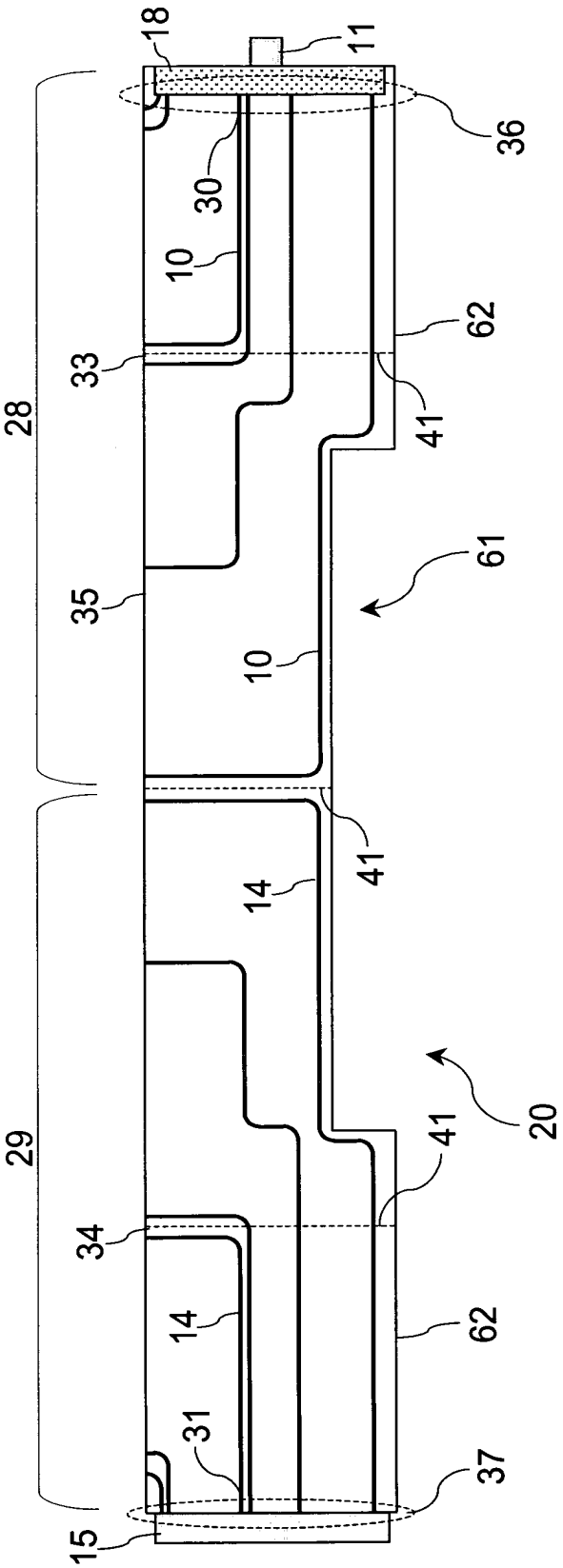


Fig. 4

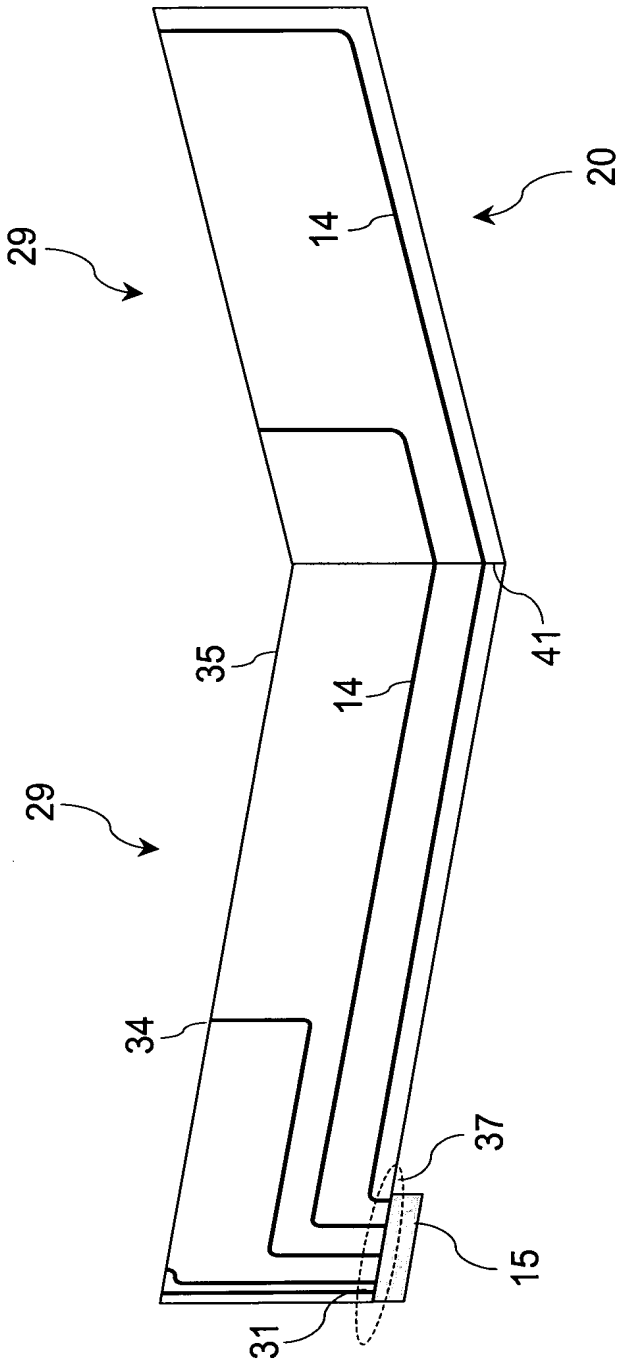


Fig. 5

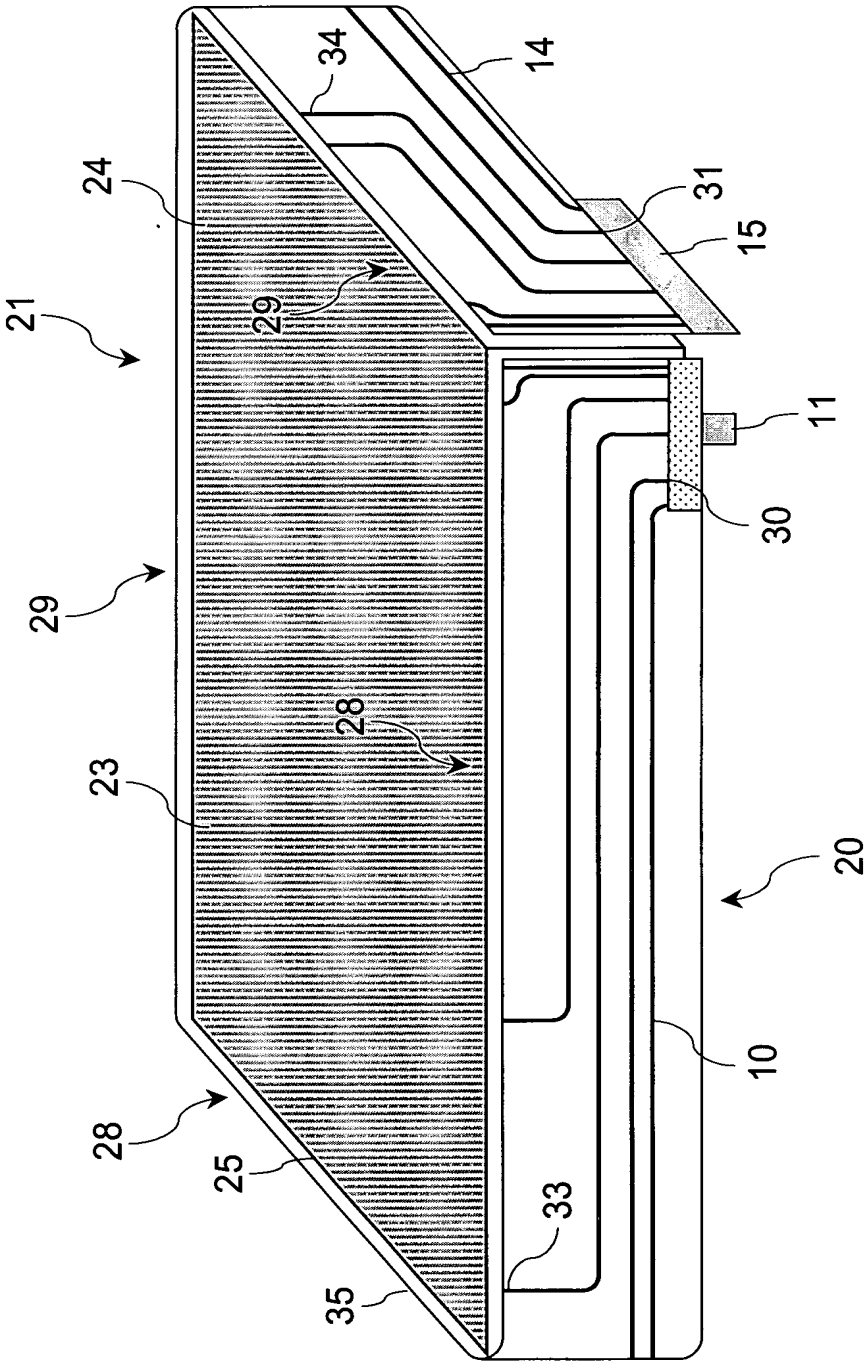


Fig. 6

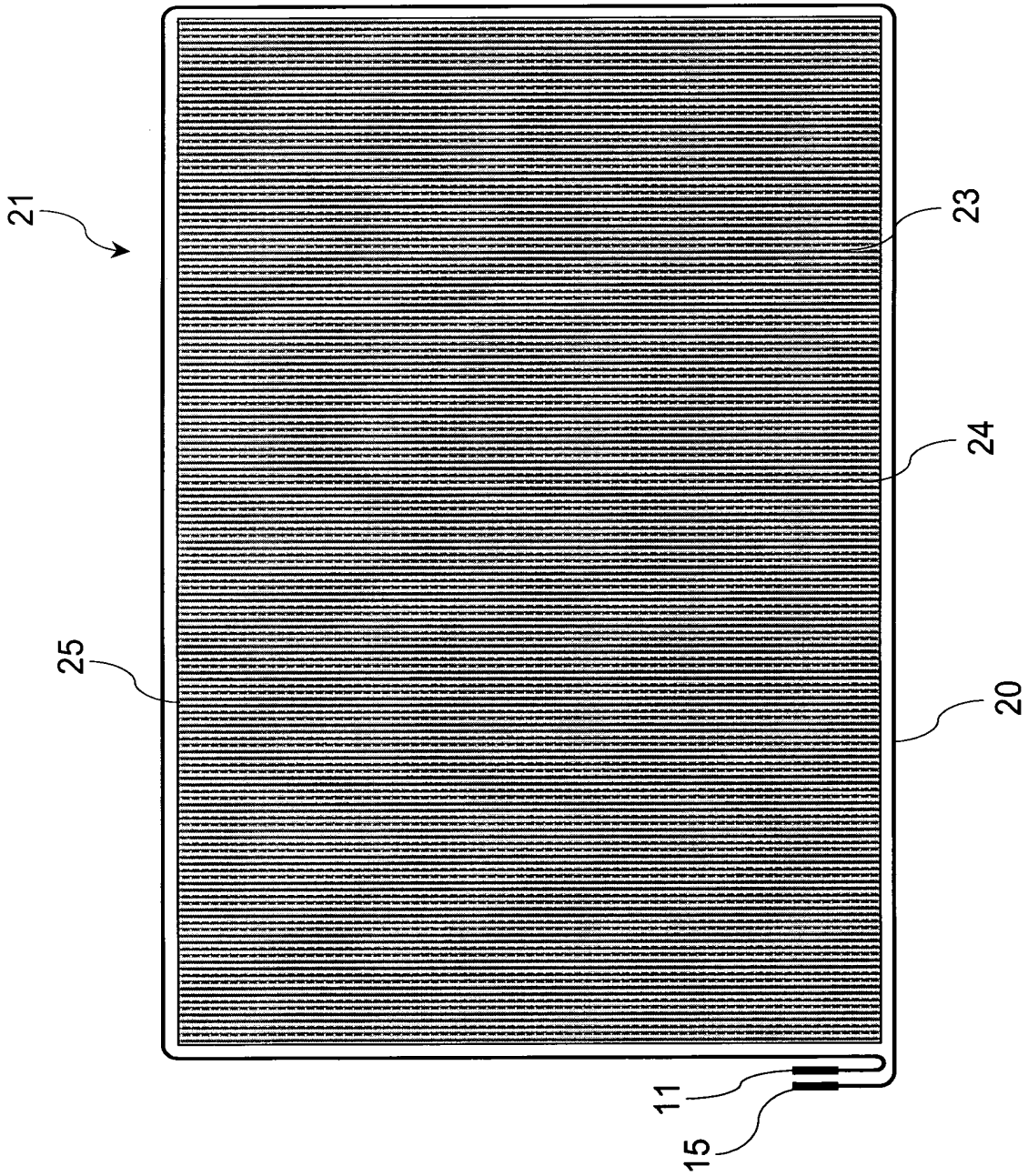


Fig. 7

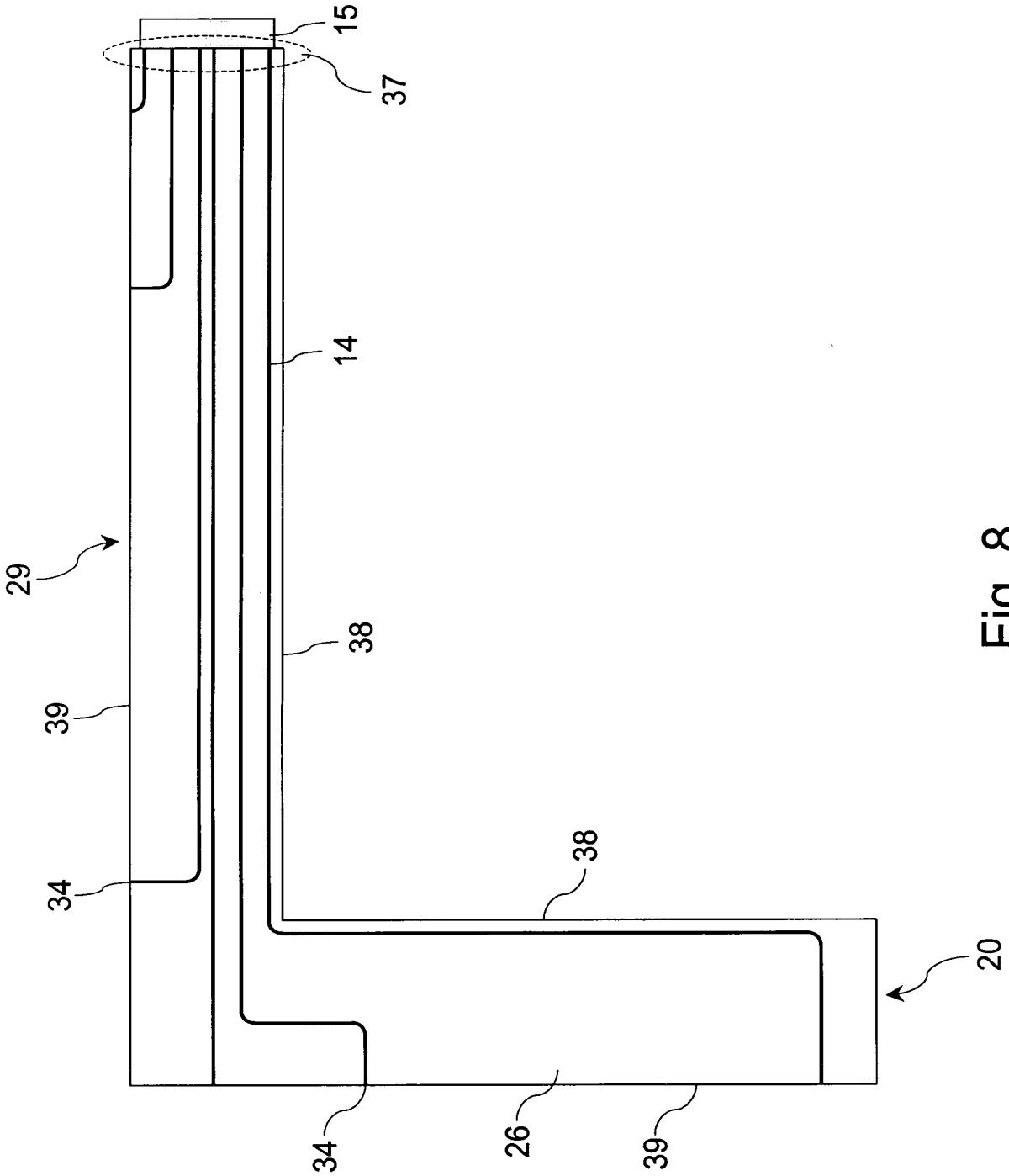


Fig. 8

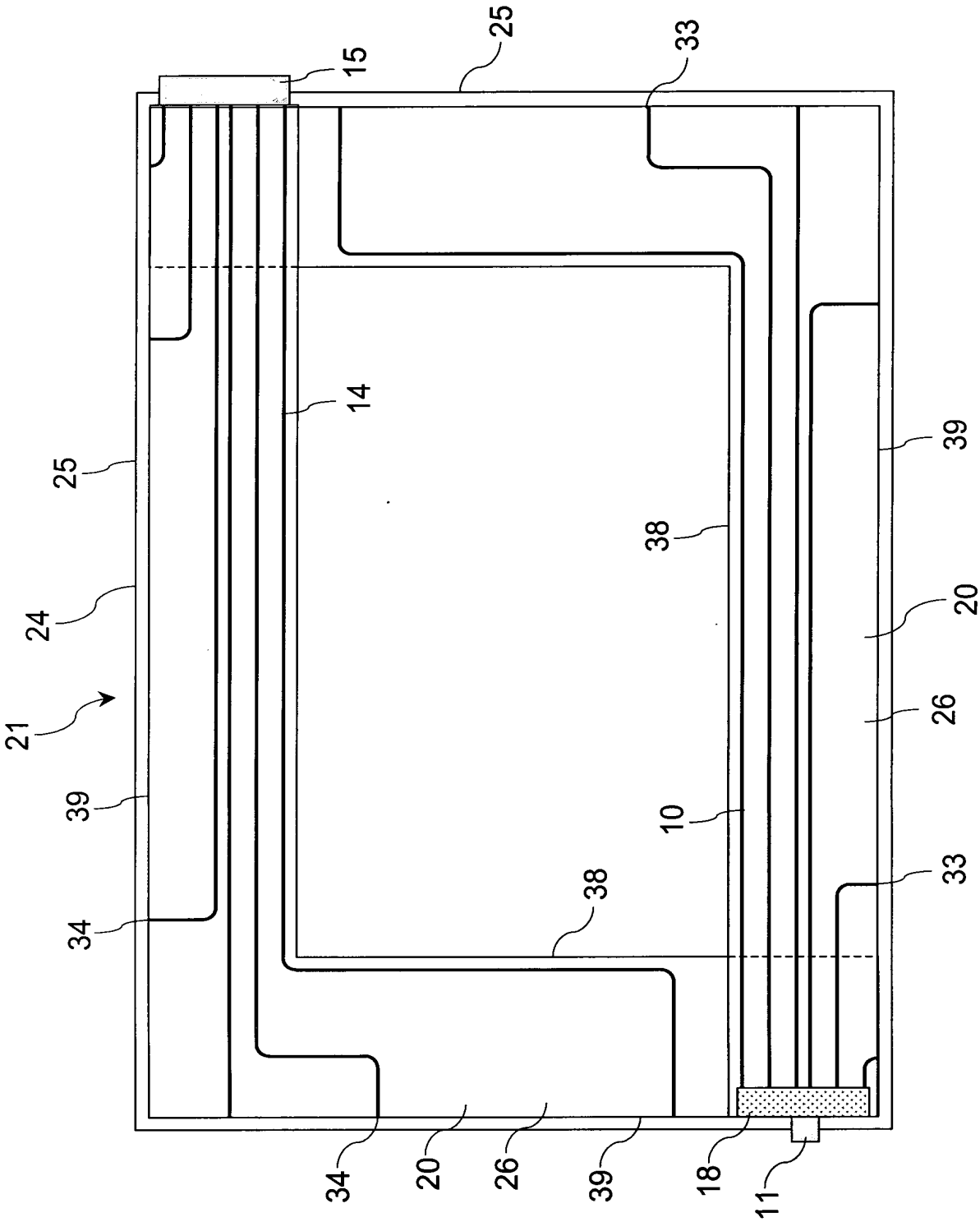


Fig. 9

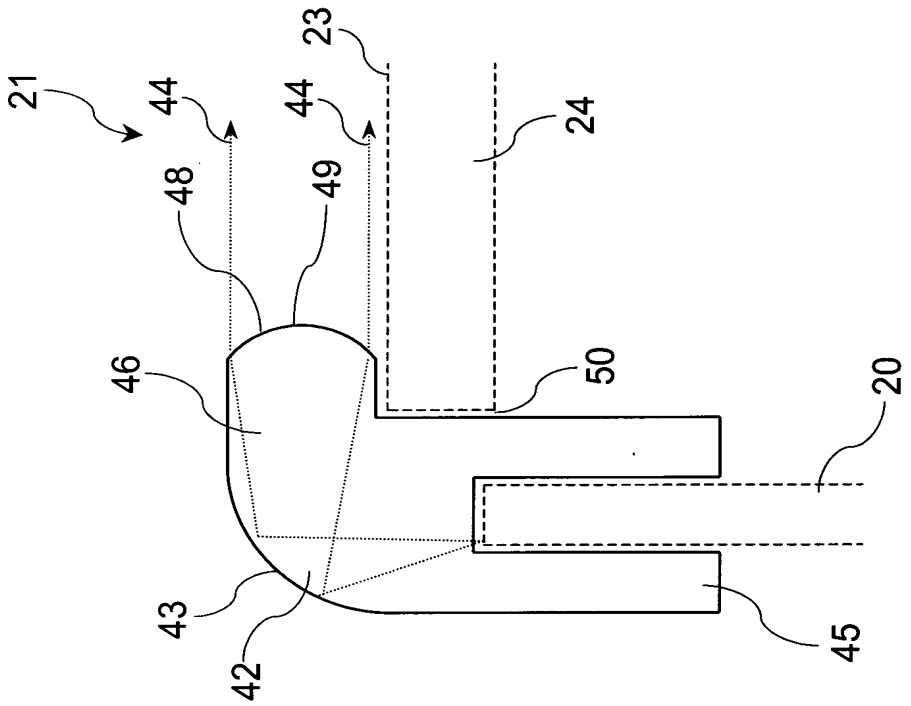

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Fig. 11

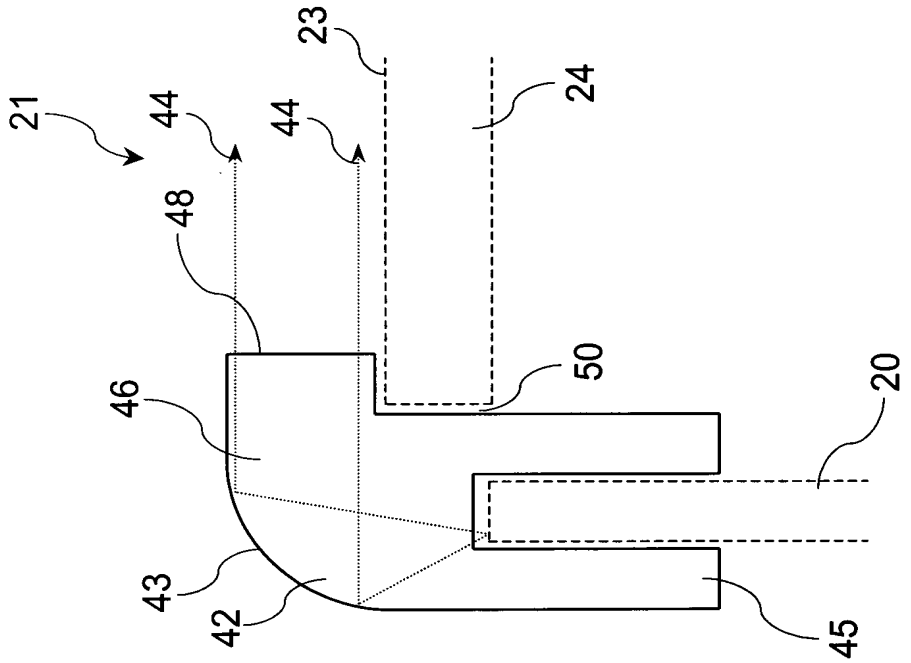

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Fig. 10

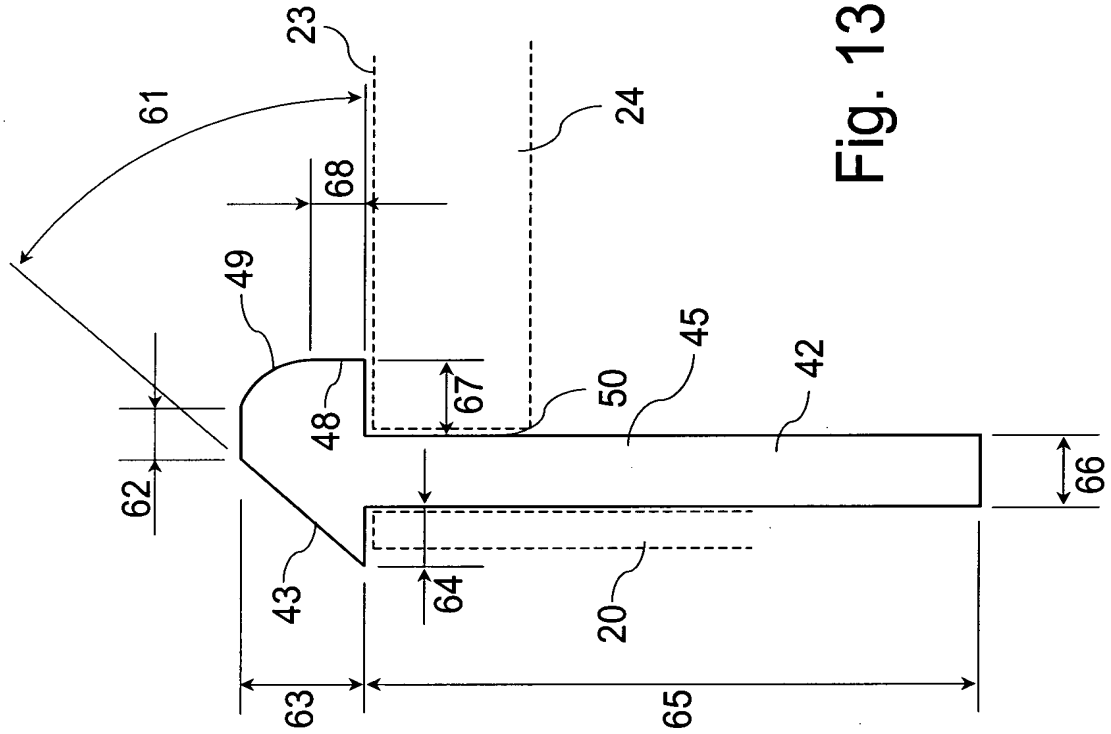

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Fig. 13

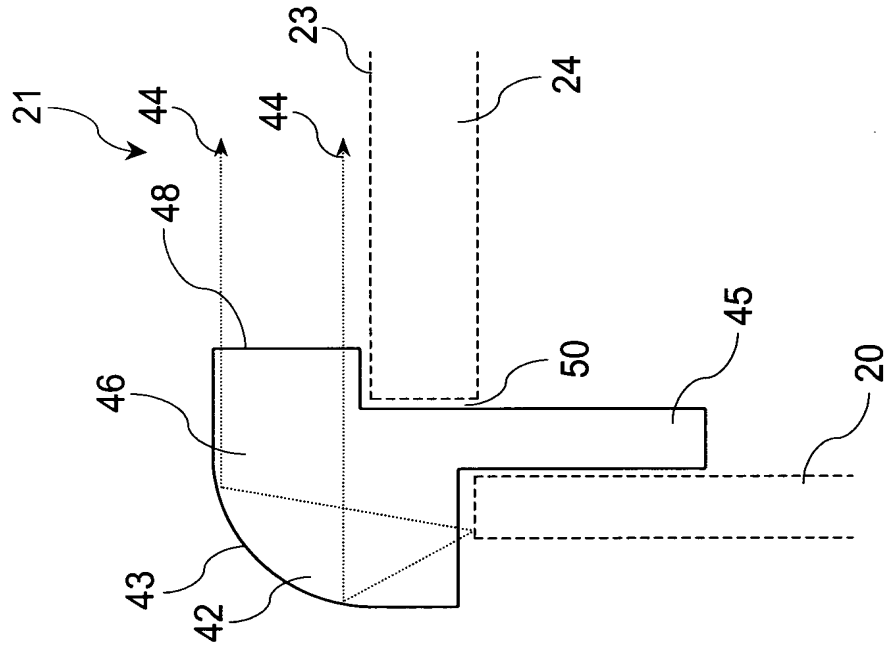

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Fig. 12

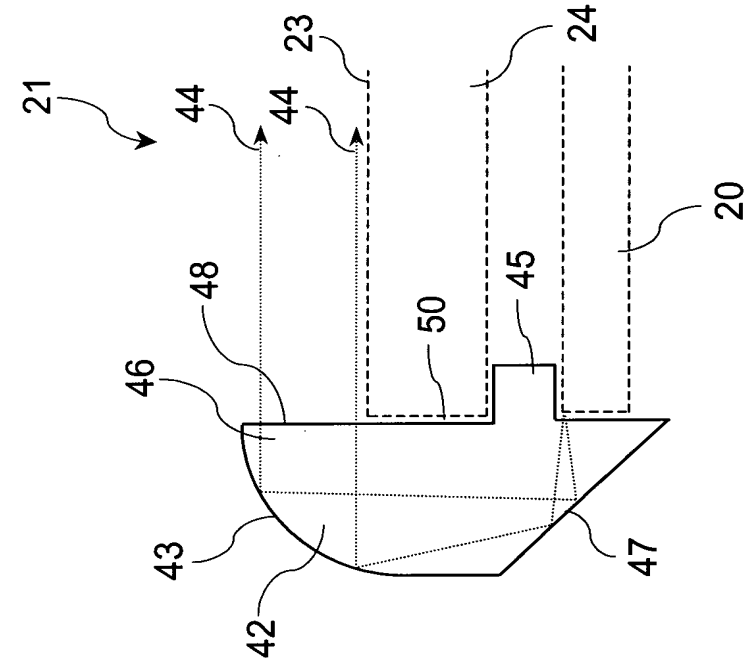

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Fig. 15

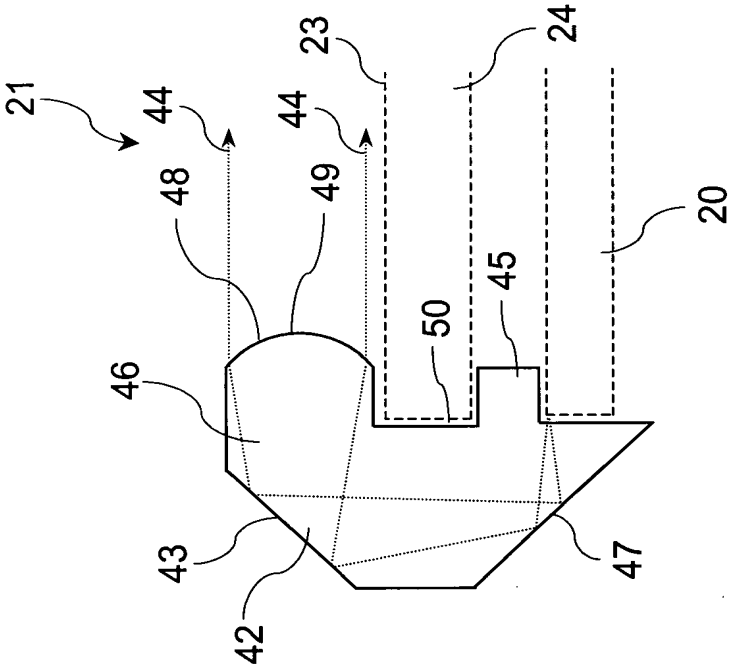

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Fig. 14

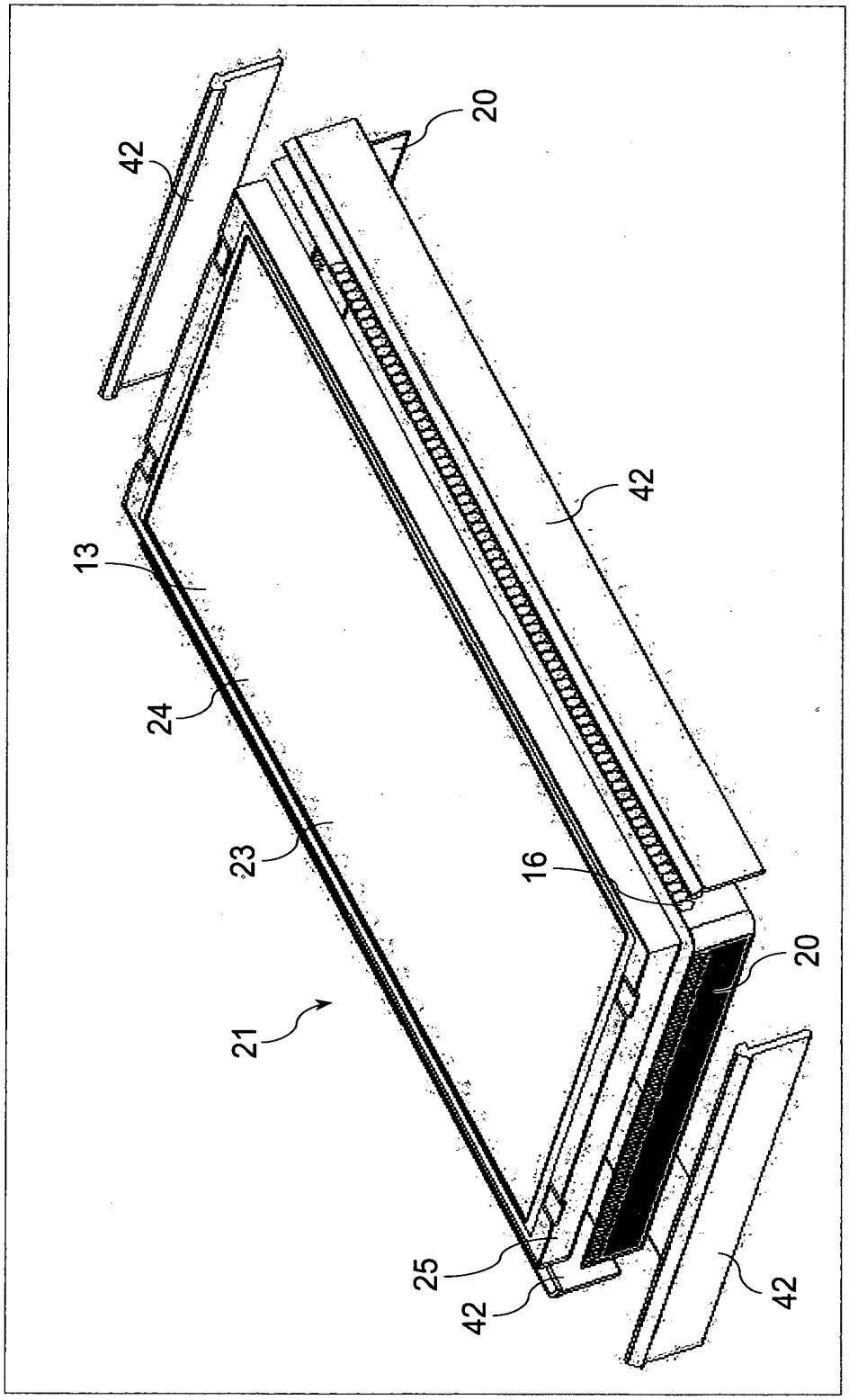


Fig. 16

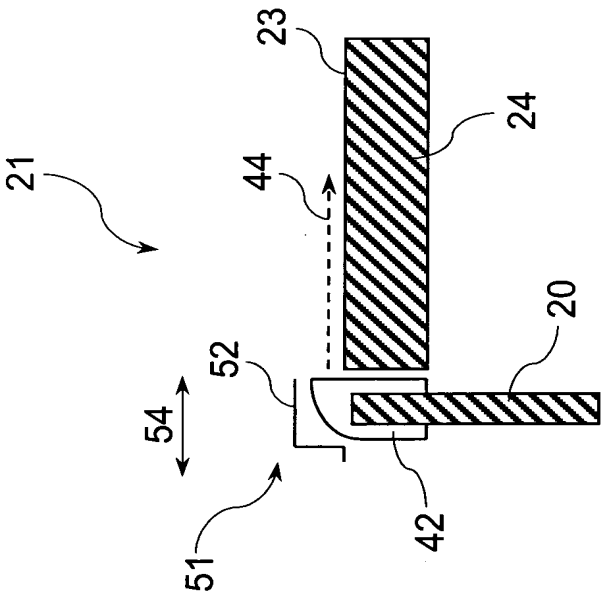


Fig. 18

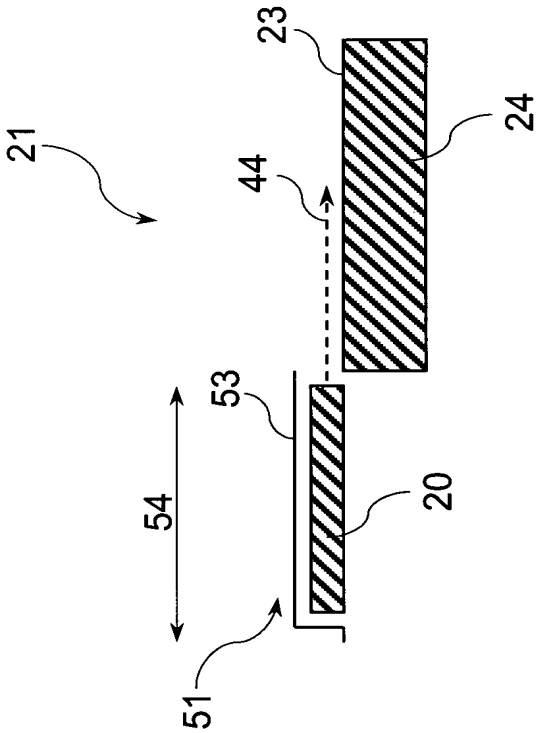


Fig. 17 (prior art)

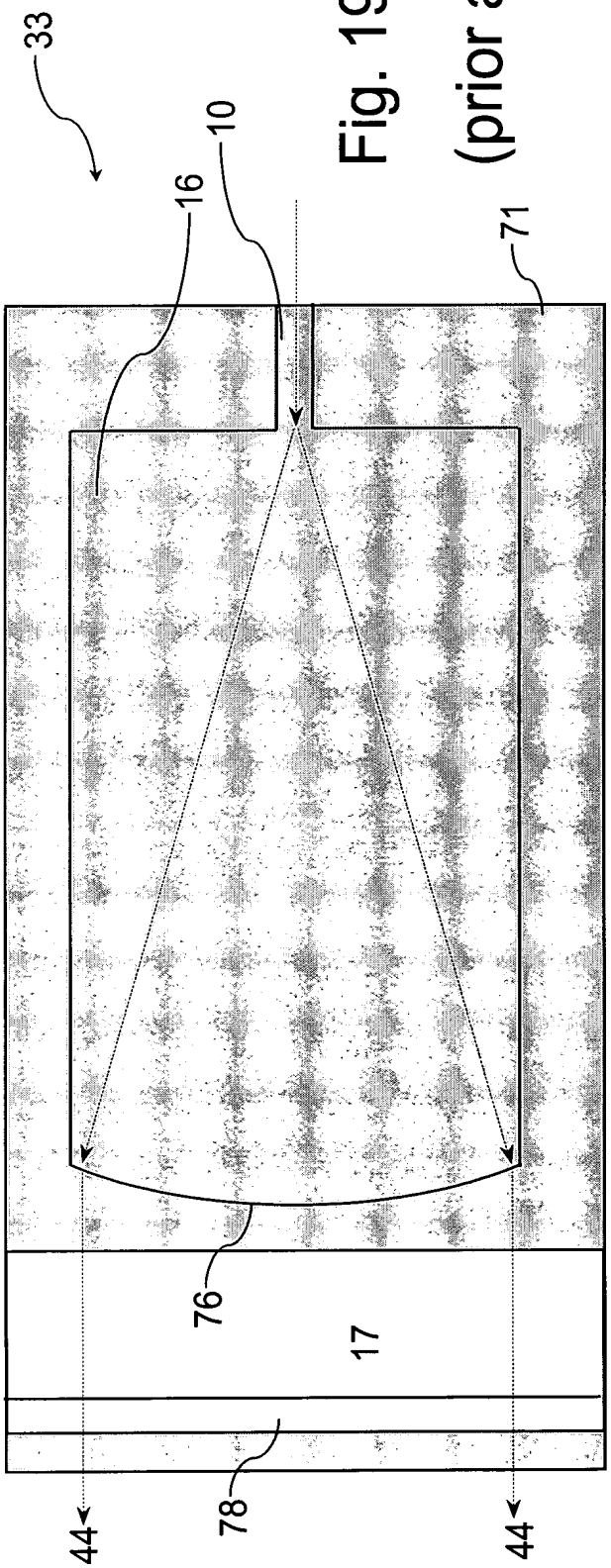


Fig. 19a (prior art)

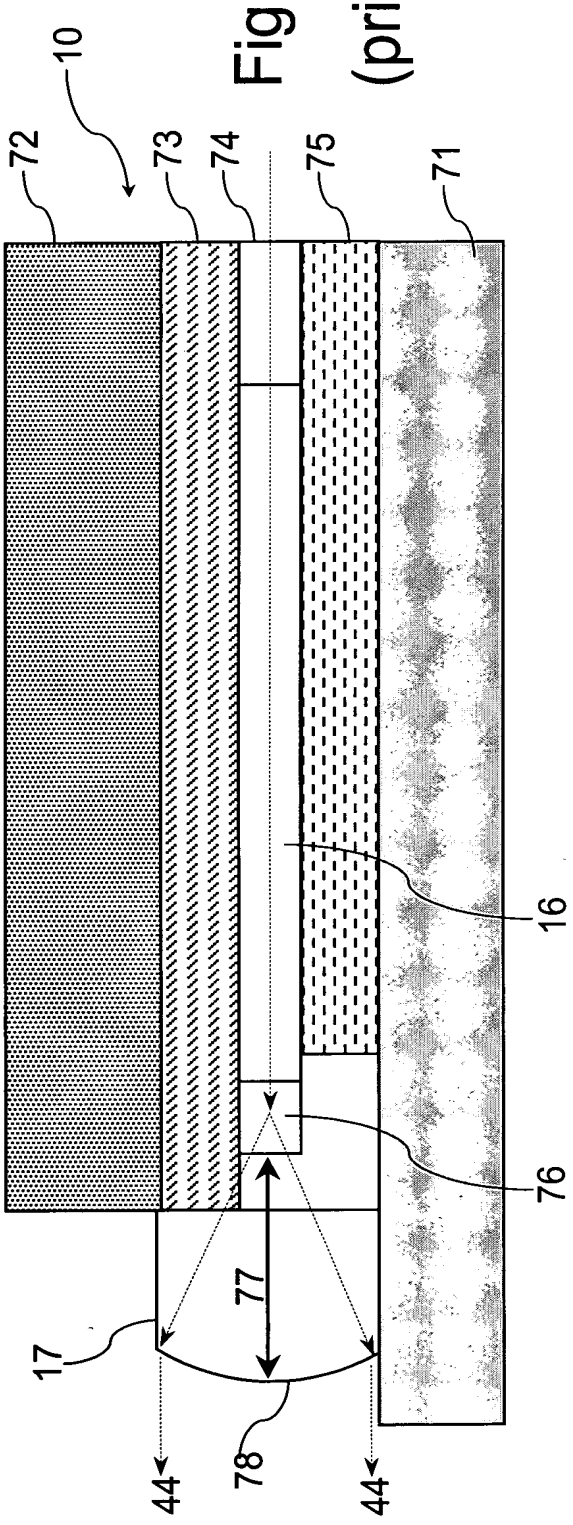


Fig. 19b (prior art)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/001390

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

G06F 3/041 (2006.01) *G06F 3/042* (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI, PCT Gazette, USPTO Web Patent Database "touchscreen, waveguide etc."

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/0001653 A1 (SMITS) 5 January 2006 Entire document.	1-25,34-42,45,47-50,52-56
X	US 2006/0002655 A1 (SMITS) 5 January 2006 Entire document.	1-25,34-42,45,47-50,52-56
X	US 2005/0271319 A1 (GRAHAM) 8 December 2005 Entire document.	1,2,4-10,13,14,16-19,21 22,26,29-31,33-38,53-56
A	WO 2002/095668 A1 (PALM, INC.) 28 November 2002 Entire document.	

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

* Special categories of cited documents

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
02 November 2007	14 NOV 2007

Name and mailing address of the ISA/AU	Authorized officer
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Form PCT iSA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2007/001390

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2006/0001653	**KR**	2007003956	US	2006002655	WO	2006004764
		WO	2006004775				
US	2005/0271319	**CN**	1993640	KR	2007004149	US	2007154133
		WO	2005121852				
WO	2002/095668	**US**	6992659	US	2002175901		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 839 of 1254

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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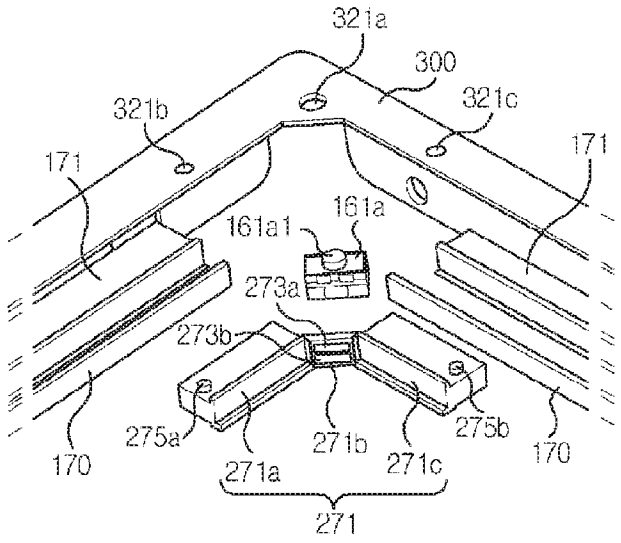
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(54) Title: OPTICAL TOUCH SCREEN AND METHOD FOR ASSEMBLING THE SAME

[Fig. 7]



(57) Abstract: The present invention relates to an optical touch screen and a method for assembling the same, the screen including a flat plate display panel; a case mounted and assembled with the flat plate display panel; brackets assembled at each corner of the case; a camera module mounted at each bracket; and a retro reflector arranged along an inner lateral surface of the case.

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Description

Title of Invention: OPTICAL TOUCH SCREEN AND METHOD FOR ASSEMBLING THE SAME

Technical Field

[1] The teachings in accordance with the exemplary embodiments of this invention relate generally to an optical touch screen and a method for assembling the same.

Background Art

[2] A touch screen or touch panel is a display which can detect a location of touch within a display area, usually performed either with the human hand or a stylus. This allows the display to be used as an input device, removing a keyboard and/or a mouse as a primary input device for interacting with the display's content.

[3]

[4] Technically speaking, the commonly used touch screens employ resistive, capacitive, ultrasonic wave, electromagnetic, vector force and optical (Infrared) touch modes. Among these types of touch screens, resistive type is the most common one, which has approximately 60% of market share (the second is capacitive type with around 24% of market share). Each of these types of touch screens has its own features, advantages and disadvantages. Now, these touch screens are briefly explained.

[5]

[6] The resistive is a common type of touch screen technology. It is a low-cost solution found in many touch screen applications, including hand-held computers, PDA's, consumer electronics, and point-of-sale-applications. The resistive touch screens are such that a pair of resistive layers facing with each other is provided on a touch screen element. The pressed position is detected by contact between the resistive layers so that one of the resistive layers is formed on a flexible film for deformation during pressing. As mentioned above, the resistive film type is widely used, but disadvantageous due to degraded mechanical and environmental reliability. At the same time, although the resistive touch screen today are widely used on consuming electronic products, it is unable to identify multiple contact points simultaneously on its display area.

[7]

[8] The ultrasonic wave touch screen first converts an electric signal into an ultrasonic wave through a transducer, and then directly transmits the ultrasonic wave through a surface of the touch panel. When the touch panel is used, the ultrasonic wave may be absorbed by contacting a pointer to cause attenuation, and an accurate position of the contact is obtained through comparison and calculation between attenuation amounts before and after use. The surface acoustic wave touch screen is disadvantageous due to

generation of noise and/or susceptibility to noise.

[9]

[10] The electromagnetic type touch screen is such that, in the field of magnetism, a magnetic field is normally generated by a coil due to electromagnetism and said magnetic field induces a voltage in another coil, also called receiver coil, under the premise that the magnetic field strength changes in the receiver coil. It is clear that a non-moving receiver coil is not capable to measure a non-altering magnetic field since no voltage is induced by said magnetic field. There are already means, which can measure a position and/or orientation of a receiver means in relation to a specific magnetic field generating means. To measure the orientation in a 3-dimensional space normally three orthogonal arranged probes are used to calculate the coordinates. These arrangements are most of the time very bulky, space taking and need a special stylus.

[11]

[12] The capacitance type touch screen adopts capacity changes generated from the combination of static electricity between arranged transparent electrodes and a human body, so as to detect coordinates of the contact position through a generated induced current. That is, the capacitance type touch screen includes one substrate having an electrode formed thereon. In the capacitance type touch panel, when, for example, a finger contacts and approaches the touch panel, a variation in capacitance between the electrode and the finger is detected, thereby detecting input coordinates. Since the capacitance type touch panel is a non-contact type, it has high durability, excellent environmental and mechanical reliability due to changeable upper barrier layer unlike the resistive film type touch panel. However, the capacitance type touch panel has disadvantages in that it is difficult to input information with fingers or a pen.

[13]

[14] The optical type touch screens principally use no films for touch recognition such that transmittance is 100%. Furthermore, no reflexibility, degradation of brightness and blurring of displays are generated from these optical touch screens. Maintenance of transmittance and brightness in displays is an important factor for image clarity, such that an optical type is adequate for implementation of high quality screens. Furthermore, the optical type touch screens utilize the principle of light source reception and blocking, such that no load is applied to a sensor as detection is not performed by physical or electrical contacts, which increases reliability for use in factory monitoring, various automation equipment and ATM's. The optical type touch screens are advantageously free from such materials as films or ITO (Indium Tin Oxide) protective films to have less susceptibility to scratches or external shocks and a lower error probability including erroneous operation.

Disclosure of Invention

Technical Problem

[15] The present invention is directed to solving an object of performing an easy assembly of an optical touch screen.

[16]

[17] Technical problems to be solved by the present invention are not restricted to the above-mentioned, and any other technical problems not mentioned so far will be clearly appreciated from the following description by skilled in the art.

Solution to Problem

[18] An object of the invention is to solve at least one or more of the above problems and/or disadvantages in a whole or in part and to provide at least the advantages described hereinafter. In order to achieve at least the above objects, in whole or in part, and in accordance with the purposes of the invention, as embodied and broadly described, and in one general aspect of the present invention, there is provided an optical touch screen, the optical touch screen comprising; a flat plate display panel; a case mounted and assembled with the flat plate display panel; brackets assembled at each corner of the case; a camera module mounted at each bracket; and a retro reflector arranged along an inner lateral surface of the case.

[19]

[20] Preferably, the optical touch screen further includes a frame mounted at an inner lateral surface between the brackets, wherein the retro reflector is mounted at the frame.

[21]

[22] Preferably, the case takes the shape of a square ring.

[23]

[24] Preferably, the brackets include first and second fixtures fixed on the case, and a connection connected to the first and second fixtures, wherein the camera module is mounted at the connection.

[25]

[26] Preferably, the connection of the bracket includes a first passage through which infrared (IR) emitted from the camera module can pass, and a second passage through which infrared (IR) incident on the camera module can pass.

[27]

[28] Preferably, the retro reflector is mounted on the first and second fixtures.

[29]

[30] Preferably, the frame is formed with a groove, and the retro reflector is formed with a lug insertable to the groove, wherein the lug formed at the retro reflector is inserted

into the groove formed at the frame, whereby the retro reflector is mounted at the frame.

[31]

[32] Preferably, the camera module includes an IR emitting diode emitting IR; an IR pass filter passing only the IR reflected from the retro reflector; and a linear sensor detecting an area touched by incidence of IR that has passed the IR pass filter.

[33]

[34] Preferably, the camera module includes a holder formed with a stair unit and an opening; an IR emitting diode mounted at the stair unit for emitting IR; and an image sensor detecting the IR through the opening.

[35]

[36] Preferably, the stair unit is formed at an upper surface of the holder, and the opening is formed at a bottom surface of the holder.

[37]

[38] Preferably, the holder is formed at one side with a first groove and is formed at the other side with a second groove, and the opening connects the first groove and the second groove, and the stair unit is formed at an upper surface of the one side.

[39]

[40] Preferably, the first groove is formed with an objective lens, the second groove is formed with an infrared pass filter that passes an infrared of a particular wave band, and a printed circuit board mounted with the image sensor is attached to the holder for blocking the second groove.

[41]

[42] Preferably, the IR pass filter is implemented by coating an IR pass filter material on a glass.

[43]

[44] In another general aspect of the present invention, there is provided a method for assembling an optical touch screen, the method comprising: preparing a bracket mounted with a camera module and a square ring-shaped case; fixing the bracket at each corner of the case; fixing a retro reflector on the case; and mounting a flat plate display panel on the case.

[45]

[46] Preferably, the brackets include first and second fixtures fixed on the case, and a connection connected to the first and second fixtures, wherein the camera module is mounted at the connection.

[47]

[48] Preferably, the camera module is formed with a first fastening lug, the first and second fixtures of the bracket are formed with second and third fastening lugs, and the

case is formed with first, second and third fastening holes corresponding to the first, second and third fastening lugs, wherein the first, second and third fastening lugs are inserted into the first, second and third fastening holes to allow the camera module and the bracket to be mounted at the case.

[49]

[50] Preferably, the step of fixing the bracket at each corner of the case is performed in such a manner that three inner corners of the square ring-shaped case are fixed by brackets on which the camera module is mounted, and one inner corner of the square ring-shaped case is mounted with a dummy bracket on which the camera module is not mounted.

[51]

[52] Preferably, the camera module includes a holder formed with a stair unit and an opening; an IR emitting diode mounted at the stair unit for emitting IR; and an image sensor detecting the IR through the opening.

[53]

[54] Preferably, the stair unit is formed at an upper surface of the holder, and the opening is formed at a bottom surface of the holder.

[55]

[56] Preferably, the holder is formed at one side with a first groove and is formed at the other side with a second groove, and the opening connects the first groove and the second groove, and the stair unit is formed at an upper surface of the one side.

Advantageous Effects of Invention

[57] The present invention has an advantageous effect in that a camera module can be easily mounted on a case through a bracket, a retro reflector can be easily assembled on a frame mounted on the case, and each constituent element can simply perform a mechanical arrangement for normally realizing an operational mechanism of an optical touch screen.

[58]

[59] The present invention has another advantageous effect in that the camera module and the retro reflector need no mount on a high-priced reinforced glass to reduce the manufacturing cost.

[60]

[61] The present invention has still another advantageous effect in that a frame and the bracket are formed with grooves, and the retro reflector is formed with a lug to allow the retro reflector to be easily fastened on the frame and the bracket by way of shield bar (rail) coupling method.

Brief Description of Drawings

[62] The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

[63] FIG. 1 is a conceptual cross-sectional view illustrating an optical touch screen according to the present invention;

[64] FIG. 2 is a conceptual view illustrating a method for detecting a coordinate of a particular area touched on an optical touch screen according to the present invention;

[65] FIGS. 3a and 3b are schematic conceptual views illustrating a linear sensor of an optical touch screen according to the present invention;

[66] FIG. 4 is a schematic perspective view illustrating a state in which an optical touch screen is fastened according to the present invention;

[67] FIG. 5 is a schematic plan illustrating a case of an optical touch screen according to the present invention;

[68] FIGS. 6a through 6d are schematic plans illustrating a method of assembling an optical touch screen according to the present invention;

[69] FIG. 7 is a schematic partial perspective view illustrating a method for assembling an optical touch screen according to the present invention;

[70] FIGS. 8a and 8b are schematic partial perspective view illustrating in detail a process of attaching a retro reflector in a method for assembling an optical touch screen according to the present invention;

[71] FIG. 9 is a schematic cross-sectional view illustrating a camera module according to the present invention;

[72] FIG. 10 is schematic cross-sectional view illustrating a camera module according to an exemplary embodiment of the present invention;

[73] FIG. 11 is a schematic partially cut-out perspective view illustrating a state where an IR pass filter is mounted to a bracket according to the present invention; and

[74] FIG. 12 is a schematic cross-sectional view illustrating a connected relationship between a camera module and a bracket according to the present invention.

Best Mode for Carrying out the Invention

[75] The following description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the following teachings, and skill and knowledge of the relevant art are within the scope of the present invention. The embodiments described herein are further intended to explain modes known of practicing the invention and to enable others skilled in the art to utilize the invention in such, or other embodiments and with various modifications required by the particular application(s) or use(s) of the present invention.

[76]

[77] The disclosed embodiments and advantages thereof are best understood by referring to FIGS. 1-12 of the drawings, like numerals being used for like and corresponding parts of the various drawings. Other features and advantages of the disclosed embodiments will be or will become apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional features and advantages be included within the scope of the disclosed embodiments, and protected by the accompanying drawings. Further, the illustrated figures are only exemplary and not intended to assert or imply any limitation with regard to the environment, architecture, or process in which different embodiments may be implemented. Accordingly, the described aspect is intended to embrace all such alterations, modifications, and variations that fall within the scope and novel idea of the present invention.

[78]

[79] It will be understood that the terms "includes" and/or "including" when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof. That is, the terms "including", "includes", "having", "has", "with", or variants thereof may be used in the detailed description and/or the claims to denote non-exhaustive inclusion in a manner similar to the term "characterized by".

[80]

[81] Furthermore, "exemplary" is merely meant to mean an example, rather than the best. It is also to be appreciated that features, layers and/or elements depicted herein are illustrated with particular dimensions and/or orientations relative to one another for purposes of simplicity and ease of understanding, and that the actual dimensions and/or orientations may differ substantially from that illustrated. That is, in the drawings, the size and relative sizes of layers, regions and/or other elements may be exaggerated or reduced for clarity. Like numbers refer to like elements throughout and explanations that duplicate one another will be omitted. Now, the present invention will be described in detail with reference to the accompanying drawings.

[82]

[83] FIG. 1 is a conceptual cross-sectional view illustrating an optical touch screen according to the present invention.

[84]

[85] An optical touch screen according to the present invention includes a camera module (160) and a retro reflector (170), all of which are mounted to a front surface of a flat plate display panel (200). The camera module (160) may include an infrared light emitting diode (100) emitting infrared light, an IR (Infrared) pass filter (130) that

passes only the infrared reflected from the retro reflector (170), and a linear sensor (150) detecting an area touched by the incident infrared that has passed the IR pass filter (130).

[86]

[87] At this time, the optical touch screen may further include an object lens (140) collecting the infrared that has passed the IR pass filter (130). Alternatively, the optical touch screen may be so configured as to allow the light emitted from the infrared light emitting diode (100) to be emitted through a lens (110).

[88]

[89] Furthermore, the retro reflector (170) reflects the infrared emitted from the infrared light emitting diode (100), where an incident angle and reflection angle of the infrared are same. Therefore, the infrared light emitting diode (100) of the camera module (160) emits an infrared, where the emitted infrared advances along the flat plate display panel (200) to be reflected from the retro reflector (170) and incident on the IR pass filter (130) of the camera module (160).

[90]

[91] At this time, the IR pass filter (130) passes only the infrared that has been reflected from the retro reflector (170), and the infrared that has passed the IR pass filter (130) is incident on the linear sensor (150). In a case a particular area of the flat plate display panel (200) is touched by a finger of a hand (250) while a user views an image displayed on the flat plate display panel (200), the infrared is blocked from the touched area to form a black spot on the linear sensor (150), whereby a coordinate of the touched particular area can be detected.

[92]

[93] Furthermore, the flat plate display panel (200) is situated under an area between the infrared light emitting diode (100) and the retro reflector (170), and in a case a user touches a particular area of an image displayed on the flat plate display panel, a driving signal is generated that corresponds to a coordinate detected by the linear sensor (150), whereby various functions including screen change, sound adjustment, screen movement, screen enlargement and screen reduction can be performed. At this time, the flat plate display panel may be one of an LCD (Liquid Crystal Display), an FED (Field Emission Display), a PDP (Plasma Display Panel), an EL (Electroluminescence), an OLED (Organic Light Emitting Diode), and an electronic paper display panel.

[94]

[95] FIG. 2 is a conceptual view illustrating a method for detecting a coordinate of a particular area touched on an optical touch screen according to the present invention, and FIGS. 3a and 3b are schematic conceptual views illustrating a linear sensor of an

optical touch screen according to the present invention.

[96]

[97] The camera module of the optical touch screen may be installed at two or three corner areas of the flat plate display panel (200). For example, as illustrated in FIG. 2, in a case first and second camera modules (161a, 161b) are mounted on two corner areas (211, 212) of the flat plate display panel (200), and a predetermined area (250) of the flat plate display panel (200) is touched, the touched predetermined area (250) is blocked of infrared, and each linear sensor of the first and second camera module (161a, 161b) is formed with a black spot. Therefore, the linear sensor can detect a co-ordinate of the touched particular area using a position of the black spot.

[98]

[99] Each of the linear sensors (150a, 150b) of the first and second camera module (161a, 161b) is mounted with 1st to nth sensing pixel (151, 152, 153, 154, 155) as illustrated in FIGS. 3a and 3b. At this time, in a case the particular predetermined area of the flat plate display panel (200) is touched, one of the 1st to nth sensing pixel (151, 152, 153, 154, 155) is formed with the black spot. Furthermore, because each of the linear sensors (150a, 150b) of the first and second camera module (161a, 161b) is installed at a different position from that of the touched area, there is a high probability that the sensing pixel of the linear sensor (150a) of the first camera module (161a) is differently positioned from the linear sensor (150b) of the second camera module (161b).

[100]

[101] For example, as depicted in FIG. 3a, a black spot (251) is formed at the second sensing pixel (152) on the linear sensor (150a) of the first camera module (161a), and as illustrated in FIG. 3b, a black spot (251) is formed at the fourth sensing pixel (154) on the linear sensor (150b) of the second camera module (161b).

[102]

[103] Meanwhile, as shown in FIG. 2, if a crosswise direction of the flat plate display panel (200) is defined as x axis, and a lengthwise direction of the flat plate display panel (200) is defined as y axis, a coordinate of the touched area (250) can be extracted, if a connection line (S1) from the touched area (250) to the linear sensor (150a) of the first camera module (161a), a first angle (θ1) formed by a crosswise direction of the flat plate display panel (200), a connection line (S2) from the touched area (250) to the linear sensor (150b) of the second camera module (161b), a second angle (θ2) formed by a crosswise direction of the flat plate display panel (200) and a crosswise length of the flat plate display panel (200) are known.

[104]

[105] Furthermore, the first angle (θ1) and the second angle (θ2) are changed according to the position of the touched area (250), and in response thereto, the 1st to the nth

sensing pixel (151, 152, 153, 154, 155) of the linear sensors (150a, 150b) are subdivided. That is, each of the 1st to the nth sensing pixel (151, 152, 153, 154, 155) of the linear sensors (150a, 150b) corresponds to the first angle (θ1) and the second angle (θ2).

[106]

[107] Therefore, in a case a black spot is formed on one of the sensing pixel of the 1st to the nth sensing pixel (151, 152, 153, 154, 155) of the linear sensors (150a, 150b) on the first and second camera modules (161a, 161b), the first angle (θ1) and the second angle (θ2) can be known, whereby a coordinate (x, y) of the touched area (250) can be extracted.

[108]

[109] Furthermore, the optical touch screen may include a coordinate extraction calculator capable of extracting real time a coordinate (x, y) of the touched area (250) touched by the aforementioned method or other methods, in a case a predetermined area (250) of the flat plate display panel (200) is touched.

[110]

[111] FIG. 4 is a schematic perspective view illustrating a state in which an optical touch screen is fastened according to the present invention, and FIG. 5 is a schematic plan illustrating a case of an optical touch screen according to the present invention.

[112]

[113] The optical touch screen according to the present invention may include a case (300) on which the flat plate display panel (200) is mounted, where the case (300) may be called a case top. The case (300) takes the shape of a square ring, and as shown in FIG. 5, an inner lateral surface of the square ring is mounted with the retro reflector (170), and two or three corner areas of the square ring is mounted and assembled with camera modules (161a, 161b, 161c).

[114]

[115] At this time, the camera modules (161a, 161b, 161c) are mounted on brackets (271, 272, 273), and each of the brackets (271, 272, 273) is mounted at three square ring corners. Furthermore, a balance one square ring corner is mounted with a dummy bracket (280) that is not mounted with a camera module. That is, the optical touch screen includes the flat plate display panel (200), the square ring-shaped case (300) on which the flat plate display panel (200) is assembled and attached, the brackets assembled on corners of the case (300), and the camera modules (161a, 161b, 161c). At least one of the brackets is a bracket that is not mounted with the camera modules (161a, 161b, 161c). An inner lateral surface of the case (300) in the brackets is mounted with the retro reflector (170). The retro reflector (170) is also mounted on the dummy bracket (280).

[116]

[117] FIGS. 6a through 6d are schematic plans illustrating a method of assembling an optical touch screen according to the present invention.

[118]

[119] The method of assembling an optical touch screen according to the present invention is to first prepare the square ring shaped case (300), as illustrated in FIG. 6a.

[120]

[121] Next, the brackets (271, 272, 273) mounted at three square ring corners of the square ring shaped case (300) are fixed, and the dummy bracket (280) that is not mounted with the camera modules (161a, 161b, 161c) is fixed at one inner lateral corner of the square ring shaped case (300) (FIG. 6b).

[122]

[123] In the brackets (271, 272, 273) mounted with the camera modules (161a, 161b, 161c), infrared is emitted from the camera modules (161a, 161b, 161c) and the brackets (271, 272, 273) are formed with openings (not shown) through which the infrared can be incident reflected from the retro reflector (170). The dummy bracket (280) is not formed with an opening which is not needed.

[124]

[125] Successively, an inner lateral surface of the case in the brackets (271, 272, 273, 280) is mounted with a frame (171) for fixing the retro reflector (170) (FIG. 6c). Referring to FIG. 6c, the brackets (271, 272, 273, 280) means the brackets (271, 272, 273) that are mounted with camera modules (161a, 161b, 161c) and the dummy bracket (280) that is not mounted with camera module.

[126]

[127] Thereafter, the retro reflector (170) is fixed at the frame (171) and the dummy bracket (280) (FIG. 6d), where the retro reflector (170) can be fixed without blocking each opening of the brackets (271, 272, 273) mounted with camera modules (161a, 161b, 161c). Following the assembly process of FIG. 6d, the flat plate display panel (200) is mounted on the case (300).

[128]

[129] Therefore, the optical touch screen according to the present invention includes a flat plate display panel; a square ring-shaped case (300) mounted and assembled with the flat plate display panel; brackets (271, 272, 273, 280) assembled at each corner of the case (300); a frame (171) mounted at an inner lateral surface of case among the brackets (271, 272, 273, 280), camera modules (161a, 161b, 161c) mounted at each bracket; and a retro reflector mounted on the frame (171).

[130]

[131] FIG. 7 is a schematic partial perspective view illustrating a method for assembling an

optical touch screen according to the present invention.

[132]

[133] The bracket (271) mounted with the camera module (161a) includes first and second fixtures (271a, 271c) fixed on the case, and a connection (271b) connected to the first and second fixtures (271a, 271c).

[134]

[135] The method for assembling the optical touch screen first includes mounting the camera module (161a) to the connection (271b) of the bracket (271), where the connection (271b) of the bracket (271) may include a first passage (273a) through which infrared (IR) emitted from the camera module (161a) can pass, and a second passage (273b) through which infrared (IR) incident on the camera module (161a) can pass.

[136]

[137] The first and second passages (273a, 273b) may be also implemented by openings formed at the connection (271b) of the bracket (271), as illustrated in FIG.7, but configuration of which is not limited thereto.

[138]

[139] Thereafter, the bracket (271) mounted with the camera module (161a) is mounted at each corner of the case (300).

[140]

[141] To be more specific, as shown in FIG.7, the camera module (161a) is formed with a first fastening lug (161a1), the first and second fixtures (271a, 271c) of the bracket (271) are formed with second and third fastening lugs (275a, 275b), and the case (300) is formed with first, second and third fastening holes (321a, 321b, 321c) corresponding to the first, second and third fastening lugs (161a1, 275a, 275b), wherein the first, second and third fastening lugs (161a1, 275a, 275b) are inserted into the first, second and third fastening holes (321a, 321b, 321c) to allow the camera module (161a) and the bracket (271) to be mounted at the case (300).

[142]

[143] Successively, the frame (171) is mounted on the case (300), and the retro reflector (170) is mounted on the frame (171). At this time, the retro reflector (170) may be mounted on the first and second fixtures (271a, 271c) of the bracket (271).

[144]

[145] Therefore, the present invention has an advantage in that a camera module can be easily mounted on a case through a bracket, a retro reflector can be easily assembled on a frame mounted on the case, and each constituent element can simply perform a mechanical arrangement for normally realizing an operational mechanism of an optical touch screen. Furthermore, the present invention has another advantage in that the

camera module and the retro reflector need no mount on a high-priced reinforced glass to reduce the manufacturing cost.

[146]

[147] FIGS. 8a and 8b are schematic partial perspective view illustrating in detail a process of attaching a retro reflector in a method for assembling an optical touch screen according to the present invention.

[148]

[149] Referring to FIG.8a, the bracket (271) mounted with the camera module (161a) and the frame (171) are mounted on the case (300), and then, as shown in FIG.8b, the retro reflector (170) is mounted on the frame (171) and a partial area of the bracket (271).

[150]

[151] At this time, only the connection (271b) of the bracket (271) is exposed, and the retro reflector (170) is encompassed by the inner lateral surface of the case (300) to reflect the IR, where the IR emitted from the camera module (161a) is emitted through the first passage (273a) of the connection (271b) at the bracket (271), and the emitted IR is reflected from the retro reflector (170) to enter the second passage (273b). Therefore, the IR emitted from the camera module (161a) does not interfere with the incident IR.

[152]

[153] Meanwhile, the frame (171) and the partial area of the bracket (271) may be formed with a groove and the retro reflector (170) may be formed with a lug insertable to the groove (171a).

[154]

[155] Thus, the present invention has an advantage in that the retro reflector (170) can be easily fastened to the frame (171) and the bracket (271), by way of shield bar (rail) coupling method, by grooves formed at the frame (171) and the bracket (271), and the lug formed on the retro reflector (170).

[156]

[157] Alternatively, in a case guides are respectively formed on an upper surface and a bottom surface of the frame (171) and the bracket (271), an area between the guides is concavely formed to allow the retro reflector (170) to be inserted into the concave area between the guides. That is, the retro reflector (170) can be fastened to the frame (171) and the bracket (271) by way of shield bar (rail) coupling method.

[158]

[159] FIG.9 is a schematic cross-sectional view illustrating a camera module according to the present invention.

[160]

[161] Referring to FIG.9, the camera module includes a holder (380) formed with a stair unit (381) and an opening (383); an IR emitting diode (100) mounted at the stair unit

(381) for emitting IR (G1); and an image sensor (150) for detecting the IR (G2) through the opening (383).

[162]

[163] The stair unit (381) may be formed at an upper surface of the holder (380), and the opening (383) may be formed at a bottom surface of the holder (380).

[164] Thus, the stair unit (381) and the opening (383) are formed at a different area of the holder (380) to prevent the IR (G1) emitted from the IR emitting diode (100) from being interfered by the IR (G2) through the opening (383), such that the IR incident on the image sensor (150) is free from the IR (G1) components emitted from the IR emitting diode (100).

[165]

[166] Therefore, the camera module according to the present invention has an advantage in that the image sensor (150) is so positioned as to allow the stair unit (381) of the holder (380) to be mounted with the IR emitting diode (100), and the IR (G2) to be detected through the opening (383), thereby preventing the IR emitted from the IR emitting diode (100) from entering the image sensor (150). That is, the camera module according to the present invention is assembled in a two-tier structure where a light emitting unit and a light receiving unit are separately disposed as shown in FIG.8.

[167]

[168] FIG. 10 is schematic cross-sectional view illustrating a camera module according to an exemplary embodiment of the present invention.

[169]

[170] Now, an exemplary embodiment of the camera module will be illustrated with reference to FIG.10.

[171]

[172] The camera module includes a holder (380) formed at one side with a first groove (381) and formed at the other side with a second groove (384), where an opening (383) connects the first groove (381) and the second groove (384), a stair unit (381) is formed at an upper surface of the one side of the holder (380), the first groove (381) is formed with an objective lens (140), the second groove (384) is formed with an infrared pass filter (131) that passes an infrared of a particular wave band, and a printed circuit board (151) mounted with the image sensor (150) is attached to the holder (380) for blocking the second groove (384), and the stair unit (381) is mounted with the IR emitting diode (100).

[173]

[174] At this time, the IR pass filter (131) may be implemented by coating on a glass an IR pass filter material that passes an infrared of a particular wave band, where the glass functions as a cover plate protecting the image sensor. Furthermore, the stair unit (381)

is mounted with the IR emitting diode (100).

[175]

[176] Therefore, the IR emitted from the IR emitting diode (100) advances to an upper surface of the flat plate display panel, and the IR reflected from the retro reflector passes the objective lens (140) and the IR pass filter (131) that passes an infrared of a particular wave band to be incident on the image sensor (150), whereby touch can be detected.

Mode for the Invention

[177] FIG. 11 is a schematic partially cut-out perspective view illustrating a state where an IR pass filter is mounted to a bracket according to the present invention, and FIG. 12 is a schematic cross-sectional view illustrating a connected relationship between a camera module and a bracket according to the present invention.

[178]

[179] The camera module is mounted at a rear surface of the connection (271b) of the bracket (271), and first and second infrared pass filters (410, 420) are mounted at a front surface of the connection (271b) of the bracket (271). At this time, the first infrared pass filter (410) is aligned on the first passage (273a) of the connection (271b) at the bracket (271), and the second infrared pass filter (420) is aligned on the second passage (273b), as illustrated in FIG. 12.

[180]

[181] Furthermore, a light leakage prevention lug (273d) may be formed between the first and second passages (273a, 273b) of the connection (271b) at the bracket (271)

[182]

[183] At this time, in a case the camera module is mounted at the connection (271b) of the bracket (271), the light leakage prevention lug (273d) is accommodated at the stair unit (381) mounted with the infrared light emitting diode (100), such that the infrared emitted from the infrared light emitting diode (100) advances only to the first passage (273a), instead of entering the image sensor (150).

[184]

[185] Therefore, the present invention is such that the camera module can be optically aligned by a simple assembly process of mounting the first and second infrared pass filters (410, 420) with the connection (271b) of the bracket (271) to advantageously simplify the processes.

[186]

[187] Furthermore, the connection (271b) of the bracket (271) is formed with the light leakage prevention lug (273d), and the camera module and the bracket are so coupled as to allow the stair unit (381) mounted with the infrared light emitting diode (100) to

be accommodated with the light leakage prevention lug (273d), whereby the infrared emitted from the infrared light emitting diode (100) is advantageously prevented from entering the image sensor (150).

[188]

[189] The previous description of the present invention is provided to enable any person skilled in the art to make or use the invention. Various modifications to the invention will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the invention. Thus, the invention is not intended to limit the examples described herein, but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

Industrial Applicability

[190] The present invention has an industrial applicability in that a frame and a bracket are formed with grooves, and a retro reflector is formed with a lug to allow the retro reflector to be easily fastened on the frame and the bracket by way of shield bar (rail) coupling method.

Claims

[Claim 1] An optical touch screen, the optical touch screen comprising: a flat plate display panel; a case mounted and assembled with the flat plate display panel; brackets assembled at each corner of the case; a camera module mounted at each bracket; and a retro reflector arranged along an inner lateral surface of the case.

[Claim 2] The optical touch screen of claim 1, wherein the optical touch screen further includes a frame mounted at an inner lateral surface between the brackets, wherein the retro reflector is mounted at the frame.

[Claim 3] The optical touch screen of claim 1, wherein the case takes the shape of a square ring.

[Claim 4] The optical touch screen of claim 1, wherein the brackets include first and second fixtures fixed on the case, and a connection connected to the first and second fixtures, wherein the camera module is mounted at the connection.

[Claim 5] The optical touch screen of claim 4, wherein the connection of the bracket includes a first passage through which infrared (IR) emitted from the camera module can pass, and a second passage through which infrared (IR) incident on the camera module can pass.

[Claim 6] The optical touch screen of claim 4, wherein the retro reflector is mounted on the first and second fixtures.

[Claim 7] The optical touch screen of claim 2, wherein the frame is formed with a groove, and the retro reflector is formed with a lug insertable to the groove, wherein the lug formed at the retro reflector is inserted into the groove formed at the frame, whereby the retro reflector is mounted at the frame.

[Claim 8] The optical touch screen of claim 1, wherein the camera module includes an IR emitting diode emitting IR; an IR pass filter passing only the IR reflected from the retro reflector; and a linear sensor detecting an area touched by incidence of IR that has passed the IR pass filter.

[Claim 9] The optical touch screen of claim 1, wherein the camera module includes a holder formed with a stair unit and an opening; an IR emitting diode mounted at the stair unit for emitting IR; and an image sensor detecting the IR through the opening.

[Claim 10] The optical touch screen of claim 9, wherein the stair unit is formed at an upper surface of the holder, and the opening is formed at a bottom

surface of the holder.

[Claim 11] The optical touch screen of claim 9, wherein the holder is formed at one side with a first groove and is formed at the other side with a second groove, and the opening connects the first groove and the second groove, and the stair unit is formed at an upper surface of the one side.

[Claim 12] The optical touch screen of claim 11, wherein the first groove is formed with an objective lens, the second groove is formed with an infrared pass filter that passes an infrared of a particular wave band, and a printed circuit board mounted with the image sensor is attached to the holder for blocking the second groove.

[Claim 13] The optical touch screen of claim 12, wherein the IR pass filter is implemented by coating an IR pass filter material on a glass.

[Claim 14] A method for assembling an optical touch screen, the method comprising: preparing a bracket mounted with a camera module and a case; fixing the bracket at each corner of the case; fixing a retro reflector on the case; and mounting a flat plate display panel on the case.

[Claim 15] The method of claim 14, wherein the brackets include first and second fixtures fixed on the case, and a connection connected to the first and second fixtures, wherein the camera module is mounted at the connection.

[Claim 16] The method of claim 15, wherein the camera module is formed with a first fastening lug, the first and second fixtures of the bracket are formed with second and third fastening lugs, and the case is formed with first, second and third fastening holes corresponding to the first, second and third fastening lugs, wherein the first, second and third fastening lugs are inserted into the first, second and third fastening holes to allow the camera module and the bracket to be mounted at the case.

[Claim 17] The method of claim 14, wherein the step of fixing the bracket at each corner of the case is performed in such a manner that three inner corners of the square ring-shaped case are fixed by brackets on which the camera module is mounted, and one inner corner of the square-ring shaped case is mounted with a dummy bracket on which the camera module is not mounted.

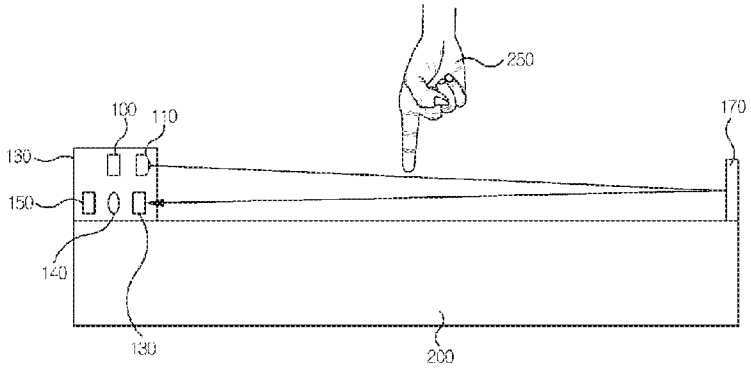
[Claim 18] The method of claim 14, wherein the camera module includes a holder formed with a stair unit and an opening; an IR emitting diode mounted

at the stair unit for emitting IR; and an image sensor detecting the IR through the opening.

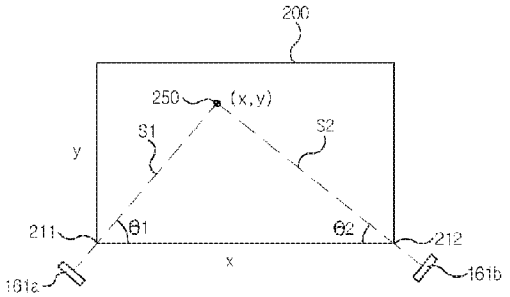
[Claim 19] The method of claim 18, wherein the stair unit is formed at an upper surface of the holder, and the opening is formed at a bottom surface of the holder.

[Claim 20] The method of claim 18, wherein the holder is formed at one side with a first groove and is formed at the other side with a second groove, and the opening connects the first groove and the second groove, and the stair unit is formed at an upper surface of the one side.

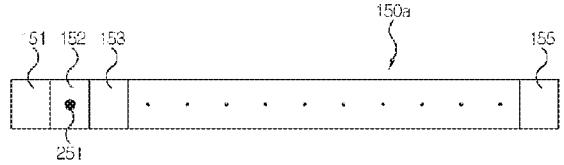
[Fig. 1]



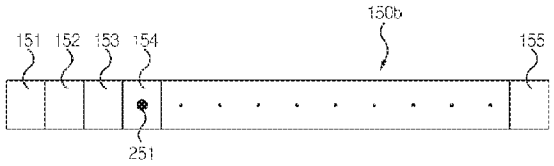
[Fig. 2]



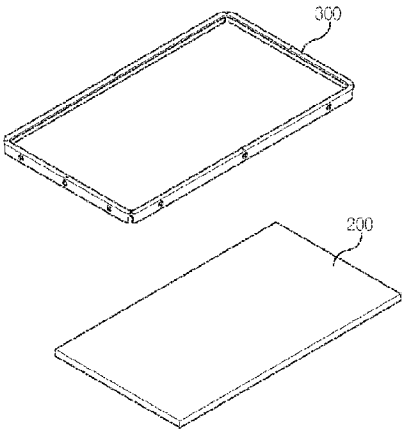
[Fig. 3a]



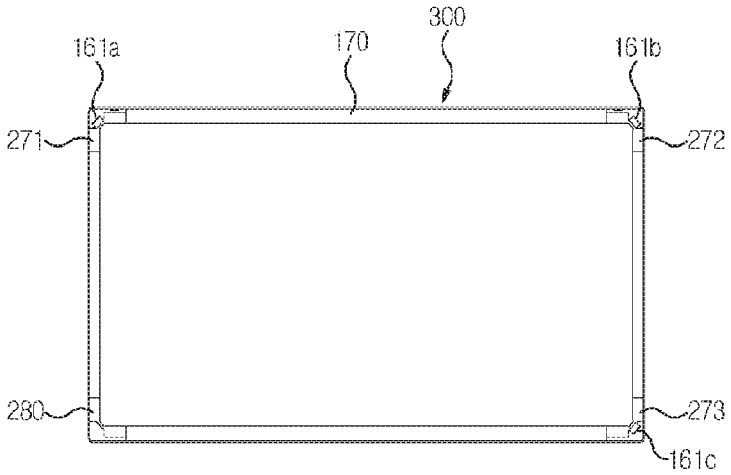
[Fig. 3b]



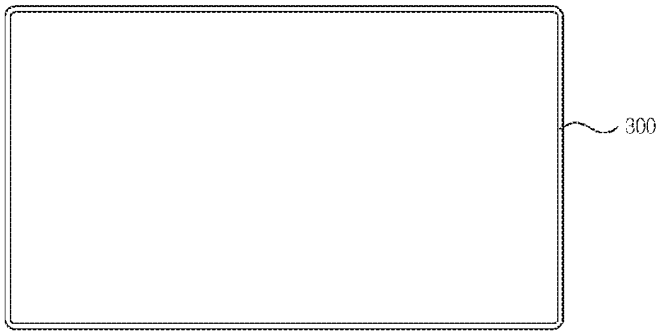
[Fig. 4]



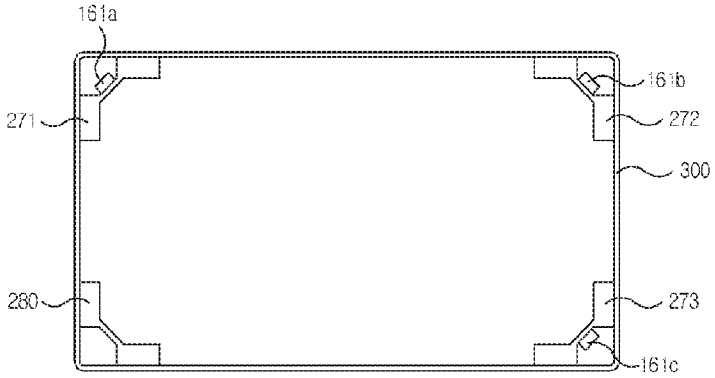
[Fig. 5]



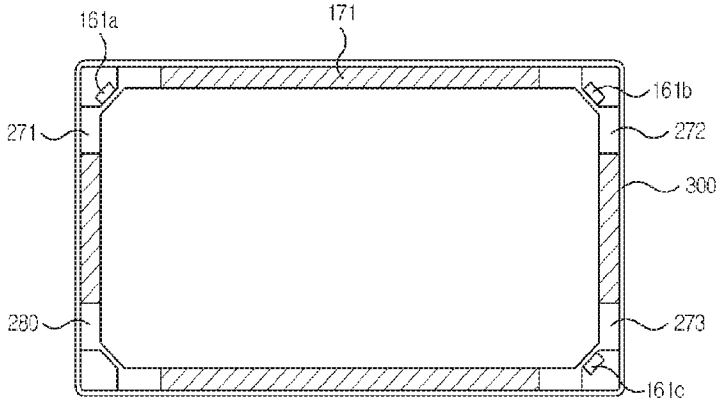
[Fig. 6a]



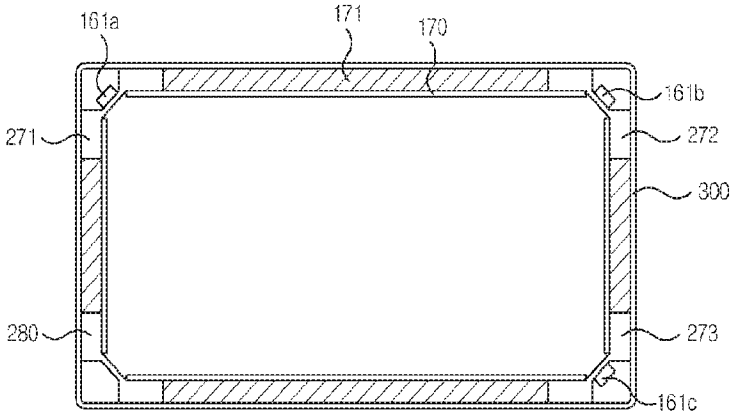
[Fig. 6b]



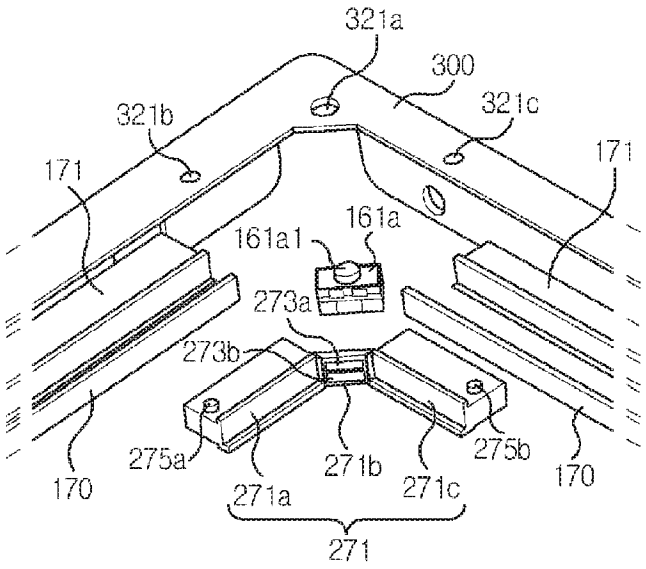
[Fig. 6c]



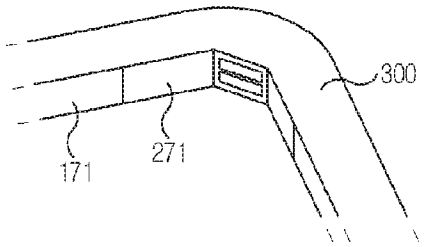
[Fig. 6d]



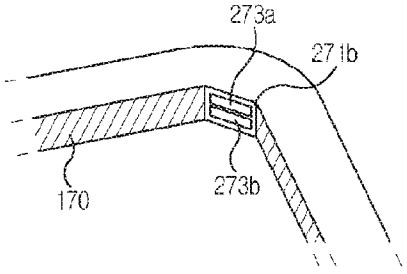
[Fig. 7]



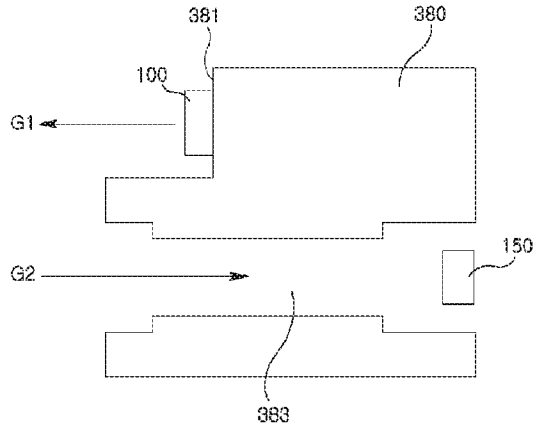
[Fig. 8a]



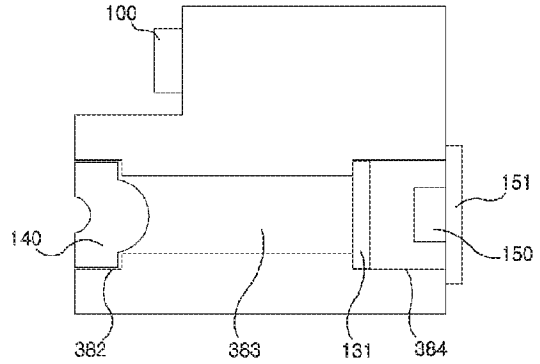
[Fig. 8b]



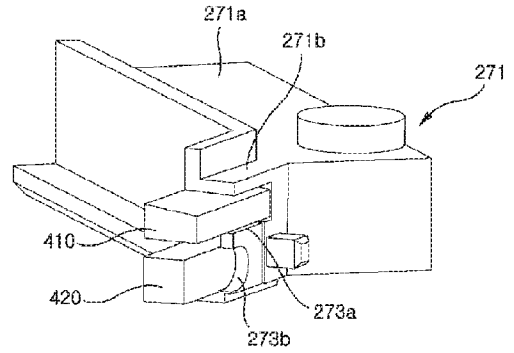
[Fig. 9]



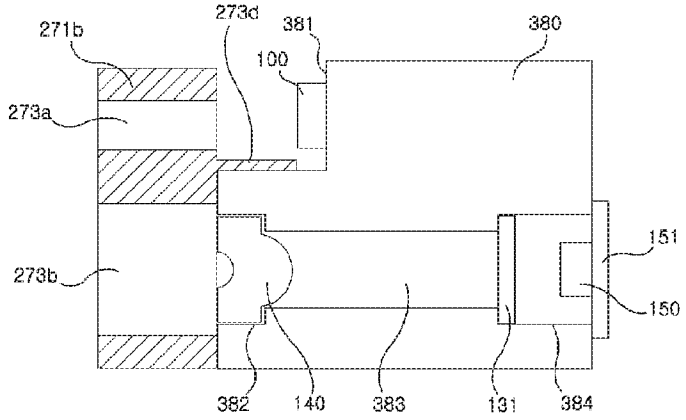
[Fig. 10]



[Fig. 11]



[Fig. 12]



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[Continued on nextpage]

(54) **Title:** PERFORMANCE MONITORING AND CORRECTION IN A TOUCH-SENSITIVE APPARATUS

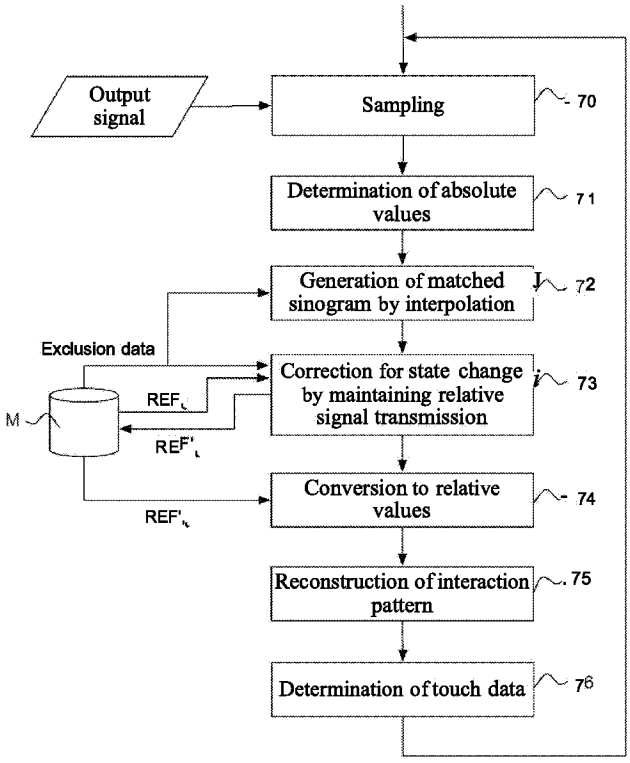


Fig. 7

(57) **Abstract:** Touch sensitivity is enabled using a touch system that comprises a panel configured to conduct signals, e.g. by TIR, along detection lines across a touch surface. A signal processor operates in a sequence of repetitions to: generate (70, 71) data samples that represent detected signal energy on the actual detection lines; generate (72, 74) based on the data samples, an interpolated sinogram comprising interpolation samples that represent fictitious detection lines which have a desired location on the touch surface; and reconstruct (75) a signal interaction pattern for the touch surface based on the interpolated sinogram. The signal processor implements an error correction (73) to counteract the influence of a change in validity status for a data sample among the data samples, by identifying interpolation samples affected by the change in validity status, and by setting each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

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PERFORMANCE MONITORING AND CORRECTION IN A TOUCH-SENSITIVE APPARATUS

Cross-reference to Related Applications

The present application is related to the following applications, which are all incorporated herein in their entirety by this reference: WO2010/064983, WO201 1/049512, WO20 11/078769, WO201 1/139213, WO20 12/12 1652, WO2012/158105, PCT/SE20 12/05 1006 filed on September 24, 2012, and PCT/SE2012/51073 filed on October 8, 2012.

The present application claims the benefit of Swedish patent application No. 1250064-1, filed 3 1 January 2012, and US provisional application No. 61/592641, filed 3 1 January 2012, both of which are incorporated herein by reference.

Technical Field

The present invention relates to touch sensing systems and data processing techniques in relation to such systems, and in particular to techniques for performance monitoring and correction.

Background Art

Touch sensing systems ("touch systems") are in widespread use in a variety of applications. Typically, the touch sensing systems are actuated by a touch object such as a finger or stylus, either in direct contact, or through proximity (i.e. without contact), with a touch surface. Touch sensing systems are for example used as touch pads of laptop computers, in control panels, and as overlays to displays on e.g. hand held devices, such as mobile telephones. A touch panel that is overlaid on or integrated in a display is also denoted a "touch screen". Many other applications are known in the art.

WO2010/064983 discloses a multi-touch system, which is based on frustrated total internal reflection (FTIR). Light sheets are coupled into a panel to propagate inside the panel by total internal reflection (TIR). When an object comes into contact with a touch surface of the panel, the propagating light will be attenuated at the point of touch. Arrays of light sensors are located around the perimeter of the touch surface to detect the received light for each light sheet and generate a signal value for each light path across the touch surface. The signal values of the light sensors are normalized by respective reference values and input into an image reconstruction algorithm that generates a two-dimensional distribution of attenuation values across the touch surface. This enables repeated determination of current position/size/shape of touches while one or more users interact with the touch surface.

In FTIR systems, the touches need to be detected against a background of interferences, e.g. originating from fingerprints and other types of smear on the touch surface. The influence of interferences may vary not only over time but also across the touch surface, making it difficult to properly detect the touches on the touch surface at all times. WO201 1/028169 proposes manipulating the reference values to compensate for the influence of contaminations in the attenuation pattern, and WO201 1/049512 proposes tracking a two-dimensional background pattern of the contamination contribution and using the background pattern to generate an attenuation pattern that is compensated for contaminations.

FTIR systems often need to be designed with a high sensitivity, since a touching object may result in only a small attenuation of the propagating light, e.g. less than 1%. Certain systems may therefore be designed to detect attenuations on the order of 0.1% - 0.01 %. To ensure proper touch detection,WO20 11/078769 proposes monitoring the temporal variability of the signal values to identify potential causes for reduced performance of the touch system, e.g. due to component failure, and implementing corrective measures to account for unreliable signal values. WO201 1/139213 further proposes the corrective measure of removing unreliable signal values from an interpolation step, which is tailored to prepare the adequate input data for a tomographic reconstruction algorithm that generates the attenuation pattern.

In view of the required sensitivity of the FTIR system, there is a continued need to improve the quality of the attenuation pattern and suppress any errors that may affect the attenuation pattern.

Summary

It is an objective of the invention to at least partly overcome one or more limitations of the prior art.

Another objective is to provide an improved technique of handling signal values that are deemed unreliable in touch systems that operate by propagating signals across a touch surface.

One or more of these objectives, as well as further objects that may appear from the description below, are at least partly achieved by means of a method of enabling touch determination, a computer program product, devices for enabling touch determination, and a touch-sensitive apparatus according to the independent claims, embodiments thereof being defined by the dependent claims.

A first aspect of the invention is a method of enabling touch determination based on an output signal from a touch-sensitive apparatus. The touch-sensitive apparatus comprises a panel configured to conduct signals from a plurality of peripheral

incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines that extend across a surface portion of the panel between pairs of incoupling and outcoupling points, at least one signal generator coupled to the incoupling points to generate the signals, and at least one signal detector coupled to the outcoupling points to generate the output signal. The method receives the output signal and operates in a sequence of repetitions to: process the output signal to generate a set of data samples, each data sample being generated to represent detected energy for one of the actual detection lines; generating an interpolated sinogram based on the data samples, the interpolated sinogram comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion; and operate an image reconstruction function on the interpolated sinogram to generate a signal interaction pattern within at least part of the surface portion. The method further comprises an error correction step which is responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples in a current repetition. The error correction step comprises: identifying interpolation samples affected by the change in validity status; and setting each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

The first aspect achieves a suppression of errors that otherwise might emerge in the signal interaction pattern as a result of the change in validity status of the data sample. The affected data sample may be a previously valid data sample which is deemed invalid in the sense that it cannot be trusted, or a previously invalid data sample which is deemed valid. As will be further explained below in relation to detailed examples, simply removing or adding a data sample based on the validity change is likely to cause local errors in the interpolated sinogram, which in turn may cause artifacts in the signal interaction pattern that are mistaken for touches. The first aspect is based on the insight that such local errors may be suppressed by stipulating that the relative signal transmission of each identified interpolation point (i.e. each affected fictitious detection line) should be unaffected by the validity change. The "relative signal transmission" or "relative transmission" is a conventional term that denotes the ratio of detected energy to a baseline or reference level. The relative signal transmission is representative of the signal interaction for the fictitious detection line, and may alternatively be expressed as an attenuation or a relative loss of energy. The first aspect thus operates to maintain the relative signal transmission (signal interaction, attenuation or loss of energy) between a current and a former repetition. It is to be noted, however, that the relative signal transmission need not be explicitly calculated, or even be known, for the error correction step to be able to manipulate the identified interpolation sample.

According to the first aspect, the data samples represent detected energy, which infers that each data sample is a value of an energy parameter which is computable from the output signal only, such as a measure of the energy (or equivalently, power or intensity) of the light that is received by the at least one signal detector via the respective outcoupling point, or a logarithm of this measure. Thus, in one embodiment, each data sample in the set of data samples is generated by extracting the detected energy for the respective actual detection line from the output signal and, optionally, by computing the logarithm of the detected energy.

In one embodiment, the interpolated sinogram is generated to represent relative values between energy values and reference energy values for the fictitious detection lines. The relative values may, but need not, be equal to the relative signal transmission. In a specific embodiment, each relative value is given as an attenuation value, so as to enable the signal interaction pattern to represent a distribution of attenuation values.

The relative values may be obtained by interpolation of either relative or absolute values.

In one embodiment, the set of data samples are first converted to a set of relative values for the actual detection lines by means of a corresponding set of reference energy values for the actual detection lines, whereupon an interpolation function is operated on the relative values to generate the interpolation samples for the fictitious detection lines. In such an embodiment, the interpolation is thus performed on the relative values for the actual detection lines. As exemplified in the detailed description, the respective relative values that are input to the interpolation function may be computed as a ratio between a respective data sample in the set of data samples and a corresponding reference energy value, or as a logarithm of such a ratio, or, if the data samples are representative of logarithmic energy, as a difference between the data samples and logarithmic reference energy values.

In an alternative embodiment, the step of generating the interpolated sinogram comprises: operating an interpolation function on the data samples to generate the energy values for the fictitious detection lines, and converting the energy values to the relative values by means of the reference energy values for the fictitious detection lines. The interpolation is thus performed on absolute values. Such an approach has been found to be particularly sensitive to validity changes among the data samples. Again, the relative values may be computed as a ratio between a respective data sample in the set of data samples and a corresponding reference energy value, or as a logarithm of such a ratio, or, if the data samples as representative of logarithmic energy, as a difference between the data samples and logarithmic reference energy values.

The time scale of the reference energy values may be set to achieve a desired property of the resulting signal interaction pattern. If the signal interaction pattern should represent interaction changes on a long time scale, the reference energy values may be given with respect to a calibration step performed at e.g. manufacture or start-up. If the signal interaction pattern should represent interaction changes on a shorter time scale, the reference energy values may be obtained as a function of energy values for the fictitious detection lines that were generated, by interpolation, in a preceding repetition with a given time difference to the current repetition.

Accordingly, in one embodiment that enables touch detection on a long time scale, the reference energy values for the fictitious detection lines are generated by operating the interpolation function on data samples obtained from the output signal in a calibration step without objects in contact with the surface portion, and the error correction step comprises manipulating the reference energy value of each identified interpolation sample so as to maintain the relative signal transmission of the corresponding fictitious detection line from the former repetition, which may (but need not) be the immediately preceding repetition. This is equivalent to assuming that the fictitious detection line (that corresponds to the identified interpolation sample) exhibits no change in interaction between the former repetition and the current repetition.

In an alternative embodiment that enables touch detection on a shorter time scale, the reference energy values are intermittently updated to represent the energy values in a preceding repetition, such that the relative values represent a change in the relative signal transmission between the current and the preceding repetition for each fictitious detection line. The reference energy values may e.g. be updated in each repetition. It is to be noted that the number of repetitions between the current repetition and the preceding repetition may be selected differently depending of the desired properties of the resulting signal interaction pattern.

To enable detection on the shorter time scale, the error correction step may operate in different ways to maintain the relative signal transmission. In one embodiment, the error correction step comprises setting the relative value of each identified interpolation sample to zero. This maintains the relative signal transmission, since the relative value represents a change in the relative signal transmission between the current and the preceding repetition. In an alternative embodiment, the error correction step comprises setting, for each identified interpolation sample, the reference energy value of the former repetition equal to the energy value of the current repetition. Both of these embodiments are capable of maintaining the relative signal transmission between the former repetition and the current repetition without requiring the relative signal transmission to be computed or tracked over time.

In a first implementation, the former repetition is immediately preceding the current repetition. In a second implementation, the former repetition is separated from the current repetition by a number of intermediate repetitions. In the second implementation, the error correction step may further comprise setting the reference energy value for the number of intermediate repetitions equal to the energy value of the current repetition. This will enable detection of touches already in the signal interaction pattern generated in the next repetition.

Typically, but not necessarily, the time separation (number of repetitions) that is used by the error correction to maintain the relative signal transmission is equal to the time separation (number of repetitions) between the energy values and the reference energy values that are used for calculating the relative values.

In one embodiment, which is designed for a touch-sensitive apparatus that comprises a plurality of signal generators and a plurality of signal detectors and is operated to turn the signal generators ON and OFF during each repetition, such that the output signal is generated to comprise ON energy values for the actual detection lines and at least one OFF energy value for each signal detector, the method of the first aspect further comprises a validation process designating a detection line as valid or invalid and for generating the exclusion data, the validation process comprising: obtaining the OFF energy values from the output signal, generating a noise estimate for each actual detection line as a function of the OFF energy values, and validating the actual detection lines based on the noise estimate.

In one embodiment, the noise estimate is generated to represent the variability in a time sequence of OFF energy values for the signal detector associated with the actual detection line.

In one embodiment, an actual detection line is designated as invalid if the noise estimate exceeds a noise limit, and/or if the ON energy value of the actual detection line exceeds a saturation limit.

In one embodiment, the step of processing the output signal to generate the set of data samples comprises: obtaining the ON energy values from the output signal, obtaining an estimated ambient value for each actual detection line based on the OFF energy value for the signal detector associated with the actual detection line, and generating an ambient-compensated energy value by subtracting the estimated ambient value from the ON energy value for each actual detection line. In one embodiment, an actual detection line is designated as invalid if the ratio between the ambient-compensated energy value and the noise estimate is less than a minimum ratio limit, and/or if the ambient-compensated energy value is less than a minimum energy limit.

In one embodiment, the validation process is configured to promote a change of designation from valid to invalid over a change of designation from invalid to valid. This provides a stabilization of the processing by reducing the need to activate the error correction.

A second aspect of the invention is a computer program product comprising computer code which, when executed on a data-processing system, is adapted to carry out the method of the first aspect.

A third aspect of the invention is a device for enabling touch determination based on an output signal from a touch-sensitive apparatus, the touch-sensitive apparatus comprising a panel configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines that extend across a surface portion of the panel between pairs of incoupling and outcoupling points, at least one signal generator coupled to the incoupling points to generate the signals, and at least one signal detector coupled to the outcoupling points to generate the output signal, said device comprising: an input for receiving the output signal; and a signal processor configured to, repeatedly in a sequence of repetitions: process the output signal to generate a set of data samples, each data sample being generated to represent detected energy for one of the actual detection lines; generate an interpolated sinogram based on the data samples, the interpolated sinogram comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion; and operate an image reconstruction function on the interpolated sinogram to generate a signal interaction pattern within at least part of the surface portion; wherein the signal processor is further configured to perform an error correction responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples in a current repetition, wherein said error correction comprises: identifying interpolation samples affected by the change in validity status; and setting each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

A fourth aspect of the invention is a device for enabling touch determination based on an output signal from a touch-sensitive apparatus, the touch-sensitive apparatus comprising a panel configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines that extend across a surface portion of the panel between pairs of incoupling and outcoupling points, at least one signal generator coupled to the incoupling points to generate the signals, and at least one signal detector coupled to the outcoupling points to generate the output signal, wherein the device is operable in a

sequence of repetitions and comprises: means for processing, in each repetition, the output signal to generate a set of data samples, each data sample being generated to represent detected energy for one of the actual detection lines; means for generating, in each repetition, an interpolated sinogram based on the set of data samples, the interpolated sinogram comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion; and means for operating, in each repetition, an image reconstruction function on the interpolated sinogram to generate a signal interaction pattern within at least part of the surface portion; wherein the device further comprises means for error correction, which is responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples in a current repetition, said means for error correction being configured to identify interpolation samples affected by the change in validity status; and set each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

A fifth aspect of the invention is a touch-sensitive apparatus, comprising: a panel configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines that extend across a surface portion of the panel between pairs of incoupling and outcoupling points; means for generating the signals at the incoupling points; means for generating an output signal based on detected signals at the outcoupling points; and the device for enabling touch determination according to the third or fourth aspects.

Any one of the above-identified embodiments of the first aspect may be adapted and implemented as an embodiment of the second to fifth aspects to achieve the corresponding technical advantages.

Still other objectives, features, aspects and advantages of the present invention will appear from the following detailed description, from the attached claims as well as from the drawings.

Brief Description of Drawings

Embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings.

Figs 1A-1B are section and top plan views of a touch-sensing FTIR system.

Fig. 2 is a 3D plot of a total attenuation pattern.

Figs 3A-3B are plots of a difference pattern representing two moving objects.

Fig. 4 is a top plan view of an FTIR system with an interleaved arrangement of emitters and detectors.

Fig. 5 is a sinogram of sampling points defined by the interleaved arrangement in Fig. 4.

Fig. 6A is a graph of a 2D interpolation function for an interleaved arrangement, and Fig. 6B illustrates the generation of interpolation points using the interpolation function of Fig. 6A.

Fig. 7 is a flow chart of a touch determination method with an interpolation that handles occurrence of corrupt sampling points.

Figs 8A-8C are time-sequences of projection values, reference values and resulting relative values to exemplify the inventive handling of corrupt sampling points when the reference values are long-term values, given by the immediately preceding frame, and given two frames back in time, respectively.

Figs 9A-9B illustrate how a 2D interpolation function may be updated when sampling points are removed from reconstruction.

Fig. 10 is a flow chart of a method for validating sampling points.

Figs 11A-l IB are block diagrams of devices that implement the methods of Fig. 7 and 10.

Figs 12A-12D illustrate different sequences of processing steps that involve an interpolation of relative values and that result in a signal interaction pattern being generated.

Figs 13A-13C illustrate different sequences of processing steps that involve an interpolation of absolute values and that result in a signal interaction pattern being generated.

Detailed Description of Example Embodiments

Below follows a description of example embodiments of a technique for enabling extraction of touch data for objects in contact with a touch surface of a touch-sensitive apparatus. Throughout the following description, the same reference numerals are used to identify corresponding elements.

1. Touch-sensitive apparatus

Embodiments of the inventions relate to signal processing in relation to a touch-sensitive apparatus which is based on the concept of transmitting energy of some form across a touch surface, such that an object that is brought into close vicinity of, or in contact with, the touch surface causes a local decrease in the transmitted energy. The apparatus may be configured to permit transmission of energy in one of many different forms. The emitted signals may thus be any radiation or wave energy that can travel in and across the touch surface including, without limitation, light waves in the visible or

infrared or ultraviolet spectral regions, electrical energy, electromagnetic or magnetic energy, or sonic and ultrasonic energy or vibration energy. Example embodiments of the invention will be described in relation to a touch-sensitive apparatus 100, which is shown in Figs. 1A-1B and is based on the concept of FTIR (Frustrated Total Internal Reflection), also denoted "FTIR system". The apparatus 100 operates by transmitting light inside a panel 1, from light emitters 2 to light sensors or detectors 3, so as to illuminate a touch surface 4 from within the panel 1. The panel 1 is made of solid material in one or more layers and may have any shape. The panel 1 defines an internal radiation propagation channel, in which light propagates by internal reflections. In the example of Fig. 1, the propagation channel is defined between the boundary surfaces 5, 6 of the panel 1, where the top surface 5 allows the propagating light to interact with touching objects 7 and thereby defines the touch surface 4. This is achieved by injecting the light into the panel 1 such that the light is reflected by total internal reflection (TIR) in the touch surface 4 as it propagates through the panel 1. The light may be reflected by TIR in the bottom surface 6 or against a reflective coating thereon. It is also conceivable that the propagation channel is spaced from the bottom surface 6, e.g. if the panel comprises multiple layers of different materials. The apparatus 100 may be designed to be overlaid on or integrated into a display device or monitor.

The apparatus 100 allows an object 7 that is brought in contact with the touch surface 4 to interact with the propagating light at the point of touch. In this interaction, part of the light may be scattered by the object 7, part of the light may be absorbed by the object 7, and part of the light may continue to propagate in its original direction across the panel 1. Thus, the touching object 7 causes a local frustration of the total internal reflection, which leads to a decrease in the energy (or, equivalently, power or intensity) of the transmitted light, as indicated by the thinned lines downstream of the touching objects 7 in Fig. 1A.

The emitters 2 are distributed along the perimeter of the touch surface 4 to generate a corresponding number of light sheets inside the panel 1. In the example of Fig. IB, each emitter 2 generates a beam of light that expands in the plane of the panel 1 while propagating in the panel 1. Each beam propagates from one or more entry or incoupling points (ports) on the panel 1. The detectors 3 are distributed along the perimeter of the touch surface 4 to receive the light from the emitters 2 at a number of spaced-apart outcoupling points (ports) on the panel 1. It should be understood that the incoupling and outcoupling points merely refer to the position where the beam enters and leaves, respectively, the panel 1. Thus, although not shown in Fig. IB, one emitter/detector may be optically coupled to a number of incoupling/outcoupling points.

The detectors 3 collectively provide an output signal, which is received and samp-

led by a signal processor 10. The output signal contains a number of sub-signals, also denoted "projection signals", each representing the energy of light emitted by a certain light emitter 2 and received by a certain detector 3. The projection values for all detection lines at time point t are collectively represented by I_t. Depending on implementation, the signal processor 10 may need to process the output signal for separation of the individual projection signals. Conceptually, the touch apparatus 100 is considered to define a grid of detection lines D on the touch surface 4, where each detection line D corresponds to a light propagation path from an emitter 2 to a detector 3, as projected onto the touch surface 4. Thus, the projection signals represent the received energy or power of light on the individual detection lines D. It is realized that the touching object 7 results in a decrease (attenuation) of the received energy on one or more detection lines D.

As will be explained below, the signal processor 10 may be configured to process the projection signals so as to determine a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 1, where each attenuation value represents a local attenuation of light. The attenuation pattern may be represented in many different ways, e.g. as attenuation values arranged in a regular x-y-grid, such as in an ordinary digital image, although other types of grids are conceivable, e.g. hexagonal patterns or triangular meshes. The attenuation pattern may be further processed by the signal processor 10 or by a separate device (not shown) for touch determination, which may involve extraction of touch data, such as a position (e.g. x,y coordinates), a shape or an area of each touching object. In the following, a "frame" denotes a repeated event starting with data collection and ending with determination of touch data.

In the illustrated example, the apparatus 100 also includes a controller 12 which is connected to selectively control the activation of the emitters 2 and, possibly, the readout of data from the detectors 3. The signal processor 10 and the controller 12 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 10 and the controller 12 may be at least partially implemented by software executed by a processing unit 14.

It is to be understood that Fig. 1 merely illustrates one example of an FTIR system. For example, the detection lines may instead be generated by sweeping or scanning one or more beams of light inside the panel 1, and the light may instead be coupled into and out of the panel 1 via the top and bottom surfaces 5, 6, e.g. by the use of dedicated coupling elements attached to the panel 1. Examples of alternative FTIR systems are e.g. disclosed in US6972753, US7432893, US2006/0 114237, US2007/0075648, WO2009/048365, WO20 10/006882, WO2010/006883,

WO2010/006884, WO20 10/0068 85, WO20 10/0068 86, WO2010/064983, and WO2010/134865, which are all incorporated herein by this reference. The inventive concept may be applied to such alternative FTIR systems as well.

2. Signal processing

It is known in the art to operate an image reconstruction function or algorithm on current projection values in the output signal, so as to determine a current attenuation pattern on the touch surface 4. By repeatedly determining, in the above-mentioned "frames", the attenuation pattern and identifying presence of touches in the attenuation pattern, it is possible to track objects that interact with the touch surface.

Embodiments of the invention may use any available algorithm for image reconstruction based on projection signal values, including tomographic reconstruction methods such as Filtered Back Projection, FFT-based algorithms, ART (Algebraic Reconstruction Technique), SART (Simultaneous Algebraic Reconstruction Technique), etc. Alternatively, the reconstruction function may generate the attenuation pattern by adapting one or more basis functions and/or by statistical methods such as Bayesian inversion. Examples of reconstruction functions designed for use in touch determination are found in WO20 10/0068 83, WO2009/077962, WO201 1/0495 11, WO201 1/139213, WO20 12/0505 10, and PCT/SE2012/051142 filed on October 24, 2012, all of which are incorporated herein by reference. Conventional image reconstruction techniques are found in the mathematical literature, e.g. "The Mathematics of Computerized Tomography" by Natterer, and "Principles of Computerized Tomographic Imaging" by Kak and Slaney.

The reconstruction function is designed based on the assumption that the input values $\boldsymbol{al}$ at time point t depend on the attenuation pattern, $\boldsymbol{A_t}$, according to a projection function $\mathcal{P}$, which reflects the properties of the physical touch system: $\boldsymbol{al} = \mathcal{P}(\boldsymbol{At})$. The reconstruction algorithm is thus designed to reconstruct $\boldsymbol{A_t}$ from $\boldsymbol{al}$ by use of a reconstruction function: $\boldsymbol{A_t} = \mathcal{P}'(\alpha \mathrm{I})$.

It is to be understood that the format of the input values $\boldsymbol{al}$ may be specific to the reconstruction function $\mathcal{P}'$. To enable reconstruction of an attenuation pattern, the input values $\boldsymbol{al}$ may be represented as attenuation values for individual detection lines. Such attenuation values may e.g. be based on transmission values obtained by dividing the projection value $\boldsymbol{l_k}$ of the k:th detection line by a respective reference value: $T_k = I_k/REF_k$. By proper choice of reference values, the transmission values may be generated to represent the fraction (e.g. in the range [0, 1]) of the available light energy that has been measured on each of the detection lines, i.e. the relative signal transmission of the detection line. The input value of each detection line may e.g. be given by: $\overline{\alpha_k}$ =

$-\log(T_k)$ or an approximation thereof, e.g. $\overline{\alpha_k} = 1 - T_k$ (valid for T_k close to 1). This choice of input value format may be understood by considering that the transmission along a detection line D_k may be represented as: $T_k = I_k/REF_k = e^{-\int a(x,y)dl}$, where a(x, y) is the attenuation pattern along the detection line D_k. Thereby, $\overline{\alpha_k}$ represents an aggregation of the attenuation along the detection line: $\overline{\alpha_k} = -\log(T_k) = \int a(x,y)dl$.

The reference values for all detection lines at time point t are collectively represented by $\boldsymbol{REF_t}$. As will be explained, the choice of reference values $\boldsymbol{REF_t}$ will decide the time scale of the reconstructed attenuation pattern $\boldsymbol{A_t}$.

In a first embodiment, further discussed in WO20 10/064983 and WO201 1/049512, as well as WO2012/121652, the reference values are given by the output signal at a certain calibration time point when no touching object (finger, stylus, etc) is present on the touch surface, such as when the assembly of the apparatus 100 is finalized, at start-up, or when a user initiates a reset operation of the apparatus 100. These reference values, also denoted calibration values and represented by $\boldsymbol{I_0}$, may be stored in a memory unit of the device 10. By using $\boldsymbol{I_0}$, the reconstructed attenuation pattern $\boldsymbol{A_t}$ will represent the total accumulated attenuation on the touch surface since the calibration time point. Such an attenuation pattern $\boldsymbol{A_t}$ is illustrated in Fig. 2 as a 3D plot in the coordinate system X,Y of the touch surface (cf. Fig. IB).

In a second embodiment, the reference values are updated repeatedly during operation of the apparatus, e.g. at time intervals *At,* by setting the reference values equal to the current projection values and using the updated reference values in the next time interval. For reasons to become apparent, the resulting input values are denoted change values and are represented by $\overline{\boldsymbol{d\alpha_t}}$. The change values are thus given by: $\overline{\boldsymbol{d\alpha_t}} = -\log(I_t/I_{t-\Delta t}) = \log(I_{t-\Delta t}) - \log(I_t)$. This expression may be re-arranged and converted into the type of input values obtained in the first embodiment:

$$\overline{\boldsymbol{d\alpha_t}} = -\log\left(\frac{I_t}{I_{t-\Delta t}}\right) = -\log\left(\frac{I_t}{I_0}/\frac{I_{t-\Delta t}}{I_0}\right) = \log\left(\frac{I_{t-\Delta t}}{I_0}\right) - \log\left(\frac{I_t}{I_0}\right) = \overline{\alpha_t} - \overline{\alpha_{t-\Delta t}}.$$

As seen, the change values $\overline{\boldsymbol{d\alpha_t}}$ represent the change in relative signal transmission for each detection line during the time interval *At.* It is also realized that the change values $\overline{\boldsymbol{d\alpha_t}}$ result in an attenuation pattern, denoted difference pattern $\boldsymbol{dA_t}$, which corresponds to the difference in attenuation patterns between time points t and t —*At,* provided that the reconstruction is at least approximately linear:

$$\boldsymbol{dA_t = \mathcal{P}'(\overline{d\alpha_t}) = \mathcal{P}'(\overline{\alpha_t}) - \mathcal{P}'(\overline{a_{t-\Delta t}}) = A_t - A_{t-\Delta t}}.$$

The time interval *At* may be set to different values depending on implementation.

In a first implementation of the second embodiment, disclosed in further detail in PCT/SE2012/51073, filed on October 8, 2012, a first and a second attenuation pattern are reconstructed on different time scales. The first attenuation pattern may be the total pattern A_t generated by the first embodiment, and the second interaction pattern may be a difference pattern dA_t generated by the second embodiment, e.g. with At in the approximate range of 5 ms - 5 s. The time interval may thus range from 1 frame to several frames. The use of a difference pattern dA_t may improve detection of fast moving objects compared to objects that move slowly or not at all on the touch surface, while also reducing the impact of contaminations on the touch surface. The difference pattern dA_t mainly indicates the temporal change in attenuation caused by moving objects in contact with the touch surface, as well as objects that are removed from or added to the touch surface during At. A moving object generally appears as a "dipole peak" in the difference pattern, i.e. a combination of a positive peak and a negative peak. Fig. 3A is a 3D plot of a difference pattern dA_t containing two dipole peaks γ_1^+, γ_1^- and γ_2^+, γ_2^-. Fig. 3B is a plan view of the difference pattern dA_t in Fig. 3A. When an object is moved during At, the corresponding touch occupies new pixels, resulting in a positive peak, and leaves old pixels, resulting in a negative peak. If an object is removed from the touch surface, the removed touch will be represented by a single negative peak in the difference pattern, and if an object is brought into contact with the touch surface, the new touch will be represented by a single positive peak. In Fig. 3B, it is realized that the objects have moved away from each other during At. In a variation of the first implementation, the change values $\overline{d\alpha_t}$ that are obtained based on the output signal are deliberately distorted, before being input to the reconstruction function, so as to enhance weakly interacting touches over strongly interacting touches and interferences (reconstruction artifacts) in the resulting difference pattern dA_t. In a further variation of the first implementation, the reference values are updated to factor in projection values from more than one time point. For example, the change values $\overline{d\alpha_t}$ may be generated as a function of a current projection value I_t and a temporally low-pass filtered projection value $\overline{I_{t-m}}$, e.g. $\overline{da_t} = log(\overline{I_{t-m}}) - log(I_t)$, where $\overline{I_{t-m}}$ or $log(\overline{I_{t-m}})$ may be computed using any temporal low-pass filter. One such example is an exponential forget filter, such as: $\overline{I_{t-m}} = \overline{I_{t-m-1}} - \varepsilon \cdot (I_{t-m} - \overline{I_{t-m-i}})$, or $log(\overline{I_{t-m}}) = log(\overline{I_{t-m-1}}) - \varepsilon \cdot (log(I_{t-m}) - log(\overline{I_{t-m-1}}))$, where $0 < \varepsilon \leq 1$. It is also possible to compute $\overline{I_{t-m}}$ or $log(\overline{I_{t-m}})$ using a moving average, etc. In all of these examples, m denotes frames and may have any suitable number, including 0.

In a second implementation of the second embodiment, disclosed in further detail in PCT/SE2012/051006, filed on September 24, 2012, the total attenuation pattern A_t is generated by accumulating the difference pattern across the time intervals At: $A_t =$

$A_{t-\Delta i} + dA_t$. In a variant of the second implementation, a total pattern, which is compensated for the influence of contaminations on the touch surface and denoted an offset pattern o_t, is generated by accumulating the difference pattern across the time intervals *At:* $o_t = o'_{t-\Delta t} + dA_t$. Before being used for accumulation in the next time interval, each pixel in the offset pattern o_t is compensated for contamination, e.g. according to an exponential forget algorithm:

$$o'_t = (1-\varepsilon)\cdot o_t \begin{cases} \varepsilon = 0, \text{if touch in pixel of } o_t \\ \varepsilon = 0.1, \text{if no touch in pixel of } o_t \end{cases}$$

which will cause the offset pattern o_t to gradually approach zero attenuation in regions without touch interaction, while other pixels/regions will have a value representative of the local touch interaction. In the second implementation, it is currently preferred that the time interval At is a single frame, i.e. that the reference values are set equal to the current projection vales and are used in the next frame.

As shown in aforesaid WO201 1/139213, the image reconstruction processing may require a transformation of the sampling points by means of interpolation to enable use of existing image reconstruction techniques, such as tomographic processing. Each sampling point corresponds to a detection line of the apparatus and may be defined by two dimensions or parameter values that represent the unique location of the detection line on the touch surface. In the following example, the dimensions are given by an angle ϕ in relation to a reference line on the touch surface and a distance s from the reference line. To further explain this concept, Fig. 4 is a top plan view of an apparatus with an "interleaved arrangement" in which the emitters 2 and detectors 3 are alternated along the perimeter of the touch surface 4 . Fig. 5 illustrates the sampling points (corresponding to detection lines, and thus to measured projection values) in the ϕ-*s*-plane for the interleaved arrangement. The data in Fig. 5 is conventionally denoted a "sinogram" and is represented by g herein. To facilitate and/or improve image reconstruction, interpolation is applied to generate a "matched sinogram", represented by g' herein, in which new sampling points are generated with a placement in the ϕ-*s*-plane that matches a standard geometry for tomographic processing. The new sampling points generated by interpolation are denoted "matched sampling points" or "interpolation points" herein. The interpolation in the sinogram corresponds to calculating projection values for fictitious detection lines with desired locations on the touch surface. Fig. 6A is an example of an interpolation function in the φ-s-plane for use in generating matched sampling points (interpolation points) for the data in Fig. 5. The interpolation function is based on Delaunay triangulation and comprises a mesh of

non-overlapping triangles adapted to the sampling points. Fig. 6B is a close-up of the rectangular region in Fig. 6A to illustrate the sampling points (stars), the Delaunay triangulation (dotted lines extending between the sampling points), and the interpolation points (circles). Thus, the values of the interpolation points are calculated by operating the Delaunay triangulation on the projection values in the sampling points. The interpolation points typically replace the sampling points in the subsequent calculations, although it is possible that a subset of the sampling points are retained to form part of the matched sampling points. As explained in aforesaid WO201 1/139213, there are a multitude of alternative interpolation techniques that may be used, including Fourier transformation and weighted average interpolation.

A further alternative is disclosed in US61/552024, filed on October 27, 201 1, in which the matched sinogram is generated, e.g. by any of the above-mentioned interpolation techniques, such that the matched sampling points transform to Fourier coefficients arranged as data points on a pseudo-polar grid in a Fourier domain.

3. Handling of faulty detection lines

As suggested in aforesaid WO201 1/139213, the apparatus may be provided with an ability of identifying faulty detection lines (also denoted "invalid" or "corrupt" detection lines), i.e. detection lines that are deemed to cause problems in the reconstruction process and/or introduce major errors in reconstructed attenuation pattern. For example, if an emitter or a detector starts to perform badly, or not at all, during operation of the apparatus, this may have a significant impact on the attenuation pattern. The apparatus may implement an error handling that validates the detection lines, e.g. every n:th frame ($n \geq 1$), and dynamically assigns a valid or invalid state to each detection line (sampling point) depending on the outcome of the validation. Different examples of validation criteria are given below in Chapter 4.

When a sampling point is set to an invalid state, it may be removed from the interpolation, at least until the sampling point is again set to the valid state. Such removal is exemplified in Fig. 6B, in which a square designates a sampling point (star) that is deemed corrupt. In the illustrated example, using the Delaunay triangulation shown by dotted lines, a removal of the corrupt sampling point will affect the values of the interpolation points marked by filled circles. It should be noted there is no direct link between the states of the sampling points and the states of the affected interpolation points. If a sampling point is set to invalid state, this does not mean that every affected interpolation point also should be set to the invalid state, but instead a value of the affected interpolation point(s) is computed by interpolation of other sampling points in the neighborhood. However, as will be further exemplified below, the removal may

cause a distortion of the values of the affected interpolation points, since the interpolation is now based on a different combination of sampling points. Thus, a state change of a detection line (sampling point) is not unlikely to result in a disruption of the matched sinogram, which in turn may lead to artifacts in the reconstructed pattern that are mistaken for touches.

3.1. Interpolation of relative values

The interpolation operates on the values of the sampling points. These values may be given as *relative values* (normalized values) for the respective detection line. As indicated above in Chapter 2, the relative values may be calculated by normalizing the projection values I_t by reference values, REF_t which may be given as calibration values I_0, recently measured energy values $I_{t-\Delta t}$, or an average $\overline{I_{t\_m}}$ of recently measured energy values for the respective detection line. Thus, the sampling points in relative format may, e.g., be given as input values al or $\overline{da_t}$, or as transmission values e.g. given by I_t/REF_t. Figs 12A-12C illustrate different processing pipelines for generating an attenuation pattern based on the projection values I_t, by operating the interpolation on relative values.

In Figs 12A-12B, the values of the sampling points are formatted as input values $\overline{\alpha_t}$ or change values $\overline{da_t}$, whereby the resulting values of the interpolation points in the matched sinogram may be directly processed for reconstruction of an attenuation pattern, $A_t = \mathcal{P}'(\overline{al})$, and a difference pattern, $dA_t = \mathcal{P}'(\overline{\alpha\alpha_t})$, respectively. In Fig. 12A, the input or change values al, $\overline{da_t}$ are generated by dividing the respective projection value by the respective reference value and taking the logarithm of the result, e.g. $-\boldsymbol{logiJt/REFt)}$. In Fig. 12B, the input or change values al, $\overline{da_t}$ are generated by taking the logarithm of the projection values and subtracting the resulting values from corresponding logarithmic reference values, e.g. $\boldsymbol{log(REF_t) - log(I_t)}$.

In Fig. 12C, the values of the sampling points are formatted as $\boldsymbol{I_t/REF_t}$, by dividing the respective projection value by the respective reference value. The resulting interpolation values are converted, by operating a logarithm function on the interpolation values, into input values al or change values $\overline{da_t}$ which are then processed for reconstruction of A_t or dA_t.

It should be noted that a difference pattern dA_t may alternatively be obtained by generating the matched sinogram to represent input values al, e.g. according to any one of the techniques in Figs 12A-12C, and then subtracting the matched sinogram by a matched sinogram obtained in a preceding frame $al - \overline{a_{t-\Delta t}}$. The difference pattern is then obtained by operating the reconstruction function on the result: $dA_t = \mathcal{P}'(\overline{al - a_{t-\Delta t}})$. This alternative is schematically depicted in Fig. 12D.

To illustrate the errors that may occur when a sampling point is removed, consider the simplified example that an interpolation point is given as the average of two sampling points (with equal weight), represented by indices A and B. Assume that the sampling points have the following calibration values $/_0{}^A, /_0{}^B$ and energy values $I_t{}^A, I_t{}^B$ at time t: $[I_t{}^A = 44, /_o{}^A = 50, l_t{}^B = 91, I_0{}^B = 100]$. Such variations, both between sampling points and over time for an individual sampling point, may occur as a result of imperfections in the FTIR system. Based on these example values, the weighted average interpolation computes the value of the interpolation point AB as: $\overline{\alpha^{AB}} = 0.5 \cdot (-\log(0.88) - \log(0.91)) \approx 0.111$. If sampling point B is deemed corrupt and therefore eliminated, the value of the interpolation point AB is instead computed as: $\overline{\alpha_{AB}} = (-\log(0.88)) \approx 0.128$. The removal of sampling point B results in a change of slightly more than 10% in the value of the interpolation point AB. This seemingly small change may be sufficient to generate artefacts in the A_t or dA_t that disrupt the touch determination.

Assuming instead that the processing aims at reconstructing a difference pattern between two consecutive frames, using the values: $[I_t{}^A = 50, /_{t-1}{}^A = 50, I_t{}^B = 100, l_{t-1}{}^B = 100]$, yields $\overline{d\alpha^{AB}} = 0.5 \cdot (-\log(1) - \log(1)) = 0$ with both sampling points A, B present at time t, and $\overline{da^{AB}} = (-\log(1)) = 0$ if sampling point B is eliminated at time t (and not at time t —1). In this particular situation, the elimination of the sampling point does not introduce any errors in the resulting difference pattern dA_t.

3.2 Interpolation of absolute values

For various reasons, it may be desirable to operate the interpolation function on *absolute values* instead of relative values. As used herein, "absolute values" refer to non-normalized values, as a distinction to relative values, which are normalized. If the interpolation function is (approximately) linear, it is possible to convert the absolute values of the interpolation points into (approximately) correct relative values after the interpolation. One reason for operating on absolute values might be to reduce the amount of memory and/or processing power required for the interpolation. The absolute values may, e.g., be given as energy I_t or logarithmic energy $log(I_t)$. Figs 13A-13C illustrate different processing pipelines for generating an attenuation pattern based on the projection values I_t, by operating the interpolation on absolute values.

In Figs 13A-13B, the values of the sampling points are given as projection values I_t (energy values). In Fig. 13A, the input or change values $\overline{\alpha_t}$, $\overline{d\alpha_t}$ are then generated by dividing the values of the interpolation points in the matched sinogram, generated in the interpolation, by a respective reference value and by taking the logarithm of the

result. The input or change values $\overline{\alpha_t}$, $\overline{d\alpha_t}$ are then processed for reconstruction of A_t or dA_t. In Fig 13B, the input or change values $\overline{\alpha_t}$, $\overline{d\alpha_t}$ are generated by taking the logarithm of the values of the interpolation points in the matched sinogram, generated in the interpolation, and by subtracting the resulting values from corresponding logarithmic reference values, e.g. $log(REF_t) - log(I_t)$.

In Fig. 13C, the values of the sampling points are formatted as logarithmic energy $log(I_t)$, by taking the logarithm of the respective projection value. The input values $\overline{\alpha_t}$ or change values $\overline{d\alpha_t}$ are then generated by a simple subtraction operation that subtracts the values of the interpolation points from a respective logarithmic reference value, e.g. $log(REF_t) - log(I_t)$.

In Figs 13A-13C, the normalization is performed after the interpolation, and the reference values are therefore given for the fictitious detection lines (i.e. the interpolation points).

The alternative for generating the difference pattern dA_t as described above in relation to Fig. 12D is equally applicable when operating on absolute values.

The removal of sampling points may introduce large errors when absolute values are interpolated. This will now be illustrated by re-visiting the simplified numeric examples presented in Chapter 3.1. Operating on $[I_t^A, I_0^A \rangle I_t^B, I_0^B]$ yields $log(I_t^{AB}) = 0.5 \cdot (log(44) + log(91)) \approx 4.148$, and $log(I_0^{AB}) = 0.5 \cdot (log(50) + log(100)) \approx 4.259$ when both sampling points A, B are present, resulting in $\overline{\alpha^{AB}} = log(I_0^{AB}) - log(I_t^{AB}) \approx 0.111$. If sampling point B is eliminated, the value of the interpolation point AB is instead computed as: $log(I_t^{AB}) = log(44) \approx 3.874$. Since $log(I_0^{AB}) = \log(50) \approx 4.259$, the input value of the interpolation point is calculated to $\overline{\alpha^{AB}} \approx 0.385$. Clearly, the removal of sampling point B results in a significantly incorrect input value $\overline{\alpha^{AB}}$ of the affected interpolation point AB.

When a difference pattern is reconstructed by operating on $[I_t^A, I_{t-1}^A, I_t^B \rangle I_{t-1}^B]$, with both sampling points A, B present at t and t —1, the value of the interpolation point AB is $log(I_{t-1}^{AB}) = 0.5 \cdot (\log(50) + \log(100)) \approx 4.259$, and $log(I_t^{AB}) = 0.5 \cdot (\log(50) + \log(100)) \approx 4.259$, which in turn yields $\overline{d\alpha^{AB}} = log(I_{t-1}^{AB}) - log(I_t^{AB}) = 0$. Eliminating sampling point B at time t yields $log(I_t^{AB}) = \log(50) \approx 3.912$, which in turn results in $\overline{d\alpha^{AB}} = log(I_{t-1}^{AB}) - log(I_t^{AB}) \approx 0.347$. Hence, in contrast to Chapter 3.1, the differential computation produces a significantly incorrect change value $\overline{d\alpha^{AB}}$ of the interpolation point AB, since the change value $\overline{d\alpha^{AB}}$ should be zero.

Generally, interpolation of absolute values, and subsequent conversion of the interpolated absolute values into relative values for input to an image reconstruction function, as exemplified in Figs 13A-13C, is vulnerable to removal of sampling points,

if the signal levels (absolute values) differ between the detection lines. This is typically the case in a commercially viable product, since it may be difficult/costly to produce a touch-sensitive apparatus with well-balanced detection lines. It is to be noted that even a small imbalance in signal levels may cause state changes of sampling points to result in interpolation errors that have a significant impact on the reconstructed pattern.

3.3 Detailed example of a process for handling state changes

A state change refers to an action of changing a sampling point from a valid state to an invalid state, or from an invalid state to a valid state. As seen in the foregoing, such a state change may cause an undesired disruption of the interpolated values in the matched sinogram. In various embodiments, the impact of state changes is addressed by an error correction step in the touch determination process. The error correction is responsive to data indicative of state changes for the sampling points in the current frame, this data being denoted "exclusion data" herein. Generally, the error correction operates to identify the interpolation points that are affected by the state change, and then actively modifies each affected interpolated point so as to ensure that the affected interpolation point has the same relative signal transmission as before the state change. In other words, the error correction operates to maintain the relative loss of power/energy/intensity for each fictitious detection line that is affected by the state change.

If the reconstruction function $\mathcal{P}'$ operates on input values $\overline{\alpha_t}$, which are given with respect to calibration values I_0, the error correction operates to maintain the input value from a preceding frame. It should be recalled that the input values may be regarded to represent the relative signal transmission. The error correction may be implemented in different ways depending the format of the values of the sampling points, i.e. the values that are interpolated. If the interpolation operates on absolute values, the error correction may operate to maintain the current value of the affected interpolation point and modify the calibration value of the affected interpolation point, so as to maintain the relative signal transmission. This means that the error correction treats the current interpolation values that are disrupted by the state change as correct values, and instead manipulates the calibration values that are used for generating the relative values for input to the reconstruction function. If the interpolation instead operates directly on relative values, the error correction may operate to set the current value of an affected interpolation point equal to the preceding value of the affected interpolation point.

If the reconstruction function $\mathcal{P}'$ operates on change values $\overline{d\alpha_t}$, which are given with respect to recently measured energy values $I_{t-\Delta t}$, $\overline{I_{t-\mathrm{m}}}$, the error correction

operates to set the change values for the affected interpolation values to zero in the frame that is affected by the state change. This may be achieved either by directly setting the change value to zero, or by setting the reference value of the affected interpolation point equal to the current value of the affected interpolation point.

In general, only a small part of all interpolation points are affected by a state change, and the remaining interpolation points contain sufficient information to allow the resulting pattern to be processed for touch determination.

It should be emphasized that the error correction is not dependent on how the state changes are identified and how the exclusion data is generated. Examples of techniques for identifying state changes are given below in Chapter 4.

The underlying principle will now be further explained with reference to the flow chart in Fig. 7, which represents an exemplifying touch determination method in a touch-sensitive apparatus, such as the above-described FTIR system. The method uses interpolation of absolute values to generate a matched sinogram.

The method involves a sequence of steps 70-76 that are repeatedly executed, typically by the signal processor 10 (Fig. 1). In the context of this description, each sequence of steps 70-76 is denoted a frame or a repetition.

Each frame starts by a data collection step 70, in which measurement values are obtained from the detectors 3 in the FTIR system, e.g. by sampling a value from each of the aforesaid projection signals. The data collection step 50 results in one projection value for each detection line. For the purpose of the following discussion, the current projection value is generally denoted I_t, although it is realized that there is one such value for each of k detection lines. It may be noted that the data may, but need not, be collected for all available detection lines in the FTIR system. The data collection step 50 may also include pre-processing of the measurement values, e.g. filtering for noise reduction, compensation for ambient light, etc.

In step 71, the projection values I_t are processed for generation of the absolute values used in the subsequent interpolation step 72, specifically logarithmic values $log(I_t)$, cf. Fig. 13C. As used herein, a "logarithm" is intended to also encompass functions approximating a true logarithmic function, in any base. In a variant, step 71 is omitted and the projection values I_t obtained in step 70 are used in the interpolation step 72, cf. Figs 13A-13B. Irrespective of implementation, the absolute values form a sinogram g.

In interpolation step 72, a matched sinogram g' is generated by interpolation of the absolute values in the sinogram g, e.g. according to any of the techniques described in Chapter 2. In the illustrated example, step 72 accesses the exclusion data, from computer memory M (as shown) or directly from a validation process, to identify state

changes. Based on the state changes, step 72 operates to remove and add sampling points, respectively, before the interpolation. Depending on interpolation function, the state changes may also cause step 72 to modify the interpolation function. As an example, Fig. 9A shows a 2D interpolation function based on Delaunay triangulation for a complete set of sampling points. If the sampling point indicated by a square in Fig. 9A is deemed invalid and removed, the 2D interpolation function may need to be updated or recomputed based on the remaining sampling points. As shown in Fig. 9B, this results in a local change of the triangles closest to the removed sampling point.

In correction step 73, the exclusion data is processed to identify all interpolation points that are affected by the respective state change. Step 73 also obtains current reference values $\boldsymbol{REF}_t$ of the ***interpolation points*** (which thus form a "reference sinogram"), or at least the reference values of the affected interpolation points. As explained in Chapter 2, the reference values may take different forms, depending on the desired properties of the reconstructed pattern. For example, the current reference values $\boldsymbol{REF}_t$ may be given as interpolated calibration values $\boldsymbol{log(I_0)}$, values of the interpolation points computed in a preceding frame $\boldsymbol{log(I_{t-\Delta t})}$ or averages of values of interpolation points computed in a number of preceding frames $\boldsymbol{log(\overline{I_{t-m}})}$. The reference values of the affected interpolation points are then actively modified to maintain the relative signal transmission of the affected interpolation points, e.g. as discussed in the foregoing. The ensemble of reference values $\boldsymbol{REF'}_t$ after modification form a "modified reference sinogram".

Step 73 is followed by a conversion step 74 which uses the modified reference sinogram $\boldsymbol{REF'}_t$ to generate the relative values for input to the reconstruction step 75, i.e. interpolated input values $\overline{\alpha_t}$ or change values $\overline{\boldsymbol{d\alpha}_t}$, depending on implementation. Reverting to the processing pipelines in Figs. 13A-13C, the conversion step 74 corresponds to the processing steps that are preformed between the interpolation and the reconstruction, if $\boldsymbol{REF}_t$ is replaced by $\boldsymbol{REF'}_t$.

If step 74 is designed to generate change values $\overline{\boldsymbol{d\alpha}_t}$, step 72 may be modified to omit the sub-step of generating the modified reference sinogram, and step 74 may instead be designed to modify the change values $\overline{\boldsymbol{d\alpha}_t}$ that are supplied to the reconstruction process by setting $\overline{d\alpha_t} = 0$ for all affected interpolation points.

Steps 73-74 will be further explained with reference to Figs 8A-8C for different choices of reference values. Figs 8A-8C illustrate, at a sequence of time steps (frames) and for a specific fictitious detection line, current interpolation values I_t, current (interpolated) reference values (I_t, I_{t-1} and I_{t-2}, respectively), as well current input values $\overline{\alpha_t}$ and change values $\overline{\boldsymbol{d\alpha}_t}$, as applicable, which are computed from the current interpolation values and the current reference values. A state change is indicated by

"X", and the modified reference values that are generated by the error correction as a result of the state change are indicated by circles. The uncorrected input and change values are shown within parenthesis, and each corrected input and change value is reproduced below the corresponding uncorrected input or change value. It should be noted that there is no change in signal interaction during the illustrated time period, i.e. the input values $\overline{\alpha_t}$ should not change over time and change values $\overline{d\alpha_t}$ should be zero.

Fig. 8A represents a process that operates on projection values to generate interpolated input values $\overline{\alpha_t}$ that represent the relative signal transmission of the fictitious detection lines. As seen, a first state change results in $l_t = 50$, which yields $\overline{\alpha_t} = -\log(I_t/I_0) \approx 0.51$. To counteract this disruption, the calibration value $/_0$ is modified to 55.3, so that the relative change is the same as in the immediately preceding frame. It is to be noted that a true touch affecting I_t in the next frame would be seen in the input value $\overline{\alpha_t}$, and thus the touch determination process is largely unaffected by the state change. A second state change results in $I_t = 75$, whereby the error correction sets the calibration value $/_0$ to 83 to maintain the relative signal transmission.

Fig. 8B represents a process that operates on projection values to generate interpolated change values $\overline{d\alpha_t}$ that represent the change in relative signal transmission from the immediately preceding frame, as indicated by the double ended arrows: $\overline{d\alpha_t} = \overline{\alpha_t} - \overline{\alpha_{t-1}}$. In the illustrated example, the interpolated change values may be calculated with respect to the preceding interpolation values: $\overline{d\alpha_t} = \log(/_{t-1}) - \log(I_t)$. As seen, a first state change results in $l_t = 50$, which yields $\overline{d\alpha_t} \approx 0.41$. To counteract this disruption, the error correction operates to set the change in relative signal transmission to zero, either by directly setting $\overline{d\alpha_t} = 0$, or by setting $I_{t-1} = I_t = 50$. It is to be noted that a true touch affecting I_t in the next frame will be seen in the change value $\overline{d\alpha_t}$, and thus the touch determination process is largely unaffected by the state change. A second state change results in $I_t = 75$, whereby the error correction again ensures that $\overline{d\alpha_t} = 0$.

Fig. 8C represents a process that operates on projection values to generate interpolated change values $\overline{d\alpha_t}$ that represent the change in relative signal transmission from two frames back in time, as indicated by the double ended arrows: $\overline{d\alpha_t} = \overline{\alpha_t} - \overline{\alpha_{t-2}}$. The interpolated change values are calculated with respect to the preceding interpolation values: $\overline{d\alpha_t} = \log(I_{t-2}) \sim l°g(I_t)$. As seen, a first state change results in $l_t = 50$, which yields $\overline{d\alpha_t} \approx 0.41$. To counteract this disruption, the error correction operates to modify the reference value by setting $/_{t-2} = I_t = 50$, so that the change in relative signal transmission is zero. Since the change in relative signal transmission is given with respect to interpolation values two frames back in time, the error correction may also operate to set the reference value for the next frame equal to the projection

value of the current frame. This ensures that a touch will show up in $\overline{d\alpha_t}$ even if it occurs in the next frame that follows after a state change. In an alternative implementation, the error correction operates to set the reference value for the next frame equal to the projection value for the next frame, which will cause a touch to show up in $\overline{d\alpha_t}$ two frames after the state change. In a further alternative implementation, the error correction does not operate to modify the reference values, but instead directly sets $\overline{d\alpha_t} = 0$ for two frames: the current frame and the next frame.

Fig. 8C may also serve to illustrate the process that operates on projection values to generate interpolated change values with respect to averages of preceding interpolation values: $\overline{d\alpha_t} = log(\overline{I_{t\_m}}) - log(I_t)$. Consider the example that $\overline{I_{t-m}}$ represents current averages of the interpolation values at four frames back in time, generated by an exponential forget function: $\overline{7_{t-4}} = \overline{I_{t-5}} - \varepsilon \cdot (7_{t-4} - \overline{7_{t-5}})$. To counteract a state change at time t, the error correction may operate to set $\overline{/_{t-4}} = \overline{/_{t-3}} = \overline{/_{t-2}} = It\text{-}i = I_t$ for the affected interpolation point. In an equivalent implementation, the error correction sets $\overline{/_{t-4}} = l_t$ in the current frame and then sets $\varepsilon = 0$ during the next three frames. Either implementation ensures that a touch will show up in $\overline{d\alpha_t}$ even if it occurs in the next frame that follows after the state change.

Reverting to Fig. 7, step 74 is followed by the reconstruction step 75 which operates an image reconstruction function on the interpolated input values $\overline{\alpha_t}$ or $\overline{d\alpha_t}$ to generate a current interaction pattern, e.g. an attenuation pattern A_t or a difference pattern dA_t, e.g. to any of the techniques described in Chapter 2.

In a subsequent determination step 76, the interaction pattern is processed for identification of touch-related features and extraction of touch data. Any known technique may be used for isolating touches within the interaction pattern. For example, ordinary blob detection and tracking techniques may be used for finding the touches. In one embodiment, a threshold is first applied to the interaction pattern, to remove noise. Any areas with interaction values that fall below or above (depending on implementation) the threshold may be further processed to find the center and shape by fitting for instance a two-dimensional second-order polynomial or a Gaussian bell shape to the attenuation values, or by finding the ellipse of inertia of the attenuation values. There are also numerous other techniques as is well known in the art, such as clustering algorithms, edge detection algorithms, etc. Step 76 may be concluded by outputting the extracted touch data.

After step 76, the process returns to the data collection step 70.

It is to be understood that one or more of steps 70-76 may be effected concurrently. For example, the data collection step 70 of a subsequent frame may be initiated concurrently with any one of steps 71-75. In another example, steps 70-74, and

possibly also step 75, may be repeated sequentially for each projection value in the output signal within a frame.

It is also to be understood that certain steps may be combined or intermixed. For example, instead of first generating a matched sinogram by interpolation (step 72) and then correcting certain interpolation values in the matched sinogram (step 73) based on the exclusion data, the error correction may be implemented as part of the interpolation in step 72, such that the interpolation directly generates a matched sinogram with corrected interpolation values.

The skilled person now realizes that the touch determination process in Fig. 7 may be modified to operate the interpolation step 72 on relative values, e.g. as shown in Figs 12A-12C. For example, step 71 may be modified to generate relative values, e.g. input values al or change values $\overline{da_t}$, or alternatively I_t/REF_t, based on the projection values I_t and corresponding reference values REF_t, e.g. represented by any of I_0, $I_{t-\Delta t}$ and $\overline{I_{t-m}}$. In contrast to the above-described example, the reference values are given for the sampling points (not the interpolation points). Further, step 73 is modified to, for all affected interpolation points, set the current relative value equal to the relative value in a preceding frame or set the current relative value to zero, in analogy with Figs 8A-8C. Still further, step 74 may be omitted if the interpolation values are given as al or $\overline{da_t}$, cf. Figs 12A-12B. If the interpolation values are given as I_t/REF_t, step 74 may be modified to convert the interpolation values into al or $\overline{da_t}$, cf. Fig. 12C.

In all embodiments disclosed herein, to increase the robustness of the error correction, it is conceivable to let a state change not only affect a current frame but also a given number of subsequent frames. For example, every state change in the exclusion data may cause step 73 to perform the error correction for a given number of consecutive frames, e.g. 2-3 frames, in which the relative signal transmission is maintained according to the principles described in the foregoing.

4. Detecting invalid detection lines

The above-mentioned error handling for validation of detection lines may be implemented to detect potentially faulty detection lines by processing the projection signals, e.g. by detecting if the projection values exceed a saturation limit, if the projection values are too weak, if the noise level in the projection signal is too high, if the signal-to-noise level in the projection signal is too low, etc. Alternatively, the validation process may detect a faulty emitter or detector based on the power signal supplied to the emitter/detector. It is also conceivable that the validation process designates all affected detection lines as "invalid" for a given number of frames whenever an operating parameter of an emitter or a detector is changed, so as to prevent

that the change in operating parameter introduces errors in the touch determination. Such an operating parameter may be the power supplied to the emitter or the gain of the detector. The power to the emitter may be changed to increase/decrease the energy of the light that is emitted when the emitter is active, and the gain of the detector may be changed to increase/decrease the sensitivity of the detector.

Further examples of validation processes are given in WO201 1/078769, WO201 1/139213 and WO2012/158105.

Embodiments of an alternative or supplement to the above-mentioned validation processes are described in the following. These embodiments utilize the energy values measured by the detectors 3 while the emitters 2 are OFF, i.e. not activated to emit a signal (light). In the following, an "ON value" denotes detected energy when a signal is conducted from the incoupling point to the outcoupling point of a detection line, and an "OFF value" denotes detected energy without a signal being conducted from the incoupling point to the outcoupling point.

The OFF values are conventionally used for so-called ambient compensation, which aims at removing or at least suppressing signal components originating from ambient light and detector dark level, including any analog-to-digital conversion (ADC) offset. Ambient light refers to light that is received by a detector while not originating from the emitters. The ON/OFF activation scheme of the emitters may enable each detector to measure an OFF value one or several times during a frame. An ambient-compensated energy value I_k for detection line k may then be obtained as: $I_k = Iraw,k \sim Iamb,k$, where $I_{raw,k}$ is the ON value or an average of ON values, i.e. the energy measured by the detector associated with detection line k when the emitter associated with detection line k is ON, and $I_{amb,k}$ is the OFF value or an average of OFF values, i.e. the energy measured by the detector associated with detection line k when all emitters are OFF. It is to be understood that the touch determination method may operate on I_k instead of $I_{raw,k}$ to improve its robustness to ambient light.

In the various embodiments, the OFF values, obtained during one or plural frames, are processed to generate a current estimate of the noise level for each individual detector, and hence for each detection line. By using the ambient measurements for validation, all influence from touching objects on the estimated noise level is avoided. Furthermore, the validation process may be designed to operate on the same data as the ambient compensation.

Fig. 10 is a flowchart of an exemplifying validation process, which involves a sequence of steps 120-124 that are executed during a frame, e.g. by the signal processor 10 (Fig. 1). The validation process is illustrated for a single detector, but it is understood that a similar process is executed for each detector in the touch-sensitive apparatus.

In step 120, one or more ON values are obtained from the detector. In step 121, one or more OFF values are obtained from the detector. As indicated by the dashed arrow, steps 120 and 121 may be repeated one or more times during a frame, depending on implementation. It is also conceivable that step 121 is performed before step 120, or that step 121 is performed both before and after step 120. In step 122, an ambient-compensated ON value is computed, e.g. as described above. In step 123, a noise estimate is computed based on OFF values obtained in the current frame, and possibly in one or more preceding frames. In step 124, the detector and/or its detection lines are validated based on the noise estimate. Any detection lines that do not pass the validation may be indicated an "invalid" in the exclusion data, while other detection lines may be indicated as "valid". The exclusion data may be stored in computer memory M for retrieval by the correction step 73 (Fig. 7) in the same or in a forthcoming frame. Alternatively, the exclusion data may be directly supplied to step 73.

Step 123 may compute the noise estimate as a standard deviation or variance of the OFF values. It is conceivable that only a subset of the OFF values measured by the detector is included in the noise estimation. For example, OFF values that are measured after ON values that are saturated to such an extent that the OFF value is likely to contain a residual signal caused by the preceding saturation, may be omitted from the noise estimation. Such OFF values may also be omitted from the ambient compensation in step 122.

In one embodiment, the noise estimate is continuously updated using the N latest OFF values. In another embodiment, the noise estimate is given by an exponential forget estimation of the variance (standard deviation) of the OFF values.

Any known algorithm for computing variance or standard deviation may be used. In certain implementations, it may be advantageous to use an online algorithm. An example of such an algorithm, which allows variance to be computed "on the fly" using two accumulators, is:

$$\widetilde{i_{noise}} \sim \frac{\Sigma(I_{amb,n})^2 - (\Sigma I_{amb,n})^2/N}{N},$$

where $I_{amb,n}$ is the n:th OFF value for a detector, and N is the total number of OFF values used for computation of variance.

A different approach may be used if there are strong low-frequency noise components present in the signals, e.g. influence of residential lighting at a frequency of 100 Hz. Depending on the ON/OFF activation scheme of the touch-sensitive apparatus, such noise components may produce high values of variance (or standard deviation),

unless care is taken. This may be avoided, e.g., by estimating the noise level based on the absolute difference between consecutive OFF values for each detector, e.g. $\widetilde{I_{noise}} = \sum|\Delta I_{amb,n}|/N$, or $\widetilde{I_{noise}} = \sqrt{\sum(\Delta I_{amb,n})^2/N}$.

The validation step 124 may apply any one of several different validation criteria, or a combination thereof.

One validation criterion stipulates that a valid detection line must fulfill: $(I_{raw,k} < Saturation)$ and $(I_k > T_{CNR} \cdot \widetilde{I_{noise}})$, where ***Saturation*** is a saturation limit (global or for each detector) and T_{CNR} is a carrier-to-noise (CNR) limit. This criterion ensures that saturated detection lines are excluded from further processing, and that only detection lines with a sufficient CNR is used in the touch determination process. The CNR limit is given by the magnitude of attenuation changes that needs to be detected. In one implementation, the CNR limit is set in the range of about 100-300. It is understood that a lower or higher CNR limit may be used. It should also be noted that saturation is evaluated for the ON value without ambient compensation, while CNR is evaluated for the ambient-compensated ON value.

Another validation criterion stipulates that the noise estimate should not exceed a maximum noise limit to be deemed valid: $\widetilde{I_{noise}} < T_{noise}$. This criterion, in contrast to the CNR criterion, identifies all of the detector's detection lines as invalid, even if one or more detection lines have a high ON value.

Another validation criterion stipulates that detection lines with $\widetilde{I_{noise}} \approx 0$ are deemed invalid. Almost zero noise may indicate that the detector is faulty or that the received energy is too low.

Another validation criterion stipulates that the ambient-compensated ON value should exceed a minimum signal limit to be deemed valid: $I_k > I_{min}$. Such a validation criterion may even replace the use of the noise estimate if the touch-sensitive apparatus is known to exhibit low noise levels.

It is to be understood that the above validation limits ***Saturation***, T_{CNR}, T_{NOISE}, I_{min} may be set individually for each detector and/or detection line.

If the evaluation parameter is close to the validation limit, the validation process may cause frequent state changes, which in turn may disturb the touch determination process. In one embodiment, one or more hysteresis windows are used in the validation step to ameliorate this problem. This means that one or more of the validation criteria has a first limit value for invalidation and a second limit value for validation. Suitably, the first and second limit values are set to promote invalidation over validation, i.e. making it harder for an invalid sampling point to be deemed valid than for a valid

sampling point to be deemed invalid. The skilled person realizes that there are many equivalent techniques to promote invalidation over validation.

It is to be understood that the validation process may be generally combined with any touch determination process that is designed to be responsive to exclusion data. Thus, the validation process may be seen as a method for processing an output signal from a touch-sensitive apparatus, which comprises a plurality of signal generators and a plurality of signal detectors that are operable to define actual detection lines that extend across a surface portion of a panel, and a controller operable to repeatedly turn the signal generators ON and OFF such that the output signal of the signal generators comprise ON energy values for the actual detection lines and OFF energy values for each signal detector. The method comprises the steps of: obtaining the OFF energy values from the output signal; generating a noise estimate for each actual detection line as a function of the OFF energy values; and validating the actual detection lines based on the noise estimate.

5. Hardware implementations

The touch determination process and the validation process according to the various embodiments disclosed herein may be implemented by a data processing device (cf. 10 in Fig. 1) which is connected to sample measurement values from the detectors 3 in the FTIR system. Fig. 11A shows an example of a data processing device 10 configured to implement the process in Fig. 7. The device 10 includes an input 10A for receiving the output signal. The device 10 further includes a data collection element (or means) 200 for obtaining the current projection values, a generation element (or means) 201 for generating absolute values, an interpolation element (or means) 202 for generating a matched sinogram with absolute values, an error correction element 203 for maintaining the relative signal transmission of affected interpolation points, a conversion element (or means) 204 for converting the absolute values of the interpolation points into relative values, a reconstruction element (or means) 205 for generating a current interaction pattern, and an output 10B for outputting the current interaction pattern. In the example of Fig. 11A, the actual extraction of touch data is carried out by a separate device 10' which is connected to receive the interaction pattern from the data processing device 10. Fig. 1IB shows an example of a data processing device 10 configured to implement the process in Fig. 10. The device 10 includes an input 10B for receiving the output signal. The device 10 further includes an element (or means) 210 for obtaining the ON values, an element (or means) 211 for obtaining the OFF values, a compensation element (or means) 212 for generating ambient-compensated ON values, a noise estimation element (or means) 213 for computing a

noise estimate based on OFF values, and a validation element 214 for validating the detection lines and generating the exclusion data for storage in memory M.

The device 10 may be implemented by special-purpose software (or firmware) run on one or more general-purpose or special-purpose computing devices. In this context, it is to be understood that each "element" or "means" of such a computing device refers to a conceptual equivalent of a method step; there is not always a one-to-one correspondence between elements/means and particular pieces of hardware or software routines. One piece of hardware sometimes comprises different means/elements. For example, a processing unit may serve as one element/means when executing one instruction, but serve as another element/means when executing another instruction. In addition, one element/means may be implemented by one instruction in some cases, but by a plurality of instructions in some other cases. Naturally, it is conceivable that one or more elements (means) are implemented entirely by analog hardware components.

The software controlled device 10 may include one or more processing units (cf. 14 in Fig. 1), e.g. a CPU ("Central Processing Unit"), a DSP ("Digital Signal Processor"), an ASIC ("Application-Specific Integrated Circuit"), discrete analog and/or digital components, or some other programmable logical device, such as an FPGA ("Field Programmable Gate Array"). The device 10 may further include a system memory and a system bus that couples various system components including the system memory to the processing unit. The system bus may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory may include computer storage media in the form of volatile and/or non-volatile memory such as read only memory (ROM), random access memory (RAM) and flash memory. The special-purpose software, the exclusion data, the reference values, and any other data needed during execution, may be stored in the system memory, or on other removable/non-removable volatile/non-volatile computer storage media which is included in or accessible to the computing device, such as magnetic media, optical media, flash memory cards, digital tape, solid state RAM, solid state ROM, etc. The data processing device 10 may include one or more communication interfaces, such as a serial interface, a parallel interface, a USB interface, a wireless interface, a network adapter, etc, as well as one or more data acquisition devices, such as an A/D converter. The special-purpose software may be provided to the device 10 on any suitable computer-readable medium, including a record medium, and a read-only memory.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary,

is intended to cover various modifications and equivalent arrangements included within the spirit and the scope of the appended claims.

For example, the reconstructed pattern need not strictly represent attenuation, but could be generated in any format that enables detection of interaction on the touch surface. Thus, the reconstructed pattern may represent local attenuation or local transmission in a broad sense and may be generally referred to as an "signal interaction pattern". With respect to the specific formats of input values $\overline{\alpha_t}$ and change values $\overline{d\alpha_t}$ used in the foregoing examples, modifications may be made, e.g., to sign, scaling or offset, without impeding the ability for touch determination.

CLAIMS

1. A method of enabling touch determination based on an output signal from a touch-sensitive apparatus (100), the touch-sensitive apparatus (100) comprising a panel (1) configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines (D) that extend across a surface portion (4) of the panel (1) between pairs of incoupling and outcoupling points, at least one signal generator (2) coupled to the incoupling points to generate the signals, and at least one signal detector (3) coupled to the outcoupling points to generate the output signal, the method operating in a sequence of repetitions, each repetition comprising the steps of:

processing (70, 71) the output signal to generate a set of data samples (I_t; $log(I_t)$), each data sample being generated to represent detected energy for one of the actual detection lines (D);

generating (72, 74) an interpolated sinogram (g') based on the set of data samples (I_t; $log(I_t)$), the interpolated sinogram (g') comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion (4); and

operating (75) an image reconstruction function on the interpolated sinogram (g') to generate a signal interaction pattern (A_t, dA_t) within at least part of the surface portion (4);

said method further comprising an error correction step (73) which is responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples (I_t; $log(I_t)$) in a current repetition, said error correction step (73) comprising: identifying interpolation samples affected by the change in validity status; and setting each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

2. The method of claim 1, wherein the interpolated sinogram $\{g')$ is generated to represent relative values ($\overline{\alpha_t}$; $\overline{d\alpha_t}$) between energy values (7_t; $log(I_t)$) and reference energy values (REF_t; $log(REF_t)$) for the fictitious detection lines.

3. The method of claim 2, wherein the step of generating (72, 74) the interpolated sinogram (g') comprises: operating (72) an interpolation function on the data samples (7_t; $log(I_t)$) to generate the energy values (7_t, $log(I_t)$) for the fictitious detection lines, and converting (74) the energy values (7_t; $log(I_t)$) to the relative values ($\overline{\alpha_t}$; $\overline{d\alpha_t}$) by means of the reference energy values (REF_t; $log(REF_t)$) for the fictitious detection lines.

4. The method of claim 2 or 3, wherein the reference energy values $(REF_t; log(REF_t))$ for the fictitious detection lines are generated by operating the interpolation function on data samples $(I_0; log(I_0))$ obtained from the output signal in a calibration step without objects in contact with the surface portion (4), and wherein the error correction step comprises manipulating the reference energy value of each identified interpolation sample so as to maintain the relative signal transmission of the corresponding fictitious detection line from the former repetition.

5. The method of claim 2 or 3, wherein the reference energy values $(REF_t; log(REF_t))$ are intermittently updated to represent the energy values $(I_{t-\Delta t}; log(I_{t-\Delta t}))$ in a preceding repetition, such that the relative values $(\overline{d\alpha_t})$ represent a change in the relative signal transmission between the current and the preceding repetition for each fictitious detection line.

6. The method of claim 5, wherein the reference energy values $(REF_t; log(REF_t))$ are updated in each repetition.

7. The method of claim 5 or 6, wherein the error correction step (73) comprises setting the relative value $(\overline{d\alpha_t})$ of each identified interpolation sample to zero.

8. The method of claim 5 or 6, wherein the error correction step (73) comprises setting, for each identified interpolation sample, the reference energy value of the former repetition equal to the energy value of the current repetition.

9. The method of claim 8, wherein the former repetition is immediately preceding the current repetition.

10. The method of claim 9, wherein the former repetition is separated from the current repetition by a number of intermediate repetitions.

11. The method of claim 10, wherein the error correction step (73) further comprises setting the reference energy value for the number of intermediate repetitions equal to the energy value of the current repetition.

12. The method of any preceding claim, wherein each data sample in the set of data samples $(log(I_t))$ is generated by extracting the detected energy for the respective actual detection line (D) from the output signal and computing the logarithm of the detected energy.

13. The method of any preceding claim, wherein the touch-sensitive apparatus (100) comprises a plurality of signal generators (2) and a plurality of signal detectors (3) and is operated to turn the signal generators (2) ON and OFF during each repetition, such that the output signal is generated to comprise ON energy values for the actual detection lines (D) and at least one OFF energy value for each signal detector (3), wherein said method further comprises a validation process (120-124) for designating an actual detection line (D) as valid or invalid and generating the exclusion data, the

validation process (120-124) comprising: obtaining (121) the OFF energy values from the output signal, generating (123) a noise estimate for each actual detection line (D) as a function of the OFF energy values, and validating (124) the actual detection lines (D) based on the noise estimate.

14. The method of claim 13, wherein the noise estimate is generated to represent a variability in a time sequence of OFF energy values for the signal detector (3) associated with the actual detection line (D).

15. The method of claim 13 or 14, wherein an actual detection line (D) is designated as invalid if the noise estimate exceeds a noise limit (T_{noise}).

16. The method of any one of claims 13-15, wherein an actual detection line (D) is designated as invalid if the ON energy value of the actual detection line (D) exceeds a saturation limit *(Isaturation)*.

17. The method of any one of claims 13-16, wherein the step of processing (70, 71) the output signal to generate the set of data samples (I_t; $log(I_t)$) comprises: obtaining the ON energy values from the output signal, obtaining an estimated ambient value for each actual detection line (D) based on the OFF energy value for the signal detector (3) associated with the actual detection line (D), and generating an ambient-compensated energy value by subtracting the estimated ambient value from the ON energy value for each actual detection line (D).

18. The method of claim 17, wherein an actual detection line (D) is designated as invalid if the ratio between the ambient-compensated energy value and the noise estimate is less than a minimum ratio limit (T_{CNR}).

19. The method of claim 17 or 18, wherein an actual detection line (D) is designated as invalid if the ambient-compensated energy value is less than a minimum energy limit (I_{min}).

20. The method of any one of claims 13-19, wherein the validation process (120-124) is configured to promote a change of designation from valid to invalid over a change of designation from invalid to valid.

21. A computer program product comprising computer code which, when executed on a data-processing system, is adapted to carry out the method of any one of claims 1-20.

22. A device (10) for enabling touch determination based on an output signal from a touch-sensitive apparatus (100), the touch-sensitive apparatus (100) comprising a panel (1) configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines (D) that extend across a surface portion (4) of the panel (1) between pairs of incoupling and outcoupling points, at least one signal generator (2) coupled to the incoupling points

to generate the signals, and at least one signal detector (3) coupled to the outcoupling points to generate the output signal, said device comprising:

an input (10A) for receiving the output signal, and

a signal processor (14) configured to, repeatedly in a sequence of repetitions:

process the output signal to generate a set of data samples $(I_t; \boldsymbol{log(I_t)})$, each data sample being generated to represent detected energy for one of the actual detection lines (D);

generate an interpolated sinogram $\boldsymbol{(g')}$ based on the set of data samples $(I_t; \boldsymbol{log(I_t)})$, the interpolated sinogram $\boldsymbol{(g')}$ comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion (4); and

operate an image reconstruction function on the interpolated sinogram $\boldsymbol{(g')}$ to generate a signal interaction pattern (A_t, dA_t) within at least part of the surface portion (4);

wherein the signal processor (14) is further configured to perform an error correction responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples $(I_t; \boldsymbol{log(I_t)})$ in a current repetition, wherein said error correction comprises: identifying interpolation samples affected by the change in validity status; and setting each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

23. A device (10) for enabling touch determination based on an output signal from a touch-sensitive apparatus (100), the touch-sensitive apparatus (100) comprising a panel (1) configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines (D) that extend across a surface portion (4) of the panel (1) between pairs of incoupling and outcoupling points, at least one signal generator (2) coupled to the incoupling points to generate the signals, and at least one signal detector (3) coupled to the outcoupling points to generate the output signal, wherein the device is operable in a sequence of repetitions and comprises:

means (200, 201) for processing, in each repetition, the output signal to generate a set of data samples $(7_t; \boldsymbol{log(I_t)})$, each data sample being generated to represent detected energy for one of the actual detection lines (D);

means (202, 204) for generating, in each repetition, an interpolated sinogram $\boldsymbol{(g')}$ based on the set of data samples $(7_t; \boldsymbol{log(I_t)})$, the interpolated sinogram $\boldsymbol{(g')}$ comprising interpolation samples which represent fictitious detection lines that have a desired location on the surface portion (4); and

means (205) for operating, in each repetition, an image reconstruction function on the interpolated sinogram $\{g'\}$ to generate a signal interaction pattern (A_t, dA_t) within at least part of the surface portion (4);

wherein the device (10) further comprises means (203) for error correction, which is responsive to exclusion data that identifies a change in validity status for a data sample among the set of data samples $(I_t; log(I_t))$ in a current repetition, said means (203) for error correction being configured to identify interpolation samples affected by the change in validity status; and set each identified interpolation sample to a value that maintains a relative signal transmission of the fictitious detection line from a former repetition.

24. A touch-sensitive apparatus (100), comprising:

a panel (1) configured to conduct signals from a plurality of peripheral incoupling points to a plurality of peripheral outcoupling points, thereby defining actual detection lines (D) that extend across a surface portion (4) of the panel (1) between pairs of incoupling and outcoupling points;

means (2, 12) for generating the signals at the incoupling points;

means (3) for generating an output signal based on detected signals at the outcoupling points; and

the device (10) for enabling touch determination according to claim 22 or 23.

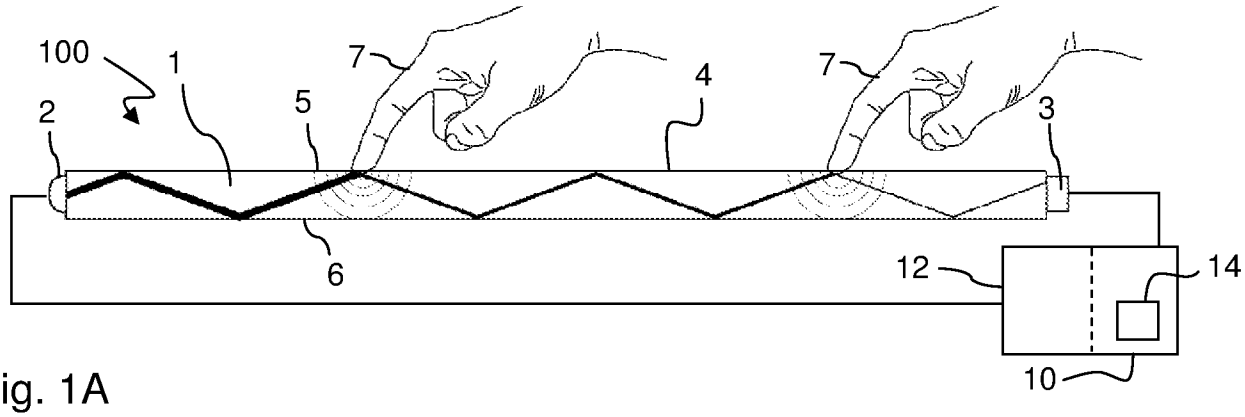


Fig. 1A

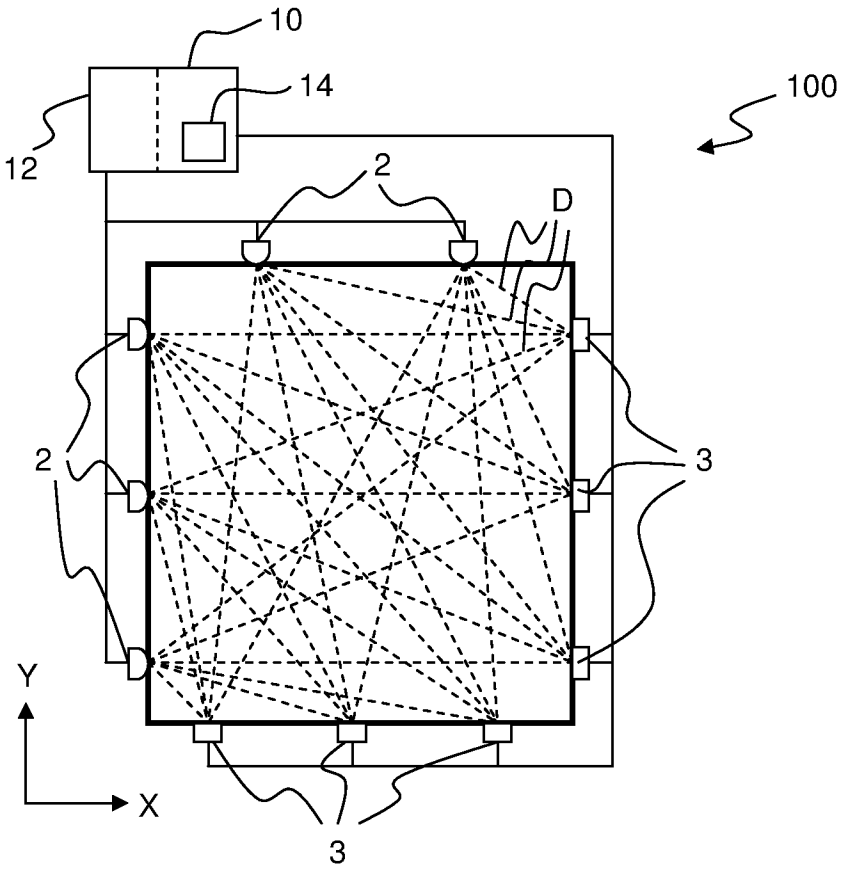


Fig. 1B

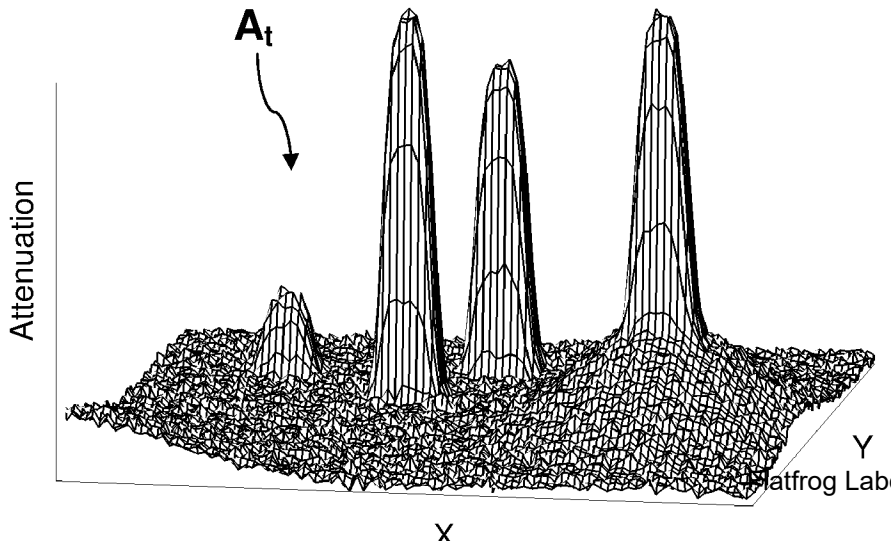


Fig. 2

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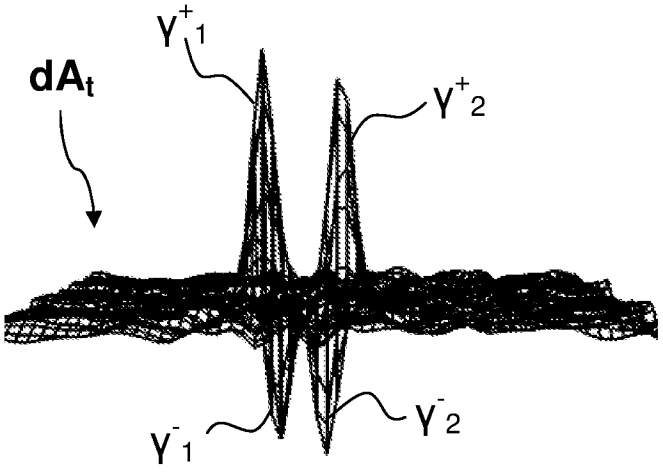


Fig. 3A

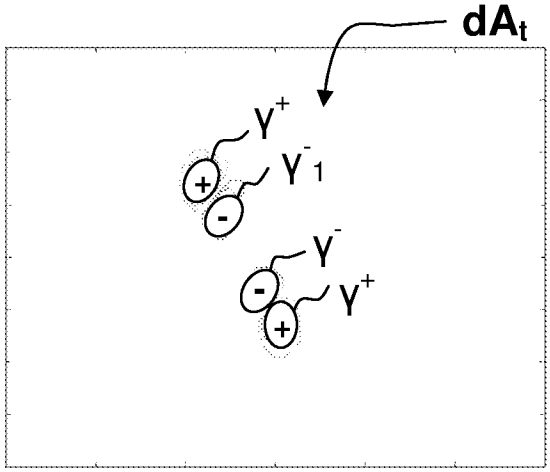


Fig. 3B

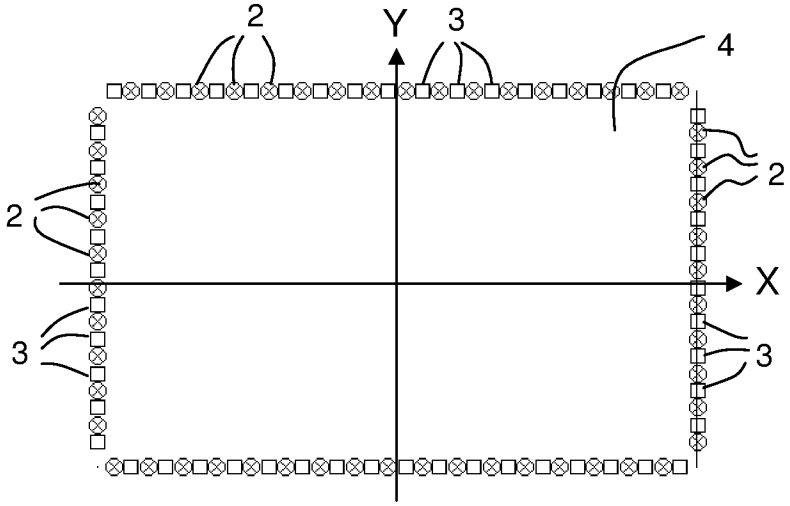


Fig. 4

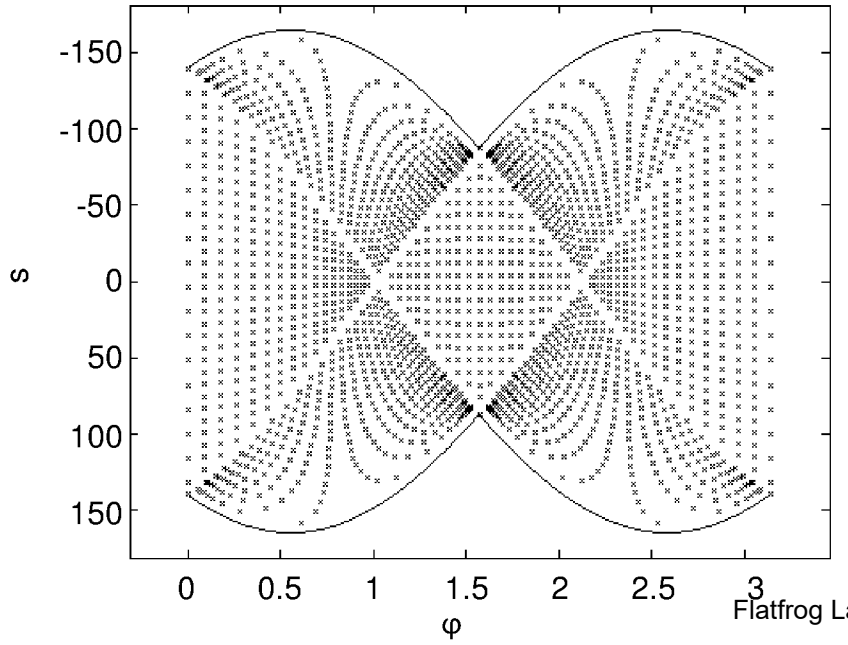


Fig. 5

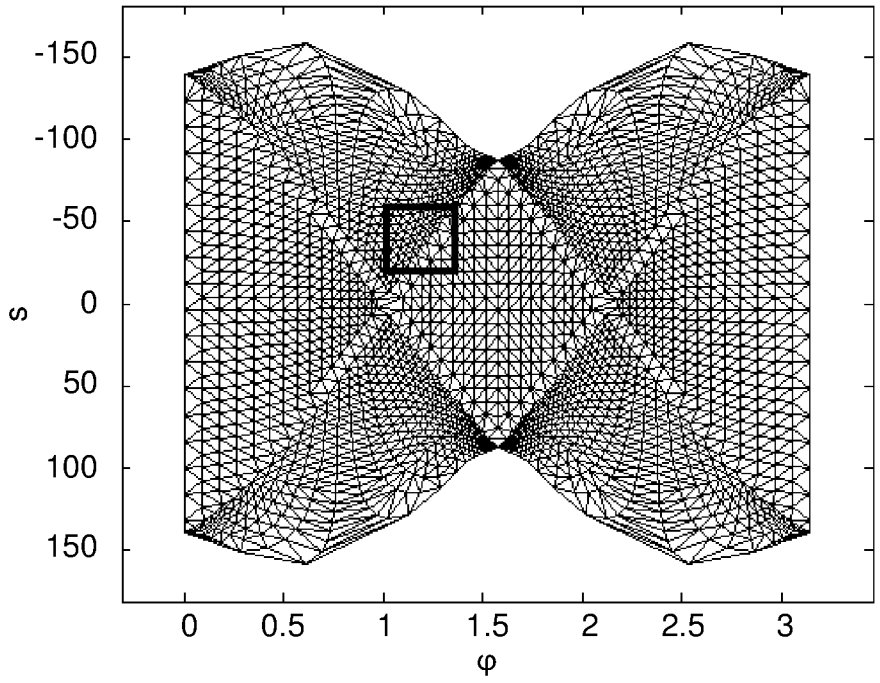

-150
-100
-50
0
50
100
150
s
0
0.5
1
1.5
2
2.5
3
φ

Fig. 6A

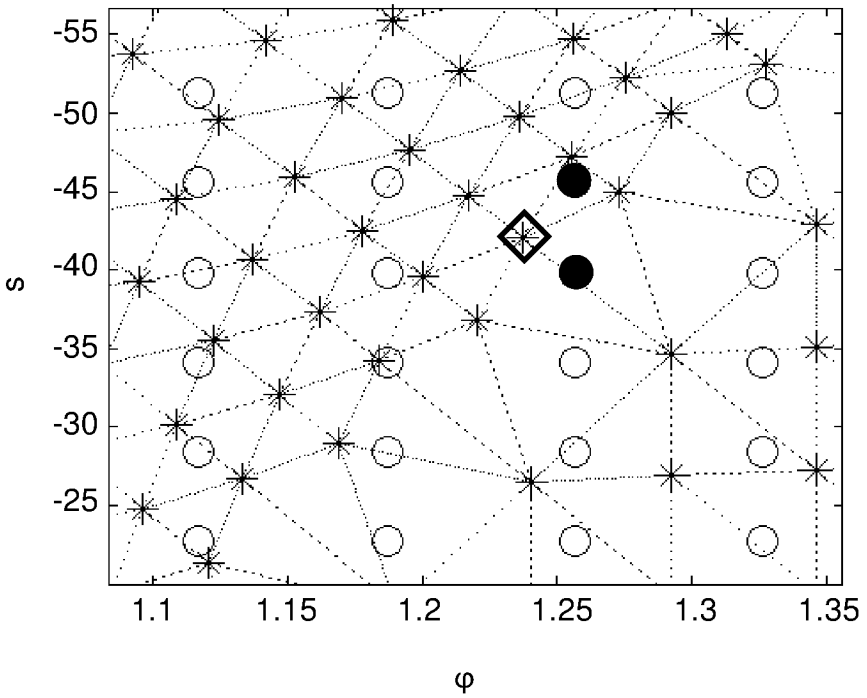

-55
-50
-45
-40
-35
-30
-25
s
1.1
1.15
1.2
1.25
1.3
1.35
φ

Fig. 6B

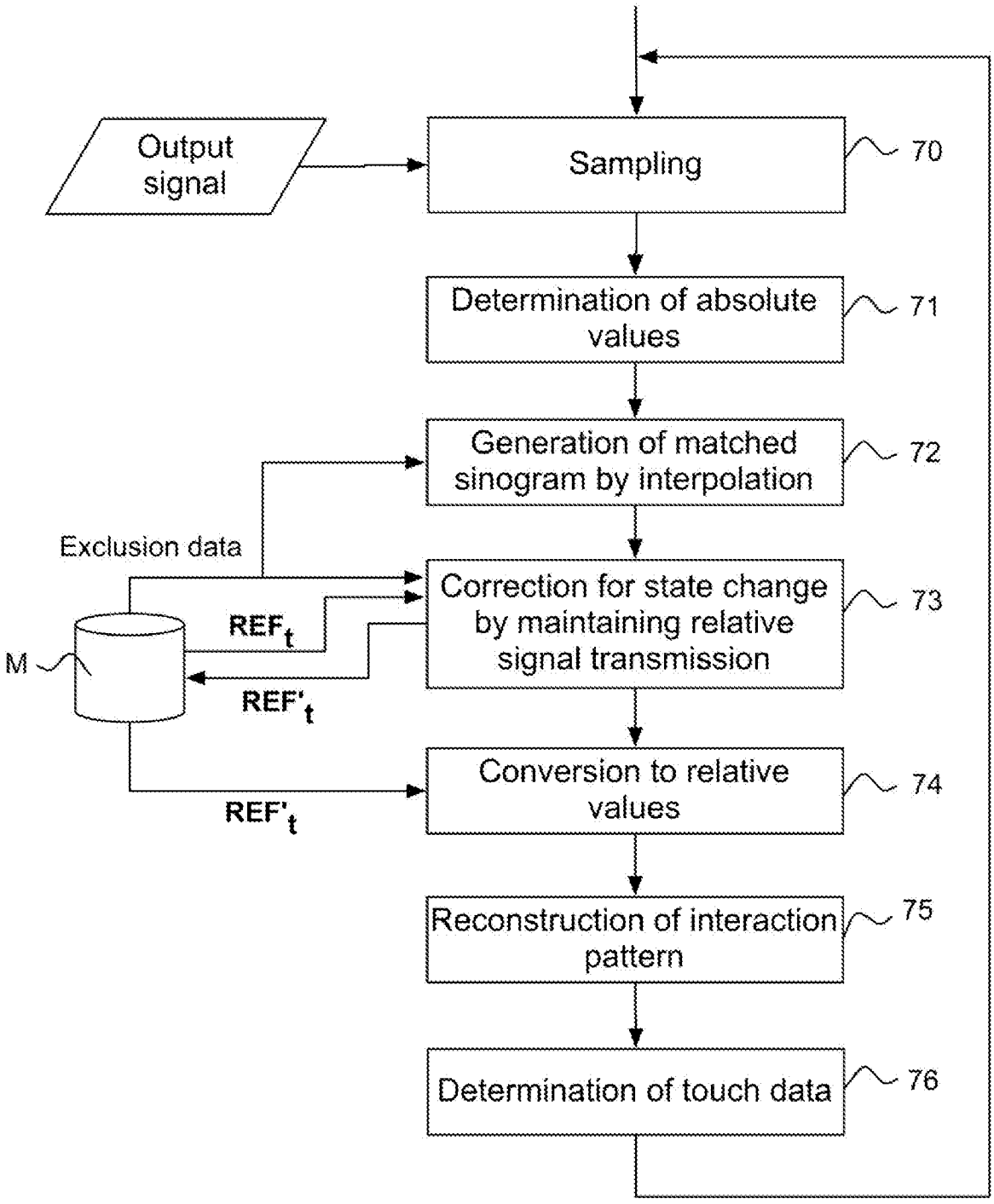

Output signal
Sampling
70
Determination of absolute values
71
Generation of matched sinogram by interpolation
72
Exclusion data
Correction for state change by maintaining relative signal transmission
73
M
REF$_t$
REF'$_t$
Conversion to relative values
74
REF'$_t$
Reconstruction of interaction pattern
75
Determination of touch data
76

Fig. 7

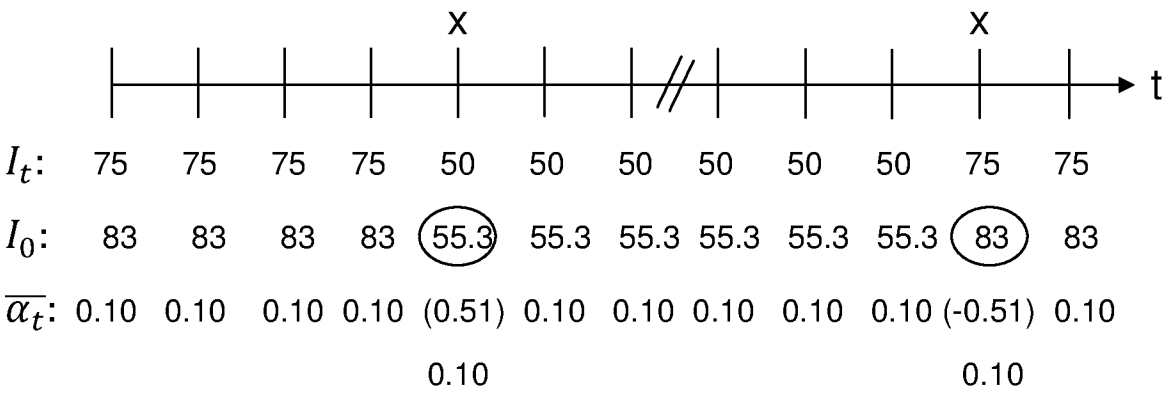


Fig. 8A

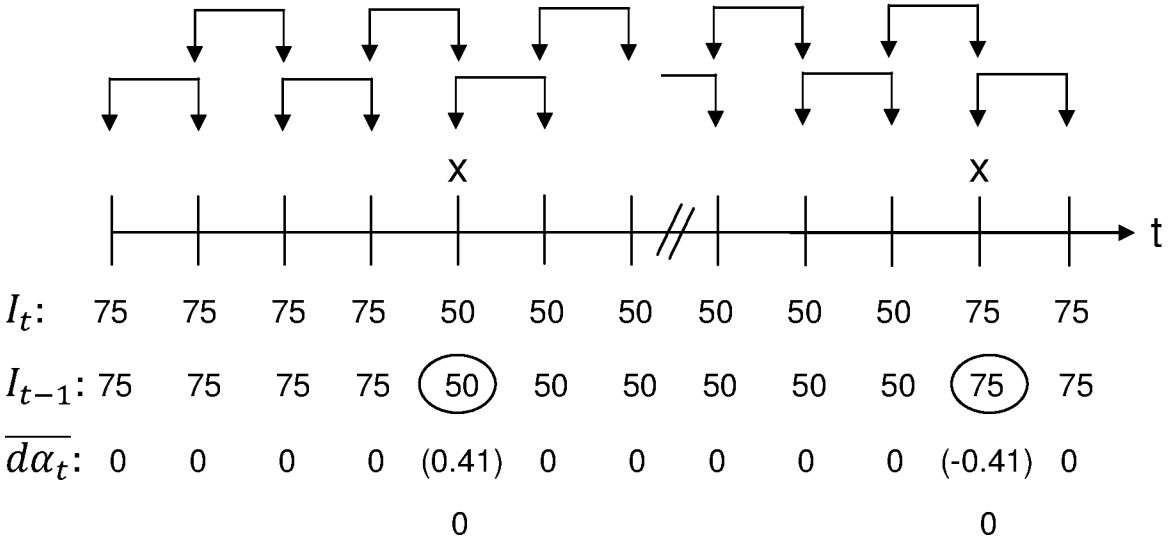


Fig. 8B

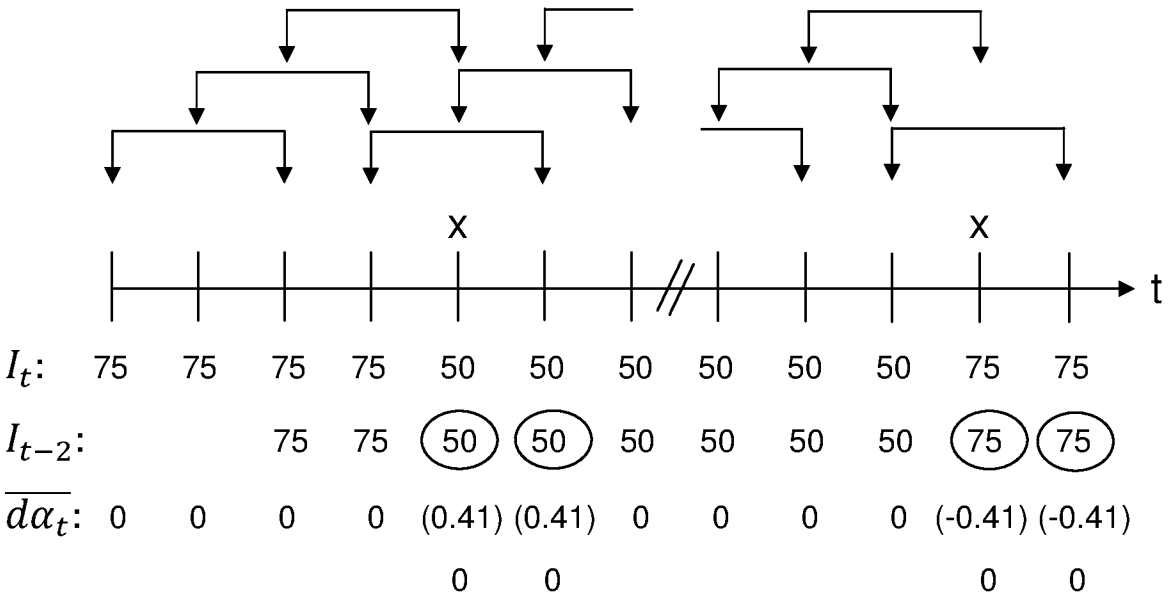


Fig. 8C

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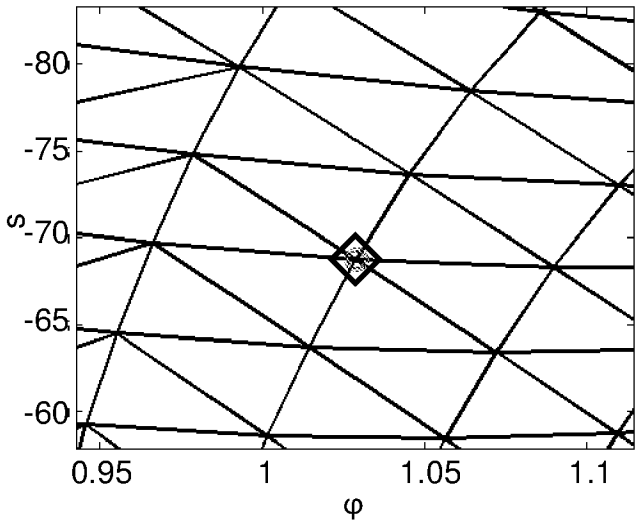


Fig. 9A

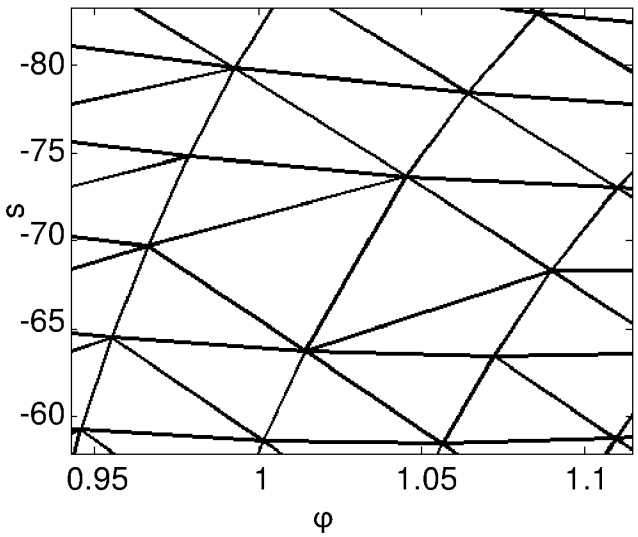


Fig. 9B

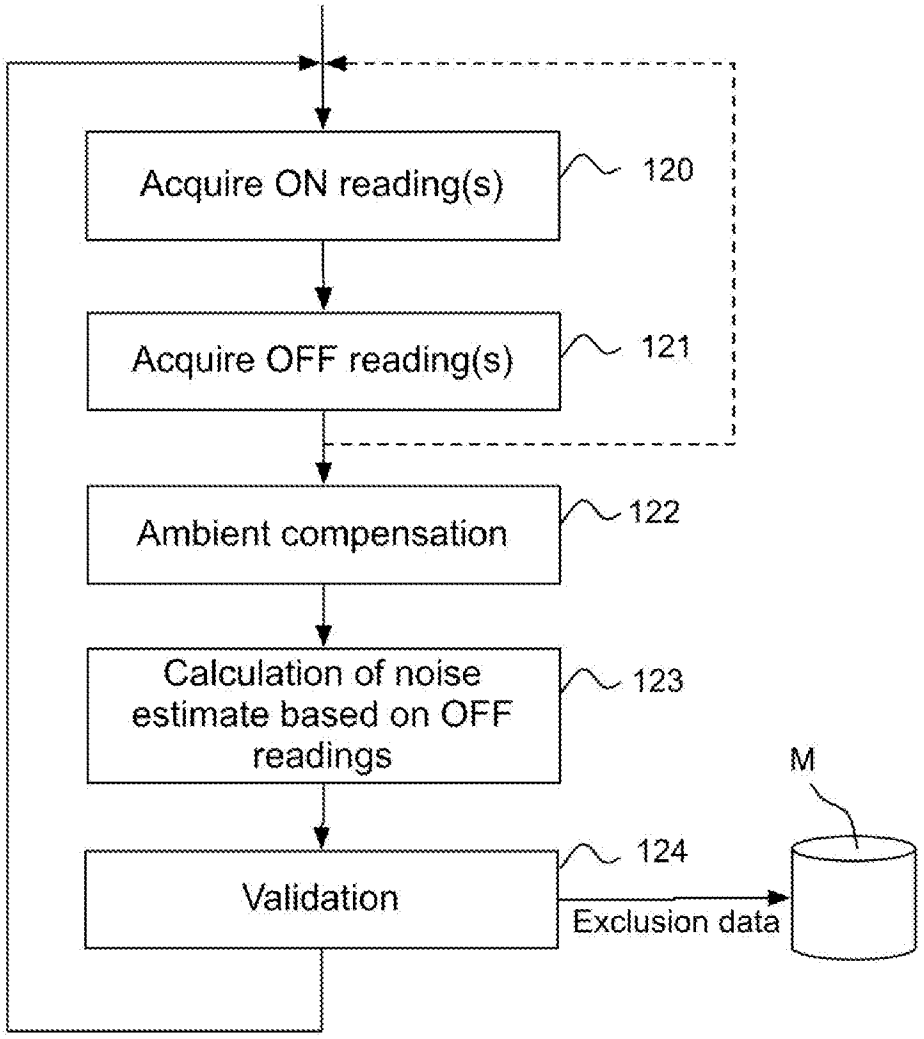


Fig. 10

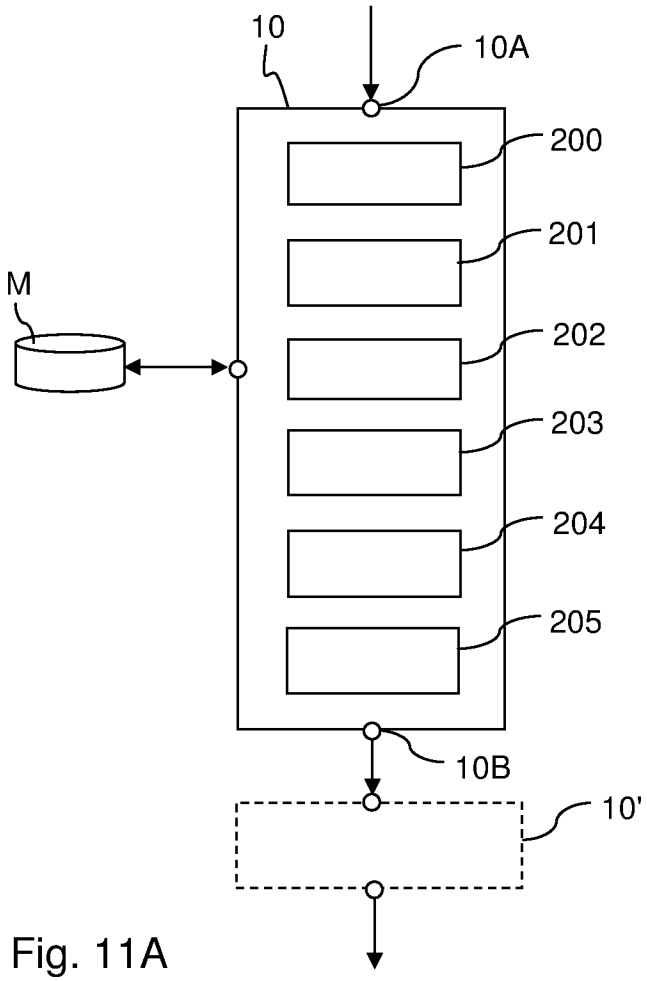


Fig. 11A

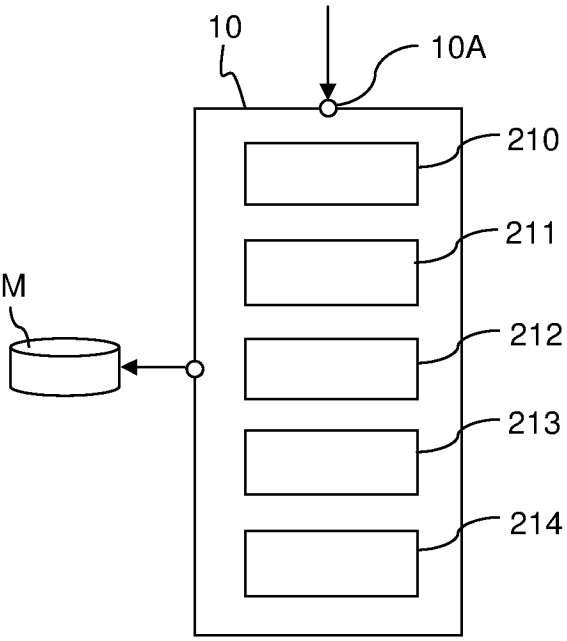


Fig. 11B

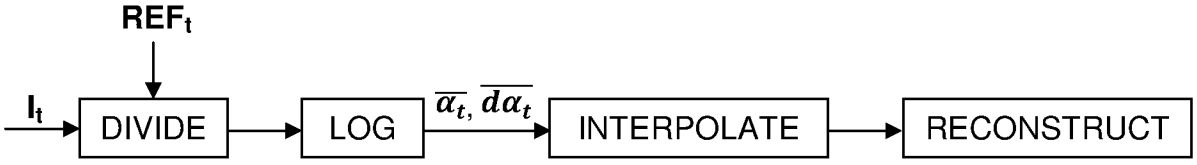


Fig. 12A

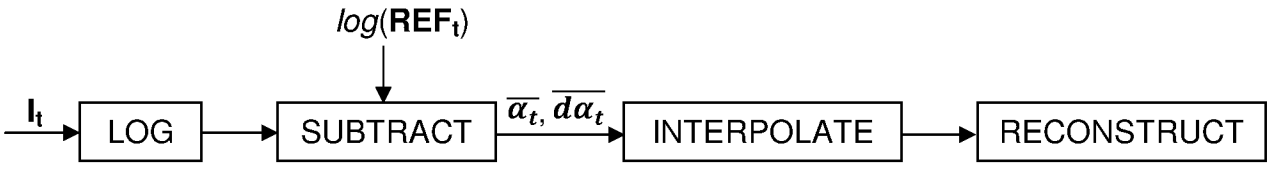


Fig. 12B

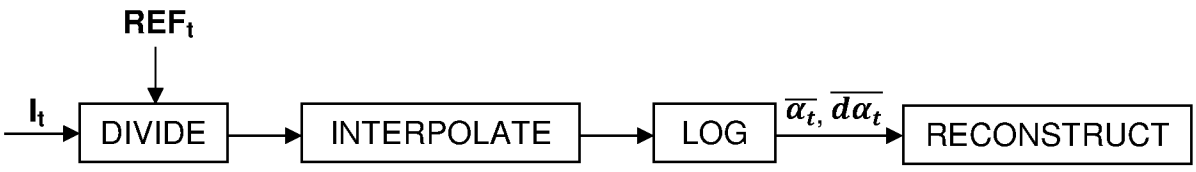


Fig. 12C

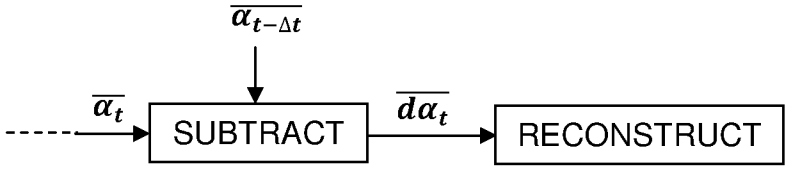


Fig. 12D

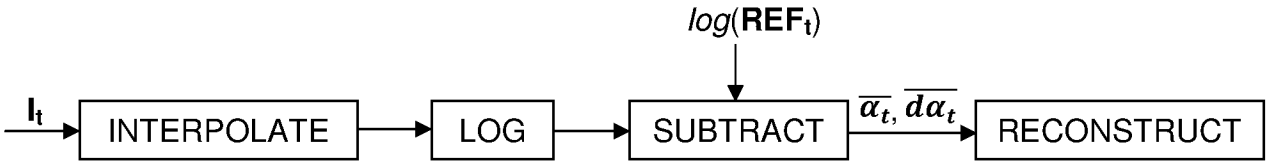


Fig. 13A

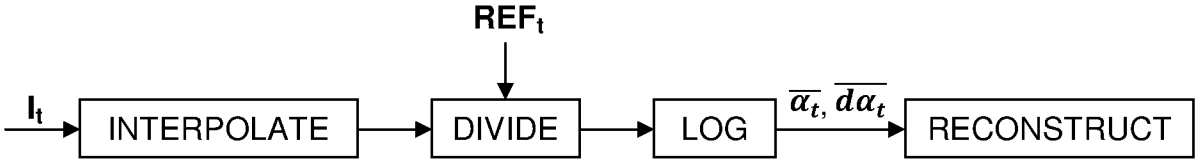


Fig. 13B

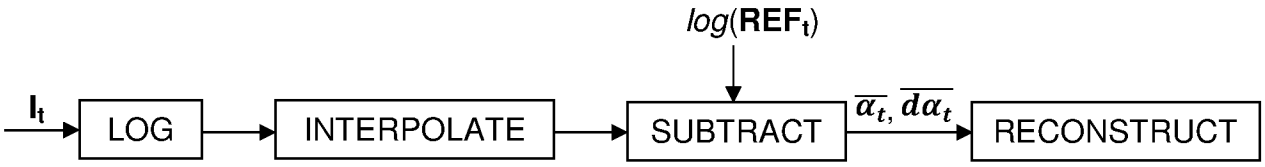


Fig. 13C

Espacenet

Bibliographic data: WO2014086084 (A1) — 2014-06-12

INFRARED TOUCH SCREEN

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Classification: **- international:** ***G06F3/00***
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Application number: WO2013CN00321 20130319 Global Dossier

Priority number(s): CN20121515263 20121205 ; CN20122662306U 20121205 ; CN20122662044U 20121205

Abstract of WO2014086084 (A1)

Disclosed is an infrared touch screen, including a light guiding pillar, a touch screen body, a circuit board and an infrared tube. A bearing platform is provided on the light guiding pillar and integrally formed with the light guiding pillar; the bearing platform is located between the touch screen body and the circuit board; and the touch screen body is fixedly connected to the bearing platform, and the circuit board is fixedly connected to the bearing platform. The invention enables infrared light emitted by an infrared ray emission tube to be transmitted to an infrared receiving tube with minimal attenuation, and can also avoid the occurrence of the edge effect, so that a touch screen body and a circuit board can be located and mounted, and the touch screen body maintains a relatively high degree of parallelism, further reducing the suspension height.

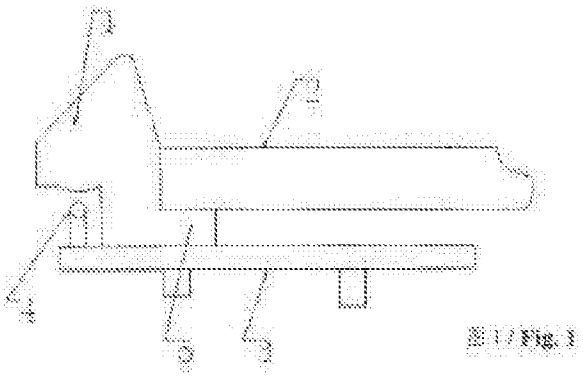


Fig. 1

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(81) 指定国 (除另有指明，要求每一种可提供的国家保护)：AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, ML, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明，要求每一种可提供的地区保护)：ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)。

本国际公布：
- 包括国际检索报告(条约第 21 条(3))。

(54) Title: INFRARED TOUCH SCREEN

(54) 发明名称 :红外触摸屏

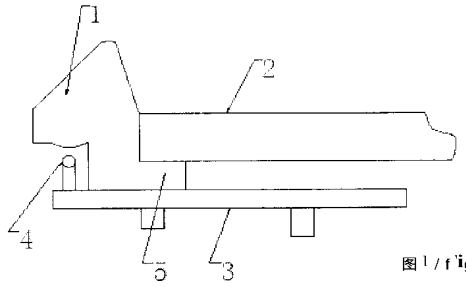


图 1 / f Fig. 1

(57) Abstract: Disclosed is an infrared touch screen, including a light guiding pillar, a touch screen body, a circuit board and an infrared tube. A bearing platform is provided on the light guiding pillar and integrally formed with the light guiding pillar; the bearing platform is located between the touch screen body and the circuit board; and the touch screen body is fixedly connected to the bearing platform, and the circuit board is fixedly connected to the bearing platform. The invention enables infrared light emitted by an infrared ray emission tube to be transmitted to an infrared receiving tube with minimal attenuation, and can also avoid the occurrence of the edge effect, so that a touch screen body and a circuit board can be located and mounted, and the touch screen body maintains a relatively high degree of parallelism, further reducing the suspension height.

(57) 摘要：本发明公开了一种红外触摸屏，包括导光柱、触摸屏体、电路板和红外管，所述导光柱上设置有与导光柱成一体的承台，所述承台位于触摸屏体和电路板之间，且触摸屏体与承台固定连接，电路板与承台固定连接。本发明能使红外线发射管发出的红外光以最少的衰减传输到红外接收管，又可以避免产生边沿效应，使触摸屏体与电路板能够进行定位安装，使触摸屏体保持较高的平行度，进一步减小悬浮高度。

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说 明 书

红外触摸屏

技术领域

[0001] 本发明涉及一种触摸屏，尤其涉及一种红外触摸屏。

背景技术

[0002] 现有红外触摸产品，其采用方式都是通过由沿着触摸区域四周安装在X、Y方向排布均匀的红外发射管和红外接收管，控制和驱动电路在MCU执行代码的控制下驱动红外发射管和红外接收管，对应扫描形成X方向和Y方向横竖交叉的红外线矩阵。当有触摸时，手指或其它物体就会挡住经过该点的横竖红外线，由控制系统判断出触摸点在触摸屏上的位置。

[0003] 目前在红外触摸屏领域，如专利号为200820109789.4的"一种应用于触摸屏上的反射镜"，此发明主要目的是：利用反射原理将，减少红外触摸屏上的发射和接收单元数量减半；如专利号为201020271758.6的"一种纯平结构的多点触摸屏"此发明的主要原理是：在普通红外触摸屏的基础上增加厂-个导光板，用于填充普通触摸屏触摸面上的凹腔，从而达到表面看似纯平的效果；如20071 0028616.X的"一种红外触摸屏及其多点触摸定位方法"等。现有红外触摸屏专利技术或产品屮无论是单点还是多点红外触摸屏，其红外触摸屏的基本组装方式，都是将红外管放于触摸屏的触摸面之上，在该结构中，都存在以下问题：1、抗光干扰的能力差。现有红外触摸屏，由于红外管是放在触摸面之上，外部的光线很容易射到红外接收单元，从而影响触摸屏的正常工作，因此一般的屏体都不能在强光(如阳光或较强的白炽灯)下正常工作。

[0004] 2、红外触摸屏触摸面的四边都存在较宽和较高的边沿凸起。在现有红外触摸屏领域，红外管一般都安装在屏体触摸面的上方，加上红外管保护结构的厚度，从而在屏体的四边形成较高和较宽的边沿凸起，对触摸屏的安装和触摸设备外观设计产生很大的限制，不容易用于制造真正的一体化红外触摸产品。

[0005] 针对上述问题，美国专利US2007/0165008 A1"一种小型红外屏触摸屏装置"，降低触摸屏边框宽度和产品成本。此装置"包括一个安装在框架里的触摸屏，一个安装在显示屏后部后面的电路板，一个安装在电路板上的红外发射装置和一个安装在电路板上的红外接收装置。一个第一反射装置和红外发射装置进行光通信，所述的第一反射装置可以改变显示屏后部红外发射装置产生的红外光束的方向，使其经过所述显示屏的前部区域。第二个反射装置与第一个反射装置进行光通信，第二个反射装置可以将改变所述显示屏前端的红外光束的

方向，使其到达显示屏后部红外检测装置。" 但该技术在应用中还存在如下不足：

1. 由于红外发射装置和红外接收装置安装在电路板上，而电路板又安装在显示屏的背面，反射装置与显示屏又是相互独立的，在红外光通路上发射装与反射装置的相对位置不易确认和可靠的固定。大家都熟知红外发射装置和红外接收装置需要一一对应，这样势必会给安装调试带来很大的麻烦，同时显示屏背面不平整及显示屏与反光结构相对位置变化都会影响到安装精度，安装精度又会直接影响到触摸产品的性能。

[0006] 2. 由于安装红外发射装置的电路板和红外接收装置的电路板，均设置在显示屏的背面，而反射装置乂超出显示屏的正面，显示屏存在一定的厚度，这将导致红外发射装置的发射的红外光传到红外接收装置接收需在反射装置中走过路径长，而导致红外接收装置接收的光强度很弱。使该红外屏装置成本高，可靠性差，抗干扰能力弱。

[0007] 3. 触摸面即为显示屏外表面，长时间使用会对显示屏造成很大影响，同时悬浮高度也没办法解决，即使用过程中还未 "点中" 触摸屏就已经响应，这样极易造成各种误操作。

[0008] 另有专利号为 2004201 17952.3 "一种使用反光镜的红外触摸屏的光路系统"，"由直立安装在与显示表面相平行的电路板上的红外发射和接收管阵列及其前方的，与显示表面成 45 度角的反光镜构成。红外发射管所发射的红外线被反光镜反射后，通过显示表面前方到达接收管前方的反光镜被反射到接收管。该结构特别适合触摸显示器.反光镜安装在显示表面和前面板之间构成光通路，发射和接收管安装在显示元件电路板上，在幅降低了触摸屏的厚度或高度。" 但是该技术在应用中存在如下不足：

1. 当安装红外发射管和接收管的电路板置于显屏的背面时，而反光镜又的超出显示屏的正面，显示屏都存在一定的厚度，这将导致红外发射管的红外光到红外接收管需走过的路径长，而导致红外接收管接收的光强度很弱。使该红外屏装置成本高，可靠性差，抗干扰能力弱。

[0009] 2. 红外光反射面与显示表面成 45 度角，若采用反光镜结构将会导致干扰光扰的进入和灰尘进入反射面造成反射性能的下降导致信号质量的下降，使工作的可靠性下降。若采用直角二棱镜的 45 度斜面作为反光面时，红外触摸屏的边沿效应会比较明显，这将严重影响触摸性能。

[0010] 3. 若该系统安装于显示屏正面时，不能达到降低触摸屏厚度或高度的效果。若电路板安装在显示屏的背面.而红外发射管和红外接收管安装的电路板上面，反光镜装置与显示屏乂是相互独立的，在红外光通路上发射管与反射装置的相对位置不易确认和可靠的固定，而红外发射管和红外接收管需要一一对应，这样势必会给安装调试带来很大的麻烦，同时显

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示屏背面不平整及显示屏与反光结构相对位置变化都会影响到安装精度，安装精度又会直接影响到触摸产品的性能。电路板安装在显示屏的背面，反光装置与显示屏又是相互独立的，两者的想对位置极不稳定。

[0011] 4. 触摸面即为显示屏外表面，长时间使用会对显示屏造成很大影响，同时悬浮高度也没办法解决，即使用过程中还未"点中"触摸屏就已经响应，这样极易造成各种误操作。

发明内容

[0012] 本发明的目的在于克服现有红外触摸屏存在的上述问题，提供一种新型的红外触摸屏。本发明能使红外线发射管发出的红外光以最少的衰减传输到红外接收管，又可以避免产生边沿效应，使触摸屏体与电路板能够进行定位安装，使触摸屏体保持较高的平行度，进一步减小悬浮高度。

[0013] 为实现上述目的，本发明采用的技术方案如下：

一种新型的红外触摸屏，包括导光柱、触摸屏体、电路板和红外管，其特征在于：所述导光柱上设置有与导光柱成一体的承台，触摸屏体四周固定设置在所述承台上。

[0014] 所述承台位于触摸屏体和电路板之间，且触摸屏体与承台固定连接，电路板与承台固定连接。

[0015] 所述导光柱内侧横向延伸形成所述承台，外侧竖向延伸形成裙边，电路板分别与承台和裙边密封固定连接，裙边、导光柱、承台和电路板围合形成一密闭腔，红外管位于密闭腔内。

[0016] 所述导光柱的横截而成倾斜的凸字形，凸字形中部的下部内凹，一侧延伸形成承台，另一侧延伸形成竖向裙边。

[0017] 所述凸字形导光柱的内凹面、外侧面、内侧面为弧形面和平面的组合。

[0018] 所述内凹面为弧形面，外侧面和内侧面为平面，外侧面与承台所在面的夹角为大于39.5°小于45°或大于45°小于55°，内侧面与承台所在面的夹角为大于64°小于90°或大于90。小于140。。

[0019] 所述内凹面为弧形面，外侧面为弧形面，内侧面为平面，内侧面与承台所在面的夹角为大于64。小于90°或大于90°小于140°。

[0020] 所述内凹面为平面，与触摸屏体平行或在同一平面上，外侧面和内侧面均为弧形面。

[0021] 所述内凹面、外侧面和内侧面均为弧形面。

[0022] 所述内凹面、外侧面和内侧面均为平面，外侧面与承台所在面的夹角为大于39.5°

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小于 45° 或大于 45° 小于 55° ，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90。小于 140° 。

[0023] 所述触摸屏体与承台的上表面平行，所述电路板与承台的下表面平行。

[00241 所述承台、电路板和触摸屏体密封连接形成一个 U 形腔体，该 U 形腔体的开口通过连接件密封连接形成密闭腔，红外管位于该密闭腔内。所述的连接件可以是防尘泡棉和密封胶的结合。

[0025] 所述触摸屏体与承台的密封连接方式为粘接，电路板与承台的密封连接方式为粘接或设置密封件并通过螺栓连接。

[0026] 所述导光柱上设置有连接槽，触摸屏体四周嵌入式设置在连接槽中。

[0027] 所述的触摸屏体截面呈倒置的 "凸" 字形，倒 "凸" 形触摸屏体上部形成屏体触摸表面，下部中间部分凸出形成凸台，触摸屏体四周固定连接在承台上，所述电路板设置于承台内侧与触摸屏体卜部凸台侧壁形成的空腔中。

[0028] 所述电路板粘接在倒 "凸" 形触摸屏体两侧的台阶处。

[0029] 所述红外线触摸屏还包括一护板，所述护板位于触摸屏体中部凸台和承台的下部，并与触摸屏体中部凸台和承台的下部粘接，电路板设置在由触摸屏体、承台、护板所围成的相对密闭腔内。

[0030] 所述护板为金属板，金属护板设置有固定金属护板的螺纹孔。

[0031] 所述护板为聚脂薄膜片。

[0032] 所述触摸屏体由双层玻璃或透明塑胶粘合形成整体。

[00331 所述触摸屏体由一张玻璃或透明塑胶切割形成。

[0034] 所述触摸屏体密封固定连接在承台上，电路扳的非元件面与触摸屏体背面粘接，且电路板上的红外管均位于承台内侧。

[0035] 所述触摸屏体与承台的上表面粘接连接。

[0036] 所述触摸屏体与导光柱的内表面嵌合连接。

[0037] 所述触摸屏体的正面或背面设置有至少一层遮挡层，所述遮挡层位于触摸屏体非显示区域内。

[0038] 所述触摸屏体的四周设置有遮挡层。

[0039] 所述遮挡层是由胶带、遮光纸、半透明材料、塑料膜或金属片制成的薄片，所述薄片与触摸屏体粘接连接。

[0040] 所述遮挡层是涂覆在触摸屏体上的油漆涂层或油墨涂层。

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[0041] 所述遮挡层的厚度为 0.003 — 2mm 。

[0042] 采用本发明的优点在于：

一、本发明中，所述导光柱上设置有与导光柱成一体的承台，所述承台位于触摸屏体和电路板之间，且触摸屏体与承台固定连接，电路板与承台固定连接，固定在电路板上的红外管位于承台外侧的导光柱下方，与现有技术中导光柱通过触摸屏体来定位的结构相比，本发明采用承台结构，触摸屏体通过承台来安装定位，在安装时，触摸屏体能够快速定位在由导光柱形成的一体式框架结构内，整体性更好，相应地使电路板、红外发射管和红外接收管也能够快速定位安装，使得红外触摸产品安装调试简便，有利于整个触摸屏结构的稳定，使触摸屏体的平行度和精确度更高，能够提升触摸屏的触摸精度和响应速度，由于承台的支撑作用，可以使用比传统红外触摸屏更薄的触摸屏体，使用更薄的触摸屏体，不仅能够节约生产材料，降低生产成本，还使红外光在触摸屏上的传输路径变短，传输路径变短能够减少红外光的发散度，提高触摸精度，更薄的触摸屏体也使整个触摸屏更富有美感，有利于增强市场竞争力；同时根据实际需要，生产不同厚度的承台，与不同厚度的触摸屏体配合，能够提高触摸屏体的平行度，无限减小触摸悬浮高度问题；解决了现有技术中触摸悬浮高度较高、触摸屏体不易定位、平行度低、设备使用寿命低及触摸屏四边有较高和较宽边沿凸起的问题。

[0043] 二、本发明中，所述导光柱内侧横向延伸形成所述承台，外侧竖向延伸形成裙边，电路板分别与承台和裙边密封固定连接，裙边、导光柱、承台和电路板围合形成一密闭腔，红外管位于密闭腔内，采用此结构，由于红外管是设置在密封腔内，能够减小外界强光对红外发射管和红外接收管的干扰，提高信号发射和接收的精确度，并且裙边具有防止灰尘进入触摸屏内的作用，可以延长触摸屏的使用寿命。

[0044] 三、本发明中，所述导光柱的横截面成倾斜的凸字形，凸字形中部的下部内凹，一侧延伸形成承台，另一侧延伸形成竖向裙边，承台和裙边均为延伸形成，与导光柱为一体式结构，导光柱对红外光* 进行会聚和/或反射和/或折射，使红外光束尽可能汇聚成平行光通过触摸屏的触摸区域，减小红外光信号的衰减，增强红外光束的信号强度，提高触摸屏的抗干扰能力。

[0045] 四、本发明中，所述凸字形导光柱的内凹面、外侧面、内侧面为弧形面和平面的组合，可适用于不同厚度、不同材质的触摸屏，并且通过弧形面和平面的组合，便于调整红外光的汇聚和反射，适当调整红外管与弧形面的距离，在发射端能将红外管发出的发射角度分散的红外光汇聚成近似平行光向前传输，在接收端又能将较大角度范围内的近似平行的红外光汇聚，即能增加检测范围又能增强接收红外光信号强度，从而有利于减少红外光信号的损

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失，提高红外触摸产品的抗干扰能力，提高红外触摸产品的触摸精度。

[0046] 五、本发明中，所述内凹面为弧形面，外侧面和内侧面为平面，外侧面与承台所在面的夹角为大于 39.5° 小于 45° 或大于 45° 小于 55° ，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° ，红外光通过内凹面汇聚和反射，便于红外光的汇聚，再通过外侧面和内侧面反射，此范围内的角度即能保证发射管发出的红外光在红外反光界面上发生全发射，防止红外信号的损失，适当调整折射界面与垂直方向的角度，又能使得反射后的红外光经折射界面折射后以平行于水平面的方向传输，同时又可以避免边沿效应。

[0047] 六、本发明中，所述内凹面为弧形面，外侧面为弧形面，内侧面为平面，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° ，红外光通过内凹面和外侧面的两次汇聚和发射，进一步保证红外光的汇聚，减少红外光的损失，再通过内侧面反射到触摸屏体上，且内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° ，可以避免边沿效应。

[0048] 七、本发明中，所述内凹面为平面，与触摸屏体平行或在同一平面上，外侧面为弧形面，内侧面为弧形面，红外光通过内凹面反射，再通过外侧面和内侧面汇聚和反射到触摸屏体上，减少了导光柱内的红外光损失，提高了触摸精度。

[0049] 八、本发明中，所述内凹面、外侧面和内侧面均为平面，外侧面与承台所在面的夹角为大于 39.5° 小于 45。或大于 45° 小于 55° ，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° ，红外光通过内凹面、外侧面和内侧面直接反射到触摸屏体上，便于控制红外光与触摸屏体之间的距离，从而有利于减小悬浮高度。

[0050] 九、本发明中，所述内凹面、外侧面和内侧面均为弧形面红外光通过三个面的汇聚和反射，进一步减小了红外光的损失。

[0051] 十、本发明中，所述触摸屏体与承台的上表面平行，所述电路板与承台的下表面平行，此结构不仅能够增强屏体的平行度，还使红外发射管与导光柱之间、红外接收管与导光柱之间的对应精度更高，有利于增强红外光的聚集度，进一步克服因触摸悬浮高度引起的触摸提前响应问题。

[0052] 十一、本发明中，所述导光柱上设置有连接槽，触摸屏体四周嵌入式设置在连接槽中，使导光柱与触摸屏体结合得更紧密，整个触摸屏中各部件的稳定性更好。

[0053] 十二、本发明中，所述承台、电路板和触摸屏体密封连接形成一个 U 形腔体，该 U 形腔体的开口通过连接件密封连接形成密闭腔，红外管位于该密闭腔内，该密闭腔对电路板及电路板上的红外发射管构成二次保护，能够防止外部强光、灰尘或水从触摸屏各部件间的

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细小缝隙进入触摸屏内部，影响红外收发管的发射接精度，此结构有利于提高触摸屏的使用寿命。

[0054] 十三、本发明中，所述触摸屏体与承台的密封连接方式为粘接，电路板与承台的密封连接方式为粘接或设置密封件并通过螺栓连接，与现有技术直接将电路板粘接在触摸屏体下方相比，首先此结构使电路板及电路板上的红外管更稳定，即使长久使用，也不会降低发射和接收精度，触摸屏的使用效果更好，其次，当电路板或触摸屏体损坏时，由于不便拆卸，现有技术需要同时更换电路板和触摸屏体，而采用此方式只需要单独更换损坏部件即可。

[0055] 十四、本发明中，所述的触摸屏体截面呈倒置的"凸"字形，倒"凸"形触摸屏体上部形成屏体触摸农面，下部中间部分凸出形成凸台，触摸屏体四周固定连接在承台上，所述电路板设置于承台内侧与触摸屏体下部凸台侧壁形成的空腔中，通过电路板位置，也就改变红外管的位置，减少了传统红外屏的边框厚度，可以做到超低超窄边框；另一方面，又可以根据光源设计成特定的光束控制透镜，满足触摸扫描检测对光源的要求。

[0056] 十五、本发明中，所述电路板粘接在倒"凸"形触摸屏体两侧的台阶处，采用该结构红外管在触摸屏体第一层背部，能有效降低触摸屏整体厚度，同时由于采用导光柱达成超薄边框，超低边框，及超低悬浮高度。

[0057] 十六、本发明中，所述红外线触摸屏还包括一护板，所述护板位于触摸屏体中部凸台和承台的下部，并与触摸屏体中部凸台和承台的下部粘接，电路板设置在由触摸屏体、承台、护板所围成的相对密闭腔内，能有效的避免灰尘，水等其它物质对红外光传输的影响，保证恶劣条件下触屏的正常使用，同时提高了产品的防护性。

[0058] 十七、本发明中，所述触摸屏体密封固定连接在承台上，电路板的非元件面与触摸屏体背面粘接连接，且电路板上的红外管均位于承台内侧，此结构使电路板及电路板上的红外管在触摸屏内更稳定，红外接收管都能精确地接收到对应红外发射管发射的经导光柱反射后的红外光。

[0059] 十八、本发明中，由于在触摸屏体非显示区域的正面或背面设置有遮挡层，因此外界强光难以穿透遮挡层并照射到红外管，减小了外界强光对红外管的干扰，提高了信号发射和接收的精确度，同时对设置在触摸屏体背面的电路板、红外管起遮挡作用，使产品外观更富有美感，有利于扩人市场竞争力；克服了现有技术中触摸屏抗光干扰能力差、产品缺乏美感的缺点。

[0060] 十九、本发明中，在所述触摸屏体的四周还问样设置冇遮挡层，此结构能够阻止外

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界强光穿过导光柱后从触摸屏体四周进入触摸屏体的显示区域，与触摸屏体非显示区域的正面或背面设置的遮挡层配合，能够对红外管全面保护，抗光干扰能力更强。

[0061] 二十、本发明中，所述遮挡层是由胶带、遮光纸、半透明材料、塑料膜或金属片制成的薄片，所述薄片与触摸屏体粘接连接，使用常见的材料和简单的粘接方式就能克服现有技术中触摸屏抗光干扰能力差、产品缺乏美感的缺点，结构简单，成本低廉；相应地使用金属片作为遮挡层，还具有减少外界电磁对电路板千扰的优点。

[0062] 二十一、本发明中，使用油漆涂层或油墨涂层作为遮挡层，不仅克服了现有技术中触摸屏抗光干扰能力差、产品缺乏美感的缺点，还具有工艺简单，成本低廉的优点。

[0063] 二十二、本发明中，所述遮挡层的厚度为 0.003—2mm，如果遮挡层厚度大于 2mm，会挡住经导光柱反射出的红外光，造成触摸悬浮高度较高，如果遮挡层厚度小于 0.003mm，外界强光将穿过触摸屏体对红外管造成干扰，而将遮挡层的厚度设置为 0.003—2mm，既能对电路板、红外管起很好的保护作用，又不会引起触摸悬浮高度较高的问题。

[0064] 二十三、本发明的技术方案将边框由传统的 20MM 降为 3MM 左右，边框高度由 5MM 降为 1..5MM 左右，悬浮高度由 3-5MM 降为 0.3MM 以内。

[0065] 二十四、本发明中，由导光柱、触摸屏体、电路板、红外管形成的触摸屏系统，与显示屏是分开设置的，既可以单独出售触摸屏，也可以与显示屏组装后一起出售，满足不同用户需要。

附图说明

[0066] 图 1 为本发明实施例 1 结构示意图

图 2 为本发明实施例 2 结构示意图

图 3 为本发明实施例 3 结构示意图

图 4 为本发明实施例 4 结构示意图

图 5 为本发明实施例 7 结构不意图

图 6 为本发明实施例 8 结构示意图

图 7 为本发明实施例 11 结构示意图

图 8 为本发明实施例 12 结构示意图

图 9 为本发明实施例 13 结构示意图

图 10 为本发明实施例 14 结构示意图

图 11 为本发明实施例 15 结构示意图

图 12 为本发明实施例 16 结构示意图

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图 13 为图 12 中的触摸屏俯视结构示意图

图中标记为：1、导光柱，2、触摸屏体，3、电路板，4、红外管，5、承台，6、裙边，7、密闭腔，8、内凹面，9、外侧面，10、内侧面，11、连接件，12、凸台，13、护板，14、螺纹孔，15、密封件，16、遮挡层，17、显示屏。

具体实施方式

[0067] 实施例 1

如图 1 所示，一种新型的红外触摸屏，包括导光柱 1、触摸屏体 2、电路板 3 和红外管 4，所述导光柱 1 上设置有与导光柱 1 成一体的承台 5，所述承台 5 位于触摸屏体 2 和电路板 3 之间，且触摸屏体 2 与承台 5 固定连接，电路板 3 与承台 5 固定连接，固定在电路板 3 上的红外管 4 位于承台 5 外侧的导光柱 1 下方。

[0068] 进一步地，所述触摸屏体 2 与承台 5 的上表面平行，所述电路板 3 与承台 5 的下表面平行。

[0069] 本发明中的红外管，包括红外接收管和红外发射管。触摸屏体 2 与承台 5 固定连接的方式可以为粘接，电路板 3 与承台 5 固定连接的方式可以为粘接或螺栓连接或螺栓与粘接配合连接。

[0070] 实施例 2

本实施例与上述实施例基本相同，主要区别在于：

如图 2 所示，本实施例中，所述导光柱 1 内侧横向延伸形成所述承台 5，外侧竖向延伸形成裙边 6，电路板 3 分别与承台 5 和裙边 6 密封固定连接，裙边 6、导光柱 1、承台 5 和电路板 3 围合形成一密闭腔 7，红外管 4 位于密闭 7 腔内。密封固定连接的方式可以采用粘接但并不局限于粘接。

[0071] 实施例 3

本实施例与上述实施例基本相同，主要区别在于：

如图 3 所示，所述导光柱的横截面成倾斜的凸字形，凸字形中部的下部内凹，一侧延伸形成承台，另一侧延伸形成竖向裙边。进一步地，裙边所在平面与电路板所在平面垂直。

[0072] 并且，所述凸字形导光柱的内凹面 8、外侧面 9、内侧面 10 为弧形面和平面的组合。

[0073] 例如，所述内凹面为弧形面，外侧面和内侧面为平面，外侧面与承台所在面的夹角为大于 39.5° 小于 45° 或大于 45° 小于 55°，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140°。

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[0074] 实施例 4

本实施例与上述实施例基本相同，主要区别在于：

如图 4 所示，所述凸字形导光柱的内凹面 8、外侧面 9、内侧面 10 为弧形面和平面的组合。

[0075] 例如，所述内凹面 8 为弧形面，外侧面 9 为弧形面，内侧面 10 为平面，内侧面 10 与承台 5 所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° 。

[0076] 实施例 5

本实施例与上述实施例基本相同，主要区别在于：

所述凸字形导光柱的内凹面 8、外侧面 9、内侧面 10 为弧形面和平面的组合。

[0077] 例如，所述内凹面 8 为平面，与触摸屏体平行或在同一平面上，外侧面 9 为弧形面，内侧面 10 为弧形面。

[0078] 实施例 6

本实施例与上述实施例基本相同，主要区别在于：

所述凸字形导光柱的内凹面 8、外侧面 9、内侧面 10 为弧形面和平面的组合。

[0079] 例如，所述内凹面为弧形面，外侧面为弧形面，内侧面为弧形面。

[0080] 实施例 7

本实施例与上述实施例基本相同，主要区别在于：

如图 5 所示，所述凸字形导光柱的内凹面 8、外侧面 9、内侧面 10 为弧形面和平面的组合。

[0081] 例如，所述内凹面 8、外侧面 9 和内侧面 10 均为平面，外侧面 9 与承台 5 所在面的夹角为大于 39.5° 小于 45° 或大于 45° 小于 55° ，内侧面 10 与承台 5 所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140° 。

[0082] 实施例 8

本实施例与上述实施例基本相同，主要区别在于：

如图 6 所示，所述导光柱 1 上设置有连接槽，触摸屏体 2 四周嵌入式设置在连接槽中。触摸屏体 2 四周嵌入连接槽中并粘接，底面四周边沿与承台 5 粘接。

[0083] 实施例 9

本实施例是对上述实施例 3 的进一步说明：

导光柱 1 的截面大致呈倾斜的 "凸" 字形，"凸" 字形导光柱一侧延伸为横向的承台 5，另一侧延伸为竖向的裙边 6，中部下端成外凸弧形面聚光界面；"凸" 字形导光柱的外侧端成倾斜平面反光界面，内侧端成倾斜的平面的折射界面。

[0084] 其工作原理是：红外线导光柱为折射率 1.488(以红外波长 0.94nm) 的 PMMA 材料，

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聚光界面设计为弧面，弧面焦点在红外发射单元(或接收单元)，反光界面与承台所在面的夹角大于 39.5° 小于 45° 或大于 45° 小于 55° (实质，反光界面与触摸面夹角大于 39.5° 小于 45° 或大于 45° 小于 55°)，当反光界面与触摸屏夹角为 48 度时，折射界面与触摸屏体夹角为 17 度，且发射端导光柱和接收端导光柱完全对称。在发射端红外发射管发出的红外光经聚光界面聚光后，大部分红外光转换为垂直向上的平行光，并且垂直向上的红外光以 48 度入射角入射红外反光界面，由于导光柱的折射率为 1.488，根据公式 (1.488 = sin90/sina) 可以计算出本材料的全反射角为 a=41.5 度，当红外光以 48 度入射角入射时，在反光界面上将发生全发射，反射后红外光与触摸屏夹角约等于 6 度，反射后的红外光以约为 11 度角入射折射界面，由折射率 1.488 计算出折射后的光以与触摸屏平行光出射；在接收端，从发射端导光柱传输过来的平行光入射到接受端红外导光柱折射界面，折射后约为 11 度入射到反光界面，发生全发射，反射后红外光经聚光界面汇聚后被红外接收管接收。利用凸透镜的聚光原理，适当调整红外管与曲面的距离，在发射端能将红外管发出的发射角度分散的红外光 (类似点光源)汇聚成近似平行光向前传输。在接收端又能将较大角度范围内的近似平行的红外光汇聚，即能增加检测范围又能增强接收红外光信号强度。从而有利于减少红外光信号的损失，提高红外触摸产品的抗干扰能力，提高红外触摸产品的触摸精度，同时又可以降低红外管发射功率，提高红外触摸产品的使用寿命。

[0085] 实施例 10

本实施例是对上述实施例 4 的进一步说明：

导光柱的截面大致呈倾斜的 "凸" 字形，"凸" 字形导光柱一侧延伸为横向的承台，另一侧延伸为竖向的裙边．屮部下端成外凸弧形面的聚光界面；"凸" 字形导光柱的外侧端成倾斜弧形面的反光界面，内侧端成倾斜的平面的折射界面。

[0086] 其工作原理是：导光柱为折射率 1.488(以红外波长 0.94nm) 的 PMMA 材料，聚光界面 8 设计为平面或弧形面，，反光界面为弧形面，折射界面与触摸屏体平面夹角为 17 度。发射端导光柱和接收端导光柱完全对称。在发射端红外发射管发出的红外光经聚光界面后，折射向上入射红外反光界面，在反光界面上将发生全发射，并且由于反光界面曲面产生聚焦成平行光 平行光以反射后红外光与触摸屏夹角约等于 6 度，反射后的红外光以约为 11 度角入射折射界面，由折射率 1.488 计算出折射后的光以与触摸面平行光出射；在接收端，从发射端导光柱传输过来的平行光入射折射界面，以约为 11 度折射角透射至反射界面，接着红外光发生全发射并由十反射界面为曲面产生聚焦而转为焦点在红外接收管的向下红外光透过聚光界面被红外接收管接收。所述红外反光界面为曲面时，类似凹面镜。具有如下优点：红外

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发射管发出的红外光经聚光界面聚光后并不能保证所有光线均为平行光，还是存在一部分有一定发散角度的红外光，利用凹面镜的聚光作用 (例如汽车灯，手电筒等) 可以将较大发散角度的红外光汇聚成平行光，从而有利于减少红外光信号的损失，提高红外触摸产品的抗干扰能力，提高红外触摸产品的触摸精度，同时又能降低红外管发射功率。

[0087] 上述所有实施例，能防止红外信号的损失，适当调整折射界面与垂直方向的角度，又能使得反射后的红外光经折射界面折射后以平行于水平面的方向传输，同时又可以避免边沿效应；有利于减少红外光信号的损失，提高红外触摸产品的抗干扰能力，提高红外触摸产品的触摸精度，同时又能降低红外管发射功率，提高红外触摸产品的实用寿命；实际产品中触摸屏固定于承台的上表面，电路板固定于承台的下表面。触摸屏固定在承台的上面,有利于整个导光柱结构的稳定，减少悬浮高度,同时也可以加强触摸手感，电路板固定(粘结或螺钉锁护)在承台的下表面，有利于红外发射和红外接收管的对位，使得红外触摸产品安装调试简便，适合大批量生产。

[0088] 实施例 11

一种新型的红外触摸屏，包括导光柱 1、触摸屏体 2、电路板 3 和红外管 4，所述导光柱 1 上设置有与导光柱 1 成一体的承台 5，所述承台 5 位于触摸屏体 2 和电路板 3 之间，且触摸屏体 2 与承台 5 固定连接，电路板 3 与承台 5 固定连接。

[0089] 进一步地，如图 7 所示，所述承台 5、电路板 3 和触摸屏体 2 密封连接形成一个 U 形腔体，该 U 形腔体的开口通过连接件 11 密封连接形成密闭腔，红外管 4 位于该密闭腔 7 内。所述的连接件 11 可以是防尘泡棉和密封胶的结合。

[0090] 本实施例的优选实施方式为，所述触摸屏体 2 与承台 5 的密封连接方式为粘接，电路板 3 与承台 5 的密封连接方式为粘接或设置密封件并通过螺栓连接。

[0091] 实施例 12

本实施例是对实施例 11 的进一步说明。如图 8 所示，所述导光柱 1 上设置有连接槽，触摸屏体 2 四周嵌入式设置在连接槽内，触摸屏体 2 底面四周与承台 5 通过密封胶密封。

[0092] 实施例 13

如图 9 所示，红外线触摸屏包括导光柱 1、触摸屏体 2、电路板 3，触摸屏体 2 截面呈倒置的 "凸" 字形，倒 "凸" 形触摸屏体 1 上部形成触摸表面，下部中间部分凸出形成凸台 12，触摸屏体 2 两侧的下部放置在导光柱 1 的承台 5 上，所述电路板 3 置于承台 5 内侧与触摸屏体下部凸台 12 侧壁形成的空腔中。电路板 3 粘接在倒 "凸" 形触摸屏体 2 两侧的下部台阶处。

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[0093] 所述红外线触摸屏还包括一护板 13，护板 13 位于触摸屏体 2 中部凸台 12 和承台 5 的下部，并与触摸屏体 2 中部凸台 12 和承台 5 的下部粘接。所述护板 13 选用金属板，金属护板上设置有固定金属护板的螺纹孔 14。可以通过螺纹孔 14 与显示屏连接。

[0094] 上述触摸屏体 2、导光柱 1、护板 13 围成一相对密闭腔 7，电路板 3 位于所述密闭腔 7 内。上述触摸屏体 2 由双层玻璃或透明塑胶粘合形成整体。

[0095] 该结构红外管 4 在触摸屏体第一层背部，能有效降低触摸屏整体厚度，同时由于采用导光元件达成超薄边框，超低边框，及超低悬浮高度，同时导光元件及触摸屏体背面，设置一安装护板以方便，触摸屏与显示设备 (显示器，一体机，平板电脑等) 的安装。

[0096] 实施例 14

本实施例与实施例 13 基本相同，主要区别如下：

如图 10 所示，所述护板 13 为聚脂薄膜片，能有效降低触摸屏整体厚度，同时由于采用导光元件达成超薄边框，超低边框，及超低悬浮高度。上述触摸屏体由一张玻璃或透明塑胶切割形成。

[0097] 该结构防水，防尘等功效更好，同时易与更换方便电路板等器件维修及更换。

[0098] 实施例 15

如图 11 所示，一种红外触摸屏，包括触摸屏体 2、导光柱 1、电路板 3，电路板 3 上固定安装有红外管 4，所述触摸屏体 2 与承台 5 的上表面粘接连接，所述电路板 3 的非元件面与触摸屏体 2 背面粘接连接，且电路板 3 上的红外管 4 均位于承台 5 内侧。

[0099] 或者所述承台 5 的下表面连接有密封件 15，所述密封件 15、触摸屏体 2 和承台 5 三者通过密封胶形成密闭腔结构，电路板 3 及电路板 3 上的红外管 4 均位于该密闭腔 7 内；密封件 15 与承台 5 优选粘接连接，但也可以通过螺栓连接或螺栓与粘接配合连接；所述密封胶包括防尘胶、防水胶、橡胶制品、硅胶制品，优选在密封的时候使用 EVI 泡绵、防尘条、EPE 等柔性实体配合密封。

[0100] 进一步的，所述密封件优选为 L 形塑料板或钣金面板，L 形一端与承台的下表面固定连接，另一端与触摸屏体背面粘接连接，但并不局限于上述设置方式，例如密封件也可以为圆弧形的金属片等。

[0101] 实施例 16

红外触摸屏，包括触摸屏体 2、导光柱 1、含红外管 4 的电路板 3，触摸屏体 2 的背面与导光柱 1 的承台 5 固定连接，所述触摸屏体 2 的正面或背面设置有至少一层遮挡层 16，所述遮挡层 16 位于触摸屏体 2 非显示区域内。

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[0102] 本实施例的优选实施方式为，所述设置在触摸屏体 2 正面或背面的遮挡层 16 与设置在触摸屏体 2 下方的显示屏 17 的边框齐平。

[0103] 进一步的，优选在所述触摸屏体 2 的四周还同样设置遮挡层 16，与触摸屏体 2 正面或背面的遮挡层 16 配合，对触摸屏体 2 全面保护，提高触摸屏的抗光干扰能力。

[0104] 本实施例的又一优选实施方式为，所述遮挡层 16 是由胶带、遮光纸、半透明材料、塑料膜或金属片制成的薄片，所述薄片与触摸屏体粘接连接，但并不局限于上述方式，也可采用现有技术中公知的其它遮光材料。

[0105] 本实施例的又一优选实施方式为，所述遮挡层 16 是涂覆在触摸屏体上的油漆涂层或油墨涂层。

[0106] 进一步的，所述遮挡层 16 可以通过印刷丝印工艺形成，即在需要遮挡的区域印刷黑色或具有花纹的图案等，还可以通过腐蚀或咬花工艺形成，即在需要遮挡的区域腐蚀或咬花，达到雾面效果，以遮挡红外管以及显示屏的金属边框，起到遮光与美化效果。

[0107] 本实施例的又一优选实施方式为，所述遮挡层 16 的厚度为 0.003 — 2mm 。

[0108] 所述触摸屏体 2 非显示区域是指除与显示屏 17 显示区域对应的屏体之外的区域。

[0109] 如图 12 和 13 所示，所述触摸屏体 2 的正面、背面和四周均设置有至少一层遮挡层 16，其中，触摸屏体 2 正面和背面的遮挡层 16 优选由相同材料制成，但并不局限于上述设置方式，例如触摸屏体正面的遮挡层由金属片制成，其背面的遮挡层由遮光纸制成，正面和背面遮挡层可以由上述任意一种材料制成。

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权 利 要 求 书

1. 一种红外触摸屏，包括导光柱（1）、触摸屏体（2）、电路板（3）和红外管（4），其特征在于：所述导光柱（1）上设置有与导光柱（1）成一体的承台（5），触摸屏体（2）四周固定设置在所述承台（5）上。

2. 根据权利要求 1 所述的红外触摸屏，其特征在于：所述承台（5）位于触摸屏体（2）和电路板（3）之间，且触摸屏体（2）与承台（5）固定连接，电路板（3）与承台（5）固定连接。

3. 根据权利要求 1 所述的红外触摸屏，其特征在于：所述导光柱（1）内侧横向延伸形成所述承台（5），外侧竖向延伸形成裙边（6），电路板（3）分别与承台（5）和裙边（6）密封固定连接，裙边（6）、导光柱（1）、承台（5）和电路板（3）围合形成一密闭腔，红外管（4）位于密闭腔内，

4. 根据权利要求 3 所述的红外触摸屏，其特征在于：所述导光柱（1）的横截面成倾斜的凸字形，凸字形中部的下部内凹，一侧延伸形成承台（5），另一侧延伸形成竖向裙边（6）。

5. 根据权利要求 4 所述的红外触摸屏，其特征在于：所述凸字形导光柱（1）的内凹面（8）、外侧面（9）、内侧面（10）为弧形面和平面的组合。

6. 根据权利要求 5 所述的红外触摸屏，其特征在于：所述内凹面（8）为弧形面，外侧面（9）和内侧面（10）为平面，外侧面（9）与承台（5）所在面的夹角为大于 39.5° 小于 45° 或大于 45° 小于 55°，内侧面（10）与承台（5）所在面的夹角为大于 64° 小于 90° 或大十 90° 小于 140°。

7. 根据权利要求 5 所述的红外触摸屏，其特征在于：所述内凹面为弧形面，外侧面为弧形面，内侧面为平面，内侧面与承台所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140。。

8. 根据权利要求 5 所述的红外触摸屏，其特征在于：所述内凹面为平面，与触摸屏体平行或在同一平面上，外侧面和内侧面均为弧形面。

9. 根据权利要求 5 所述的红外触摸屏，其特征在于：所述内凹面（8）、外侧面（9）和内侧面（10）均为平面，外侧面（9）与承台（5）所在面的夹角为大于 39.5° 小于 45° 或大于 45° 小于 55°，内侧面（10）与承台（5）所在面的夹角为大于 64° 小于 90° 或大于 90° 小于 140°。

10. 根据权利要求 1—9 中任一项所述的红外触摸屏，其特征在于：所述触摸屏体（2）与承台（5）的上表面平行，所述电路板（3）与承台（5）的下表面平行。

11. 根据权利要求 1 所述的红外触摸屏，其特征在于：所述承台（5）、电路板（3）和触摸

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屏体 (2) 密封连接形成一个 U 形腔体，该 U 形腔体的开口通过连接件 (11) 密封连接形成密闭腔 (7)，红外管 (4) 位于该密闭腔 (7) 内。

12. 根据权利要求 10 所述的红外触摸屏，其特征在于：所述触摸屏体 (2) 与承台 (5) 的密封连接方式为粘接，电路板 (3) 与承台 (5) 的密封连接方式为粘接或设置密封件并通过螺栓连接。

13. 根据权利要求 10 所述的红外触摸屏，其特征在于：所述导光柱 (1) 上设置有连接槽，触摸屏体 (2) 四周嵌入式设置在连接槽中。

14. 根据权利要求 1 所述的红外触摸屏，其特征在于：所述的触摸屏体 (2) 截面呈倒置的"凸"字形，倒"凸"形触摸屏体 (2) 上部形成屏体触摸表面，下部中间部分凸出形成凸台 (12)，触摸屏体 (2) 四周固定连接在承台 (5) 上，所述电路板 (3) 设置于承台 (5) 内侧与触摸屏体 (2) 下部凸台 (12) 侧壁形成的空腔中。

15. 根据权利要求 14 所述的红外触摸屏，其特征在于：所述电路板 (3) 粘接在倒"凸"形触摸屏体 (2) 两侧的台阶处。

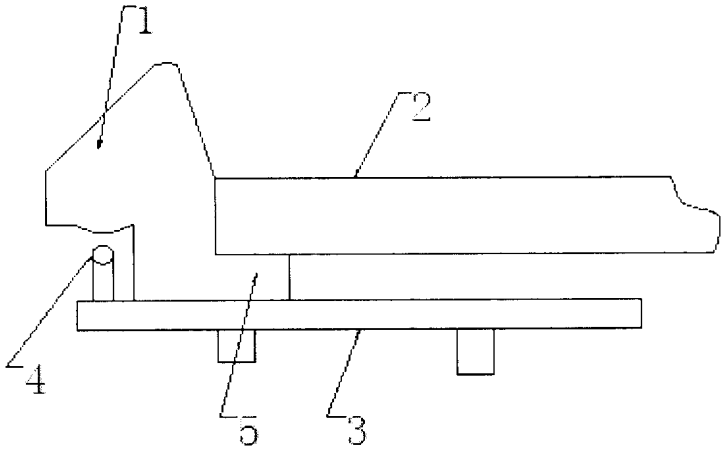
16. 根据权利要求 14 或 15 所述的红外触摸屏，其特征在于：还包括一护板 (13)，所述护板 (13) 位于触摸屏体 (2) 中部凸台 (12) 和承台 (5) 的下部，并与触摸屏体 (2) 中部凸台 (12) 和承台 (5) 的下部粘接，电路板 (3) 设置在由触摸屏体 (2)、承台 (5)、护板 (13) 所围成的相对密闭腔 (7) 内。

17. 根据权利要求 1 所述的红外触摸屏，其特征在于：所述触摸屏体 (2) 密封固定连接在承台 (5) 上，电路板 (3) 的非元件面与触摸屏体 (2) 背面粘接，且电路板 (3) 上的红外管 (4) 均位于承台 (5) 内侧。

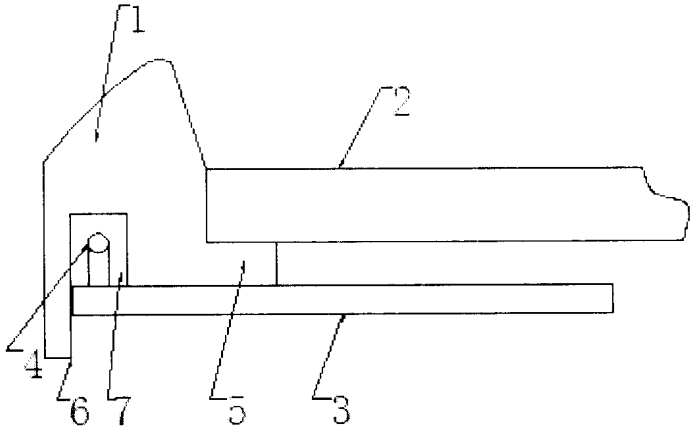
18. 根据权利要求 1—9、11、12、13、14、15 或 17 所述的红外触摸屏，其特征在于：所述触摸屏体 (2) 的正面或背面设置有至少一层遮挡层 (16)，所述遮挡层 (16) 位于触摸屏体 (2) 非显示区域内。

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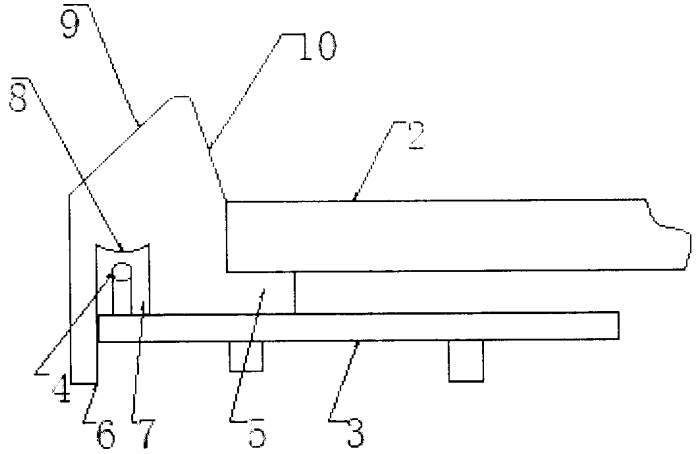
说 明 书 附 图



【图号】 图 1

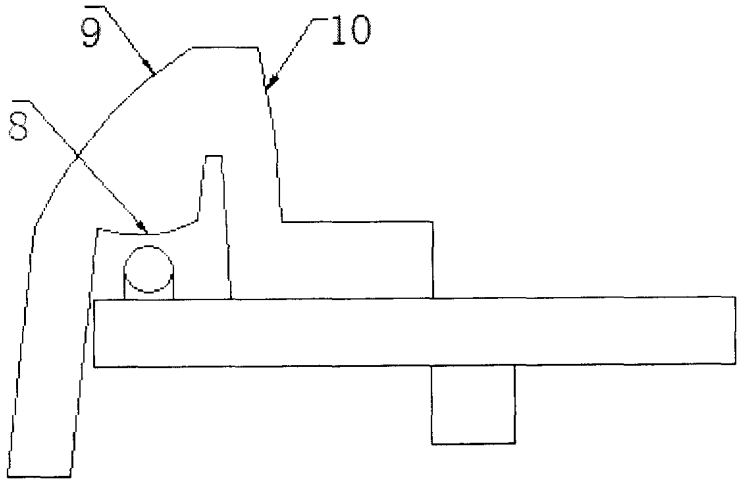


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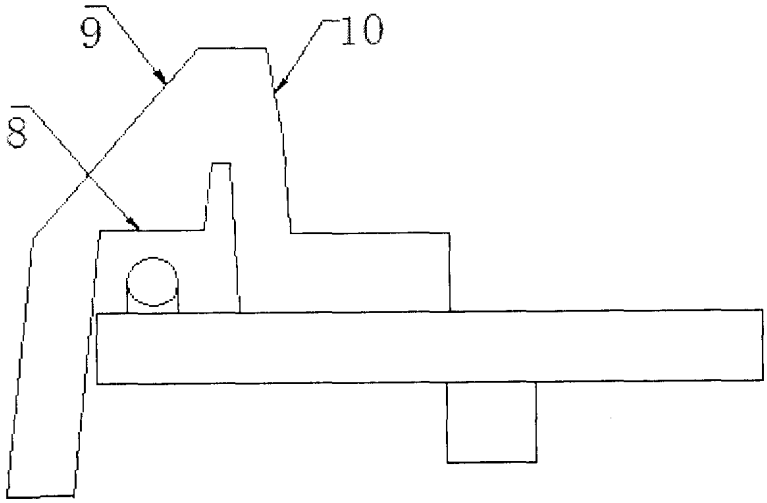


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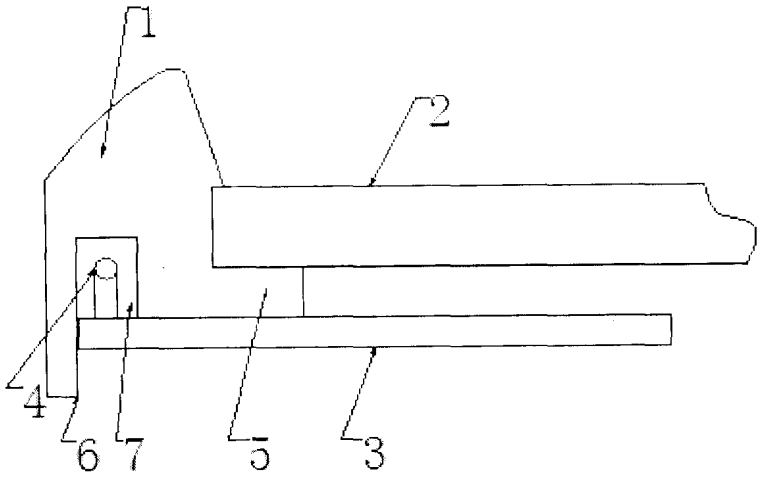
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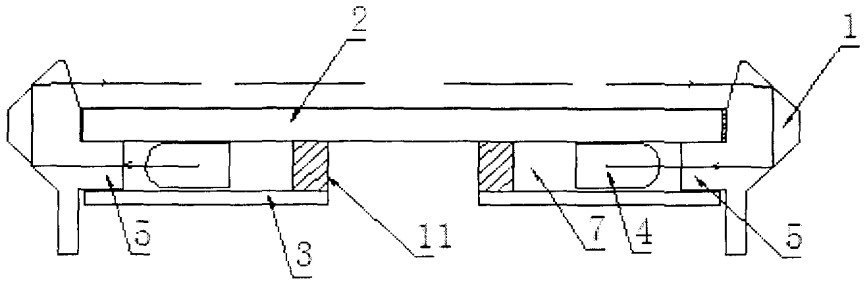


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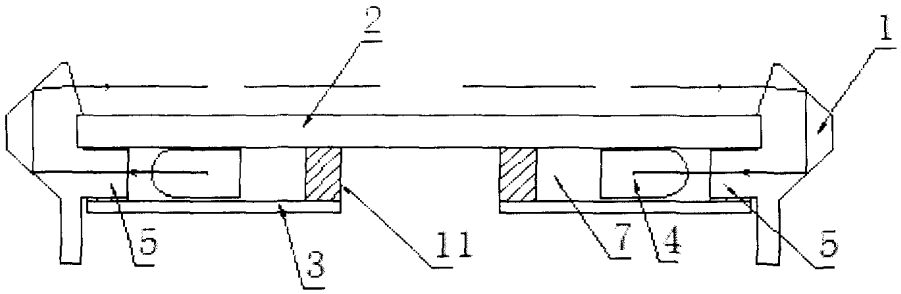


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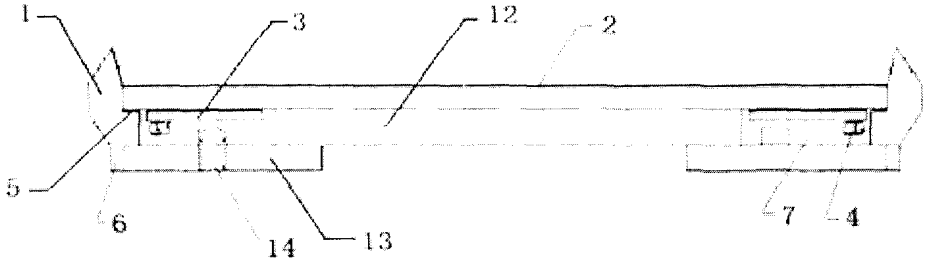
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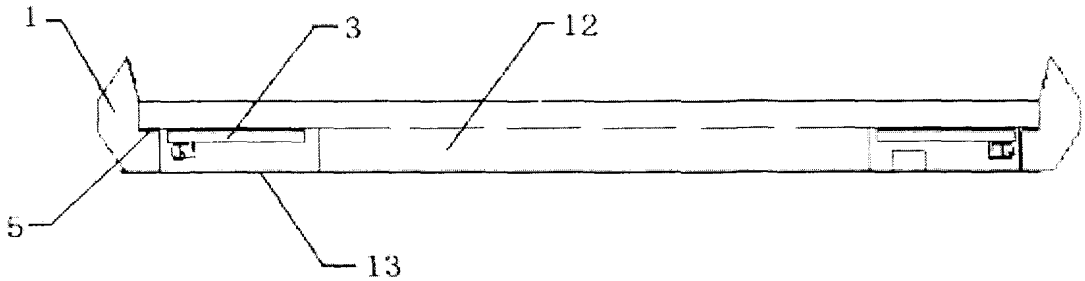
【图号】 图 7



【图号】 图 8

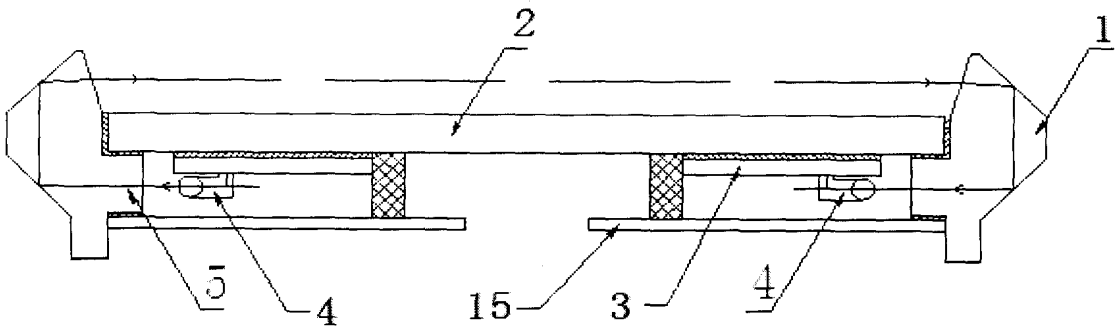


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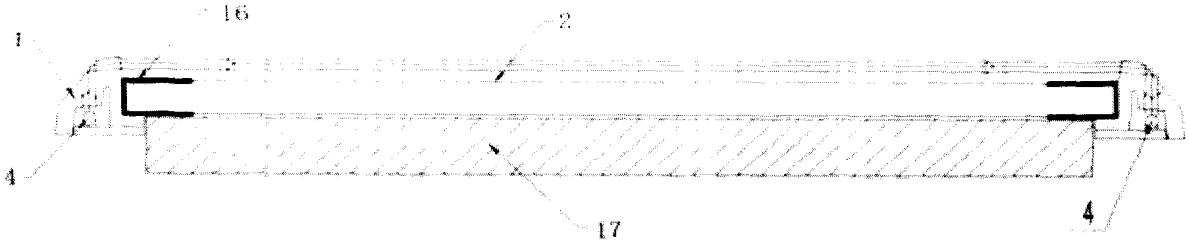


【图号】 图 10

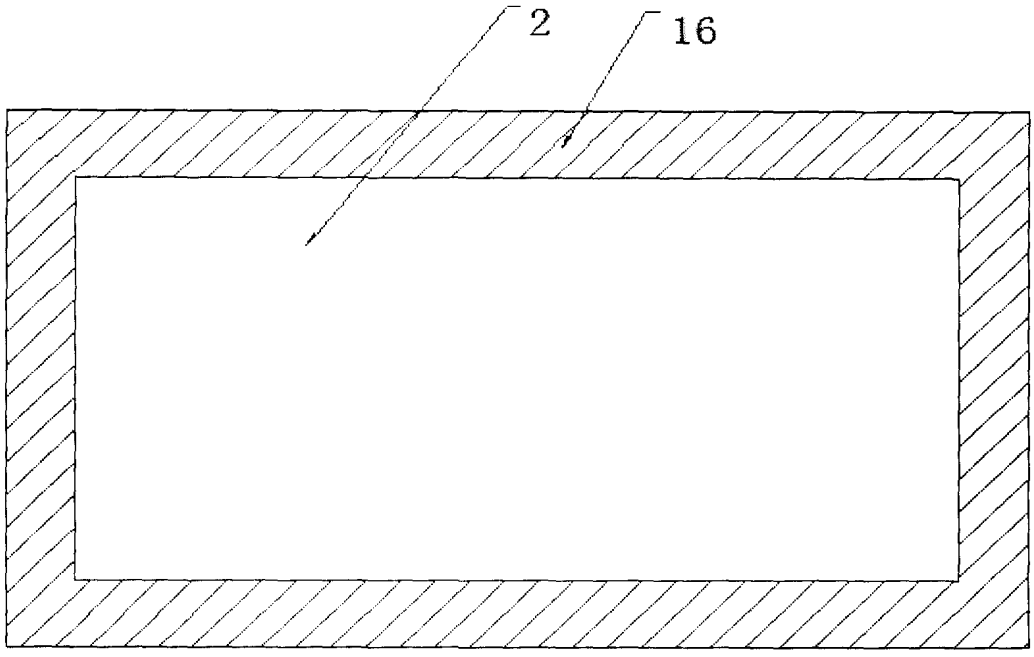
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【图号】 图 11



【图号】 图 12



【图号】 图 13

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/000321

A. CLASSIFICATION OF SUBJECT MATTER

G06F 3/00 (2006.01) i

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 3/-

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

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

CNPAT, CNKI, WPI, EPODOC: infrared, touch screen, light, guide, integrative, bearing platform, install, fix, embed, slot, adhibit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102622133 A (CHENGDU GENERAL TOUCH TECHNOLOGY CO., LTD.) 01 August 2012 (01.08.2012), description, paragraphs [0036] and [0037] and figure 2	1, 2, 10, 12, 13, 17., 18
A		3-9, 11, 14-16
A	CN 102722295 A (BEIJING IRTOUCH SYSTEMS CO., LTD.) 10 October 2012 (10.10.2012). , the whole document	1-18
P, X	CN 102968223 A (CHENGDU GENERAL TOUCH TECHNOLOGY CO., LTD.), 13 March 2013 (13.03.2013), claims 1-18	1-18

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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 September 2013 (05.09.2013)	19 September 2013 (19.09.2013)

[Name and mailing address of the ISA
State Intellectual Property Office of the P. R. China
No. 6, Xitucheng Road, Jimenqiao
Haidian District, Beijing 100088, China
[Facsimile No. (86-10) 62019451

Authorized officer

WU, Min

Telephone No. (86-10) 62411697

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN20 13/000321

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102622133 A	01.08.2012	None	
CN 102722295 A	10.10.2012	None	
CN 102968223 A	13.03.2013	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

国 际 检 索 报 告

国际申请号
PCT/CN2013/000321

A．主题的分类

G06F 3/00 (2006.01) ;

按照国际专利分类(IPC) 或者同时按照国家分类和 IPC 两种分类

B．检索领域

检索的最低限度文献(标明分类系统和分类号)

IPC: G06F 3/-

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词 (如使用))

CNPAT,CNKI: 红外，触摸屏，导光，传导，一体，承台，安装，固定，嵌入，槽，粘

WPI, EPODOC: infrared, touch screen, light, guide, integrative, bearing platform, install, fix, embed, slot, adhibit

C．相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
X	CN 102622 133 A，(成都吉锐触摸技术股份有限公司)，01. 8 月 2012 (01. 08. 2012)，说明书第 [0036] 、[0037] 段，附图 2	1-2 ,10 ,12-13 ,17-18
A		3—9, 11, 14—16
A	CN 102722295 A，(北京汇冠新技术股份有限公司)，10. 10 月 2012 (10. 10. 2012)，全文	1—18
P, X	CN 102968223 A，(成都吉锐触摸技术股份有限公司)，13. 3 月 2013 (13. 03. 2013)，权利要求 1-18	1—18

□ 其余文件在 C 栏的续页中列出。 ☒ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的¾ ¾ ¾ ¾公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件 (如具体说明的)

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
05. 9 月 2013 (05. 09. 2013)	19.9 月 2013 (19.09.2013)
ISA/CN 的名称和邮寄地址： 中华人民共和国国家知识产权局 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号： (86-10)62019451	受权官员 吴敏 电话号码：(86-10) 62411697

PCT/ISA/210 表(第 2 页)(2009 年 7 月)

国际检索报告

关于同族专利的信息

国际申请号
PCT/CN2013/000321

检索报告中引用的专利文件	公布日期	同族专利	公布日期
CN 102622 133 A	01. 08. 2012	无	
CN 102722295 A	10. 10. 2012	无	
CN 102968223 A	13. 03. 2013	无	

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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(43) International Publication Date
26 June 2014 (26.06.2014)

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(10) International Publication Number
WO 2014/098744 A1

(51) International Patent Classification:
G02B 6/00 (2006.01) *G06F 3/03* (2006.01)
G02B 5/00 (2006.01)

(21) International Application Number:
PCT/SE2013/051537

(22) International Filing Date:
17 December 2013 (17.12.2013)

(25) Filing Language: English

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(30) Priority Data:
1251474-1 20 December 2012 (20.12.2012) SE
61/740,093 20 December 2012 (20.12.2012) US

(71) Applicant: **FLATFROG LABORATORIES AB** [SE/SE]; Traktorvagen 11, S-226 60 Lund (SE).

(72) Inventors: **CRAVEN-BARTLE, Thomas;** Östervang 12, S-247 32 Sodra Sandby (SE). **BERGSTRÖM, Hakan;** Åkestorpsvagen 42, S-247 95 Torna Hallestad (SE). **KARLSSON, Ivan;** Blidvadersvagen 6 G, S-222 28 Lund (SE). **WASSVIK, Ola;** Illstorp 709, S-273 57 Brosarp (SE). **SERNELIUS, David;** Orvar Odds väg 2, 5 tr, S-l 12 54 Stockholm (SE).

(74) Agent: **Patent Department;** FlatFrog Laboratories AB, Traktorvagen 11, S-226 60 Lund (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: IMPROVEMENTS IN TIR-BASED OPTICAL TOUCH SYSTEMS OF PROJECTION-TYPE

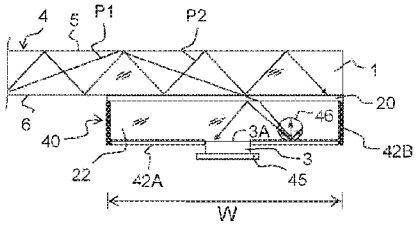


Fig. 10B

(57) Abstract: A touch-sensitive apparatus operates by light frustration (FTIR) and comprises a light transmissive panel (1) that defines a front surface (5) and a rear surface (6), light emitters optically connected to the panel (1) so as to generate light that propagates by total internal reflection inside the panel, and light detectors (3) optically connected to the panel (1) so as to define a grid of propagation paths inside the panel (1) between pairs of light emitters and light detectors (3). Each light detector (3) is optically connected to the panel (1) via an angular filter (20). The filter (20) is applied to an outcoupling region on at least one of the front and rear surfaces (5, 6) and is configured to transmit light only within a confined range of angles with respect to the normal of the outcoupling region. The confined range extends from a lower angle limit θ_{min} to an upper angle limit θ_{max}. The lower angle limit θ_{min} is equal to or larger than a critical angle 9c, which is given by 9c = arcsin (l/n $_{panel}$), with n_{panel} being the refractive index of the light transmissive panel (1) at the outcoupling region.

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IMPROVEMENTS IN TIR-BASED OPTICAL TOUCH SYSTEMS OF PROJECTION-TYPE

Cross-reference to Related Applications

The present application claims the benefit of Swedish patent application No. 1251474-1, filed 20 December 2012, and US provisional application No. 61/740093, filed 20 December 2012, both of which are incorporated herein by reference.

Technical Field

The present invention generally relates to optical touch-sensing systems, and in particular to such systems that operate by projection measurements of light that propagates by total internal reflection (TIR) inside a light transmissive panel.

Background Art

Touch-sensing systems ("touch systems") are in widespread use in a variety of applications. Typically, the touch systems are actuated by a touching object such as a finger or stylus, either in direct contact, or through proximity (i.e. without contact), with a touch surface. Touch systems are for example used as touch pads of laptop computers, in control panels, and as overlays to displays on e.g. hand held devices, such as mobile telephones. A touch panel that is overlaid on or integrated in a display is also denoted a "touch screen". Many other applications are known in the art.

There are numerous known techniques for providing touch sensitivity, e.g. by incorporating resistive wire grids, capacitive sensors, strain gauges, etc into a touch panel. There are also various types of optical touch systems, which e.g. detect shadows cast by touching objects onto a touch surface, or detect light scattered off the point(s) of touching objects on a touch panel.

One specific type of optical touch system uses projection measurements of light that propagates on a plurality of propagation paths inside a light transmissive panel that defines a touch surface. The projection measurements thus quantify a property, e.g. power, of the light on the individual propagation paths, when the light has passed the panel. The light propagates inside the panel by total internal reflection (TIR) against the touch surface, such that objects on the touch surface causes the propagating light on one or more propagation paths to be attenuated, commonly denoted FTIR (Frustrated Total Internal Reflection). For touch determination, the projection measurements may be processed by simple triangulation, or by more advanced image reconstruction techniques that generate a two-dimensional distribution of disturbances on the touch surface,

i.e. an "image" of everything on the touch surface that affects the measured property. Examples of such touch systems are found in US3673327, US4254333, US6972753, US7432893, US2006/01 14237, US2007/0075648, WO2009/048365, US2009/0153519, WO20 10/006882, WO20 10/064983, WO2010/134865 and WO2012/105893.

The prior art suggests several different approaches for introducing the light into the panel and for detecting the light downstream of the touch surface. For example, US7432893 proposes coupling light into the panel via revolved prisms that are attached to the rear surface of the panel, and detecting the light at photodetectors that are directly attached to the front surface of panel. In WO2010/064983, light is coupled into and out of the panel via the edge surface that connects the front and rear surfaces of the panel, or via wedges that are attached to the front or rear surface of the panel. In WO2012/105893, a sheet-like microstructured element, e.g. a tape of light transmissive material, is provided on the front or rear surface of the panel for coupling light into and out of the panel.

One challenge when designing an optical touch system of this type is to enable consistent touch determination despite the fact that the detectors need to detect small changes in weak optical signals in presence of potentially significant interferences that affect the reliability of the optical signals. One such interference is caused by ambient light, e.g. from sunlight or residential lighting, that may impinge on the detectors and influence the optical signals. Another interference is caused by accumulation of contamination on the touch surface, such a fingerprints, drops of saliva, sweat, smear, liquid spills, etc. The contamination will interact with the propagating light and cause changes to the optical signals that may be difficult to distinguish from changes caused by "true objects", e.g. objects that are actively manipulated in contact with the touch surface.

In touch-sensitive devices, there is also a general trend to avoid attaching components to the front surface. These components may form a frame around the touch-sensitive region and thereby reduce the ratio of the active area (the surface area that is available for touch interaction) to the total surface area of the touch-sensitive device. Furthermore, if the components protrude from the front surface of the panel, it may be necessary to provide a bezel at the perimeter of the panel to protect and hide the components and possibly any wiring connected to the components. Given the nature of user interaction with touch-sensitive devices, such a bezel may disrupt the user experience and even prevent certain types of interaction. The bezel may also cause dirt and other contaminants to accumulate in the area where the bezel joins the panel. To overcome this problem, it is desirable to design touch systems for flush mount of the panel in the supporting frame of the touch-sensitive device, i.e. such that the front surface of the panel is essentially level with the surrounding frame material. This is also

known as "edge-to-edge".

In aforesaid US7432893, the impact of ambient light is reduced by attaching the photodetectors to the front surface, such that the photodetectors face away from the ambient light that enters the panel through the front surface. This solution requires a significant bezel to hide and protect the photodetectors and the associated wiring. US7432893 also proposes to intermittently measure ambient levels at the photodetectors and compensate the respective projection measurement for the measured ambient level.

The influence of contamination may be handled by dedicated signal processing that actively estimates the influence of contamination over time and compensates for this influence, e.g. as disclosed in WO2011/028169, WO2011/049512 and WO2012/121652.

However, in view of the weak optical signals and small attenuation caused by touching objects, there is room for further improvement when it comes to increasing the robustness of the touch system to ambient light and contamination on the touch surface.

In the field of LCD display technology, which is outside the field of touch-sensitive systems, it is known to couple light from LEDs into thin light guide panels as part of so-called backlights (BLUs, Backlight units) for LCD displays. The light guide panel is located behind the LCD and is configured to emit light from its top surface to uniformly illuminate the rear side of the LCD. One approach for coupling the LEDs to the light guide panel is proposed in the article "Injecting Light of High-Power LEDs into Thin Light Guides", by Cornelissen et al, published in Proc. SPIE 7652, International Optical Design Conference 2010, pp 7652121-7652126, 2010. According to this approach, the top surface of the LED is modified to have a rough surface behaving like a Lambertian reflector. A dielectric multilayer filter is deposited on the bottom of the light guide panel, and the top surface of the LED is optically coupled to the filter by a silicone adhesive. The filter is optimized to only transmit light emitted from the LED at angles larger than the critical angle at the light guide-air interface. The purpose of the multilayer is thus to only transmit light that can propagate in the light guide. The light emitted at smaller angles is reflected back toward the rough LED surface where it is subsequently recycled by reflection and redistribution. Further elaboration on this incoupling approach is given in the article "Dielectric multilayer angular filters for coupling LEDs to thin light guides", by Mu et al, published in Proc. SPIE 8170, pp 817001-1-817001-10, 2011.

Summary

It is an objective of the invention to at least partly overcome one or more of the above-identified limitations of the prior art.

Another objective is to provide a touch-sensitive apparatus that has a reduced sensitivity to ambient light.

A further objective to provide a touch-sensitive apparatus that has a reduced sensitivity to contamination on the touch surface.

A still further objective is to provide a touch-sensitive apparatus that has a flat front surface, without bezel or other projecting structures.

Yet another objective is to provide a compact touch-sensitive apparatus.

Another objective is to provide a touch-sensitive apparatus suitable for mass-production.

One or more of these objectives, as well as further objectives that may appear from the description below, are at least partly achieved by touch-sensitive apparatuses according to the independent claims, embodiments thereof being defined by the dependent claims.

A first aspect of the invention is a touch-sensitive apparatus, comprising: a light transmissive panel that defines a front surface and an opposite, rear surface; a plurality of light emitters optically connected to the light transmissive panel so as to generate propagating light that propagates by total internal reflection inside the light transmissive panel across a touch-sensitive region on the light transmissive panel; a plurality of light detectors optically connected to the light transmissive panel so as to define a grid of propagation paths across the touch-sensitive region between pairs of light emitters and light detectors; wherein each light detector is optically connected to the light transmissive panel via an angular filter which is applied to an outcoupling region on at least one of the front and rear surfaces and is configured to transmit the propagating light only within a confined range of angles with respect to the normal of the outcoupling region; and wherein the confined range extends from a lower angle limit θ_{min} to an upper angle limit θ_{max}, wherein the lower angle limit θ_{min} is equal to or larger than a critical angle θ_C which is given by $\theta_C = \arcsin(1/n_{panel})$, with n_{panel} being the refractive index of the light transmissive panel at the outcoupling region.

In one embodiment, the lower angle limit θ_{min} exceeds the critical angle by an angle $\Delta\Theta$, which is at least 5°, 10° or 15°.

In another embodiment, the lower angle limit θ_{min} is equal to or larger than a first cut-off angle $\theta_W = \arcsin(n_w / n_{panel})$, with n_w being the refractive index of water, $n_{panel} > n_w$.

In one embodiment, the lower angle limit θ_{min} is equal to or larger than a second cut-off angle $\theta_f = \arcsin(n_f / n_{panel})$, with n_f being the refractive index of finger fat, $n_{panel} > n_f$.

In one embodiment, the upper angle limit θ_{max} is equal to or smaller than a third

cut-off angle θ_{cs} = arcsin (1.55/n $_{panel}$), $n_{panel} > 1.55$.

In one embodiment, the light transmissive panel is mounted onto a front surface of a display device by a lamination layer of light transmissive material which is arranged in contact with the rear surface of the light transmissive panel and the front surface of the display device, wherein the lower angle limit θ_{min} is approximately equal to or larger than a laminate cut-off angle θ_{ci} = arcsin (n_{lam}/n_{panel}), with n_{lam} being the refractive index of lamination layer, $n_{lam} < n_{panel}$.

In an alternative embodiment, the touch-sensitive apparatus further comprises a layered light absorber comprising a coupling layer of light transmissive material on the rear surface of the light transmissive panel, and an absorbing layer of light-absorbing material on the coupling layer, said coupling layer having an index of refraction $n_{coupi} < n_{panei}$. The lower angle limit θ_{min} of the angular filter may be approximately equal to or larger than an absorber cut-off angle θ_{CC} = arcsin (n_{coupl}/n_{panel}), and the layered light absorber may extend from the respective outcoupling port and may have a width which, along the detection lines that extend to the respective light detector, is at least equal to a distance between consecutive reflections in the rear surface for propagating light that impinges on the rear surface with an angle of incidence of θ_{CC} to a normal of the rear surface. It may be preferable that the layered light absorber is arranged to overlap a major part, or essentially all, of the touch-sensitive region.

In one embodiment, the angular filter is configured to define essentially the same confined range of angles for all detection lines that extend to the respective light detector.

In one embodiment, the angular filter is configured as a dielectric multilayer structure. The touch-sensitive apparatus may further comprise a light recycler which is arranged beneath the angular filter to define a light reflective enclosure with respect to the angular filter and a light-sensitive surface of the respective light detector.

In one recycler embodiment, the light reflective enclosure is at least partly diffusively reflecting to angularly re-distribute the light that enters the light reflective enclosure via the angular filter.

In one recycler embodiment, the light reflective enclosure comprises a light reflective bottom surface that is spaced from and extends parallel to the angular filter and a reflective side wall structure that extends between the light reflective bottom surface and the angular filter. In one implementation, the side wall structure may be specularly reflective, and at least a portion of the bottom surface may be diffusively reflective.

In one recycler embodiment, the light reflective enclosure may be filled by a light transmissive material.

In an alternative recycler embodiment, the light reflective enclosure is hollow, and a disruptive structure is provided on the angular filter so as to face the light reflective enclosure, wherein the disruptive structure is configured to transmit and redirect at least part of the light transmitted by the angular filter into the light reflective enclosure. The disruptive structure may be one of a non-imaging, diffusively transmitting structure, and an imaging structure configured to refract the light transmitted by the angular filter.

In one recycler embodiment, the light detector is arranged with the light-sensitive surface facing the angular filter. In an alternative recycler embodiment, the light detector is arranged to project into the light enclosure such that the light-sensitive surface is facing the side wall structure.

In one recycler embodiment, the light reflective enclosure comprises a microstructure that defines a mirror with an optical power so as to re-direct the transmitted propagating light onto the light-sensing surface.

In one recycler embodiment, the light recycler is configured as a funnel which is configured to specularly reflect the transmitted propagating light from the angular filter towards the light-sensitive surface of the light detector.

In an embodiment without a light recycler, a body of light-transmissive material is attached to the angular filter, and the light detector is attached to the body such that a light-sensitive surface of the light detector directly receives the transmitted propagating light from the angular filter.

In one embodiment, the angular filter is arranged to transmit the propagating light to the respective light detector within a respective outcoupling port on the rear surface, wherein the extent of the respective outcoupling port, along the detection lines that extend to the respective light detector, is at least equal to a distance between consecutive reflections in the rear surface for the propagating light that impinges on the angular filter with an angle of incidence of θ_{min} to a normal of the angular filter.

In one embodiment, the touch-sensitive apparatus comprises a specularly reflective edge element which is arranged, adjacent to the outcoupling region, on an edge portion that connects the front surface and the rear surface of the light transmissive panel, so as to specularly reflect the propagating light that impinges on the specularly reflective edge element.

In one embodiment, the propagating light comprises light in an infrared wavelength region, and wherein the touch-sensitive apparatus further comprises a visibility shield which is arranged intermediate the rear surface and the angular filter, the visibility shield being configured to block light that is visible to the human eye and to transmit at least part of said light in the infrared wavelength region.

In one embodiment, each light emitter is optically connected to the light

transmissive panel via an angular filter which is applied to an incoupling region on at least one of the front and rear surfaces and is configured to transmit light from the respective light emitter only within a confined range of angles inside the light transmissive panel. The confined range of angles of the angular filter on the incoupling region may be matched to the confined range of angles of the angular filter on the outcoupling region, e.g. by the angular filter on the incoupling region being identical to the angular filter on the outcoupling region. In one embodiment, the touch-sensitive apparatus, further comprises a light recycler which is arranged beneath the angular filter on the incoupling region, so as to define a light reflective enclosure with respect to the angular filter and a light-emitting surface of the respective light emitter.

A second aspect of the invention is a touch-sensitive apparatus comprising: a light transmissive panel that defines a front surface and an opposite, rear surface; a plurality of light emitters optically connected to the light transmissive panel so as to generate propagating light that propagates by total internal reflection inside the light transmissive panel across a touch-sensitive region on the light transmissive panel; and a plurality of light detectors optically connected to the light transmissive panel so as to define a grid of propagation paths across the touch-sensitive region between pairs of light emitters and light detectors; wherein the light transmissive panel is mounted onto a front surface of a display device by a lamination layer of light transmissive material which is arranged in contact with the rear surface of the light transmissive panel and the front surface of the display device; and wherein the lamination layer has a refractive index n_{lam} which is smaller than a refractive index n_{panel} of the light transmissive panel at the rear surface and which is chosen such that a laminate cut-off angle $\theta_{ci} =$ arcsin (n_{lam}/n_{panel}) exceeds a critical angle θ_C which is given by $\theta_C =$ arcsin $(1/n_{panel})$ by an angle $\Delta\theta$, which is at least 5°, 10° or 15°.

In one embodiment, the laminate cut-off angle θ_{ci} is equal to or larger than a first cut-off angle $\theta_W =$ arcsin (n_w/n_{panel}), with n_w being the refractive index of water, $n_{panel} > n_w$.

In another embodiment, the laminate cut-off angle θ_{ci} is equal to or larger than a second cut-off angle $\theta_f =$ arcsin (nf/n_{vane}), with n_f being the refractive index of finger fat, $n_{panel} > n_f$.

In one embodiment, the light emitters are optically coupled to the light transmissive panel such that the propagating light is generated to impinge on the lamination layer at an angle that is equal to or larger than the laminate cut-off angle $\theta_{c,l}$.

A third aspect of the invention is a touch-sensitive apparatus comprising: a light transmissive panel that defines a front surface and an opposite, rear surface; a plurality of light emitters optically connected to the light transmissive panel so as to generate

propagating light that propagates by total internal reflection inside the light transmissive panel across a touch-sensitive region on the light transmissive panel; and a plurality of light detectors optically connected to the light transmissive panel so as to define a grid of propagation paths across the touch-sensitive region between pairs of light emitters and light detectors; wherein a layered light absorber is provided on the rear surface of the light transmissive panel, said layered light absorber comprising a coupling layer of light transmissive material on the rear surface of the light transmissive panel, and an absorbing layer of light-absorbing material on the coupling layer, and wherein the coupling layer has a refractive index n_{coupl} which is smaller than a refractive index *impanel* of the light transmissive panel at the rear surface and which is chosen such that an absorber cut-off angle θ_{CC} = arcsin $(n_{coup}\ i/n_{pane\ l})$ exceeds a critical angle θ_C which is given by θ_C = arcsin (l/n $_{panel}$) by an angle $\Delta\Theta$, which is at least 5°, 10° or 15°.

In one embodiment, the absorber cut-off angle θ_{CC} is equal to or larger than a first cut-off angle θ_W = arcsin (n_w/n_{panel}), with n_W being the refractive index of water, $n_{panel} > n_W$.

In another embodiment, the absorber cut-off angle θ_{CC} is equal to or larger than a second cut-off angle θf = arcsin $(nf/n_{vane}\ i)$, with n_f being the refractive index of finger fat, $n_{panel} > n_f$.

In one embodiment, the light emitters are optically coupled to the light transmissive panel such that the propagating light is generated to impinge on the coupling layer at an angle that is equal to or larger than the absorber cut-off angle θ_{CC}.

In one embodiment, the layered light absorber is arranged to overlap a major part, or essentially all, of the touch-sensitive region.

It is realized that any one of the embodiments of the first aspect may be adapted and implemented as an embodiment of the second and third aspects. For example, each light detector may be optically connected to the light transmissive panel via an angular filter which is applied to an outcoupling region on at least one of the front and rear surfaces and is configured to transmit the propagating light only within a confined range of angles with respect to the normal of the outcoupling region, wherein the confined range may extend from a lower angle limit θ_{min} to an upper angle limit θ_{max}, and wherein the lower angle limit θ_{min} may be equal to or larger than a critical angle θ_C, which is given by θ_C = arcsin (l/n $_{panel}$), with n_{panel} being the refractive index of the light transmissive panel at the outcoupling region.

Still other objectives, features, aspects and advantages of the present invention will appear from the following detailed description, from the attached claims as well as from the drawings.

Brief Description of Drawings

Embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings.

Fig. 1 is a section view of a light transmissive panel to illustrate the principle of using TIR for touch detection.

Fig. 2 is a top plan view of an exemplifying touch-sensitive apparatus.

Fig. 3 is a 3D plot of an attenuation pattern generated based on energy signals from a TIR-based projection-type touch-sensitive apparatus.

Fig. 4 is a section view of a light outcoupling structure according to a first embodiment.

Fig. 5A is a plot of transmission as a function of incidence angle for an angular filter included in the first embodiment, and Fig. 5B is a perspective view of the range of angles that are transmitted by the angular filter.

Fig. 6 is a section view to illustrate characteristic angles of the angular filter and characteristic angles of the panel.

Fig. 7 is a section view to illustrate incoupling of ambient light via contamination on the touch surface.

Fig. 8 is a section view to illustrate a relation between bounce angles in a two-layer panel.

Fig. 9A is a section view to illustrate bounce angles in a panel which is laminated to a display device, and Fig. 9B illustrates a panel with a layered light absorber between light incoupling and outcoupling structures to control bounce angles for propagating light in the panel.

Fig. 10A is a section view of a light outcoupling structure according to a second embodiment.

Figs 10B-10C are section and plan views of a light outcoupling structure according to a third embodiment.

Figs 10D-10H are section views of variations of the first to third embodiments.

Figs 11A-11B are section and plan views of a first alternative outcoupling structure.

Figs 12A-12B are section and plan views of a second alternative outcoupling structure.

Figs 13A-13B are section views of outcoupling structures combined with a layered light absorber.

Figs 14A-14B are section and plan views of a light incoupling structure according to a first embodiment, Figs 14C-14D are section views of variations of the first

embodiment.

Figs 15A-15B are bottom plan views of a sequence of structures arranged on a panel to couple light into and/or out of the panel.

Fig. 16 is a graph of light reflectivity at a panel-water interface as a function of angle of incidence inside the panel.

Figs 17A-17B are graphs of signal attenuation measured before, during and after a finger tap without and with the layered light absorber on the panel in Fig. 9B.

Detailed Description of Example Embodiments

In the following, various inventive light coupling structures will be presented as installed in an exemplifying TIR-based projection-type touch-sensitive apparatus. Throughout the description, the same reference numerals are used to identify corresponding elements.

1. Touch-sensitive apparatus

Fig. 1 illustrates the concept of touch detection based on attenuation of propagating light, commonly denoted FTIR (Frustrated Total Internal Reflection). According to this concept, light is transmitted inside a panel 1 along a plurality of well-defined propagation paths. The panel 1 is made of solid material in one or more layers and may have any shape. The panel 1 defines an internal radiation propagation channel, in which light propagates by internal reflections, also denoted "bounces" in the following. In the example of Fig. 1, the propagation channel is defined between the boundary surfaces 5, 6 of the panel 1, and the front surface 5 allows the propagating light to interact with touching objects 7 and thereby defines the touch surface 4. The interaction is enabled by injecting the light into the panel 1 such that the light is reflected by total internal reflection (TIR) in the front surface 5 as it propagates through the panel 1. The light may be reflected by TIR in the rear surface 6 or against a reflective coating thereon. It is also conceivable that the propagation channel is spaced from the rear surface 6, e.g. if the panel comprises multiple layers of different materials. The panel 1 may thus be made of any solid material (or combination of materials) that transmits a sufficient amount of light in the relevant wavelength range to permit a sensible measurement of transmitted energy. Such material includes glass, poly(methyl methacrylate) (PMMA) and polycarbonates (PC). The panel 1 typically has a refractive index in the range of 1.3-1.7. For example, PMMA has a refractive index of about 1.5 and PC has a refractive index of about 1.6 in the near infrared (NIR). The panel 1 may be designed to be overlaid on or integrated into a display device or monitor (not shown).

As shown in Fig. 1, an object 7 that is brought into close vicinity of, or in contact

with, the touch surface 4 may interact with the propagating light at the point of touch. In this interaction, part of the light may be scattered by the object 7, part of the light may be absorbed by the object 7, and part of the light may continue to propagate in its original direction across the panel 1. Thus, the touching object 7 causes a local attenuation or "frustration" of the total internal reflection, which leads to a decrease in the energy (or equivalently, the power or intensity) of the transmitted light, as indicated by the thinned lines to the right of the touching objects 7 in Fig. 1.

Fig. 2 illustrates an example embodiment of a touch-sensitive apparatus 100 that is based on the concept of FTIR. Emitters 2 are distributed along the perimeter of the touch surface 4, beneath the panel 1, to project light onto an incoupling structure on the panel 1 such that at least part of the light is captured inside the panel 1 for propagation by internal reflections in the propagation channel. Detectors 3 are distributed along the perimeter of the touch surface 4, beneath the panel 1, and are optically coupled to the panel 1 so as to receive part of the propagating light from a respective outcoupling structure. The light from each emitter 2 will thereby propagate inside the panel 1 to a number of different detectors 3 on a plurality of light propagation paths D. Even if the light propagation paths D correspond to light that propagates by internal reflections inside the panel 1, the light propagation paths D may conceptually be represented as "detection lines" that extend across the touch surface 4 between pairs of emitters 2 and detectors 3, as indicated by dashed lines in Fig. 2. Thus, the detection lines correspond to a projection of the propagation paths onto the touch surface 4. Thereby, the emitters 2 and detectors 3 collectively define a grid of detection lines ("detection grid") on the touch surface 4, as seen in a top plan view. It is appreciated that Fig. 2 is an example, and that a (significantly) larger number of emitters 2 and/or detectors 3 may be included in the apparatus 100. Also, the distribution of emitters 2 and detectors 3 may differ.

As used herein, the emitter 2 may be any type of device capable of emitting radiation in a desired wavelength range, for example a diode laser, a VCSEL (vertical-cavity surface-emitting laser), an LED (light-emitting diode), an incandescent lamp, a halogen lamp, etc. The emitter 2 may also be formed by the end of an optical fiber. The emitters 2 may generate light in any wavelength range. The following examples presume that the light is generated in the near infrared (NIR), i.e. at wavelengths of about 750 nm-1400 nm. Analogously, the detector 3 may be any device capable of converting light (in the same wavelength range) into an electrical signal, such as a photo-detector, a CCD device, a CMOS device, etc.

The detectors 3 collectively provide an output signal, which is received and sampled by a signal processor 10. The output signal contains a number of sub-signals, also denoted "projection signals", each representing the energy of light received by a certain

light detector 3 from a certain light emitter 2. Depending on implementation, the signal processor 10 may need to process the output signal for separation of the individual projection signals. The projection signals represent the energy, intensity or power of light received by the detectors 3 on the individual detection lines D. Whenever an object touches a detection line, the received energy on this detection line is decreased ("attenuated").

The signal processor 10 may be configured to process the projection signals so as to determine a property of the touching objects, such as a position (e.g. in the x,y coordinate system shown in Fig. 2), a shape, or an area. This determination may involve a straight-forward triangulation based on the attenuated detection lines, e.g. as disclosed in US7432893 and WO2010/015408, or a more advanced processing to recreate a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 1, where each attenuation value represents a local degree of light attenuation. An example of such an attenuation pattern is given in the 3D plot of Fig. 3, where the peaks of increased attenuation represent touching objects. The attenuation pattern may be further processed by the signal processor 10 or by a separate device (not shown) for determination of the position, shape or area of touching objects. The attenuation pattern may be generated e.g. by any available algorithm for image reconstruction based on projection signal values, including tomographic reconstruction methods such as Filtered Back Projection, FFT-based algorithms, ART (Algebraic Reconstruction Technique), SART (Simultaneous Algebraic Reconstruction Technique), etc. Alternatively, the attenuation pattern may be generated by adapting one or more basis functions and/or by statistical methods such as Bayesian inversion. Examples of such and other reconstruction functions designed for use in touch determination are found in WO2009/077962, WO2011/049511, WO2011/139213, WO2012/050510, WO2013/062471, WO2013/133757, WO2013/165305 and WO2013/165306, all of which are incorporated herein by reference.

In the illustrated example, the apparatus 100 also includes a controller 12 which is connected to selectively control the activation of the emitters 2 and, possibly, the readout of data from the detectors 3. Depending on implementation, the emitters 2 and/or detectors 3 may be activated in sequence or concurrently, e.g. as disclosed in WO2010/064983. The signal processor 10 and the controller 12 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 10 and the controller 12 may be at least partially implemented by software executed by a processing unit 14, such as a CPU.

Embodiments of structures for outcoupling and detection of light will now be explained in detail with reference to Figs 4-12. Generally, these embodiments are

presented in the context of the touch-sensitive apparatus shown in Fig. 2.

2. Outcoupling structure

Fig. 4 illustrates a section that may be taken along any one of the detection lines D of the touch-sensitive apparatus in Fig. 2. For simplicity, only a portion of the apparatus at and around the outcoupling structure is shown. The outcoupling structure is made up of a sheet-like angular filter 20 which is applied with its front face to the panel 1 at the periphery of the touch surface 4 to define an outcoupling port for the light propagating in the panel 1. A detector 3 is applied with its light-sensing surface 3A onto the rear face of the angular filter 20. In an alternative (not shown), a spacer of light transmissive material is disposed between the surface 3A and the filter 20. The angular filter 20 is designed to only be transmissive to light within a given angular range, i.e. for light that impinges on the filter 20 at certain angles of incidence to the normal N (Fig. 5B) of the filter 20. Fig. 5A is a plot of the transmission of the filter 20 as a function of angle of incidence. As seen, the filter 20 transmits light within a given angular range between a lower limit θ_{min} and an upper limit θ_{max}, while reflecting light that impinges on the filter at other angles of incidence. Any criterion may be used for defining the limits θ_{min}, θ_{max}, e.g. a percentage (e.g. 25, 50 or 75) of absolute or maximum transmission. Fig. 5B illustrates the angular range in relation to a single position on the front surface of the filter 20. As seen, the angular range is equal in all directions in the plane of the filter 20. Preferably, the angular range is essentially the same at all positions on the filter 20.

It should be understood that the filter 20 need not be designed to define the given angular range for all wavelengths, but only for a limited wavelength range that includes the wavelength(s) of the propagating light. In a preferred embodiment, the angular filter 20 is reflective to all angles outside the limited wavelength range. In one example, the propagating light has a wavelength 850 nm with a bandwidth of 20 nm, and the filter 20 is designed to have an angular range $[\theta_{min} - \theta_{max}]$ in the wavelength range of 800-900 nm, and to be reflective to light at wavelengths from 400 nm to 800 nm, and possibly also at wavelengths above 900 nm, irrespective of angle of incidence. Alternatively, a dedicated wavelength filter may be installed in front of or behind the angular filter 20 to be absorbing or reflective to incoming light outside the limited wavelength range, for all angles of incidence.

It should also be understood that the filter 20 is designed to provide the angular range $[\theta_{min} - \theta_{max}]$ for a specific installation, i.e. when mounted with its front face to the panel 1 and with its rear side to the surface 3A (or a spacer). For example, the design may be adapted to the refractive index of the panel 1 and the refractive index of

the light-sensing surface 3A (or the spacer).

The filter 20 may be designed as a dielectric multilayer structure of at least two different materials, similar to an interference filter. It lies within the reach of the person skilled in optical design to select appropriate materials and number of layers to achieve the desired angular range for light at a wavelength generated by the emitters 2.

In embodiments of the invention, the filter 20 is tailored to suppress the amount of ambient light received at the light-sensing surface 3A in relation to the amount of useful light, i.e. light that has propagated on one or more detection lines from a respective incoupling structure. This effect may be achieved by adapting the angular range of the filter 20 to the angles of incidence (AOI) of the propagating light on the filter 20. Ambient light typically contains daylight and/or light from artificial light sources. Such ambient light includes NIR light which, if it falls on the surface 3A, will interfere with the detection of the propagating NIR light inside the panel 1. As exemplified by ray A1 shown in Fig. 4, ambient light that falls on the front surface 5 is refracted into the panel 1 and would have impinged on the surface 3A were it not for the angular filter 20. The angular filter 20 is designed to reflect the ambient light A1 back towards the front surface 5. As exemplified by ray P1, light that propagates in the panel 1 by TIR and strikes the filter at an AOI within the angular range of the filter 20, is transmitted to the light-sensing surface 3A. Fig. 4 also indicates a ray P2 that propagates in the panel 1 by TIR and strikes the filter 20 at a smaller AOI, which is outside the angular range of the filter 20. This ray P2 is reflected by the filter 20. Any ambient light that falls onto the touch surface 4 will, irrespective of its angle to the touch surface 4, be transmitted through the panel 1, as exemplified by ray A2. The ambient light will not be captured by TIR in the panel 1 since it cannot be refracted into the panel 1 at an angle larger the critical angle (see below).

The use of an angular filter 20 provides a simple technique for selecting the light that is passed to the detector 3 to be represented in the projection signals. The angular filter 20 allows the apparatus 100 to be manufactured with relative ease at low cost and high reliability.

The present Applicant has realized that advantageous technical effects may be achieved by careful selection of the lower limit θ_{min} of the filter 20. Fig. 6 illustrates, in section view, a portion of the panel 1, where different characteristic angles of the panel 1, as well as the limits θ_{min}, θ_{max} of the filter 20, are mapped to a position on the front surface 5. In this example, it is assumed that the panel 1 is made of a single material and has the same refractive index n_{panel} at the front and rear surfaces 5, 6. All angles are defined with respect to the normal N of the front surface 5.

Fig. 6 indicates the critical angle θ_C, which is given by $\theta_C = \arcsin(1/n_{panel})$

and is the minimum AOI of the light that propagates by TIR between the surfaces 5, 6. Fig. 6 also indicates a cut-off angle θ_W for interaction between the propagating light and water deposited on the front surface 5. Propagating light that strikes the surface 5 at AOIs below θ_W will be partly coupled out of the panel 1 and into water on the surface 5, whereas propagating light at AOIs above θ_W will be totally reflected at the interface between the surface 5 and water. According to Snell's law: $n_{panel} \cdot \sin(\theta_W) = n_W \cdot \sin(90°)$, which yields $\theta_W = \arcsin(n_W / n_{panel})$, where the refractive index of water, n_W, is in the range 1.31-1.34, depending on temperature, wavelength, salt content, etc. Fig. 6 also indicates a cut-off angle θf for interaction between the propagating light and finger fat deposited on the front surface 5. Propagating light that strikes the surface 5 at AOIs below θf will be partly coupled out of the panel 1 and into finger fat on the surface 5, whereas propagating light at AOIs above θf will be totally reflected at the interface between the surface 5 and finger fat. According to Snell's law: $n_{panel} \cdot \sin(\theta_f) = n_f \cdot \sin(90°)$, which yields $Q = \arcsin(n_f / n_{panel})$, where the refractive index of finger fat, n_f, typically is in the range of 1.36-1.48, depending on temperature, wavelength, composition, etc. Measurement results presented in "Some observations on fingerprint deposits", by G L Thomas and T E Reynoldson, published in J. Phys. D: Appl. Phys , Vol. 8, pp 724-729 (1975), indicate that n_f may be distributed over the range of 1.40-1.54, with a histogram peak at 1.48-1.50.

Even if the cutoff angles θ_W and θf may not have universally applicable values, given that the refractive indices of water and finger fat fall within a respective range, it is possible to conduct experiments to determine an average or an otherwise representative value of n_W and n_f, respectively, for a particular use case. The examples herein assume $n_W = 1.33$ and $n_f = 1.45$ —1.46. For a panel made of soda-lime glass with *Npanel* = 1-51, assuming $n_W = 1.33$ and $n_f = 1.46$, the cutoff angles are $\theta_C = 41.5°$, $\theta_W = 62°$, and $\theta f = 75°$. For a panel made of PMMA with $n_{panel} = 1.49$, assuming $n_W = 1.33$ and $n_f = 1.45$, the cutoff angles are $\theta_C = 42°$, $\theta_W = 63°$, and $\theta_f = 77°$.

In one embodiment, the angular range of the filter 20 is set to $\theta_{min} \approx \theta_C < \theta_{filter} < 90°$. This will ensure that all propagating light reaches the light-sensing surface 3A while preventing a major part of the ambient light from striking the light-sensing surface 3A.

Further suppression of interferences, i.e. unwanted signal components at the light-sensing surface 3A, may be achieved by setting θ_{min} to exceed θ_C.

In one such embodiment, the angular range is set to $\theta_{min} = \theta_C + \Delta\Theta < \theta_{max} < 90°$, with $\Delta\Theta$ equal to, or larger than, e.g. 5°, 10° or 15°. This embodiment has been found to reduce the influence of ambient light that is coupled into the panel 1 through deposits on the touch surface 4, such as water, saliva, fingerprints, smear, etc

(collectively denoted "contamination" or "surface contamination" herein). With reference to ray A2 in Fig. 4, it was mentioned that all ambient light that falls onto the touch surface 4 will pass through the panel 1. However, the present Applicant has found that this is only true for a perfectly clean touch surface 4. As indicated in Fig. 7, contamination 30 on the touch surface 4 may allow ambient light at an angle of incidence near or larger than θ_C to leak into the panel 1 and be trapped by TIR therein. The present Applicant has realized that this ambient light may have a sizeable influence on the measured signal levels at the detector 3. The Applicant has also found, surprisingly, that the trapped ambient light is largely concentrated to a limited range of AOIs at the filter 20, close to and above the critical angle θ_C. Thus, a portion of the trapped ambient light may be prevented from reaching the detector 3 by choosing $\theta_{min} = \theta_C + \Delta\Theta$ with an angular span $\Delta\Theta$ equal to or larger than the limited range of AOIs. It is currently believed that the concentration of the ambient light to the limited range of AOIs is caused by Mie scattering in the contamination 30, as well as refraction by contamination droplets, causing the ambient light to enter the panel with a slightly widened distribution, as indicated by 32 in Fig. 7. The widening due to Mie scattering and refraction in contamination droplets may be in the range of ±5° to ±10°. The ambient light typically falls onto the contamination 30 at many different angles. Since all ambient light that enters the panel 1 at an angle below θ_C will pass through the panel 1 and since the intensity of the ambient light typically decreases with increasing angle to the normal N of the panel, the trapped ambient light will be concentrated at and slightly above θ_C. It should also be noted that if the refractive index of the panel 1 is larger than the refractive index of the contamination 30: $n_{panel} > n_{cont}$, the AOIs for the ambient light refracted into the panel 1 via the contamination 30 cannot exceed $arcsm(n_{cont}/n_{panel})$.

The present Applicant has found that further advantageous and unexpected effects are achieved by designing the filter 20 with a given relation between the lower limit θ_{min} and the cut-off angle θ_W or θ_f.

In one such embodiment, the angular range is set to $\theta_{min} \leq \Theta \leq \theta_{max}$, where $\theta_{min} \geq \theta_W$ and $\theta_{max} < 90°$. Thus, the filter 20 is designed to only transmit light with AOIs that are equal to or larger than the cut-off angle θ_W for water. This embodiment has the ability of significantly reducing the influence on the resulting projection signals from water-containing deposits on the touch surface 4. As noted above, the portion of the propagating light that strikes water at AOIs below θ_W will be at least partially coupled out of the panel 1 and interact with the water. Thus, the portion of the propagating light that reaches the filter 20 at AOIs below θ_W has been significantly more attenuated by water than the remainder of the propagating light. This embodiment

also has the ability of reducing the impact of differences in finger interaction between users and even between fingers of a single user. These differences may make it difficult to properly detect all touching objects on the touch surface, and it may require the signal processor 10 to be configured with a large dynamic range for retrieving and processing the projection signals. A significant part of the differences in finger interaction has been found to emanate from different moisture levels on the fingers. The filter design of this embodiment will suppress the influence of moisture in the projection signals and thus reduce the impact of differences in finger interaction.

In this embodiment, the propagating light that is transmitted by the filter 20 has impinged on the touch surface 4 with AOIs at or above θ_W. At these AOIs, the propagating light will still be coupled into the outermost layer of the finger that form part of the epidermis, since this layer *(stratum corneum)* is known to have a refractive index of about 1.55 in the infrared, e.g. according to measurement results presented in *"A survey of some fundamental aspects of the absorption and reflection of light by tissue"*, by R.J. Scheuplein, published in J. SOC. COS. CHEM. 15, 111-122 (1964), and *"The optics of human skin"*, by Anderson and Parrish, published in Journal of Investigative Dermatology 77, 1, 13-19 (1981). This means that propagating light is coupled into the finger for AOIs at least up to a cutoff angle $\theta_{SC} = \arcsin(1.55/n_{panel})$. If $n_{panel} \leq 1.55$, the cutoff angle θ_{SC} is not relevant, and all AOIs below 90° will interact with the stratum corneum (and other outer layers of the finger). If $n_{panel} > 1.55$, it is conceivable to set $\theta_{min} \leq \theta_{SC}$ for the filter 20, should there be a need to suppress propagating light at AOIs above θ_{SC}.

It should also be noted that this embodiment may eliminate, or at least significantly suppress, ambient light that has been coupled into the panel via water on the touch surface 4 and has propagated by TIR to the filter 20. As explained above, this ambient light has a maximum AOI of $\arcsin(n_{cont}/n_{panel})$, which is equal to θ_W with $n_{cont} = n_W$.

In another embodiment, the angular range is set to $\theta_{min} \leq \Theta \leq \theta_{max}$, where $\theta_{min} \geq \theta_f$ and $\theta_{max} < 90°$. This embodiment has the ability of significantly reducing the influence on the resulting projection signals from deposits containing finger fat, e.g. fingerprints, on the touch surface 4. Fingerprints are typically a substantial part of the contamination on the touch surface, and a major concern when processing the projection signals for detecting the touching objects. It is thus a significant technical achievement to be able to suppress the influence of fingerprints, and it will reduce the requirements on the signal processor 10 to track and compensate for surface contamination. This embodiment also has the ability of further reducing the impact of differences in finger interaction, since it suppresses the interaction caused by fat on the fingers. Furthermore,

this embodiment may essentially eliminate, or at least significantly suppress, ambient light that has been coupled into the panel via finger fat on the touch surface 4 and has propagated by TIR to the filter 20. This ambient light has a maximum AOI of $arcsm(n_{cont}/n_{panel})$, which is equal to θ_f with $n_{cont} = n_f$.

Reverting to Fig. 4, the width W of the filter 20 (in the direction of the respective detection line) may be optimized with respect to the range of AOIs of the propagating light that should be transmitted onto the light-sensing surface 3A. To ensure that all of this propagating light (i.e. the light with appropriate AOIs) strikes the filter at least once, the width W may be set to exceed the relevant minimum distance between bounces in the rear surface ("minimum bounce distance"). If the panel is made of a single material, the minimum bounce distance is given by $2 \cdot t \cdot \tan(\theta_{min})$, where t is the thickness of the panel 1. To achieve a consistent detection of the propagating light within the limits $\theta_{min}, \theta_{max}$, it may be desirable to set the width to exceed the relevant maximum distance between bounces in the rear surface ("maximum bounce distance"). If the panel is made of a single material, the maximum bounce distance is given by $2 \cdot t \cdot \tan(\theta_{max})$. In practice, the width W may be given by other design considerations, which may (but need not) set the limit θ_{max} of the filter 20. Further, the skilled person is able to calculate the minimum bounce distance and the maximum bounce distance for a panel consisting of more than one layer.

The foregoing design rules for the angular filter were given for a panel 1 with a single index of refraction. However, corresponding design rules are applicable for the angular filter 20 when applied to a panel 1 made up of two or more layers with different index of refraction. Fig. 8 illustrates a panel 1 formed by a top layer with index of refraction n_1 and a bottom layer with index of refraction n_2. Light having an angle of incidence θ_1 at the front surface 5 will impinge on the rear surface 6 with an angle of incidence $\theta_2 = \arcsin(n_1/n_2 \cdot \sin(\theta_1))$. This means that the limits $\theta_{min}, \theta_{max}$ of the filter 20, if mounted on the rear surface 6, should be set with respect to the critical angle θ_C at the front surface 5 as represented at the rear surface 6, or with respect to the cut-off angles θ_W, θ_f at the front surface 5 as represented at the rear surface 6. The skilled person realizes that n_{panel} in the above expressions for θ_C, θ_W and θf is the refractive index of the panel 1 at the outcoupling region where the filter is mounted. In the example of Fig. 8, $n_{panel} = n_2$.

A different situation may arise if the panel 1 is laminated to a display 34 by means of a lamination layer 36 of light transmissive material, as shown in Fig. 9A. If the display 34 does not reflect light back to the panel 1, the lamination layer 36 may be designed with a smaller refractive index n_{lam} than the panel. This will cause light that impinges on the interface between the panel and the lamination layer 36 at angles equal

to $\theta_{c,i} = \arcsin(n_{lam}/n_{panel})$, or larger, to be totally reflected at this interface. Light that impinges on the interface at smaller angles, e.g. as indicated by a dotted arrow in Fig. 9A, will be transmitted via the lamination layer 36 to the display 34. This means that the minimum AOI of the light that propagates by TIR between the surfaces 5, 6 and strikes the filter 20, is $\theta_{c,i}$ rather than θ_C. In such an embodiment the angular range of the filter 20 may be set according to $\theta_{min} \leq \Theta \leq \theta_{max}$, where $\theta_{min} \geq \theta_{c,i}$ and $\theta_{max} < 90°$. Of course, the angular range may instead be designed with respect to θ_W or θ_f, according to the embodiments described above.

It should be noted that a lamination layer 36 may generally be introduced between the rear surface 6 of the panel 1 and any external device when it is desirable to "optically isolate" the propagating light in panel from the external device, whereby the propagating light is shifted to larger angles of incidence by virtue of $\theta_{c,i} > \theta_C$. Based on the foregoing discussion, it is understood that it may be desirable to select the material of the lamination layer 36 such that $\theta_{c,i} \geq \theta_W$ or $\theta_{c,i} \geq \theta_f$, so as to reduce the attenuation caused by contamination on the touch surface 4. In another variant, it may be desirable to select the material of the lamination layer 36 such that $\theta_{c,i} \geq \theta_C + \Delta\Theta$, where $\Delta\Theta$ is selected to reduce the influence of ambient light that enters the panel via contamination on the touch surface 4, as discussed above with reference to Fig. 7.

A similar concept may be implemented even if the panel 1 is not laminated to a display 34. This concept is illustrated in Fig. 9B, in which an assembly of layers 37, 38 is applied to the rear surface 6 to extend between an incoupling structure, which couples an emitter 2 to the panel 1, to an outcoupling structure, which couples a detector 3 to the panel 1, in this example via an angular filter 20. A coupling layer 37 of light transmissive material is applied to the rear surface 6 and a light absorbing layer 38 is applied to the coupling layer 37. The layers 37, 38 may be provided as thin, sheet-like elements. The light absorbing layer 38 absorbs at least in the wavelength range of the light injected by the emitter 2 and is preferably transmissive in the visible wavelength range so that e.g. an underlying display may be seen through the front surface 5. Such a display may be either spaced from or attached (laminated) to the absorbing layer 38. The refractive index n_{coupl} of the coupling layer 37 may be tailored in relation to the refractive index n_{panel} of the panel 1, so as to selectively define the minimum AOI of the light that propagates in the panel 1. Thus, if the coupling layer 37 is designed with a smaller refractive index n_{coupl} than the panel, the minimum AOI of the light that propagates by TIR between the surfaces 5, 6 and reaches the outcoupling site is $\theta_{CC} = \arcsin(n_{coupl}/n_{panel})$ rather than θ_C. It is understood that the material of the coupling layer 37 may be selected such that $\theta_{CC} \geq \theta_W$ or $\theta_{CC} \geq \theta_f$, so as to reduce the attenuation caused by contamination on the touch surface 4. In another variant, the

material of the coupling layer 37 may be selected such that $\theta_{CC} \geq \theta_C + \Delta\Theta$, where $\Delta\Theta$ is selected to reduce the influence of ambient light that enters the panel via contamination on the touch surface 4, as discussed above with reference to Fig. 7.

Advantageous effects are obtained even if the assembly of layers 37, 38 do not extend across the entire rear surface 6 between the incoupling and outcoupling structures. For example, the assembly of layers 37, 38 may be spaced from both the incoupling structure and the outcoupling structure. Further alternatives are discussed further below with reference to Figs 13A-13B and Fig. 14D.

It should be noted that the concepts of using a lamination layer 36 or a coupling layer 37 to control the minimum AOI of the propagating light need not be combined with an angular filter in the outcoupling structure and/or an angular filter in the incoupling structure (see below), in order to reduce the impact of ambient light or contamination. However, such a combination may be desirable in certain implementations. For example, the angular filter 20 may be installed in the outcoupling structure to block ambient light that falls onto the front surface 5 and is refracted towards the outcoupling structure (cf. ray A1 in Fig. 4). However, it is to be understood that the impact of such ambient light may be reduced by other techniques, e.g. by modulation of the propagating light or by installing a dedicated shielding layer on the front surface 5 above the outcoupling structure. It may also be advantageous to combine a lamination layer 36 or coupling layer 37, for controlling the minimum AOI of the propagating light, with an angular filter in the outcoupling structure, so as to relax the requirements on the layer 36, 37 and the filter 20, respectively. Thus, a less than optimal selection of the layer 36, 37 may be compensated by the angular filter 20, and vice versa. The lower limit of the filter 20 may be set as: $\theta_{min} \geq \theta_{CC}$. Of course, the angular range may instead be designed with respect to θ_W or θ_f, as described hereinabove.

It should also be noted that, for efficient utilization of light, the light emitter 2 may be coupled to the panel 1 such that the injected light impinges on the lamination layer 36 (or the coupling layer 37) at an AOI that is essentially equal to or exceeds $\theta_{c,i}$ (or θ_{CC}) to avoid that useful light is leaked into the layer 36 (or 37). Such an implementation may also serve to further reduce the impact of contamination on the front surface 5. In Fig. 9B, the incoupling structure injects a ray PI which, in the absence of surface contamination, would be specularly reflected at the front surface 5 and then coupled into layer 37 and absorbed by layer 38. However, as illustrated, the ray PI strikes the contamination 30 on the front surface 5, and some of the resulting scattered light, represented by ray SI, may propagate to the outcoupling site. If sensed by the detector 3, the scattered light SI might disrupt the detection of touches. It is understood that the impact of contamination is reduced if the incoupling structure is designed such that a

major portion, or ideally all, of the injected light is injected at angles that sustain propagation in the panel 1, represented by ray P2 in Fig. 9B.

In the foregoing, it has been assumed that the cutoff angles θ_W and θf are given by the TIR angle at the interface between the panel and water and finger fat, respectively. However, it shall be appreciated that the TIR angles correspond to 100% reflection at the interface, and that the reflectivity at the interface does not exhibit a step change at the TIR angle but is a continuous, but steep, function within increasing AOI until the TIR angle. This is illustrated in Fig. 16, which is a graph of the reflectivity R at a panel-to-water interface as a function of AOI, Θ given by the equations:

$$R_p = \left| \frac{n_{panel} * \cos\theta - n_w * \sqrt{1 - \left(\frac{n_{panel}}{n_w} \sin\theta\right)^2}}{n_{panel} * \cos\Theta + n_w * \sqrt{1 - \left(\frac{n_{panel}}{n_w} \sin\theta\right)^2}} \right|^2$$

$$R_s = \left| \frac{n_{panel} * \sqrt{1 - \left(\frac{n_{panel}}{n_w} \sin\theta\right)^2} - n_w * \cos\Theta}{n_{panel} * \sqrt{1 - \left(\frac{n_{panel}}{n_w} \sin\theta\right)^2} + n_w * \cos\Theta} \right|^2$$

$$R = \frac{R_s + R_p}{2}$$

with $n_{panel} = 1.51$ and $n_w = 1.33$.

As understood from Fig. 16, it is possible to define the cutoff angles θ_W and θf at a given fraction of 100% reflection, e.g. 0.25 or 0.50, while still achieving an essentially complete suppression of the influence of water and finger fat, respectively. In practice, this means that it is possible to adjust the cutoff angles slightly from the TIR angles towards smaller AOIs: $\theta_W = \arcsin(n_w / n_{panel}) - \delta\theta$ and $\theta_f = \arcsin(n_f / n_{panel}) - \delta\theta$, where $\delta\theta$ is typically less than 2°. As used herein, any reference to θ_W and θf is intended to inherently include this minor shift $\delta\theta$.

Generally, it may be desirable to limit the size of the individual detectors 3, and specifically the extent of the light-sensing surface 3A. For example, the cost of light detectors may increase with size. Also, a larger detector typically has a larger capacitance, which may lead to slower response (longer rise and fall times) of the detector. It is realized that it may be difficult to reduce the extent W of the detector 3 in the embodiment of Fig. 4, without sacrificing the ability to consistently detect the propagating light.

Fig. 10A illustrates an alternative embodiment that at least partly overcomes this problem. Like in Fig. 4, the angular filter 20 is applied to the rear surface 6, but the detector 3 is arranged with its light-sensing surface 3A essentially perpendicular to the

main extent of the panel 1. As used herein, "essentially perpendicular" is intended to include deviations of about ±20° or less from perpendicular. A spacer 22 is disposed between the angular filter 20 and the light-sensing surface 3A. The spacer 22 may be made of any suitable light transmissive material, such a plastic material or glass, or a silicone compound, a glue, a gel, etc. In the example of Fig. 10A, the spacer 22 is made of the same material as the panel 1, i.e. $n_{spacer} = n_{panel}$. By arranging the surface 3A vertically, the extent of the surface 3A may be reduced significantly compared to the embodiment in Fig. 4. When the extent of the angular filter is W, the minimum vertical extent of the surface 3A may be given by $W/\tan(\theta_{min})$ to ensure that all of the transmitted light from the filter 20 is received at the surface 3A. The extent of the surface 3A may be reduced further by selecting the material of the spacer 22 such that $n_{spacer} <$ ***npaneh*** causing the transmitted light to be refracted away from the normal and resulting in a smaller projected height at the location of the surface 3A.

Even if the outcoupling structure in Fig. 10A allows for a smaller light-sensing surface 3A, the extent of the surface 3A is still dependent on the angular range of the filter 20. Further, the vertical extent of the surface 3A has a direct impact on the thickness of the apparatus 100. At present, the embodiment in Fig. 10A is believed to be useful only when θ_{min} is larger than about 45°, to avoid that the height of the outcoupling structure becomes excessive.

This problem is at least partly overcome by the embodiment illustrated in Figs 10B-IOC. As shown in section in Fig. 10B, the angular filter 20 is applied to the rear surface 6, and a light recycler 40 is arranged beneath the filter 20 in surrounding relationship to the light-sensing surface 3A. The recycler 40 is designed to internally reflect the light that is transmitted by the filter 20 and to modify the angular distribution of the transmitted light. The recycler 40 defines a reflective enclosure around the light-sensing surface 3A. The enclosure is filled by a spacer material 22, e.g. any of the spacer materials discussed in relation to Fig. 10A. The recycler 40 comprises a reflective bottom surface 42A with an opening for the detector 3 (illustrated as mounted on a PCB 45) and reflective sidewalls 42B that extend from the bottom surface 42A to the filter 20. In the illustrated embodiment, the bottom surface 42A is diffusively reflective to impinging light, whereas the sidewalls 42B are specularly reflective to impinging light. As used herein, "specular reflection" is given its ordinary meaning, which refers to the mirror-like reflection of light from a surface, in which light from a single incoming direction (a ray) is reflected into a single outgoing direction. Specular reflection is described by the law of reflection, which states that the direction of incoming light (the incident ray) and the direction of outgoing light reflected (the reflected ray) make the same angle with respect to the surface normal, and that the incident, normal, and

reflected directions are coplanar. As used herein, "diffuse reflection" is given its ordinary meaning, which refers to reflection of light from a surface such that an incident ray is reflected at many angles rather than at just one angle as in specular reflection. The diffuse reflection is also known as "scattering". The skilled person appreciates that many surfaces/elements/materials exhibit a combination of specular and diffuse reflection. As used herein, a surface is considered "diffusively reflective" when at least 20% of the reflected light is diffuse. The relation between diffuse and specular reflection is a measurable property of all surfaces/elements/materials.

To exemplify the function of the outcoupling structure, Fig. 10B illustrates a single ray P1 that is transmitted and refracted into the recycler 40 by the filter 20. The ray strikes the bottom wall 42A and is diffusively reflected, as indicated by the encircled rays 46. The diffusively reflected light spreads over a large solid angle in the recycler 40, and some of this light is specularly reflected by the filter 20 onto the light-sensing surface 3A. Although not shown, other parts of the diffusively reflected light is likely to undergo further reflections in the recycler 40, against the sidewalls 42B, the angular filter 20 and the bottom wall 42A, and eventually impinge on the surface 3A. It should be noted that the angular filter 20 will also transmit light from the recycler 40 back into the panel 1, specifically light that has an angle of incidence within a given angular range which may, but need not, be identical to the angular range $[\theta_{min} - \theta_{max}]$. If these angular ranges are identical, or at least substantially overlapping, it is necessary to redistribute the light by diffuse reflection inside the recycler 40 to prevent that the light that enters the recycler 40 from the panel 1 escapes back into the panel 1 via the filter 20. If the filter 20 is designed such that the angular ranges are sufficiently different (cf. Fig. 10E, below), the recycler 40 may be configured with only specularly reflective walls 42A, 42B.

In the embodiment of Fig. 10B, the use of specular side walls 42B ensures that all of the light that enters the recycler 40 via the filter 20 is re-directed by specular reflection(s) towards the bottom of the recycler 40, where it is either redistributed by diffuse reflection in the bottom wall 42A or directly received by the light-sensing surface 3A. The diffusively reflected light is typically, but not necessarily, emitted with a main direction that is perpendicular to the bottom wall 42A, as shown in Fig. 10B. The bottom wall 42A may e.g. be a near-Lambertian diffuser. The use of a planar bottom wall 42A, as in Fig. 10B, ensures that most of the diffusively reflected light hits the filter 20 at AOIs outside the angular range, such that a main portion of the diffusively reflected light is reflected by the filter 20 back into the recycler 40.

In an alternative, both the bottom wall 42A and the side walls 42B are diffusively reflective. In another alternative, the side walls 42B are diffusively reflective, while the

bottom surface 42A is specularly reflective. In all embodiments, it is possible that only a part of the bottom wall 42A and/or the side walls 42B is diffusively reflective. Generally, it may be advantageous to provide diffusive scattering on surfaces that are arranged such that a significant portion of the light impinging on these surfaces would otherwise be specularly reflected onto the filter 20 within the angular range.

In yet another alternative, the bottom wall 42A is not specularly or diffusively reflective, but provided with a micro-structure, which is configured to reflect and re-direct impinging light onto the light sensing-surface 3A, by specular reflection against the filter 20 and possibly by reflection against the specular side walls 42B. The micro-structure thus forms a mirror with an optical power that is tailored to the incoming light, i.e. the light that is transmitted by the filter 20 and hits the micro-structure on the bottom wall 42A, either directly or by reflection(s) in the side walls 42B. The use of specularly reflective side walls 42B may facilitate the design of the micro-structure, but it is possible to use diffusively reflective side walls 42B, or a combination thereof. The micro-structure may be implemented as a sheet-like Fresnel mirror.

Compared to the embodiments in Fig. 4 and Fig. 10A, there is no direct relation between the extent of the angular filter 20 and the required size of the light-sensing surface 3A, since the recycler 40 is designed to retain a portion of the transmitted light by internal reflections until it impinges on the surface 3A. Furthermore, there is large freedom of placing the detector 3 in relation to the recycler 40, and it can even be accommodated in a side wall 42B instead of the bottom wall 42A. It is realized that the outcoupling structure may be optimized with respect to manufacturing requirements, without any major loss in outcoupling efficiency. Also, assembly tolerances may be relaxed.

As shown in the plan view of Fig. 10C, the combination of angular filter 20 and recycler 40 will collect light from all directions in the plane of the panel 1, provided that the incoming light impinges on the angular filter 20 with AOIs within the angular range $[\theta_{min} - \theta_{max}]$. Thus, the outcoupling structure in Fig. 10C can accept light from many different directions in the plane of the panel 1 and define the end point of detection lines from different emitters (cf. Fig. 2). In the example of Fig. 10C, the recycler 40 is circular in plan view, but other shapes are possible, e.g. elliptical or polygonal. As described in relation to Fig. 4, it may be desirable that the extent W of the recycler along each of the detection lines is equal to at least the minimum bounce distance or at least the maximum bounce distance.

In all embodiments, the specularly reflective wall(s) of the recycler 40, if present, may be implemented by an external coating, layer or film which is applied to the spacer material 22, e.g. a metal such as aluminum, copper or silver, or a multilayer structure, as

is well-known to the skilled person.

In all embodiments, the diffusively reflective wall(s) of the recycler 40, if present, may be implemented by an external coating, layer or film of diffusively reflective material which is applied to the spacer material 22. In one implementation, the diffusively reflective material is a matte white paint or ink. In order to achieve a high diffuse reflectivity, it may be preferable for the paint/ink to contain pigments with high refractive index. One such pigment is TiO_2, which has a refractive index n=2.5-2.7. It may also be desirable, e.g. to reduce Fresnel losses, for the refractive index of the paint binder (vehicle) to match the refractive index of the spacer 22. For example, depending on refractive index, a range of vehicles are available such as oxidizing soya alkyds, tung oil, acrylic resin, vinyl resin and polyvinyl acetate resin. The properties of the paint may be further improved by use of e.g. EVOQUE™ Pre-Composite Polymer Technology provided by the Dow Chemical Company. There are many other diffusively reflective coating materials that are commercially available, e.g. the fluoropolymer Spectralon, polyurethane enamel, barium-sulphate-based paints or solutions, granular PTFE, micro-porous polyester, Makrofol® polycarbonate films, GORE® Diffuse Reflector Product, etc. Also, white paper may be used. Alternatively, the diffusively reflective material may be a so-called engineered diffuser. Examples of engineered diffusers include holographic diffusers, such as so-called LSD films provided by the company Luminit LLC.

According to other alternatives, the diffusively reflective wall(s) of the recycler 40 may be implemented as a micro-structure in the spacer material 22 with an overlying coating of specularly reflective material. The micro-structure may e.g. be provided in the spacer material 22 by etching, embossing, molding, abrasive blasting, etc. Alternatively, the micro-structure may be attached as a film or sheet onto the spacer material 22. The above-described mirror with an optical power tailored to incoming light may also be provided as a micro-structure in or on the spacer material 22.

Below follows a description of variants of the outcoupling structure in Fig. 4. Unless explicitly excluded, the bottom wall 42A and the side walls 42B may be configured according to any of the embodiments, alternatives and variants described in relation to Figs 10B-10C.

Fig. 10D illustrates an outcoupling structure that may improve the ability of the outcoupling structure to achieve a consistent detection of the propagating light within the limits $\theta_{min}, \theta_{max}$, when the width W of the angular filter 20 and the light-sensing surface 3A is smaller than the maximum bounce distance or even smaller than the minimum bounce distance. This is achieved by providing the edge surface, which connects the front and rear surfaces 5, 6, with a specularly reflective coating 48 at the location of angular filter 20. As shown, the coating 48 will operate to reflect, back into

the panel 1, the propagating light that passes above the angular filter 20, including propagating light that strikes the filter 20 at AOIs outside the angular range $[\theta_{min} - \theta_{min}]$ and propagating light that does not strike the angular filter 20. It is realized that the coating 48 will reflect the incoming light without changing its AOIs. Thus, a portion of the reflected light will have AOIs that fall within the angular range of the filter 20. Such reflected light will be transmitted by the filter 20 to the extent that it strikes the filter 20 on its way back towards the touch surface 4. Thereby, the reflective coating 48 operates to increase the outcoupling efficiency.

It is not strictly necessary to arrange the angular filter 20 directly adjacent to the edge surface for the coating 48 to perform its function of increasing outcoupling efficiency. However, such a placement may be preferred to ensure that light on different detection lines can be reflected by the coating 48 onto the angular filter 20.

The reflective coating 48 may be generally implemented to increase outcoupling efficiency in all embodiments disclosed herein.

Fig. 10E illustrates a variant of the outcoupling structure in Fig. 10B. The recycler 40 is configured as a hollow case, i.e. without spacer material. This is achieved by providing the angular filter 20 with a disruptive optical element 52 on its exit surface to enable the light transmitted by the angular filter 20 to enter the hollow recycler 40. In the absence of the disruptive optical element 52, the light passing the filter 20 would have been reflected back into the filter 20 by TIR in the exit surface. In one embodiment, the element 52 is a transmissive imaging component that refracts the incoming light. The imaging component 52 thus defines an optical power that is tailored to the light passing the filter 20, e.g. to refract the light onto the light sensitive surface 3A and/or dedicated portions of the bottom and sidewalls 42A, 42B. Thereby, the walls 42A, 42B may, but need not, be specularly reflective. Such an imaging component 52 may achieve highly efficient coupling of light into the recycler 40, but may require careful positioning with respect to the filter 20 and the recycler 40. The optical power may be defined by a micro-structure that spans the surface of the imaging component 52. In one example, the micro-structure defines a sheet-like Fresnel lens.

In another embodiment, the disruptive optical element 52 is a non-imaging, diffusively transmitting component ("transmissive diffuser"). In this embodiment, the light that enters the recycler 40 is diffusive. Since light is angularly redistributed on entry, the walls 42A, 42B may, but need not, be specularly reflective. Preferably, the transmissive diffuser 52 is shift invariant to the incoming light, so that it does not have to have a specific position to the incoming light. In one example, the transmissive diffuser 52 is configured without refracting structures. Such a transmissive diffuser 52 may be implemented as a film of diffusing particles in a simple, robust and cost

effective manner. The film may be applied to the filter 20 by painting, spraying, lamination, gluing, etc. Any inherently translucent material may be used for forming the film, e.g. a matte white paint or ink. However, the paint may be optimized to obtain a desired diffusive transmission ratio, e.g. by including pigments with low refractive index or spherical objects of different materials. In another example, the transmissive diffuser 52 comprises refracting structures on the side facing the away from the filter 20. In such a transmissive diffuser, also known as an engineered diffuser, the refracting structures may be implemented as an arrangement (e.g. random, pseudo-random, hexagonal, etc) of microstructures (e.g. micro-lenses, micro-cones or micro-prisms) tailored to generate a desired diffuse transmission. The engineered diffuser may be a separate flat or sheet-like device which is attached to the filter 20, or may be a surface structure on the filter 20 provided by etching, embossing, molding, abrasive blasting, etc.It is to be understood that the disruptive optical element 52 may also be implemented in the embodiment in Fig. 10A, to obviate the need for spacer material 22 between the angular filter 20 and the detector 3.

Fig. 10F illustrates a further variant of the outcoupling structure in Fig. 10B. Here, the detector 3 is side-looking when mounted on a PCB 45. The detector 3 is inserted into the spacer material 22 such that the light-sensing surface 3A projects beyond the bottom surface 42A of the recycler 40 and is perpendicular to the extent of the panel 1 and the angular filter 20. By arranging a side-looking detector 3 inside the recycler 40, it is possible to provide an increased light-sensing surface 3A for a given opening in bottom surface 42A, especially if the light-sensing surface 3A extends around the perimeter of the detector 3. The increased light-sensing surface 3A may result in an increased outcoupling efficiency. In a variant, the top surface of the detector 3 may be provided with a diffusively reflective structure to enhance the angular redistribution of light inside the recycler 40.

Fig. 10G illustrates a further variant of the outcoupling structure in Fig. 10B, in which the recycler 40 is configured as a funnel tailored to direct the light transmitted by the filter 20 onto the light-sensing surface 3A. The funnel is defined by the walls 42A, 42B, which are specularly reflective. It should be noted that the recycler 40 may have other shapes than shown in Fig. 10G. For example, the bottom wall 42A may be parabolic. Other suitable shapes may be obtained by optical system optimization, such as by ray tracing. Furthermore, the walls 42A, 42B may be merged into a common funnel structure, which may be parabolic or have any optimized shape. The recycler 40, and optionally the filter 20, may be integrated with the detector 3 into a package, which is attached to the rear surface 6 during manufacture of the apparatus.

Fig. 10H illustrates a variant of the outcoupling structure in Fig. 4. In Fig. 10H,

the apparatus 100 further comprises a visibility filter 50, which is arranged to hide (shield) the angular filter 20, the detector 3 and the internal structure of the apparatus 100 from view through the front surface 5. The visibility filter 50 is non-transmissive (reflecting and/or absorbing) to visible light and transmissive to NIR light, and preferably only transmissive to NIR light in the wavelength region of the propagating light. The visibility filter 50 may be implemented as a coating or film, in one or more layers. In Fig. 10H, the visibility filter 50 extends from the inner edge of the angular filter 20 to the edge of the panel 1, although the visibility filter 50 may extend further beyond the angular filter 20 towards the center of the panel. In Fig. 10H, the visibility filter 50 is arranged beneath the panel 1, intermediate the rear surface 6 and the angular filter 20. This enables the front surface 5 to be perfectly flat and free of projecting elements. In a variation, not shown, the visibility filter 50 is arranged intermediate the angular filter 20 and the detector 3. In a further variation, not shown, the visibility filter 50 is applied to the front surface 5. It is to be understood that the visibility filter 50 may be implemented in conjunction with any outcoupling structure described herein.

There are other ways of integrating the angular filter in the outcoupling structure than by arranging the above-described multilayer structure in front of the detector 3. For example, the angular filter may be formed by a structure that geometrically and mechanically limits the light rays that can reach the detector, as exemplified below with reference to Figs 11-12.

Fig. 11A is a side view of a first alternative outcoupling structure as attached to the panel 1, and Fig. 11B is a top plan view of the outcoupling structure. The outcoupling structure forms an angular filter 20 by defining an angularly limited propagation path from an outcoupling port 60 to the light-sensitive surface 3A. The angular filter 20 is defined by non-transmissive layers 61-63 on a body of light transmissive material 22, e.g. any of the spacer materials discussed in relation to Fig. 10A. Layers 61 and 62 are arranged on top of the body, to define the outcoupling port 60 at the interface between the body and the panel 1. Layer 61 is light-absorbing and formed as an annulus segment. Layer 61 only needs to be absorbing to light inside the body. Layer 62 is specularly reflective and formed as a semi-circle, which may extend to the inner radius of the annulus segment, as shown, or to the outer radius of the annulus segment (i.e. between layer 61 and the panel 1). The top of the body is attached to the rear surface 6 of the panel 1, and the light detector 3 is attached to a short-side of the body such that the surface 3A is shielded beneath the layers 61, 62. Layer 63 is specularly reflective and attached to bottom side of the body.

Fig. 11A illustrates one propagating ray P1 that passes the outcoupling port 60 at an AOI within the angular range of the filter 20 and is reflected by layer 63 onto surface

3A. Fig. 11A also illustrates a propagating ray P2 that propagates in the panel 1 by TIR and passes the outcoupling port 60 and is reflected by layer 63 onto layer 61 which absorbs the ray. As seen, the structure of layers 61-63 define the angular range of the filter 20. The width of the layer 61 along the respective detection line defines θ_{min}, for a given vertical height of the body. To achieve similar θ_{min} for all detection lines in the plane of the panel, layer 61 is shaped as an annulus segment, although more complicated shapes are conceivable to achieve a corresponding effect.

Fig. 12A is a side view of a second alternative outcoupling structure as attached to the panel 1, and Fig. 12B is a top plan view of the outcoupling structure. Like the first variant in Fig. 11, the outcoupling structure forms an angular filter 20 by layers 71-73 attached to a body of light transmissive material which is attached to the rear surface 6 of the panel 1. Layer 71 is arranged on top of the body, to define an outcoupling port 70 at the interface between the body and the panel 1. Layer 71 is specularly reflective and, in this example, formed as a semi-circle. Layer 72 is light-transmissive and attached to the bottom surface of the body, and has a refractive index that causes light that impinges on the outcoupling port 70 at AOIs above θ_{min} to be reflected by TIR at the interface between the body and layer 72, whereas light at smaller AOIs is transmitted into layer 72 and is absorbed by layer 73 of light-absorbing material. It is realized that the refractive index of layer 72 is given by $n_{72} = n_{panel} \cdot \sin(\theta_{min})$. The function of the outcoupling structure exemplified by one ray P1 that passes the filter 20 and one ray P2 that is coupled into layer 72.

In both of the first and second variants, it is conceivable that the refractive index n_{spacer} of the body is selected to yield a desired θ_{max} by TIR in the interface between the body and the panel: $n_{spacer} = n_{panel} \cdot \sin(\theta_{max})$.

Fig. 13A illustrates a variant of the embodiment in Fig. 4, in which an assembly of layers 87, 88 (denoted "layered absorber" in the following) is attached to the rear surface 6 adjacent to the outcoupling structure. Layer 87 is light-transmissive and attached to the rear surface 6, and layer 88 is light-absorbing and attached to layer 87. Layers 87, 88 may be configured in correspondence with the coupling layer 37 and the light-absorbing layer 38, respectively, as described above with reference to Fig. 9B. Thereby, the layered absorber will absorb all light that impinges thereon with an AOI below $\theta_{CC} = \arcsin(n_{coupl}/n_{panel})$, where n_{coupl} is the index of refraction of the coupling layer 87. It is realized that the layered absorber may combine with the angular filter 20 to limit the angles of the light that reaches the detector 3. The layered absorber may be configured with a width $WI \geq 2 \cdot t \cdot \tan(\#_{c,c})$, in the direction of the respective detection line, to ensure that the propagating light with AOIs below θ_{CC} strikes the coupling layer 87 at least once. The provision of the layered absorber may relax the

requirements of the angular filter 20, and it may even be possible to omit the angular filter 20, in this and all other outcoupling structures described herein, since the layered absorber effectively forms an angular filter to the light that propagates in the panel 1 towards the outcoupling structure. The limit angle θ_{CC} may be selected to reduce the impact of ambient light and contamination as described above for the assembly of layers 37, 38 (Fig. 9B). The layered absorber may be combined with all outcoupling structures described herein. As a further example, Fig. 13B illustrates such a combination with the outcoupling structure in Fig. 10B which includes a recycler 40.

The sensitivity to contamination may be reduced by increasing the width W1 of the layered absorber. In one extreme, the assembly of layers 87, 88 spans the entire rear surface 6 from the outcoupling structure to the incoupling structure. At this extreme, the layered absorber is identical to the assembly of layers 37, 38 in Fig. 9B. The reason for the improvement with increasing width W1 is believed to be that the propagating light that reaches the detector 3 is less affected by light scattering in surface contamination. As mentioned in relation to Fig. 9B, light that propagates in the panel 1 is scattered when it hits surface contamination, and part of the scattered light will propagate in the panel 1 and possibly be further scattered against surface contamination, and so on. This means that the intensity distribution as a function of AOI for the light that reaches the filter 20, and the amount of light received by the detector 3, will depend on the current distribution of contamination on the touch surface 4. This may, e.g., make it difficult to detect a finger tap on the touch surface 4, since the finger tap leaves a fingerprint which may cause a signal change at the detector 3 that at least partly masks the signal change caused by the finger being lifted from the touch surface. A larger width W1 of the layered absorber will reduce the intensity redistribution caused by light scattering in surface contamination. This effect is seen in Figs 17A-17B, which illustrate time-resolved signal attenuation measured for a detection line on a touch surface heavily contaminated by sebum, while a short finger tap (touch-down followed by touch-up) occurs within the time window At. Fig. 17A shows the result for a panel without a layered absorber, and Fig 17B shows the result with a layered absorber ($\theta_{CC} = 70°$) that spans the entire rear surface between the incoupling and outcoupling structures (cf. Fig. 9B). Signal attenuation is defined as I/I0, where I is the measured intensity at the detector 3, and 10 is the measured intensity without a finger on the detection line. As seen, the measured attenuation rises to a peak at touch-down and then returns to an elevated level at touch-up. The elevated level is caused by the fingerprint left by the finger tap on the touch surface. However, the difference in attenuation between touch-down and touch-up is increased by a factor of 2 in Fig. 17B compared to Fig. 17A. It is understood that the layered absorber may improve the ability to detect a touch-up event

during a finger tap.

3. Incoupling structure

Generally, any type of incoupling structure may be used for coupling light into the panel 1 of the touch-sensitive apparatus. In certain implementations, it may be advantageous for the incoupling structure to include an angular filter similar to the one in the above-described outcoupling structures. A few embodiments of such light incoupling structures will be explained in detail with reference to Fig. 14. Generally, these embodiments are presented in the context of the touch-sensitive apparatus shown in Fig. 2.

Fig. 14A illustrates a section that may be taken along any one of the detection lines **D** of the touch-sensitive apparatus in Fig. 2. For simplicity, only a portion of the apparatus at and around the incoupling structure is shown. The incoupling structure includes a sheet-like angular filter 120 which is applied with its front face to the rear surface 6 of the panel 1 to define an incoupling port at the periphery of the touch surface 4. In the illustrated example, the angular filter 120 is implemented as a multilayer structure, which may be similar to, or even identical to, the angular filter 20 described above in relation to Figs 4-5. A recycler 140 is arranged beneath the angular filter 120 in surrounding relationship to a light-emitting surface 2A of an emitter 2. The recycler 140 defines a reflective enclosure around the light-emitting surface 2A. The enclosure is filled by a spacer material 122, e.g. any of the spacer materials discussed in relation to Fig. 10A. The recycler 140 comprises a reflective bottom surface 142A with an opening for the emitter 2 (illustrated as mounted on a PCB 45) and reflective sidewalls 142B that extend from the bottom surface 142A to the filter 120.

The angular filter 120 is configured to only be transmissive to light from within the recycler 140 within a given angular range $[\theta'_{min} - \theta'_{max}]$ with respect to the normal of the filter 120. Light at other angles of incidence is reflected, specularly or diffusively, back into the recycler 140.

In the embodiment of Fig. 14A, the bottom surface 142A is diffusively reflective to impinging light, whereas the sidewalls 142B are specularly reflective to impinging light. The function of the incoupling structure is exemplified for a few rays originating from the light-emitting surface 2A. As shown, light is emitted from the surface 2A in a divergent beam of light. Some light is emitted onto the filter 120 at angles that are directly transmitted into the panel 1 (one ray shown), whereas other light is reflected against the filter 120 back towards the bottom surface 142A (one ray shown), where it is diffusively reflected, as indicated by the encircled rays 46. Some of this diffusively emitted light is transmitted into the panel 1 by the filter 120, either directly or after reflection in the side wall 142B. The rest of the diffusively reflected light will be

recirculated by further reflections inside the recycler 140. Thus, the recycler 140 operates to gradually concentrate the light from the emitter 2 into the angular range $[\theta'_{min} - \theta'_{max}]$ by multiple reflections inside the recycler 140. Due to the speed of light, this process is instant compared to the time scale used by the signal processor 10 for sampling data from the detectors 3. In a variation, both the bottom wall 142A and the side walls 142B are diffusively reflective. In another alternative, the side walls 142B are diffusively reflective, while the bottom surface 142A is specularly reflective. In all embodiments, it is possible that only a part of the bottom wall 142A and/or the side walls 142B is diffusively reflective.

The use of an angular filter 120 provides a simple, efficient and robust technique for providing light within a well-defined angular range $[\theta'_{min} - \theta'_{max}]$ inside the panel 1.

It should be noted, that the width W of the incoupling structure may be set to be less than the minimum bounce distance for the in-coupled light, which is given by $2 \cdot t \cdot \tan(\theta'_{min})$ if the panel 1 consists of a single material. This ensures that light transmitted by the angular filter 120 and impinging on the front surface 5 at θ'_{min}, or there above, will not be reflected back onto the angular filter 120.

The incoupling structure of Fig. 14A is configured to introduce light into the panel 1 within an angular range $[\theta'_{min} - \theta'_{max}]$ that at least approximately matches the angular range $[\theta_{min} - \theta_{max}]$ of the angular filter 20 in the outcoupling structure. The (approximate) matching of the angular ranges between the incoupling and outcoupling structures will ensure efficient utilization of the available light energy, and it may also reduce the impact of surface contamination, by analogy with the discussion above with reference to Fig. 9B. The matching may be inherently achieved by installing identical angular filters 20, 120 in the incoupling and outcoupling structures.

As shown in the plan view of Fig. 14B, the combination of angular filter 120 and recycler 140 will couple light into the panel for propagation in all directions in the plane of the panel 1, provided that the incoming light impinges on the angular filter 120 with AOIs within the angular range $[\theta'_{min} - \theta'_{max}]$. Thus, the incoupling structure in Fig. 14B can define the starting point of detection lines to different detectors 3 (cf. Fig. 2). In the example of Fig. 14B, the recycler 140 is circular in plan view, but other shapes are possible, e.g. elliptical or polygonal.

Fig. 14C illustrates a variant of the incoupling structure in Fig. 14A. Here, the emitter 2 is side-emitting when mounted on a PCB 45. The emitter 2 is inserted into the spacing material 122 such that the light-emitting surface 2A projects beyond the bottom surface 142A of the recycler 140 and is perpendicular to the extent of the panel 1 and the angular filter 120. By arranging a side-emitting emitter 2 inside the recycler 40, it is

possible to increase the light-emitting surface 2A for a given opening in bottom surface 142A. Furthermore, the top surface of the emitter 2 may be provided with a diffusively reflective surface, to enhance the angular redistribution in the recycler 140. Also, the angular redistribution may be improved since the light from the emitter 2 is at least partly directed towards the bottom wall 142A and the side walls 142B, instead of directly against the angular filter 120 as in Fig. 14A.

Fig. 14D illustrates a variant of the embodiment in Fig. 14A, in which the above-mentioned layered absorber, consisting of layers 87, 88, is attached to the rear surface 6 adjacent to the incoupling structure. For the same reason as in Figs 13A-13B, the layered absorber preferably has a width $W1 \geq 2 \cdot t \cdot \tan(\#_{c\text{-}c})$, and as explained above the effects of the layered absorber may increase with increasing width W1. The layered absorber may be combined with all conceivable incoupling structures. The use of the layered absorber may enable the angular filter 20 to be omitted altogether, in this and all other incoupling structures described herein.

It should also be noted that the above-described visibility filter (cf. 50 in Fig. 10H) may be implemented in conjunction with any incoupling structure described herein, e.g. intermediate the rear surface 6 and the angular filter 120.

Fig. 15A is a bottom plan view of a part of a touch-sensitive apparatus, to illustrate a sequence of emitters 2 and/or detectors 3 that are optically coupled to a panel 1 near one of the panel edges, via a visibility filter 50 which is applied to the rear surface 6 to extend as a coherent, elongate strip along the panel edge. Each emitter 2 and detector 3 is coupled to the panel 1 by a coupling structure, which is formed by an angular filter 20/120 and a recycler 40, 140. The combination of angular filters 20/120 and recyclers 40/140 are arranged as discrete units along the panel edge. Fig. 15B illustrates an alternative implementation, where the angular filter 20/120 is applied onto the visibility filter 50 to extend as a coherent, elongate strip along the panel edge. Thus, the same angular filter 20/120 is used for coupling all emitters 2 and/or detectors 3 to the panel 1 along the panel edge. The recyclers 40/140 may be arranged side-by-side onto the angular filter 120, as shown, or they may be arranged with a mutual spacing, similar to Fig. 15A.

The coupling structures in Figs 15A-15B may be applied to the panel 1 in a sequence of operations, which include applying the visibility layer 50 on the panel 1, applying the angular filters 20/120 onto the visibility layer 50, and applying prefabricated recyclers 40/140 onto the angular filters 20/120. Alternatively, the angular filters 20/120 and the recyclers 40/140 may be provided as a single prefabricated strip which is attached onto the visibility layer 50 on the panel 1 (if present). In another alternative, the recyclers 40/140 are produced by a sequence of processing steps *in situ* on the panel,

including e.g. attaching the spacer material 22/122 to the angular filter 20/120, applying a dedicated coating to the side walls 42B/142B while masking the bottom wall 42A/142A, applying a dedicated coating to the bottom walls 42A/142A while masking the openings for the detectors/emitters 2, 3, and attaching the detector/emitters 2, 3 to the openings.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and the scope of the appended claims.

For example, while technical advantages may be obtained by utilizing angular filters, in particular multilayer structures, for both outcoupling and incoupling, it is conceivable to combine the inventive outcoupling structures that utilize angular filters with conventional incoupling structures, e.g. large prisms or sheet-like microstructures as discussed in the Background section, by direct attachment to the front or rear surface, or by optical coupling via the edge surface.

In certain installations, one or both of the incoupling and outcoupling structures may be arranged on the front surface 5 instead of the rear surface 6.

The foregoing description indicates that certain selections of the lower limit θ_{min} (e.g. with respect to the cutoff angles $\theta_{c,l}$, $\theta_{c,c}$, θ_w, θ_f) results in significant performance improvement. However, it is possible that performance improves gradually as the lower limit θ_{min} is increased from the critical angle θ_C, e.g. in steps 1°, at least in certain installations. Testing of a certain installation may thus indicate that an acceptable performance improvement is attained at another selected θ_{min}, e.g. any angle between θ_C and θ_W, between θ_W and θ_f, and between θ_f and θ_{SC}. The same applies to the selection of refractive index of the lamination layer/coupling layer for suppressing the influence of contamination via the cutoff angle $\theta_{c,l}/\theta_{c,c}$.

CLAIMS

1. A touch-sensitive apparatus, comprising:

a light transmissive panel (1) that defines a front surface (5) and an opposite, rear surface (6);

a plurality of light emitters (2) optically connected to the light transmissive panel (1) so as to generate propagating light that propagates by total internal reflection inside the light transmissive panel (1) across a touch-sensitive region (4) on the light transmissive panel (1);

a plurality of light detectors (3) optically connected to the light transmissive panel (1) so as to define a grid of propagation paths (D) across the touch-sensitive region (4) between pairs of light emitters (2) and light detectors (3);

wherein each light detector (3) is optically connected to the light transmissive panel (1) via an angular filter (20) which is applied to an outcoupling region on at least one of the front and rear surfaces (5, 6) and is configured to transmit the propagating light only within a confined range of angles with respect to the normal of the outcoupling region; and

wherein the confined range extends from a lower angle limit θ_{min} to an upper angle limit θ_{max}, wherein the lower angle limit θ_{min} is equal to or larger than a critical angle θ_C, which is given by θ_C = arcsin (1/n $_{panel}$), with n_{panel} being the refractive index of the light transmissive panel (1) at the outcoupling region.

2. The touch-sensitive apparatus of claim 1, wherein the lower angle limit θ_{min} exceeds the critical angle by an angle AΘ, which is at least 5°, 10° or 15°.

3. The touch-sensitive apparatus of claim 1, wherein the lower angle limit θ_{min} is equal to or larger than a first cut-off angle θ_W = arcsin (n_w / n_{panel}), with n_w being the refractive index of water, $n_{panel} > n_w$.

4. The touch-sensitive apparatus of claim 1, wherein the lower angle limit θ_{min} is equal to or larger than a second cut-off angle θ_f = arcsin (n_f/n_{panel}), with n_f being the refractive index of finger fat, $n_{panel} > n^{\wedge}$.

5. The touch-sensitive apparatus of any preceding claim, wherein the upper angle limit θ_{max} is equal to or smaller than a third cut-off angle θ_{sc} = arcsin (1-55/n $_{panel}$), $n_{panel} >$ 1-55.

6. The touch-sensitive apparatus of any preceding claim, wherein the light transmissive panel (1) is mounted onto a front surface of a display device (34) by a lamination layer (36) of light transmissive material which is arranged in contact with the rear surface (6) of the light transmissive panel (1) and the front surface of the display device (34), and wherein the lower angle limit θ_{min} is approximately equal to or larger

than a laminate cut-off angle θ_{Cl} = arcsin (n_{lam}/n_{panel}), with n_{lam} being the refractive index of lamination layer (36), $n_{lam} < n_{panel}$.

7. The touch-sensitive apparatus of any one of claims 1-5, further comprising a layered light absorber comprising a coupling layer (37, 87) of light transmissive material on the rear surface (6) of the light transmissive panel (1), and an absorbing layer (38, 88) of light-absorbing material on the coupling layer (37, 87), said coupling layer (37, 87) having an index of refraction $n_{coupl} < n_{panel}$.

8. The touch-sensitive apparatus of claim 7, wherein said lower angle limit θ_{min} of the angular filter (20) is approximately equal to or larger than an absorber cut-off angle θ_{CC} = arcsin (n_{coupl}/n_{panel}).

9. The touch-sensitive apparatus of claim 8, wherein the layered light absorber extends from the respective outcoupling port and has a width (Wl) which, along the detection lines (D) that extend to the respective light detector (3), is at least equal to a distance between consecutive reflections in the rear surface (6) for propagating light that impinges on the rear surface (6) with an angle of incidence of θ_{CC} to a normal of the rear surface (6).

10. The touch-sensitive apparatus of claim 8 or 9, wherein the layered light absorber is arranged to overlap a major part, or essentially all of the touch-sensitive region (4).

11. The touch-sensitive apparatus of any preceding claim, wherein the angular filter (20) is configured to define essentially the same confined range of angles for all detection lines (D) that extend to the respective light detector (3).

12. The touch-sensitive apparatus of any preceding claim, wherein the angular filter (20) is configured as a dielectric multilayer structure.

13. The touch-sensitive apparatus of claim 12, further comprising a light recycler (40) which is arranged beneath the angular filter (20) to define a light reflective enclosure with respect to the angular filter (20) and a light-sensitive surface (3A) of the respective light detector (3).

14. The touch-sensitive apparatus of claim 13, wherein the light reflective enclosure comprises a light reflective bottom surface (42A) that is spaced from and extends parallel to the angular filter (20) and a reflective side wall structure (42B) that extends between the light reflective bottom surface (42A) and the angular filter (20). 15. The touch-sensitive apparatus of claim 14, wherein the side wall structure (42B) is specularly reflective, and at least a portion of the bottom surface (42A) is diffusively reflective.

16. The touch-sensitive apparatus of claim 13, 14 or 15, wherein the light reflective enclosure is at least partly diffusively reflecting.

17. The touch-sensitive apparatus of any one of claims 13-16, wherein the light reflective enclosure is filled by a light transmissive material (22).

18. The touch-sensitive apparatus of any one of claims 13-16, wherein the light reflective enclosure is hollow, and wherein a disruptive structure (52) is provided on the angular filter (20) so as to face the light reflective enclosure, wherein the disruptive structure (52) is configured to transmit and redirect at least part of the light transmitted by the angular filter (20) into the light reflective enclosure.

19. The touch-sensitive apparatus of claim 18, wherein the disruptive structure (52) is a non-imaging, diffusively transmitting structure.

20. The touch-sensitive apparatus of claim 18, wherein the disruptive structure (52) is an imaging structure configured to refract the light transmitted by the angular filter (20).

21. The touch-sensitive apparatus of any one of claims 13-20, wherein the light detector (3) is arranged with the light-sensitive surface (3A) facing the angular filter (20).

22. The touch-sensitive apparatus of any one of claims 13-20, wherein the light detector (3) is arranged to project into the light enclosure such that the light-sensitive surface (3A) is facing the side wall structure (42B).

23. The touch-sensitive apparatus of claim 13 or 14, wherein the light reflective enclosure comprises a microstructure (42A) that defines a mirror with an optical power so as to re-direct the transmitted propagating light onto the light-sensing surface (3A).

24. The touch-sensitive apparatus of claim 13 or 14, wherein the light recycler (40) is configured as a funnel which is configured to specularly reflect the transmitted propagating light from the angular filter (20) towards the light-sensitive surface (3A) of the light detector (3).

25. The touch-sensitive apparatus of claim 12, wherein a body (22) of light-transmissive material is attached to the angular filter (20), and wherein the light detector (3) is attached to the body (22) such that a light-sensitive surface (3A) of the light detector (3) directly receives the transmitted propagating light from the angular filter (20).

26. The touch-sensitive apparatus of any preceding claim, wherein the angular filter (20) is arranged to transmit the propagating light to the respective light detector (3) within a respective outcoupling port on the rear surface (6), wherein the extent (W) of the respective outcoupling port, along the detection lines (D) that extend to the respective light detector (3), is at least equal to a distance between consecutive reflections in the rear surface (6) for the propagating light that impinges on the angular filter (20) with an angle of incidence of θ_{min} to a normal of the angular filter (20).

27. The touch-sensitive apparatus of any preceding claim, further comprising a specularly reflective edge element (48) which is arranged, adjacent to the outcoupling region, on an edge portion that connects the front surface (5) and the rear surface (6) of the light transmissive panel (1), so as to specularly reflect the propagating light that impinges on the specularly reflective edge element (48).

28. The touch-sensitive apparatus of any preceding claim, wherein the propagating light comprises light in an infrared wavelength region, and wherein the touch-sensitive apparatus further comprises a visibility shield (50) which is arranged intermediate the rear surface (6) and the angular filter (20), the visibility shield (50) being configured to block light that is visible to the human eye and to transmit at least part of said light in the infrared wavelength region.

29. The touch-sensitive apparatus of any preceding claim, wherein each light emitter (2) is optically connected to the light transmissive panel (1) via an angular filter (120) which is applied to an incoupling region on at least one of the front and rear surfaces (5, 6) and is configured to transmit light from the respective light emitter (2) only within a confined range of angles inside the light transmissive panel (1).

30. The touch-sensitive apparatus of claim 29, wherein the confined range of angles of the angular filter (120) on the incoupling region is matched to the confined range of angles of the angular filter (20) on the outcoupling region.

31. The touch-sensitive apparatus of claim 30, wherein the angular filter (120) on the incoupling region is identical to the angular filter (20) on the outcoupling region.

32. The touch-sensitive apparatus of any one of claims 29-31, further comprising a light recycler (140) which is arranged beneath the angular filter (120) on the incoupling region, so as to define a light reflective enclosure with respect to the angular filter (120) and a light-emitting surface (2A) of the respective light emitter (2).

33. A touch-sensitive apparatus, comprising:

a light transmissive panel (1) that defines a front surface (5) and an opposite, rear surface (6);

a plurality of light emitters (2) optically connected to the light transmissive panel (1) so as to generate propagating light that propagates by total internal reflection inside the light transmissive panel (1) across a touch-sensitive region (4) on the light transmissive panel (1); and

a plurality of light detectors (3) optically connected to the light transmissive panel (1) so as to define a grid of propagation paths (D) across the touch-sensitive region (4) between pairs of light emitters (2) and light detectors (3);

wherein the light transmissive panel (1) is mounted onto a front surface of a display device (34) by a lamination layer (36) of light transmissive material which is

arranged in contact with the rear surface (6) of the light transmissive panel (1) and the front surface of the display device (34); and

wherein the lamination layer (36) has a refractive index n_{lam} which is smaller than a refractive index n_{panel} of the light transmissive panel (1) at the rear surface (6) and which is chosen such that a laminate cut-off angle $\theta_{c,l} = \arcsin(n_{lam}/n_{panel})$ exceeds a critical angle θ_C which is given by $\theta_C = \arcsin(1/n_{panel})$ by an angle $\Delta\Theta$, which is at least 5°, 10° or 15°.

34. The touch-sensitive apparatus of claim 33, wherein the laminate cut-off angle $\theta_{c,l}$ is equal to or larger than a first cut-off angle $\theta_W = \arcsin(n_w/n_{panel})$, with n_w being the refractive index of water, $n_{panel} > n_w$.

35. The touch-sensitive apparatus of claim 33, wherein the laminate cut-off angle $\theta_{c,l}$ is equal to or larger than a second cut-off angle $\theta_f = \arcsin(n_f/n_{panel})$, with n_f being the refractive index of finger fat, $n_{panel} > n_f$.

36. The touch-sensitive apparatus of any one of claims 33-35, wherein the light emitters (2) are optically coupled to the light transmissive panel (1) such that the propagating light is generated to impinge on the lamination layer (36) at an angle that is equal to or larger than the laminate cut-off angle θ_{ci}.

37. A touch-sensitive apparatus, comprising:

a light transmissive panel (1) that defines a front surface (5) and an opposite, rear surface (6);

a plurality of light emitters (2) optically connected to the light transmissive panel (1) so as to generate propagating light that propagates by total internal reflection inside the light transmissive panel (1) across a touch-sensitive region (4) on the light transmissive panel (1); and

a plurality of light detectors (3) optically connected to the light transmissive panel (1) so as to define a grid of propagation paths (D) across the touch-sensitive region (4) between pairs of light emitters (2) and light detectors (3);

wherein a layered light absorber is provided on the rear surface of the light transmissive panel (1), said layered light absorber comprising a coupling layer (37, 87) of light transmissive material on the rear surface (6) of the light transmissive panel (1), and an absorbing layer (38, 88) of light-absorbing material on the coupling layer (37, 87), and

wherein the coupling layer (37, 87) has a refractive index n_{coupl} which is smaller than a refractive index n_{panel} of the light transmissive panel (1) at the rear surface (6) and which is chosen such that an absorber cut-off angle $\theta_{CC} = \arcsin(n_{coup\,i}/n_{pane\,i})$ exceeds a critical angle θ_C which is given by $\theta_C = \arcsin(1/n_{panel})$ by an angle $\Delta\Theta$, which is at least 5°, 10° or 15°.

38. The touch-sensitive apparatus of claim 37, wherein the absorber cut-off angle θ_{CC} is equal to or larger than a first cut-off angle $\theta_W = \arcsin\ (n_w/n_{panel})$, with n_w being the refractive index of water, $n_{panel} > n_w$.

39. The touch-sensitive apparatus of claim 37, wherein the absorber cut-off angle θ_{CC} is equal to or larger than a second cut-off angle $\theta_f = \arcsin\ (n_f/n_{panel})$, with n_f being the refractive index of finger fat, $n_{panel} > n$^.

40. The touch-sensitive apparatus of any one of claims 37-39, wherein the light emitters (2) are optically coupled to the light transmissive panel (1) such that the propagating light is generated to impinge on the coupling layer (37, 38) at an angle that is equal to or larger than the absorber cut-off angle θ_{CC}.

41. The touch-sensitive apparatus of any one of claims 37-40, wherein the layered light absorber is arranged to overlap a major part, or essentially all, of the touch-sensitive region (4).

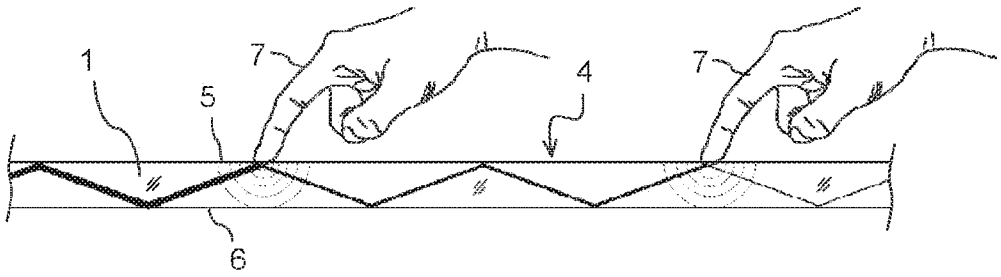


Fig. 1 (Prior Art)

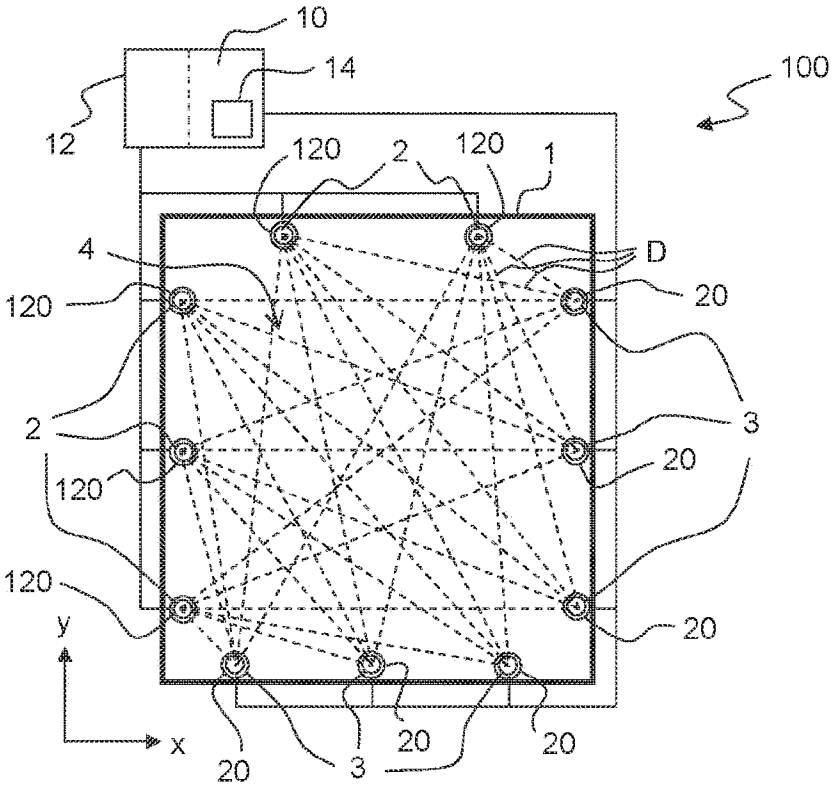


Fig. 2

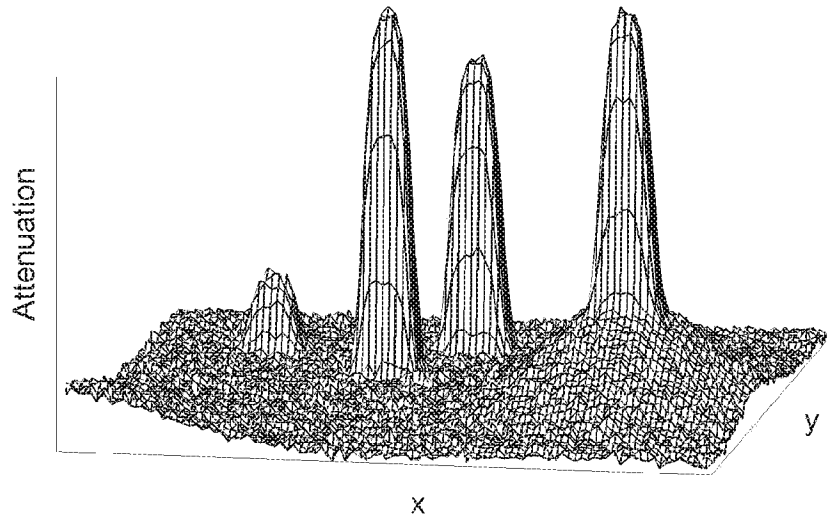


Fig. 3

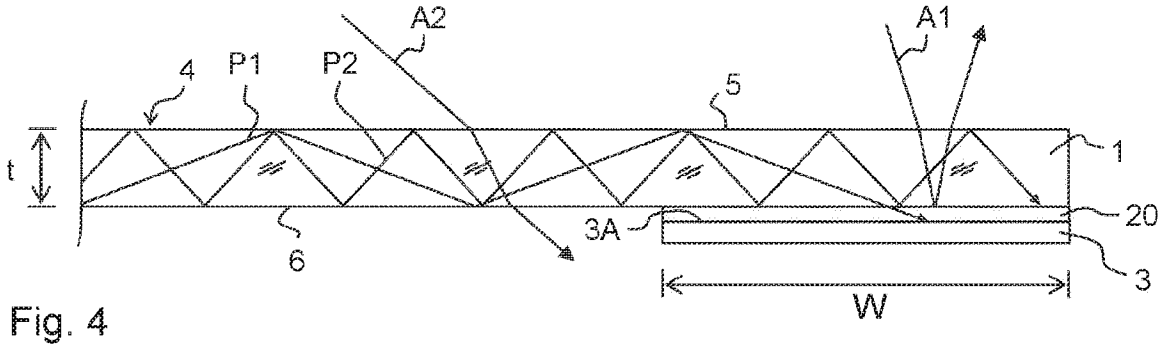


Fig. 4

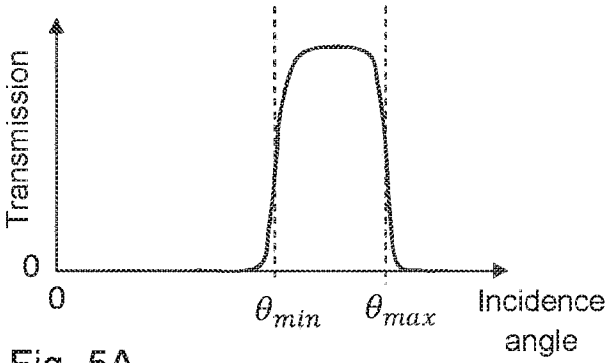


Fig. 5A

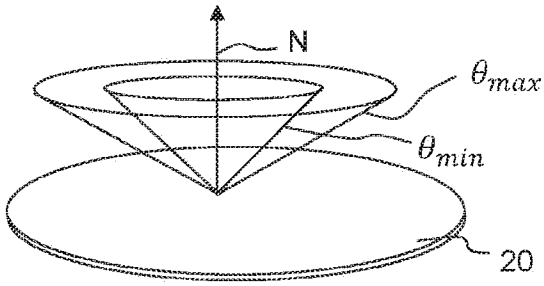


Fig. 5B

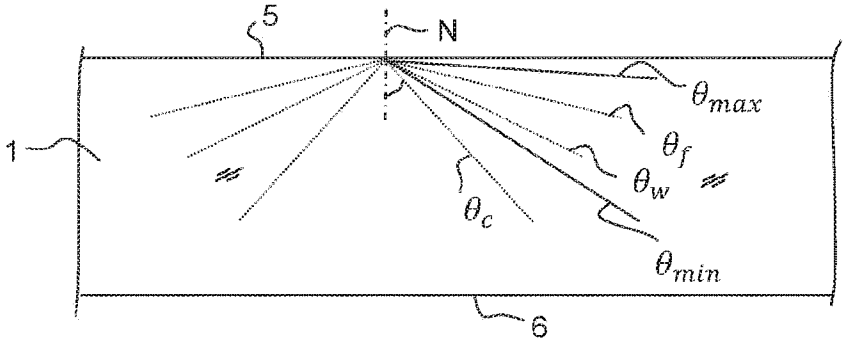


Fig. 6

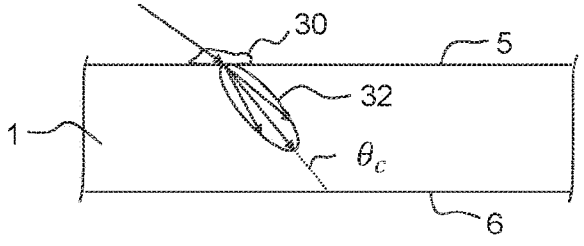


Fig. 7

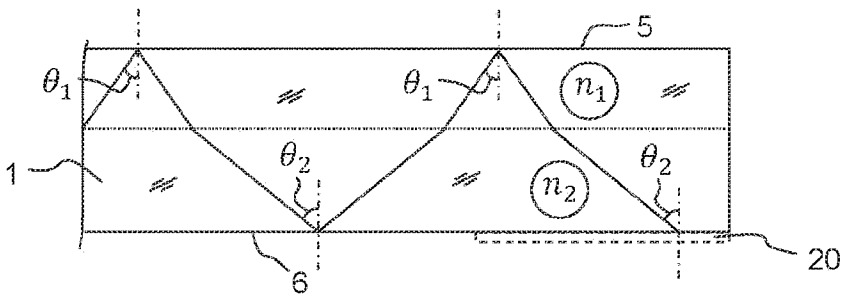


Fig. 8

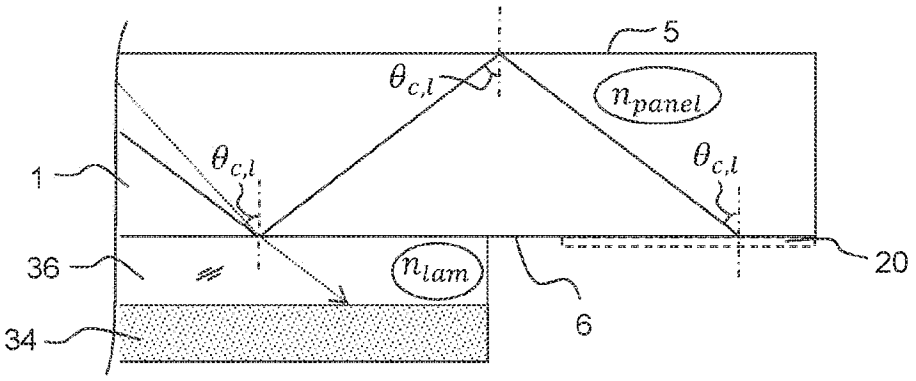


Fig. 9A

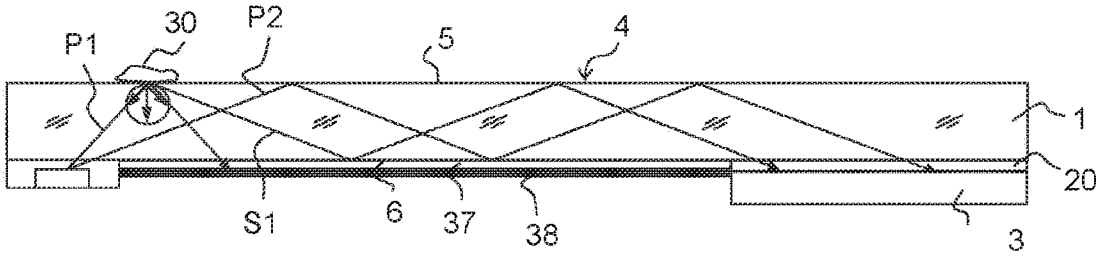


Fig. 9B

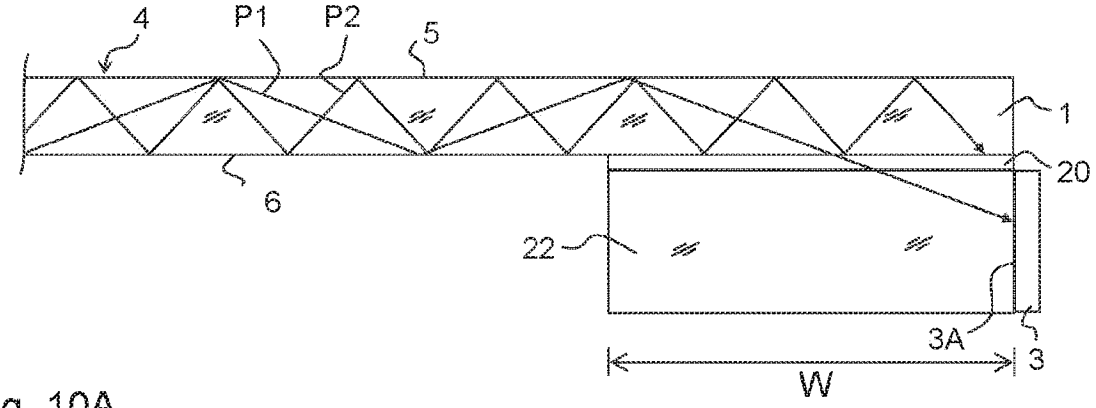


Fig. 10A

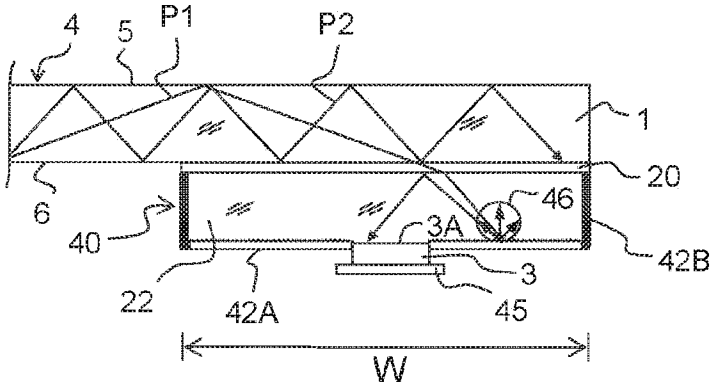


Fig. 10B

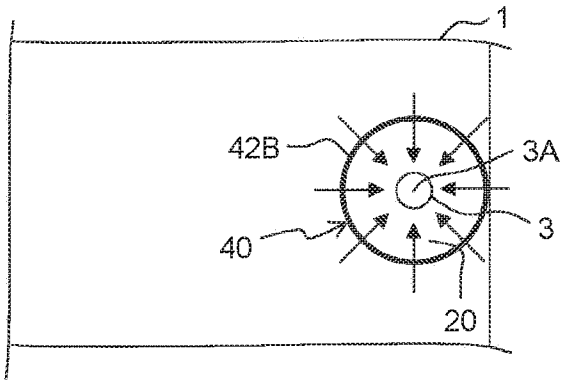


Fig. 10C

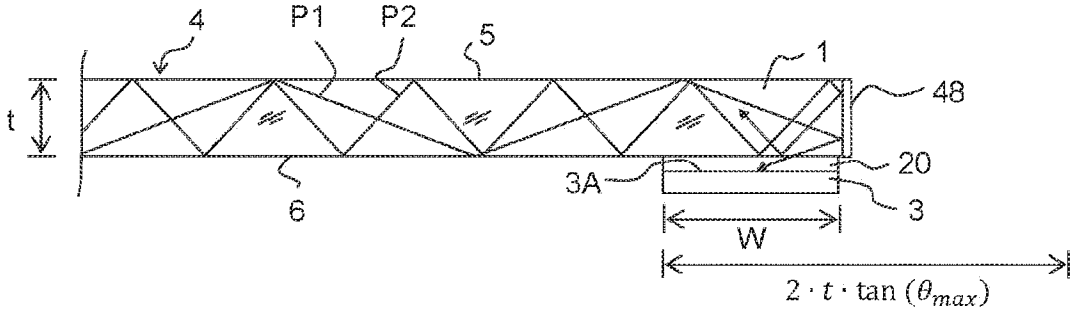


FIG. 10D

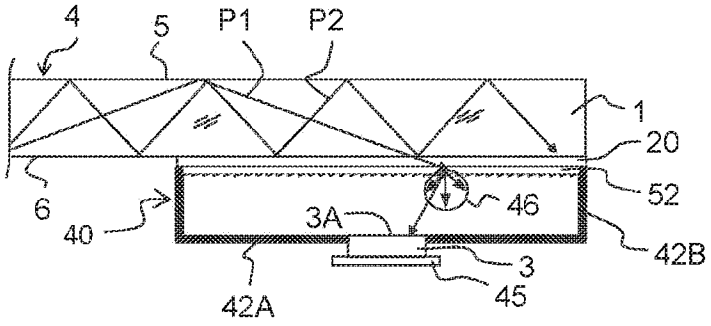


Fig. 10E

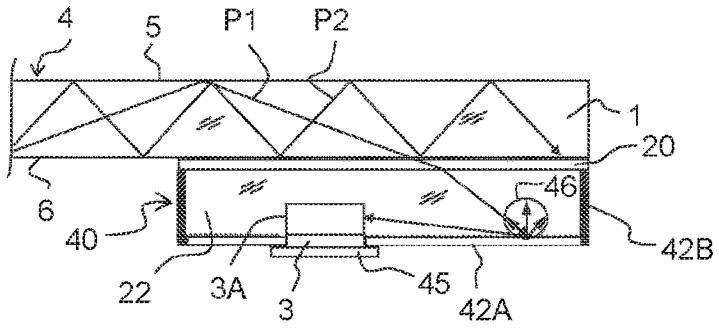


Fig. 10F

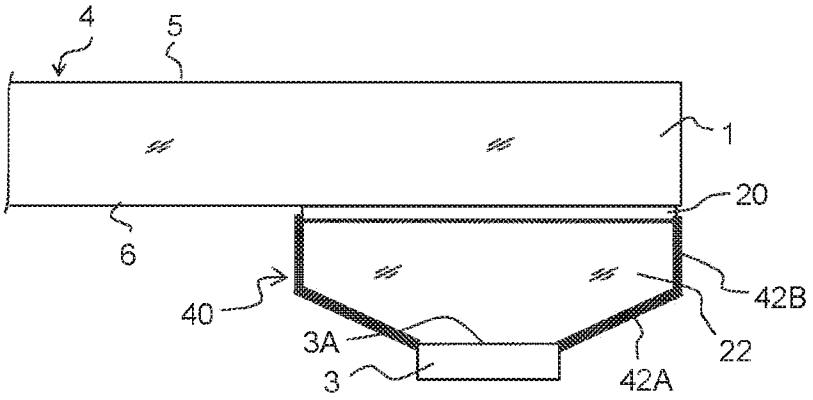


Fig. 10G

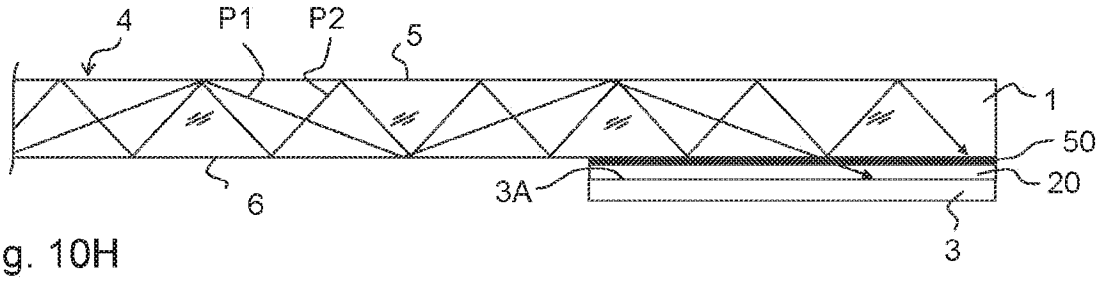


Fig. 10H

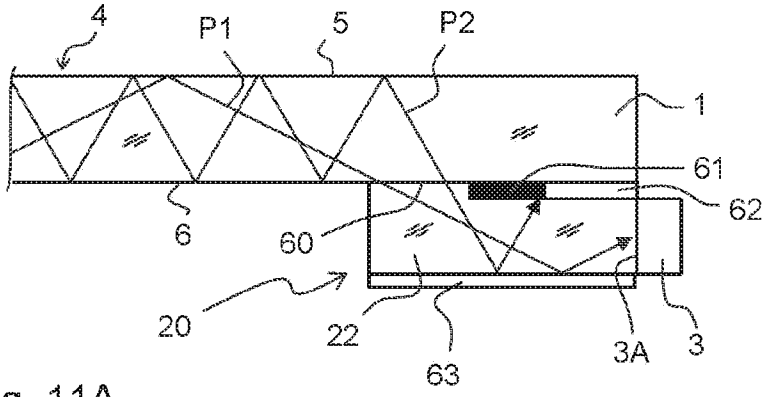


Fig. 11A

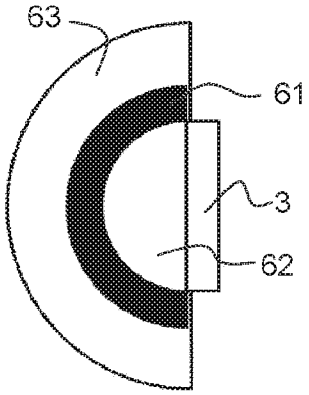


Fig. 11B

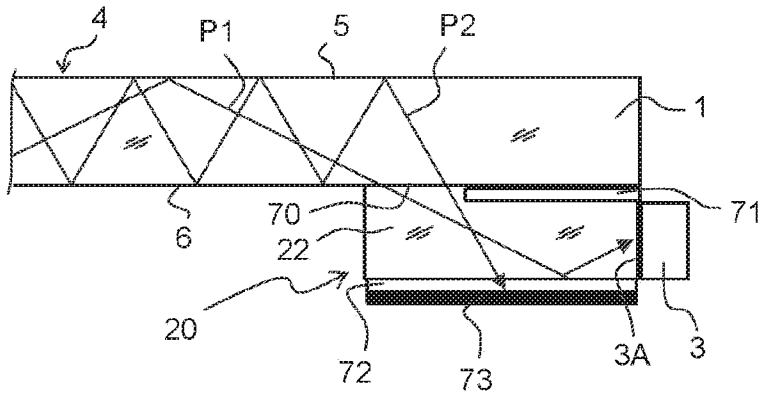


Fig. 12A

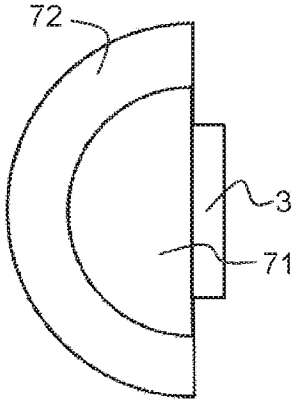


Fig. 12B

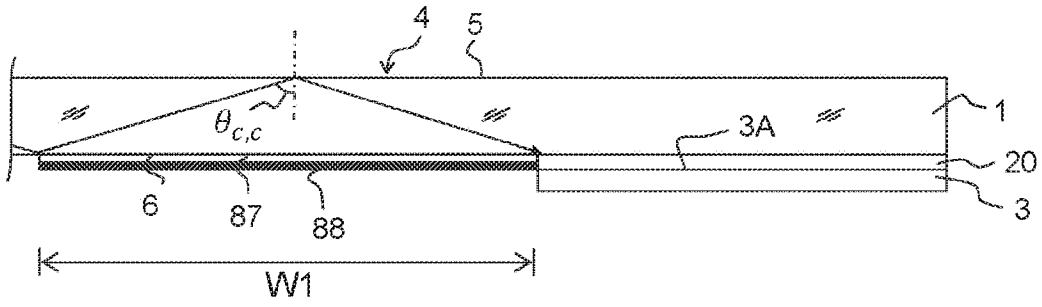


Fig. 13A

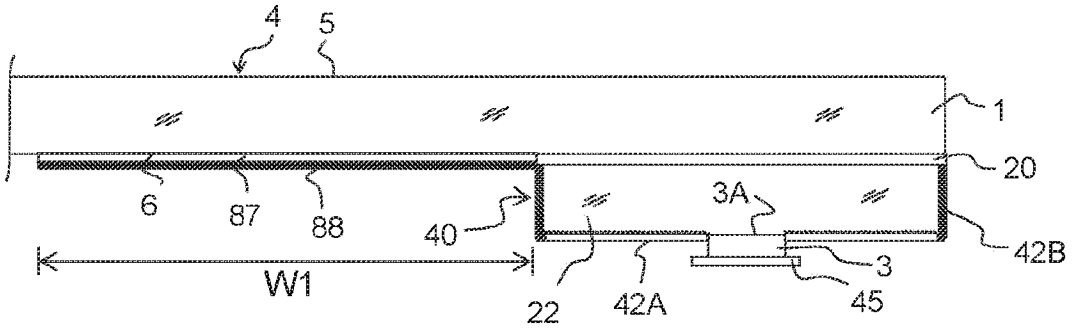


Fig. 13B

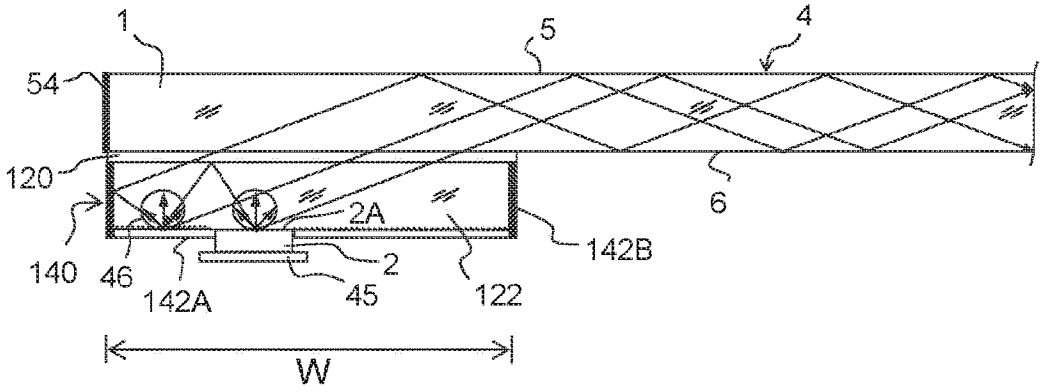


Fig. 14A

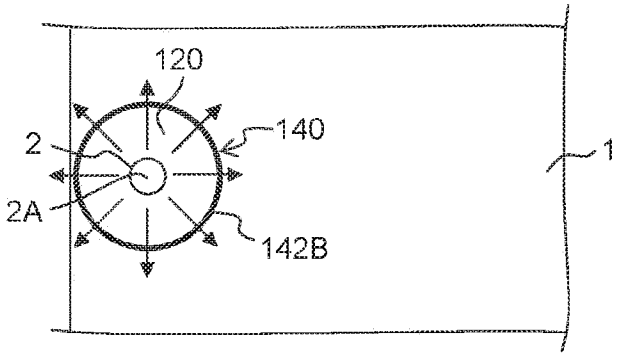


Fig. 14B

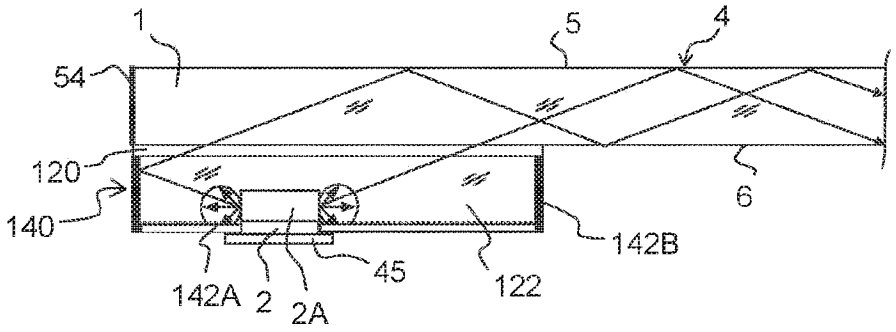


Fig. 14C

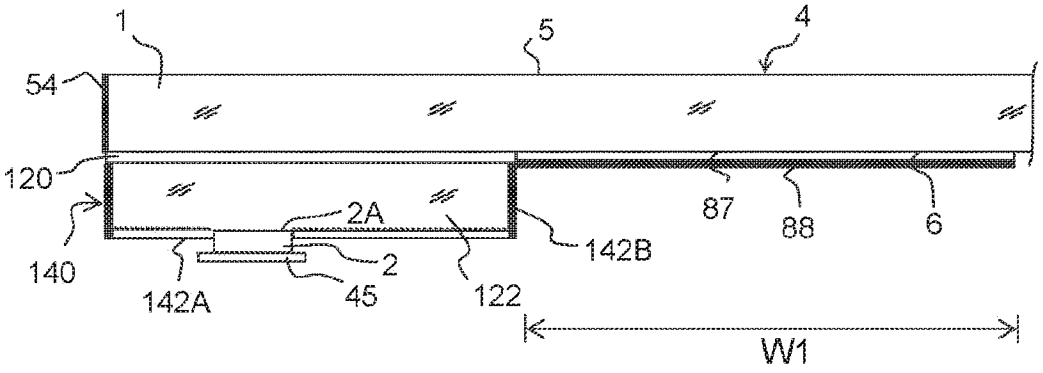


Fig. 14D

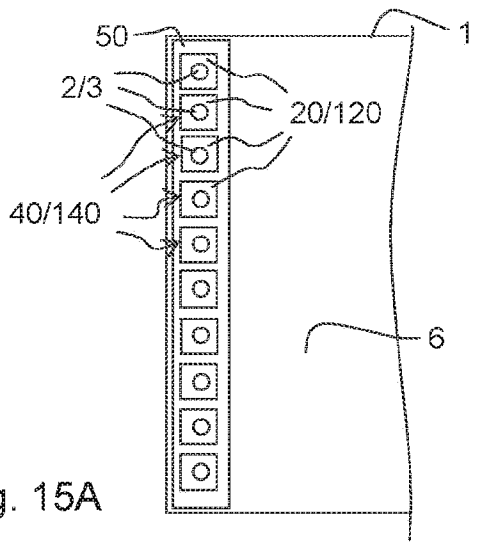


Fig. 15A

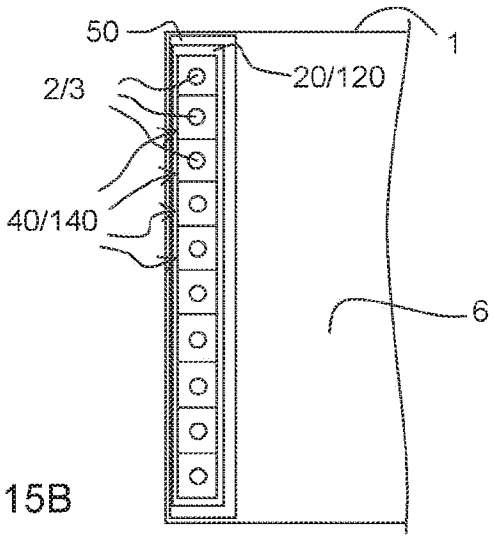


Fig. 15B

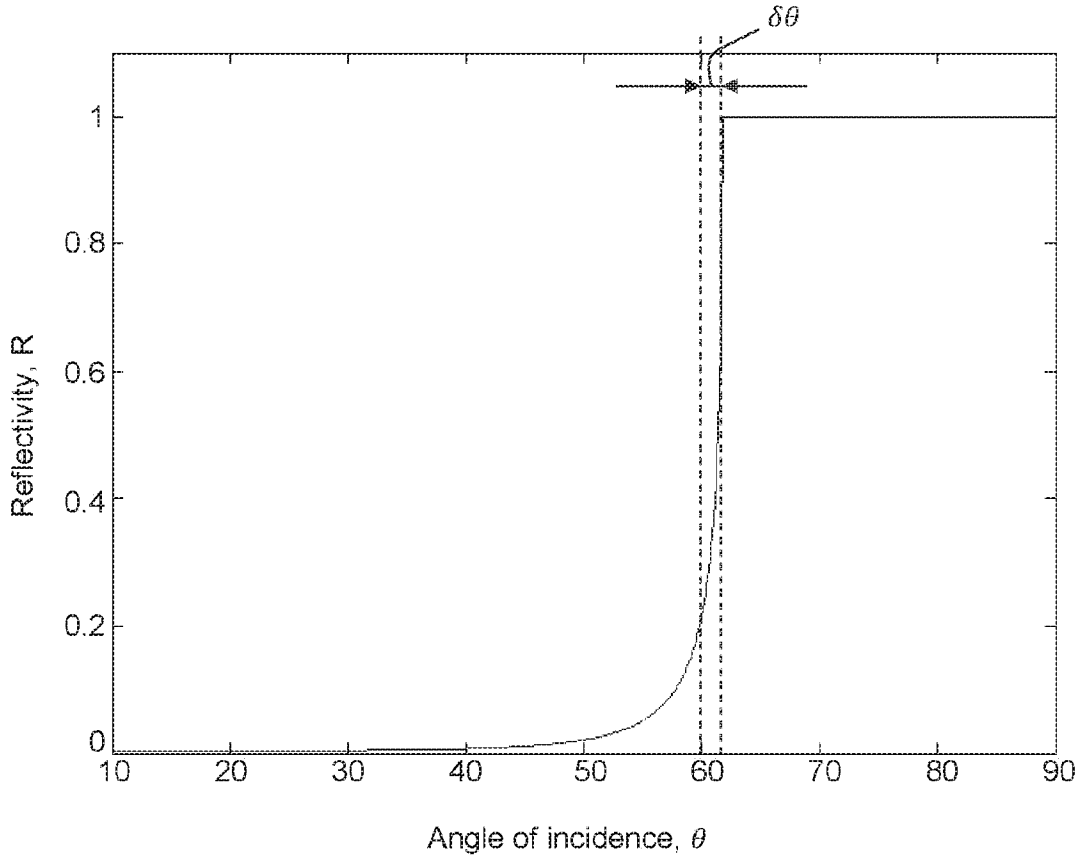


Fig. 16

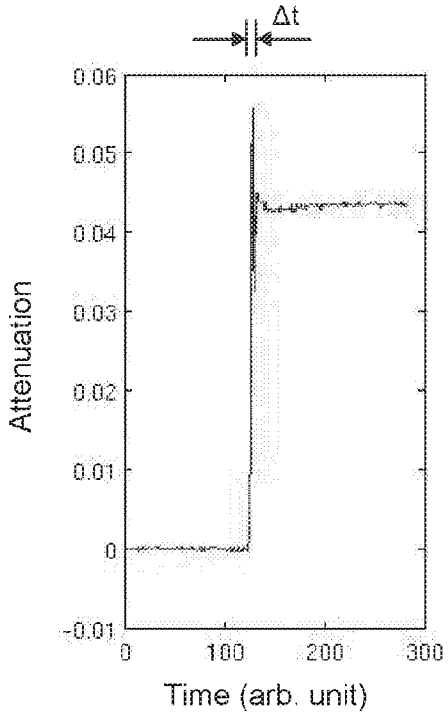


Fig. 17A

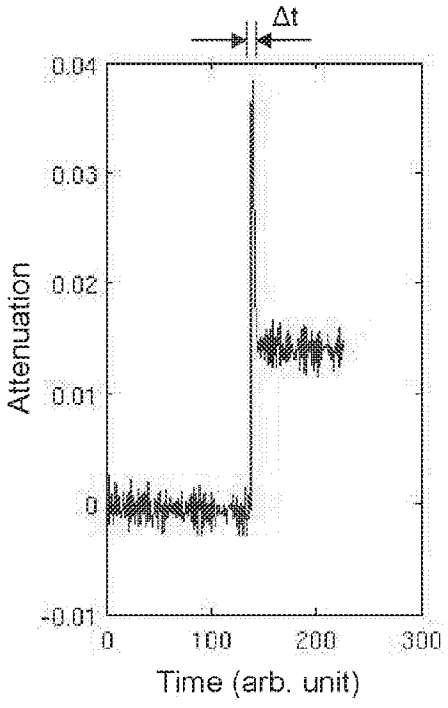


FIG. 17B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 3/051 537

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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: G02B, G06F

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 20070031 96 A2 (O PEN APS ET AL), 11 January 2007 (2007-01 - 1 1); abstract; page 7, line 15 - line 29; page 8, line 12 - line 15; page 8, line 29 - page 9, line 21; page 15, line 21 - line 24; page 16, line 17 - line 23	1-12, 25-31, 33-41
A	--	13-24, 32
Y	WO 201 0006884 A2 (FLATFROG LAB AB ET AL), 21 January 201 0 (201 0-01 -21); abstract; page 11, line 22 - page 12, line 2	1-12, 25-31, 33-41
A	~	13-24, 32

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international fding 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
25-04-201 4	25-04-201 4

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-1 02 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Sebastian Diskay Telephone No. +46 8 782 25 00

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 985 of 1254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2472444 A (LIGHT BLUE OPTICS LTD), 9 February 201 1 (201 1-02-09); abstract; page 4, line 10 - line 19; claims 1-5	1-41

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IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 986 of 1254

Continuation of: second sheet

International Patent Classification (IPC)

G02B 6/00 (2006.01)
G02B 5/00 (2006.01)
G06F 3/03 (2006.01)

WO	20070031 96	A2	11/01/2007	EP	190791 8	A2	09/04/2008
				US	200901 22020	A 1	14/05/2009
				US	7995039	B2	09/08/201 1
WO	201 0006884	A2	21/01/201 0	AU	2009272923	A 1	21/01/201 0
				CA	2728034	A 1	21/01/201 0
				CN	102067074	A	18/05/201 1
				EP	231 8906	A2	11/05/201 1
				TW	201 007530	A	16/02/201 0
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(54) **Title:** METHOD AND APPARATUS FOR DETECTING VISIBLE AMBIENT LIGHT

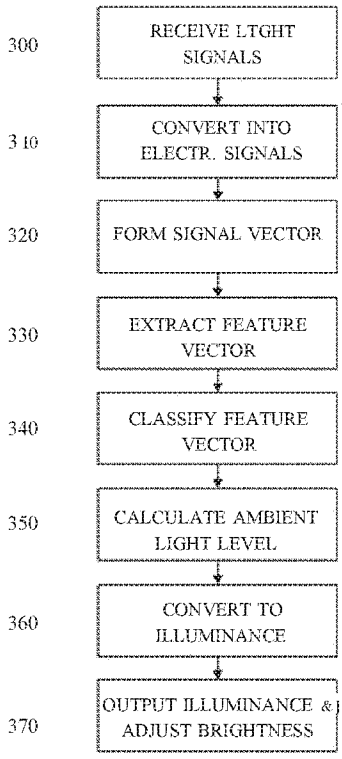


Fig. 7

(57) **Abstract:** Method and touch-sensitive apparatus for determining the amount of visible ambient light incident on the touch-sensitive apparatus comprising a first array of light-sensing elements, the method comprising receiving light signals at a plurality of light-sensing elements in the first array; converting the light signals into electrical signals, identifying at least one type of ambient light source from the signal by comparing features in the signal with characteristic features of one or more known light sources and obtaining information related to the amount of visible ambient light incident on the panel generated by the at least one type of ambient light source in relation to the amount of ambient light registered at the plurality of light-sensing elements.

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Method and apparatus for detecting visible ambient light

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of Swedish patent application No. 1251512-8, filed 27-Dec-2G12, and US provisional application No. 61/746278, filed 27-Dec-2012.

TECHNICAL FIELD

The present invention relates to a method and apparatus for determining the amount of visible ambient light on a touch-sensitive apparatus. In particular, the apparatus for determining the visible ambient light comprises a first array of light-sensing elements.

BACKGROUND

Light sensors can be found in a large variety of applications today, most notably in consumer electronics. Their function is to detect the amount of light falling onto a display. Using the backlight function of the display, the brightness of the display can then be adjusted in relation to the amount of light detected.

Ambient light sensors are sensitive to visible light and the backlight power of a display is often made proportional to the amount of visible light falling onto the display.

Present day example solutions in detecting ambient light sources are described in documents US201 1248170A1, US201 10025661 A1 and KR20030033832.

US201 1248170 deals with a system for detecting the amount of visible light from one or more ambient lights sources analyzing the light signal received by a photodiode comprising an IR-sensitive light-sensing element stacked on top of a detector sensitive to visible light. The IR-sensitive element is constructed to be transparent to visible light. By calculating the ratio of the light intensities incident on the stacked light-sensing element the type of ambient light source can be characterized. One disadvantage of the solution is that it requires a specially constructed light-sensing element to work properly. Also, it is dependent on detection of both infrared and visible light for determining the type of ambient light source.

A different solution is disclosed in US201 10025661 Al, where it is attempted to characterize the ambient light source by focusing on the source voltage driving the ambient light source. Light from one or more ambient light sources is gathered from a number of light-sensing elements during several overlapping intervals, which are

chosen to match one or more periods for known power sources driving ambient lighting. Integrating a signal over several of these periods reduces the influence of the power source signal when compensating for ambient light falling on the detectors. One disadvantage of this solution is that it cannot distinguish ambient light sources driven by the same power supply.

Finally, in the Korean patent application KR20030033832, a color content of the registered visible light from an ambient light source is analyzed and used to compensate the white balance of an image produced by a digital camera. It is to be noted that the solution requires ambient sensors sensitive to visible light and does not use the information obtained to compensate for the brightness of a display, but rather color fidelity of a captured image.

There is thus a need for a simple, cost-effective way of characterizing one or more ambient light sources in order to be able to provide accurate information for e.g. controlling the brightness of a display unit.

SUMMARY

A solution to at least some of the problems encountered in known technology is provided by the invention according to independent claims.

Preferable embodiments of the solution according to the present invention are presented in the dependent claims.

According to one aspect of the present invention the solution is provided by a method for determining the amount of visible ambient light on a touch-sensitive apparatus comprising a first array of light-sensing elements. The method according to one aspect of the invention comprises receiving light signals at a plurality of light-sensing elements in the first array, converting the light signals into electrical signals, identifying at least one type of ambient light source from the signal by comparing features in the signal with characteristic features of one or more known light sources and obtaining information related to the amount of visible ambient light incident on the panel generated by the at least one type of ambient light source in relation to the amount of ambient light registered at the plurality of light-sensing elements.

According to another aspect of the present invention, the solution to at least some of the problems mentioned earlier is given by a method for determining the visible ambient light level incident on a touch-sensing apparatus comprising a light transmissive panel defining a touch surface and an opposite surface, where light generated by an illumination arrangement comprising emitters propagates in the panel by total internal reflection. The method comprising receiving light signals at a plurality of light-sensing elements in a first array belonging to the touch-sensing apparatus, converting the light signals into electrical signals, identifying at least one type of ambient light source from

the signal by comparing features in the signal with characteristic features of one or more known light sources and obtaining information related to the amount of visible ambient light generated by the at least one type of ambient light source identified which is incident on the panel.

The method according to the present invention has the advantage that it can use existing light detectors to identify one or more ambient light sources accurately. These existing light detectors may also be used in a touch-sensitive apparatus for detecting touches onto a surface of a transparent panel in which light transmitted by light-emitting elements propagates through total internal reflection and where a touch onto the surface introduces disturbances to the reflection of the light which after detection by the light detectors can be detected as touches. Hence, dedicated ambient light sensors which would add to the cost of a touch-sensitive apparatus are not needed. Once the one or more ambient light sources are identified, this information may be used to calculate a corresponding brightness value for a transmissive panel onto which the ambient light is incident and to adjust the brightness to make the information displayed on the panel readable by a user.

According to another aspect of the present invention, the solution is given by a touch-sensitive apparatus for determining the amount of visible ambient light incident onto a touch-sensitive panel. The apparatus comprises a first array of light-sensing elements configured to convert incident ambient light signals into electrical signals, a memory unit configured to store characteristic signal features for a plurality of known ambient light sources and a processor configured to identify at least one type of ambient light source from the signal by comparing features in the signal with the stored characteristic signal features of the one or more known light sources and wherein the processor is further configured to relate the amount of visible ambient light incident on a touch-sensitive panel of the apparatus generated by the ambient light source identified by the processor.

According to yet another aspect of the present invention, the solution is given by a touch-sensitive apparatus for determining the amount of visible ambient light incident onto the apparatus. The apparatus comprises a light transmissive panel defining a touch surface and an opposite surface, an illumination arrangement comprising emitters configured to generate light into the panel, such that light is propagated in the panel by total internal reflection, a first array of light-sensing elements configured to receive the light generated by the emitters and ambient light incident onto the touch surface of the panel and to convert the incident ambient signals light into electrical signals, a memory unit configured to store characteristic signal features for a plurality of known ambient light sources. The touch-sensitive apparatus further comprises a processor configured to identify at least one type of ambient light source from the signal by comparing features in the signal with the stored characteristic signal features of the one or more known light sources and wherein the processor is further configured to relate the amount of ambient light received by the plurality of light-sensing elements to the amount of visible ambient

light incident on the transmissive panel and generated by the ambient light source identified.

Having the advantages listed for the method according to the present invention earlier in the description, these same advantages also apply to the touch-sensitive apparatus according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 displays a known touch-sensitive apparatus according to known technology in a top view.

Fig. 2 displays the touch-sensitive apparatus in a sectional view.

Fig. 3 displays the touch-sensitive apparatus from Fig. 2 where ambient light is incident onto the apparatus.

Fig. 4 displays a spectral distribution of some known light sources in the visible and infrared spectrum.

Figs. 5 and 6 display a time-domain representation of two common light source classes.

Fig. 7 displays a flow chart of one embodiment of a method according to the present invention.

DETAILED DESCRIPTION

In the following detailed description a number of example embodiment of the present invention are given. These embodiments serve only to clarify the principles on which the present invention rests and should therefore not be constmed as limiting the present invention to these embodiments exclusively. Ultimately, the present invention is only limited by the scope of the accompanying claims.

It should also be added that certain details not relevant to the explanation of the present invention have been omitted in the embodiments presented in the description below.

Fig. 1 displays a known touch-sensitive apparatus belonging to the applicant in a top view and described in detail in the published patent application WO 201 1/139213 Al. The touch-sensitive apparatus comprises a panel 1, an illumination arrangement 3 comprising emitters 2 and an illumination control unit 3A, and a light detection arrangement 5 comprising detectors 4 and a detection control unit 5A. The touch-sensitive apparatus is according to one embodiment a multi-touch system, thus enabling detection of a multiplicity of touches. The emitters 2 introduce light L into the panel at in-coupling points, an in-coupling point defining a point on the panel 1 where light L

from an emitter 2 enters the panel 1. The detectors 4 detect the energy of the light at out-coupling points, an out-coupling point defining a point on the panel where the light propagating in the panel 1 leaves the panel 1 for subsequent detection by a detector 4. It is only the in-coupling and out-coupling points of the detectors 4 and emitters 2, respectively, that have to be arranged along the periphery of the panel: the detectors 4 and emitters 2 may be arranged at a distance from the panel 1. Light may enter and leave the panel 1 through the edges of the panel 1, or through the top or bottom surface of the panel, e.g. by the use of an appropriate light coupling element. Moreover, the touch-sensitive apparatus comprises a control unit 6 configured to control the emission of light L propagating in the panel 1 and the collection of data from the detectors 4 via the detection control unit 5A. The control unit 6 may also be directly connected to the emitters 2 and the detectors 4. Also, the touch-sensitive apparatus comprises a mode selector 7 for selecting the emission pattern in dependence of occurrence of touches on the touch service. The mode selector 7 is not essential to the description of the invention and will not be elaborated further. The control unit also comprises a processor 8 which may include a memory (not shown) performing calculations used by the control unit 6 to control the function of the touch-sensitive apparatus.

In Fig. 2 the touch-sensitive apparatus from Fig. 1 is displayed in a sectional view. Light L from the emitter 2 is injected into the light transmissive panel 1 and propagates inside the panel 1 while being reflected in the top and bottom surfaces 1a, 1b. Light may be reflected by total internal reflection (TIR) at least in the top surface 1a which forms a touch surface. The bottom surface 1b may reflect the light by TIR, or by a reflective coating (not shown) applied to the bottom surface 1b. At some other end of the panel 1, the energy of the transmitted light is detected by the detector 4. In the event of an object touching the touch surface of the panel 1, the object interacts with the light beam inside the panel 1 and frustrates the TIR. Frustrated total internal reflection (FTIR), in which energy is dissipated into the object from an evanescent wave formed by the propagating light, provided that the object has a higher refractive index than the material surrounding the panel surface material and is placed within less than several wavelengths distance from the surface, may be used in the present invention. During the frustration of TIR, part of the light beam will be absorbed by the object, and another part will be reflected and/or scattered by the object. The remaining light beam will continue with total internal reflection as before but now attenuated due to the absorption, reflection and scattering, as illustrated in FIG. 2 with a slightly thinner line.

The apparatus detects touches p1, p2 on the top surface 1a by analyzing an ensemble of energy values determined for different detection lines s_j. A detection line s_i (illustrated by dotted lines in Fig. 1) is defined as the light path between one in-coupling and one out-coupling point, and an emitter 2 and a detector 4 at ends of a detection line are referred to as an emitter-detector pair.

The occurrence of one or more touches **pi,** p2 may be determined by identifying changes in the ensemble of energy values. To determine the position of a plurality of

touches pi, p2 on the top surface la, the energy values for the detection lines are compared against a reference value for the respective detection line. The reference value may be an energy value measured at an earlier time. Alternatively the energy values may be converted into transmission values. Each detector 4 measures the energy $d_t$iof the transmitted light for a particular detection line S_i, and the reference value that the energy value d_{ti} is compared with is a background energy value d_n for the detection line. The transmission value for detection line S_i may be computed as, $T_t = d_t i / d_n$. The transmission may alternatively also be computed as a difference value, $T_t = d_{ti} - d_n$. Such a difference value may e.g. be used to quickly derive approximate touch data from the measured energy values.

The background energy value can be obtained by calibrating the touch sensitive apparatus at start up, i.e. by setting the background energy value d_n equal to the energy-measured for detection line S_i when no objects are touching the touch surface.

As illustrated in Figure 2, the transmitted light may carry information about a plurality of touches. In an FTIR system, each touch point p_n (corresponding to a touching object) has a transmission τ_n, which generally is in the range 0-1 , but normally in the range 0.7-0.99. The total transmission T, along a detection line S_-, is at least approximately given by the product of the individual transmissions t_n of the touch points p_n on that detection line: $T = \Pi\tau_i$, (I)

For example, two touch points p_1 and p_2 with transmissions 0.9 and 0.8, respectively, on a detection line S_i, yield a total transmission T_j =0.72. The second touch point p_2 will attenuate a part of the light L that reaches the second touch point, hence the multiplication. With an FTIR setup it is thus possible to "see through" touches on the panel 1.

The entire touch-sensitive apparatus and the method of detecting touches on the surface of the apparatus are described in detail in the published patent application WO 201 1/139213 A1 filed by the applicant which is hereby incorporated by reference.

Fig. 3 displays the touch-sensitive apparatus from Fig. 2 where the emitters (not shown) have been switched off and only ambient light L_A is registered by the detector 4. We assume for the sake of simplicity that we have one ambient light source 9 such as a halogen lamp and that the light source 9 is located far away from the touch-sensitive panel 1. We thus assume that the ambient light rays L_A are incident parallel onto the upper panel surface 1a and that they are evenly distributed over the panel surface la. Ambient light LAfrom the remote light source LAwill upon entry into the transmissive panel 1 be scattered, where a part of the scattered ambient light Ls will propagate in the transmissive panel 1 by total internal reflection. Totally internally reflect light is illustrated by the light rays L_{TIR} in Fig. 3. It is this part of the incident ambient light L_A that will be registered by the one or more detectors 4.

Fig. 4 displays a diagram over the spectral distribution of different ambient light sources as a function of the relative power produced by each ambient light source.

Looking at the dotted curve 110 which represents the spectral distribution of a flash tube, it is apparent that there are three distinct wavelength areas where the majority of the relative power is located - namely in the ultraviolet between about 300-400 nm, in the visible domain and moreover in the far-infrared region between about 1000-1900 nm. Hence, depending on the type of light-sensing element used and having in mind that most ambient light-sensing elements today are either sensitive to infrared or visible light, measuring only in the infrared domain will not give an accurate picture of the ambient light source in the visible domain.

This problem becomes even more pronounced when using infrared light-sensing elements having their peak sensitivity somewhere in the near-infrared region of the light spectrum. In that scenario, when receiving light from a quartz-halogen lamp 120 or a tungsten lamp 130, the light-sensing element will sense a large incident light-intensity (where it should be remembered that received power is proportional to the square of light intensity), while in reality, the intensity of the incident visible light for these ambient light sources is rather low.

A resultant controlling of the backlight or brightness of a display will most probably overcompensate for the incident ambient light if the brightness controlling mechanism is only relying upon the intensity of the received infrared light.

As evident from the figure, the majority of the light intensity or power produced by a quartz-halogen lamp 420 and a tungsten lamp 130 is in the infrared domain - i.e. the majority of the power is simply produced as heat radiation.

In contrast, a fluorescent lamp 140 as commonly used in office and factory buildings has essentially all of its power concentrated in the visible light spectrum with spectrum peaks around 600 and 700 nm.

A neon lamp 150 also has a similar spectral distribution as the fluorescent lamp.

As a side remark, a sodium lamp 160 has a majority of its spectral distribution in the visible domain with a power peak around 700 nm.

In contrast, light from a natural source (i.e., sun light) is more evenly distributed across the entire spectrum.

Thus, when using infrared Sight-sensing elements for detecting incident light it is important to bear in mind the different spectral distributions of different light sources and how they differ in the infrared and visible domain as illustrated in Fig. 1.

Fig. 5 displays a time- and frequency signature of a common halogen lamp. In the upper part of the figure the time domain output of the halogen lamp expressed in seconds is displayed as a function of amplitude expressed in Watts, The lower part of the figure

displays the light output from the halogen lamp expressed as frequency in Hz in terms of amplitude expressed in W.

Fig. 6 displays the time- and frequency signature of an energy saving lamp (ESL) in the same fashion as in Fig. 5.

When comparing the two ambient light sources it is apparent that the time-domain behaviors differ significantly and that the halogen lamp oscillates with a lower frequency than the energy saving lamp. Furthermore, looking at the temporal frequency content of the two light sources it becomes apparent that the energy-saving lamp has a number of characteristic frequencies in the high frequency range, while the frequency spectrum of the halogen lamp is located at lower frequencies, corresponding to a rectified 50 Hz oscillation..

These different behaviors will be used further down in the description to identify the type or types of ambient light sources whose light has been detected by the detector 4.

Using Figs. 1-3 as examples the present invention will be explained.

In Fig. 1 the plurality of detectors 4 are used to detect light L propagating inside the transmissive panel 1. In order for the detectors 4 to only measure ambient light L_A incident onto the upper surface 1a of the panel 1, the control unit 6 is configured to switch the emitters 2 off. As already explained earlier in Fig. 3, ambient light L_A incident onto the upper surface 1a of the panel 1 will be scattered into the panel, while part of the scattered ambient light will be detected by the plurality of detectors 4. In the embodiment in Fig. 1 it is assumed that the detectors are sensitive to infrared light, which is preferred, or to visible light. In case the detectors 4 are sensitive to visible light it is assumed that their sensitivity curves differ from those of the human eye. Moreover, while the detectors 4 are displayed as being arranged around the edge of the transmissive panel 1, they may also be arranged around the periphery of the upper surface 1a or the lower surface 1b of the transmissive panel 1.

Now, output electrical signals corresponding to the light signals from one or more ambient sources are produced by each of the plurality of light-sensing elements 4 and received by the detector control unit 5A and from there sent further to the control unit 6. Moreover, the control unit 6 is configured to read out output values from the detectors 4 using the processor 8 form a signal vector representing ambient light signal received at each of the plurality of detectors 4. The processing unit 8, in turn, may comprise or is connected to a memory unit (not shown) configured to store a number of template vectors corresponding to different ambient light sources. Also, the processor 8 is configured to perform a correlation (or alternatively, a convolution) operation between the signal vector formed and the template vectors stored in the memory unit and thereby identify the type or types of ambient light source(s) detected by the plurality of detectors 4. The processor 8 may perform the identification by firstly extracting a feature vector from the correlation, convolution or other comparison operation between

the signal and the template vectors and secondly by classifying the resultant feature vector according to a pattern recognition method which will be described more in detail in Fig. 7. Moreover, the control unit 6 is configured to instruct the processor 8 to calculate the level of ambient light incident on the upper surface 1a of the transmissive panel 1. The reason for this is that the plurality of detectors 4 only register a certain portion of the scattered ambient light Lg. One way to calculate the amount of ambient light incident onto the upper surface 1a of the panel is to assume that in the absence of contaminations on the upper panel surface 1a the amount of scattered incident ambient light LA is known and can be modeled by a known relation stored in the memory unit connected or present in the processor 8. Using this relation (which may or may not be linear) the control unit 6 may finally determine the amount of ambient light incident onto the panel. However, if the detectors 4 are only sensitive to infrared light it will be necessary for the control unit 6 to instruct the processor 8 to calculate the amount of visible ambient light from the calculated amount of incident ambient light. This will be necessary even in the case the plurality of detectors 4 are sensitive to visible light, since frequently the sensitivity curve for a detector 4 differs from the illuminance curve of the human eye.

The control unit 6 may also be configured to instruct the processor 8 to calculate a brightness value which may be used to adjust the brightness of the transmissive panel dependent on the amount of ambient light incident on the panel. This may be useful in cases where the transmissive panel is located above a backlight-powered display or where such a display is integrated with the transmissive panel. In this way power may be saved.

It shall be mentioned that in a normal case when measuring the ambient light level, the control unit 6 is configured to instruct the emitting control unit 3A to switch off all emitters and to instruct the detector control unit 5A to read out output values from the detectors. It is not necessary for the control unit 6 to instruct the reading out of all detector values. It may be sufficient to read out a few detector values which are sufficient to establish the level of ambient light incident on the transmissive panel 1.

Depending on implementation, the control unit 6 may instruct the detector control unit 5A to read out detector output values with a certain sampling rate which is chosen such that a sufficient number of sampling values are available from which an essentially accurate identification of the light signal and thus of the one or more ambient light sources may be performed. According to one variant, the control unit 6 may perform a sampling of the light-sensing element output values with sampling frequencies ranging from a couple of kHz to several hundred kHz, where electric signal values after every reading are composed into a signal vector. The sampling frequency and the length of the signal vector chosen will determine which frequencies can be used to classify the one or more ambient light sources.

In the discussion above, it was assumed that no surface contamination is present on the upper surface 1a of the transmissive panel 1. Usually however, there will be always some form of finger prints, smears, dust or other types of surface contaminations present on the upper surface 1a. These can be either modeled as being evenly distributed over the entire upper surface 1a of the transmissive panel or to be evenly distributed in certain sub-areas of the panels. In both cases the ambient light incident onto the contaminated surface will be scattered differently from the surface and into the transmissive panel which will affect the amount of light detected by the plurality of detectors 4. If the surface contamination is distributed evenly over the entire first surface 1a, then the control unit 6 may instruct the processor 8 to add a correction factor to each value in the signal vector. In case the contamination distribution is not even over the entire surface of the transmissive panel, i.e. there is a significant difference in the amount of ambient light registered between a first group of detectors 4 and a second group of detectors 4, then the control unit 6 may divide the transmissive panel into sub-areas each with associated detectors. The control unit 6 may then instruct the processor to add a sub-area dependent correction factor to detector output values belonging to detectors of the specific sub-area in question. The correction factor may be a simple constant or a known linear or non-linear relation.

Fig. 7 illustrates a flowchart of an embodiment of a method according to the present invention. In this embodiment we use light-sensitive elements with main sensitivity in the infrared spectrum. However, it should be emphasized that the embodiment in Fig. 7 would equally hold true for light-sensitive elements having their main sensitivity in the visible domain.

At step 300, a touch-sensitive apparatus, such as the touch-sensitive apparatus from Fig. *1* receives light signals at its array of light-sensitive elements. As mentioned earlier, the array of light-sensitive elements may be sensitive to infrared light or light in the visible spectrum.

Thereafter, at step 310, the light signals are converted into electrical signals by the detectors, amplified and converted into their digital counterparts by the detector control unit 5A.

Besides the known conversion from optical to electrical signal in the light-sensing elements, the amplified and A/D-converted output electrical signals from the light-sensing elements are at step 320 sampled into a signal vector representative of the ambient light signals incident on the touch-sensing apparatus. The sampling may involve reading output signal values from all light-sensing elements in the array or only a plurality of the light-sensing elements. It may be added that these output values may be read out during a time interval during which light-emitting elements in the touch-sensitive apparatus are switched off.

Although not illustrated by the flow chart in Fig. 7, the reading out and sampling of the output values from all or a part of the light-sensitive elements in the detector array may

occur during a set of time intervals, i.e. continuously. Also possible is to read and sample the output values during time intervals which may be predefined or user-defined.

At step 330, the signal vector from step 320 is combined with a template signal vector or characteristic signal matrix in order to extract a feature vector which may have one or more features representative of one or more known ambient light sources. These features may be characteristic frequencies present in an ambient light source, characteristic time-related behavior of light from an ambient light source or some other signal characteristic which uniquely defines an ambient light source. One way to extract a feature vector at step 330 may be to perform a correlation operation between the signal vector and the one or more characteristic signal vectors or with a characteristic signal matrix in which the columns are represented by the characteristic signal vectors for each known ambient light source. Another possibility is to perform a convolution operation between the signal vector and the one or more characteristic signal vectors for each known ambient light source and thereby extract the feature vector representative of the signal characteristics of the light incident from the one or more ambient light source onto the touch-sensitive apparatus.

It should be mentioned that while the conversion of the light signals received in step 3 10 is performed in the time domain, the signal vector at step 320 may be formed in the time or frequency domain. One possible way to form the signal vector at step 320 may be to perform an FFT-operation on the time domain signal vector. The principles of the FFT-algorithm are known and will not be elaborated further in this description.

In case the signal vector is formed in the frequency domain, the operations described for step 330 will then be performed in the frequency domain as well.

it should also be mentioned that there are more possible feature extraction methods than correlation or convolution which are mentioned in the earlier paragraph and the above two simply serve as examples to illustrate the underlying principles of the present invention.

At step 340 the feature vector extracted at the previous step is classified in order to obtain information on which type or types of ambient light sources are illuminating the touch-sensitive apparatus. Without going into too much detail any known pattern recognition algorithm may be used to perform this operation. For example, a branch metric algorithm may be used which compares the extracted feature vector with a plurality of candidate signal vectors each corresponding to a specific class of ambient light sources, such as incandescent lamps, halogen lamps, LED-lamps and similar.

At step 350 the amount of infrared ambient light incident onto surface of the touch-sensitive panel is determined. In order to perform this operation, the ambient light incident on the one or more light-sensitive elements (which in this example are sensitive to IR light), such as the light-sensitive elements in Fig. 1, is determined first. This may be necessary, since there will most probably be a difference between the amount of

ambient light incident onto the touch-sensitive apparatus and the amount of ambient light registered by the one or more light-sensitive elements in the touch-sensitive apparatus. One source of the discrepancy may be contaminations on the surface of the touch-sensitive plate stemming from fingerprints, smears, dust and other contamination sources. These contaminations lead to a different scattering of the ambient light through the light transmissive panel 1 and to the light-sensing elements. Also, the touch-sensitive apparatus as presented in Figs. 1 and 2 relies upon the principle that some part of the ambient light will be scattered by the light transmissive panel and it is this part that may be registered by the one or more light-sensitive elements. One simple way of modeling the contamination of the touch-sensitive panel may be to assume that the contaminations are on average evenly distributed over the entire surface of the touch-sensitive panel. In this case the influence of the contaminations on the ambient light incident on the touch-sensitive panel may be taken account by using a correction factor C_{cont}. Multiplying the signal vector formed at step 320 by the correction factor will yield a corrected signal vector more realistically representing the real amount of ambient light incident on the touch-sensitive panel. Taking the absolute value of the thus corrected signal vector may then yield the average intensity value of the ambient light incident onto the surface of the touch-sensitive panel. In case of a more uneven distribution of the surface contamination over the upper surface of the light transmissive panel the model described earlier with the partition of the light transmissive panel into sub-areas may be applied. Please note that this corrected intensity value still represents the amount of infrared ambient light incident onto the touch-sensitive panel from one or more ambient light source.

Thus, it is necessary to transform the corrected average intensity value from step 350 into an intensity value of visible light seen by the human eye which takes into account the type or types of ambient light source which is generating the ambient light. Therefore, at step 360, the processor of the touch-sensitive apparatus, such as the processor 8 will calculate a conversion factor corresponding to the type of ambient light source identified at step 340. If several ambient light sources have been identified at step 340, then the processing unit may for example calculate a conversion factor for each ambient light source classified at step 340 and thereafter a general conversion factor which may be an average value.

It should be noted here that steps 350 and 360 are interchangeable, i.e. the calculation of a conversion factor or conversion factors for the ambient light source(s) detected may be performed on the signal vector from step 320 first and then the correction factor may be applied thereafter.

At step 370, the processor calculates from the corrected and converted intensity value of ambient light incident on obtained at steps 350 and 360 a brightness value for a display connected to the touch-sensitive apparatus of Figs. 1 and 2. This value may then be used to adjust the brightness of the display to correspond to the ambient light level.

It should be noted that in the description of the steps in the flowchart in Fig. 7 it has been assumed that the light-sensing elements are mainly sensitive to infrared ambient light. However, the method may equally work with light-sensitive elements which are sensitive to visible light. In that case the conversion factor for the ambient light source or sources detected would again be calculated at step 360 to reflect the amount of light visible to the human eye.

CLAIMS

1. Method for determining the amount of visible ambient light incident on a touch-sensitive apparatus comprising a first array of light-sensing elements, the method comprising the steps:
- receiving light signals at a plurality of light-sensing elements in the first array;
- converting the light signals into electrical signals;
- identifying at least one type of ambient light source from the signal by comparing features in the signal with characteristic features of one or more known light sources and;
- obtaining information related to the amount of visible ambient light incident on the panel generated by the at least one type of ambient light source in relation to the amount of ambient light registered at the plurality of light-sensing elements.

2. Method according to claim 1, further comprising the step of forming a signal vector from the electrical signals by sampling the converted electrical signals from the plurality of light-sensing elements.

3. Method according to claim 1 or 2, wherein the step of identifying at least one type of ambient light source by comparing features in the signal comprises extracting a feature vector by comparing the signal vector with at least one template vector representative of a known ambient light source.

4. Method according to claim 3, further comprising classifying the feature vector obtained according to a closest match obtained during the comparison with a known ambient light source.

5. Method according to one of the claims 1-4, wherein obtaining information related to the amount of visible ambient light incident on the panel comprises determining a correction factor indicative of the amount of scattering of the incident ambient light into the panel.

6. Method according to one of the claims 1-5, where obtaining information related to the amount of visible light incident on the panel comprises determining a conversion factor indicative of the amount of visible light incident on the panel in relation to the amount of ambient light detected by the one or more light—sensing elements.

7. Method according to one of the claims 1-6, further comprising the step calculating a brightness value from the information related to the amount of visible light incident on the panel.

8. Method according to claim 7, further comprising compensating the brightness of the panel using the brightness value.

9. Method according to one of the claims 1-8, further comprising the step of generating light signals in a plurality of light-emitting elements belonging to a first array of light-emitting elements in the touch-sensitive apparatus during a first time period and receiving ambient light signals at the plurality of light-sensing elements during a second time period where the light-emitting elements are switched off.

10. Method according to one of the claims 1-8, further comprising:
- generating light signals **in** a plurality of light-emitting elements belonging **to** a first array of light-emitting elements **in** the touch-sensitive apparatus during a first **time** period:
- receiving the light signals during the first time period at a plurality of light-sensitive elements;
- receiving ambient light signals at the plurality of light-sensitive elements during a second time period where the plurality of light-emitting elements are switched off.'

11. Method according to one of the claims 1-10, further comprising:
- generating light signals in a plurality of light-emitting elements belonging to a first array **of light-emitting** elements in the touch-sensitive apparatus;
- receiving **the** light signals at a plurality of light-sensitive elements and;
- measuring energy of the light signal for a particular detection line received at each of the plurality of light-sensitive elements;
- computing a relative change between the energy of the light signal for each particular detection line received at each of the plurality of light-sensitive elements and a reference energy value for the light signal for the particular detection line and;
- determining touch data for the transmissive panel based on the relative change.

12. Method for determining **the** visible ambient **light** level incident on a touch-sensing apparatus comprising a light transmissive panel defining a touch surface and an opposite surface, where **light** generated by an illumination arrangement comprising emitters propagates in the panel by total internal reflection, the method comprising **the** steps:
- receiving light signals at a plurality of light-sensing elements **in** a first array belonging **to the** touch-sensing apparatus;
- converting the light signals into electrical signals;
- identifying **at** least one type of ambient light source from the signal by comparing features in the signal **with** characteristic features of one or more known light sources and;

- obtaining information related to the amount of visible ambient light generated by the at least one type of ambient light source identified which is incident on the panel.

13. Touch-sensitive apparatus for determining the amount of visible ambient light incident onto a touch-sensitive panel of the apparatus, comprising:
- a first array of light-sensing elements configured to convert incident ambient light signals into electrical signals;
- a memory unit configured to store characteristic signal features for a plurality of known ambient light sources;
characterized in that
the touch-sensitive apparatus further comprises a processor configured to identify at least one type of ambient light source from the signal by comparing features in the signal with the stored characteristic signal features of the one or more known light sources and wherein the processor is further configured to relate the amount of visible ambient light incident on a touch-sensitive panel of the apparatus generated by the ambient light source identified by the processor.

14. Touch-sensitive apparatus according to claim 13, wherein the first array of light-sensing elements is sensitive to infrared light.

15. Touch-sensitive apparatus according to claim 13 or 14, wherein the first array of light-sensing elements is sensitive to visible light.

16. Touch-sensitive apparatus according to one of the claims 13-15, wherein the first array of light-sensing elements is arranged along the periphery of the light-sensitive apparatus.

17. Touch-sensitive apparatus for determining the amount of visible ambient light incident onto the apparatus, comprising:
- a light transmissive panel defining a touch surface and an opposite surface,
- an illumination arrangement comprising emitters configured to generate light into the panel, such that light is propagated in the panel by total internal reflection;
- a first array of light-sensing elements configured to receive the light generated by the emitters and ambient light incident onto the touch surface of the panel and to convert the incident ambient signals light into electrical signals;
- a memory unit configured to store characteristic signal features for a plurality of known ambient light sources,
characterized in that
the touch-sensitive apparatus further comprises a processor configured to identify at least one type of ambient light source from the signal by comparing features in the signal with the stored characteristic signal features of the one or

more known light sources and wherein the processor is further configured to relate the amount of visible ambient light received by the plurality of light-sensing elements to the amount of visible ambient light incident on the transmissive panel and generated by the ambient light source identified.

5

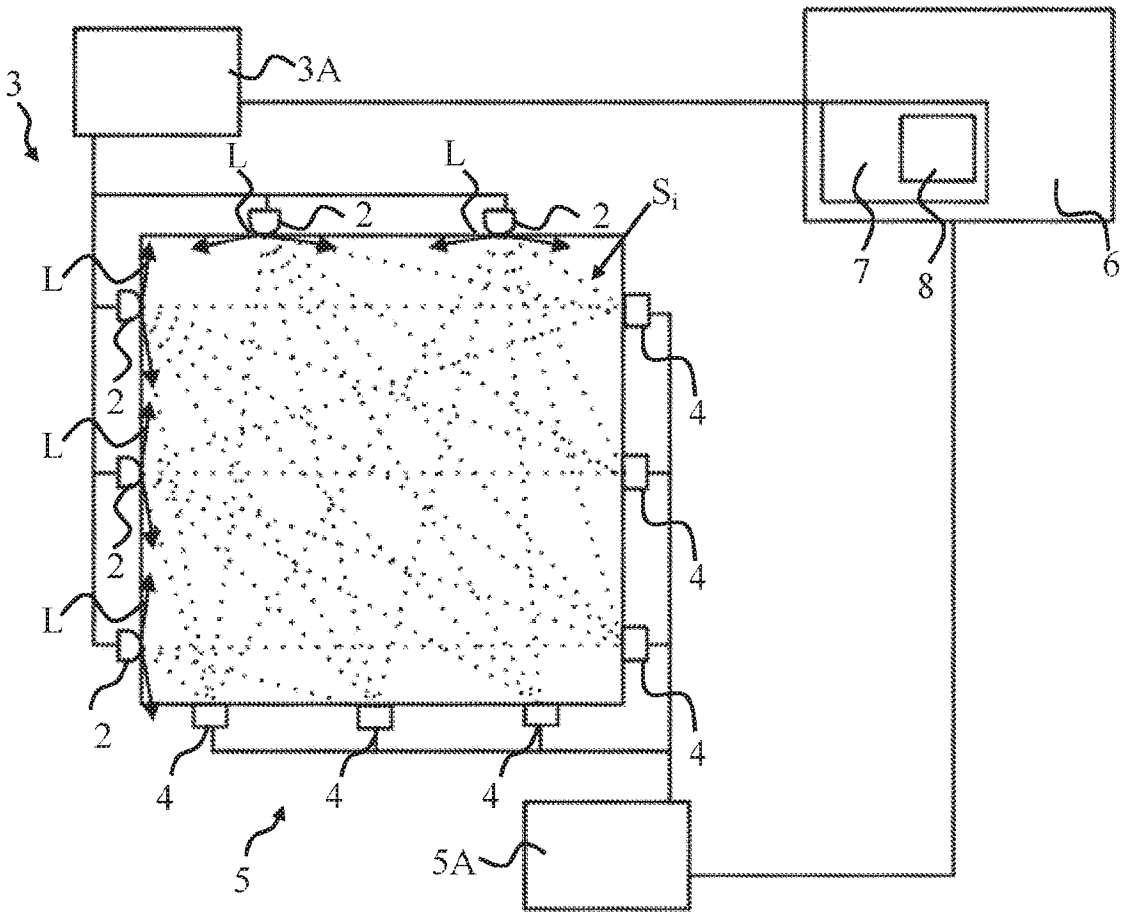


Fig. 1 (Prior art)

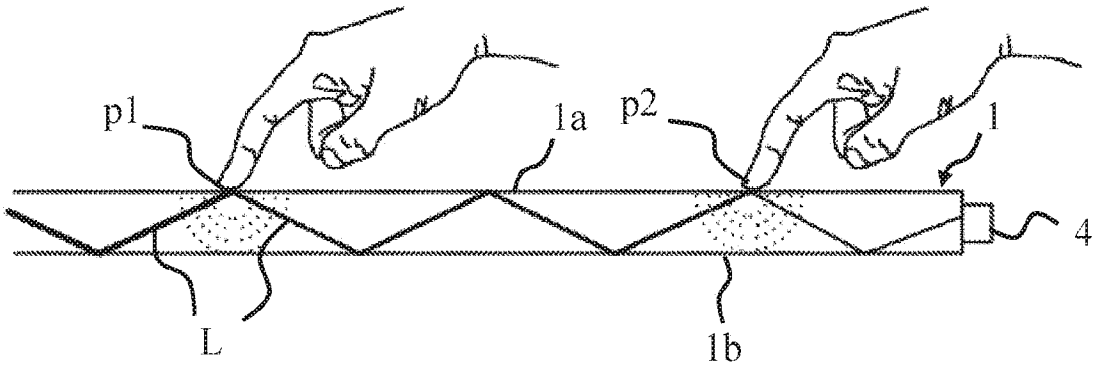


Fig. 2 (Prior art)

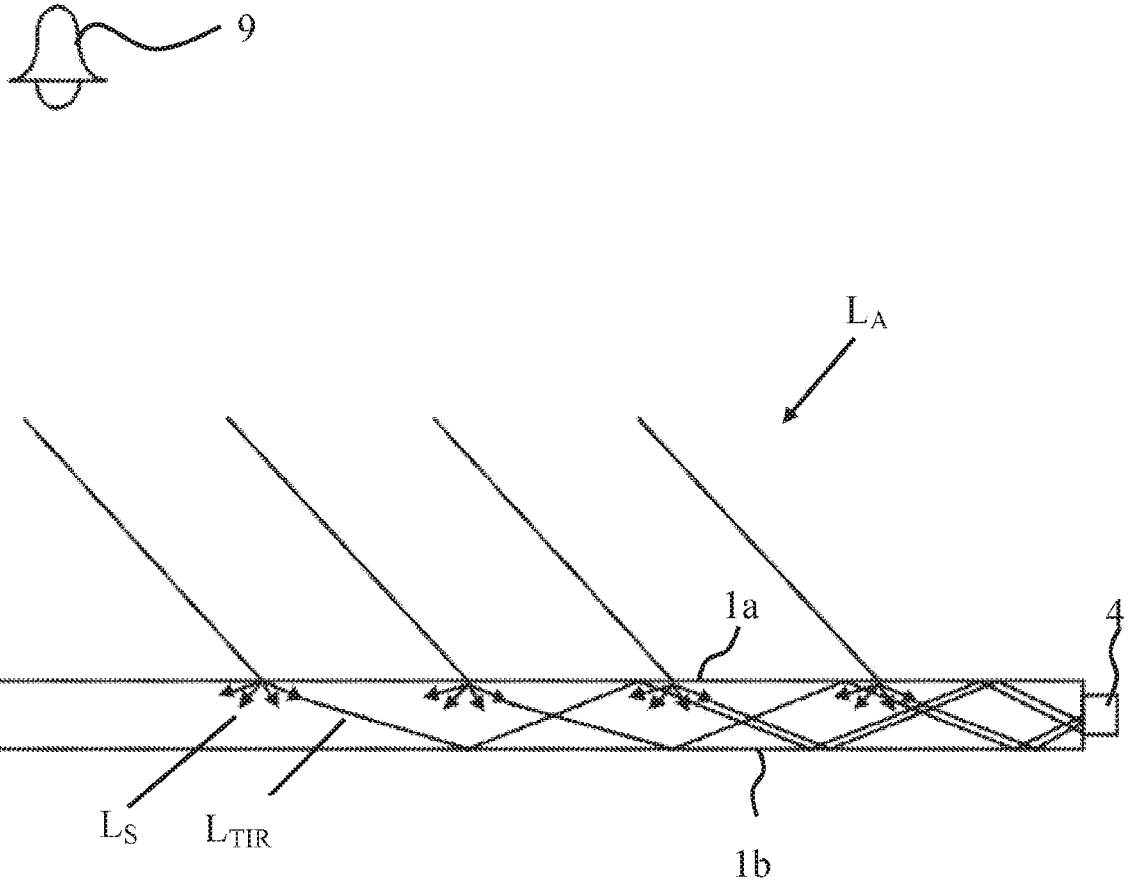


Fig. 3

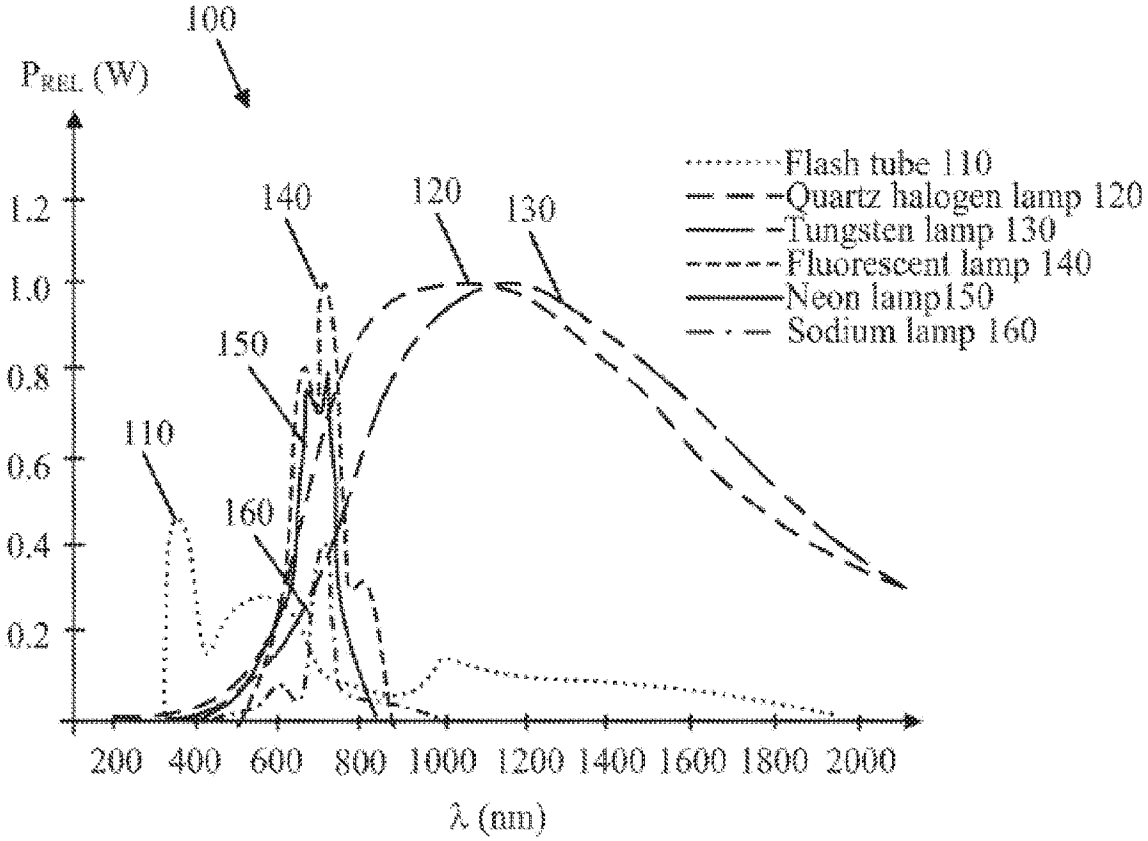


Fig. 4 (Prior art)

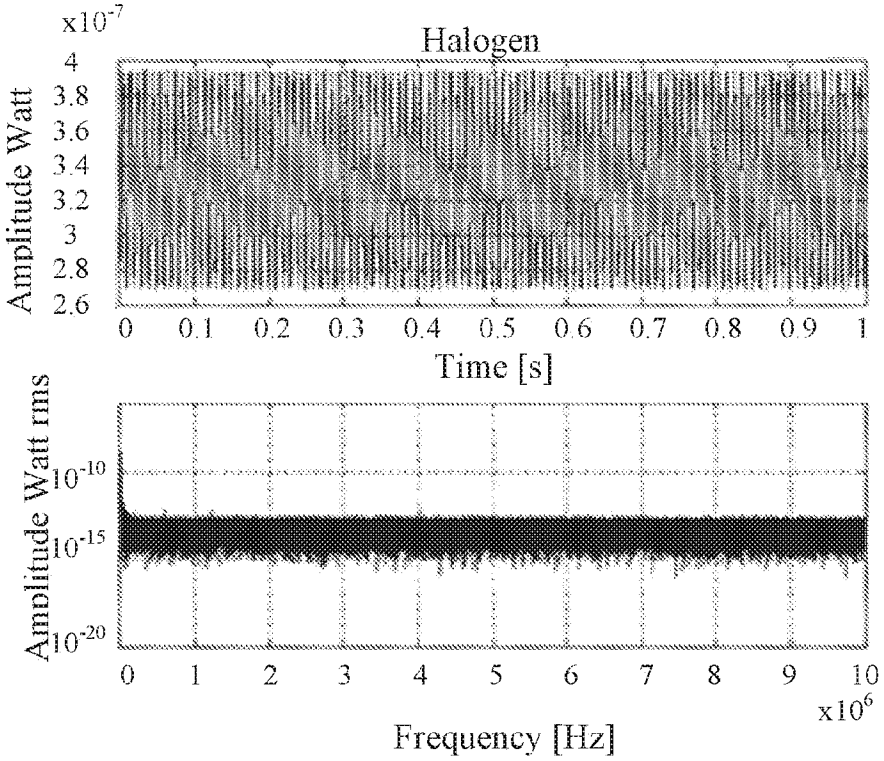

Halogen
x10-7
Amplitude Watt
Time [s]
Amplitude Watt rms
Frequency [Hz]
x10^6

Fig. 5

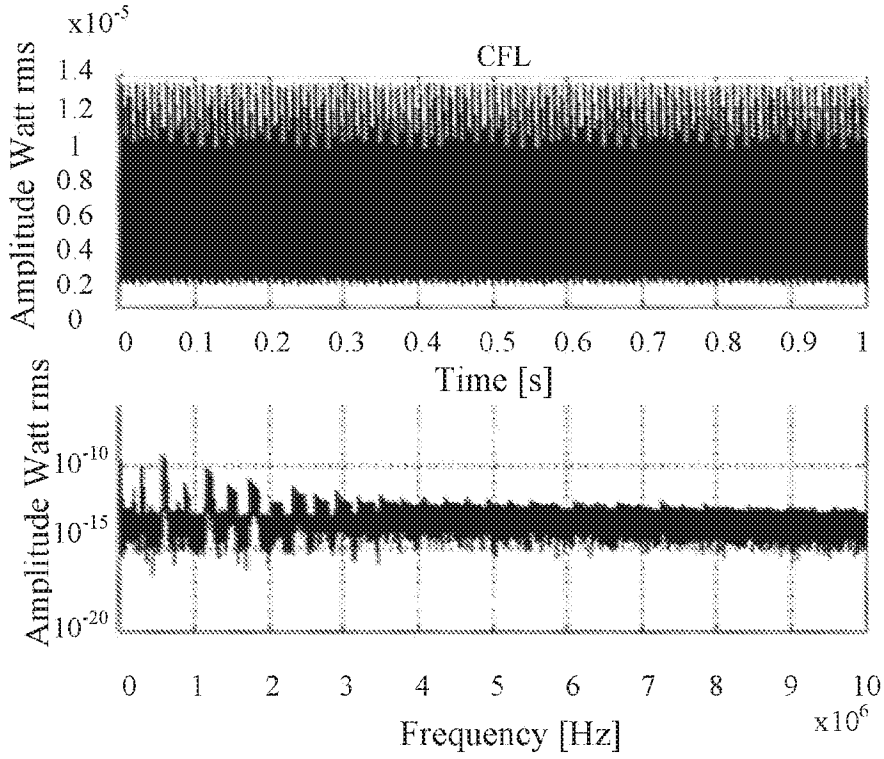

CFL
x10-5
Amplitude Watt rms
Time [s]
Frequency [Hz]
x10^6

Fig. 6

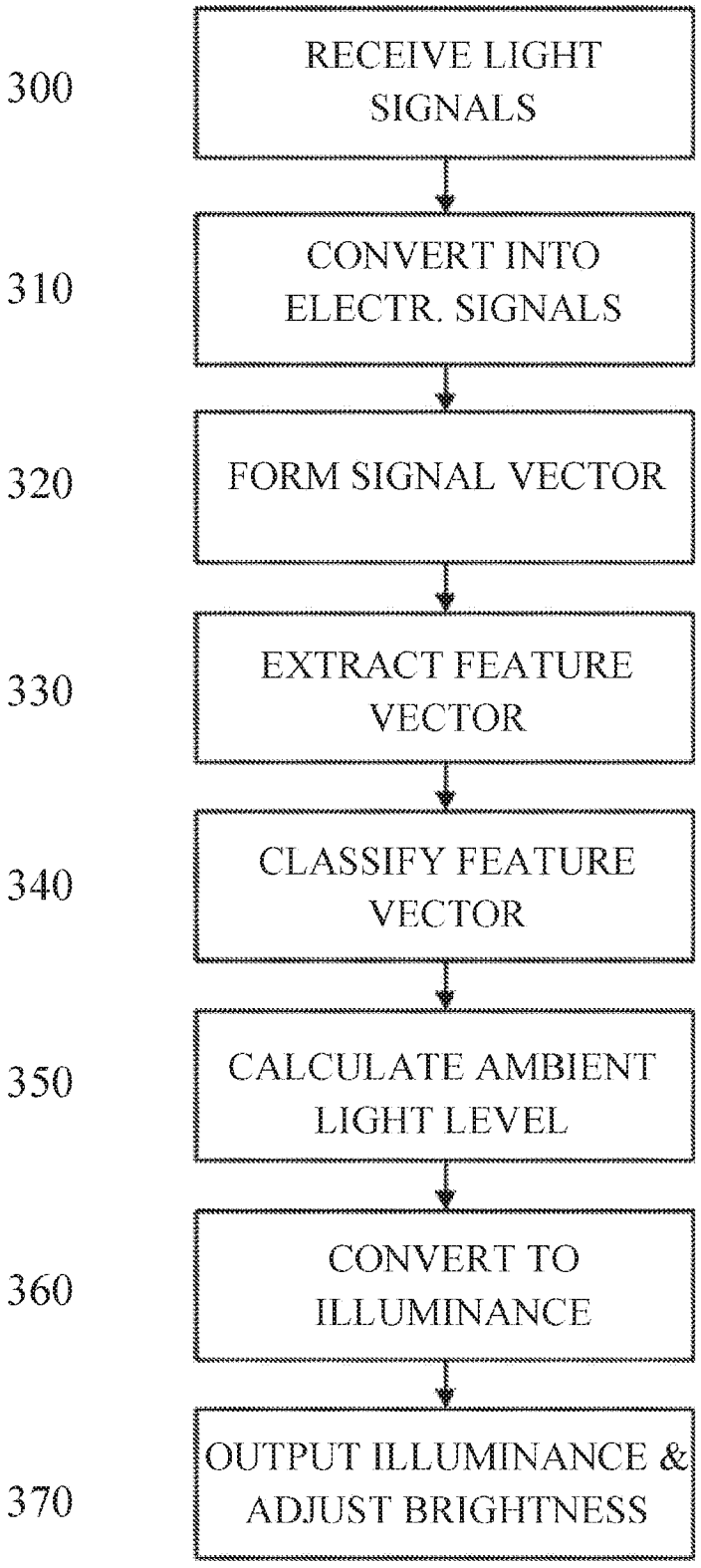

300
RECEIVE LIGHT SIGNALS
310
CONVERT INTO ELECTR. SIGNALS
320
FORM SIGNAL VECTOR
330
EXTRACT FEATURE VECTOR
340
CLASSIFY FEATURE VECTOR
350
CALCULATE AMBIENT LIGHT LEVEL
360
CONVERT TO ILLUMINANCE
370
OUTPUT ILLUMINANCE & ADJUST BRIGHTNESS

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 3/051 6 14

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. 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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Y	US 20040095402 A 1 (NAKANO TAKAO), 20 May 2004 (2004-05-20); abstract; paragraphs [01 32]-[01 33], [01 55]; figure 20; claim 16	1-2, 5-1 6
A	~	3, 4, 17

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international fding 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
30-04-201 4	02-05-201 4
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-1 02 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Omar Al-Askary Telephone No. +46 8 782 25 00

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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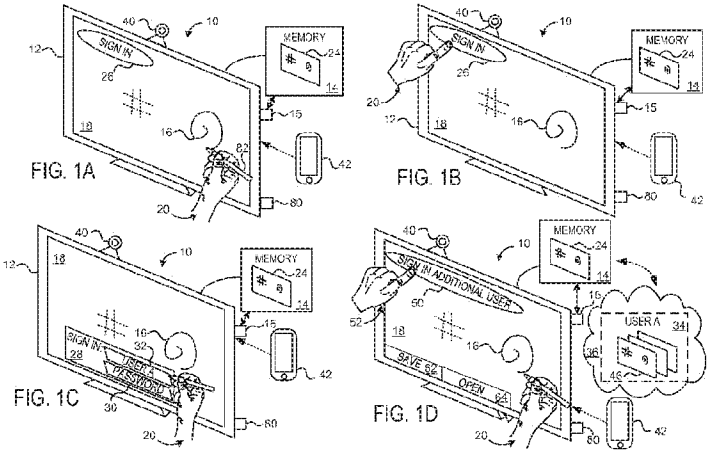
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(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title:** CLAIMING DATA FROM A VIRTUAL WHITEBOARD



(57) **Abstract:** A method of storing data from a whiteboard application executed on a computing system including an interactive display device is provided. The method comprises storing, in a memory of the computing system, whiteboard data input to the whiteboard application in response to user interaction with the interactive display device, displaying a login selector on the interactive display device, upon detecting actuation of the login selector, identifying the user based on credentials of the user; and in response to identifying the user, (i) retrieving previews of stored whiteboard files from a user account in a cloud-based storage system corresponding to the identity of the user, (ii) displaying the previews on the interactive display device, and (iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

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Declarations under Rule 4.17:

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

CLAIMING DATA FROM A VIRTUAL WHITEBOARD

BACKGROUND

[0001] Prior whiteboard applications have been used via computer systems, enabling displayed content to be drawn upon or otherwise manipulated via input devices such as mice, trackpads, touchscreens, etc. In this way, the whiteboard application can provide the functionality of a physical dry-erase or chalkboard in a computing context. Whiteboard applications are commonly used in collaborative settings such as meetings, brainstorming sessions, classrooms, etc. Therefore, in some instances a plurality of users may manipulate content presented via the whiteboard application in one or more sessions. The data associated with the manipulation of the content may be saved locally by the computing system. However, the computing system using the whiteboard application may be used by a number of users. Therefore, storing the data locally may create security concerns. Furthermore, storing the data locally may increase the amount of storage needed in the computing system. Therefore, offloading the content may be desirable to alleviate the security concerns and decrease local storage needs. However, offloading the content to a portable storage device (e.g., thumbdrive), for example, can be cumbersome and require many awkward steps involving numerous input commands. Consequently, it may be inefficient for one or more users to offload the content quickly during a collaborative session. As a result, users may find interaction with the whiteboard application slow and awkward. Moreover, it may be difficult to upload the offloaded content for use in a subsequent whiteboard session, leading to additional interactive inefficiency.

SUMMARY

[0002] A method of storing data from a whiteboard application executed on a computing system including an interactive display device is provided. The method comprises storing, in a memory of the computing system, whiteboard data input to the whiteboard application in response to user interaction with the interactive display device, displaying a login selector on the interactive display device, upon detecting actuation of the login selector, identifying the user based on credentials of the user; and in response to identifying the user, (i) retrieving previews of stored whiteboard files from a user account in a cloud-based storage system corresponding to the identity of the user, (ii) displaying the previews on the interactive display device, and (iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

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[0003] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve any or all disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1A depicts a computing system configured to store data from a whiteboard application executed on the computing system.

[0005] FIG. 1B depicts the computing system of FIG. 1A further configured to display a login selector on an interactive display device.

[0006] FIG. 1C depicts the computing system of FIG. 1A further configured to identify the user via a sign in prompt requesting the user enter a user ID and a password.

[0007] FIG. 1D depicts the computing system if FIG. 1A further configured to access a user account on a cloud-based storage system.

[0008] FIG. 2A depicts the computing system of FIGS. 1A-1D further configured to display a logout selector on the interactive display device.

[0009] FIG. 2B depicts the operation of the logout selector of FIG. 2A.

[0010] FIG. 3A depicts the computing system of FIGS. 1A-1D further configured to retrieve previews of stored whiteboard files from the user account on the cloud-based storage system.

[0011] FIG. 3B depicts the computing system of FIG. 3A configured to display a stored whiteboard file corresponding to a selected preview.

[0012] FIG. 4 depicts the computing system of FIGS. 1A-1D further configured to create virtual sticky-notes and recognize privacy keywords via handwriting recognition.

[0013] FIGS. 5A and 5B depict a flowchart for a method for storing data from a whiteboard application executed on the computing system in accordance with an embodiment of the present disclosure.

[0014] FIG. 6 schematically depicts a non-limiting embodiment of a computing system in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0015] A whiteboard application executed by a computing system including an interactive display device is described herein. The whiteboard application is configured to quickly and efficiently upload and download data to and from a cloud-based storage

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device during a whiteboard application user session. Specifically, data may be generated via the whiteboard application and subsequently sent to a cloud-based storage system when a user provides credentials to a user account in the cloud-based storage system. Additionally, previews of files stored in the cloud-based storage device can also be presented via the interactive display device in response to the user entering user credentials. As a result, a user can not only easily offload desired content to a cloud-based storage system but also quickly preview content stored in the cloud-based storage system, thereby enhancing the current whiteboard session. In this way, a user can quickly capture content and send the captured content to a cloud-based system for later use as well as preview previously captured content stored in the cloud-based system.

[0016] FIG. 1A depicts a computing system 10 configured to store data from a whiteboard application 18 executed on the computing system 10. The computing system 10 may be configured to include an interactive display device 12 (e.g., interactive touch sensitive display device) and a memory 14 including instructions executable by a processor 15. The whiteboard application 18 may be stored in memory 14 as instructions executable by the processor 15. The computing system 10 may be further configured to record, in the memory 14, a whiteboard file 24. The whiteboard file 24 may include whiteboard data 16 input into the whiteboard application 18 by a user 20 via the interactive display device 12.

[0017] The interactive display device 12 may include a sensing device 80. The sensing device may include one or more of a capacitive touch sensor, an optical touch sensor, etc. The interactive display device 12 may include a liquid crystal display (LCD), an organic light-emitting diode (OLED), active-matrix organic light-emitting diode (AMOLED), projection display, etc., for presenting graphics. The interactive display device 12 is configured to receive and process ink inputs and touch inputs. It will be appreciated that an ink input includes an interactive input with a stylus 82. The interactive display device 12 may further be configured to receive and process multi-touch inputs. Additionally, it will be appreciated that the aforementioned inputs may be sent to the memory 14 and processor 15 for processing via the whiteboard application 18.

[0018] FIG. 1B depicts the computing system 10 further configured to display a login selector 26 on the interactive display device 12. The login selector 26 may be a soft button generated graphically by the interactive display device 12 or a hard button physically present on the interactive display device 12, itself. Upon detecting actuation of the login selector 26, the computing system 10 may then be further configured to identify

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the user 20 based on credentials of the user 20. In one example, the login selector 26 may be a soft button persistently displayed on the interactive display device 12 via the whiteboard application 18. In this way, a user can quickly select the login selector while the whiteboard application is executed. However, other whiteboard application user interface configurations have been contemplated, such as using biometric indicators including facial image recognition to log a user in, or using a device identifier received from a user device (e.g., mobile phone, watch, stylus, etc.) to log a user in, as described below.

[0019] FIG. 1C depicts the computing system 10 further configured to identify the user 20 via a sign in prompt 28 requesting the user 20 enter a user ID 30 and a password 32. The user 20 is identified by the computing system 10 as "USER A". The computing system 10 may also be further configured to identify the credentials of the user 20 via facial recognition. For example, the computing system 10 may be configured to compare a captured image of the user 20 captured with camera 40 to a stored profile image associated with a cloud-based account (e.g., online account) of the user 20. The camera 40 linked to the computing system 10. In addition, the computing system 10 may be configured to identify the user 20 by wirelessly detecting the credentials of the user stored in a linked portable device. In FIG. 1C, the linked portable device is depicted as cell phone 42 which may be configured to communicate wirelessly with the computing system 10. It should be noted, however, that the computing system 10 may be configured to wirelessly detect the credentials of a user 20 via another suitable device, such as a security token (e.g., fob), stylus, or watch.

[0020] FIG. 1D depicts the computing system 10 further configured to access a user account 34 on a cloud-based storage system 36. The user account 34 corresponds to the identity of the user 20 established by the computing system 10, as described above with respect to FIG. 1C. Upon accessing the user account 34, the computing system 10 may be configured to upload the whiteboard file 24 from the memory 14 of the computing system 10 to the user account 34. For example, the computing system may be configured to display on the interactive display device 12 a save selector 62 and, upon detecting actuation of the save selector 62 by the user 20, to upload the whiteboard file 24 to the user account 34.

[0021] Turning briefly to FIG. 2A, the computing system 10 may be further configured to display a logout selector 38 on the interactive display device. As shown in FIG. 2B, the computing system 10 may be then configured to revoke access to the user

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account 34 upon detecting actuation of the logout selector 38 by the user 20. Additionally, previews of the files stored in the cloud-based storage system may be removed from the interactive display device upon detecting actuation of the logout selector. The previews are discussed in greater detail herein.

[0022] Turning next to FIG. 3A, the computing system 10 may be further configured to retrieve previews 44 of stored whiteboard files 46 from the user account 34 on the cloud-based storage system 36. For example, the computing system 10 may be configured to display an open selector 64 on the interactive display device 12 and, upon detecting actuation of the open selector 64 by the user 20, to retrieve previews 44 of the stored whiteboard files 46 from the user account 34. The computing system may then be configured to display the previews 44 on the interactive display device 12. The previews 44 may be displayed by the computing device as a horizontal strip of preview images, with the preview images grouped chronologically. The previews 44 may be further grouped into folders. Additionally or alternatively, the previews may be presented as tiles (e.g., tiles aligned in a grid pattern) or stacked with each preview having a different z-order. The computing system 10 may be further configured to allow the user 20 to select one of the previews 44 via the interactive display device 12. Upon detecting a selection by the user 20, the computing system 10 may be configured to retrieve the stored whiteboard file 46 corresponding to the selected preview 44. As shown in FIG. 3B, the computing system 10 may then be configured to display the stored whiteboard file 46 on the interactive display device 12. The whiteboard application may be configured to enable the user manipulate the whiteboard file, such as adding additional content, erasing content, modifying content, etc. For instance, a user may implement an ink input and/or touch input to generate additional graphics (e.g., alphanumeric symbols) in the whiteboard file.

[0023] Turning back to FIG. ID, the computing system 10 may be further configured to display a second login selector 50 on the interactive display device 12. The computing system 10 may be configured to identify a second user 52 based on credentials of the second user 52 after detecting actuation of the second login selector 50 by the second user 52. The computing system 10 may then be configured to access a second user account on a cloud-based storage system corresponding to the identity of the second user 52 and upload the whiteboard file 24 from the memory 14 of the computing system 10 to the second user account. Although only the user account 34 is depicted in FIG. ID, it should be noted that the computing system 10 may be configured to upload the whiteboard file 24 from the memory 14 to the second user account, as well. For example, it should be

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further noted that the computing system 10 may be configured to allow multiple user to operate in a split-screen mode wherein the whiteboard data from one predetermined half of the interactive display device is uploaded to the user account of the first user, and the whiteboard data from the other half may be uploaded to the user account of the second user. In another example, multiple users may be able to select portions of the whiteboard data and upload only the selected portion to their user account.

[0024] Turning next to FIG. 4, the computing system 10 may be configured to create virtual sticky-notes 54 via the interactive display device 12. The virtual sticky-notes 54 may contain content such as text input by the user and may be associated with a location or an element in the whiteboard data. For example, if a virtual sticky-note 54 is placed on a location within the whiteboard data of the whiteboard application 18, the virtual sticky-note 54 will remain in that location even if the whiteboard data is scrolled or resized on the interactive display device 12. The virtual sticky-notes 54 may also be configured such that multiple virtual sticky-notes may be stacked, resized, or arranged on the screen by the user 20. The computing system 10 may be further configured to record the virtual sticky-notes 54 in the memory 14 and to upload the virtual sticky-notes 54 to the user account 34 as a part of a whiteboard file 56. As such, the virtual sticky-notes can be stored on the computing system 10 and in user account 34 of the user 20.

[0025] FIG. 4 further depicts the computing system 10 configured to detect a privacy keyword 58 via handwriting recognition on the interactive display device 12. In the example shown in FIG. 4, the computing system 10 is configured to detect the word "Secret" or another suitable privacy keyword, such as confidential, private, etc., via handwriting recognition. The computing system 10 may then be configured to assign a privacy level 60 to the whiteboard file 56 based on the privacy keyword 58. The computing system may then be configured to restrict access to the whiteboard file 56 based on the privacy level 60. For example, the computing system 10 may be configured to restrict access to the whiteboard file 56 by locking the file and not allowing any unauthorized users to upload the whiteboard file 56. Alternately, the computing system 10 may be configured to restrict access to a whiteboard file 56 by not displaying a preview of the file among the previews of stored files retrieved from the user account 34 if unauthorized users are currently logged into the computing system 10. In another example, the computing system 10 may restrict access to a whiteboard file 56 by displaying a warning message when an additional user logs into the computing system 10, if the additional user is not authorized to upload the whiteboard file 56.

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[0026] FIG. 5 is a flowchart depicting a method 500 of storing data from a whiteboard application executed on a computing system including an interactive display device. At 502, the method 500 includes receiving ink inputs and/or touch inputs at the interactive display device. It will be appreciated that the ink inputs may be implemented via a stylus and the touch inputs may be implemented via digits of a user, for instance.

[0027] Next at 504 the method includes generating whiteboard data based on the received inputs in response to receiving the inputs. In one example, the whiteboard data is in a data format specific to the whiteboard application. However, other whiteboard data formats have been contemplated. Further in one example, the whiteboard data includes at least one of modifiable ink input data, touch input data, and sticky-note data associated with a location or another element in the whiteboard data. It will be appreciated that the sticky-note data may mimic the functionality of physical sticky notes on a physical whiteboard.

[0028] At 506 the method includes storing, in a memory of the computing system, the whiteboard data in response to receiving the inputs at the interactive display. In one example, the whiteboard data may be stored in the memory in direct response to receiving the inputs at the interactive display. In the context of the invention direct response means that there are not intervening input commands implemented between the corresponding actions. Next at 508 the method includes detecting a privacy keyword via handwriting recognition on the interactive display device and at 510 the method includes assigning a privacy level to the whiteboard data based on the privacy keyword. The privacy keyword may be "secret", "classified", "confidential", etc. At 512 the method includes restricting access to the whiteboard data based on the privacy level. In this way, a user may provide increased security to data quickly and intuitively through interaction with the interactive display device.

[0029] At 514 the method includes displaying a login selector on the interactive display and at 516 the method includes detecting actuation of the login selector. Detecting actuation of the login selector may include detecting actuation of a button via user input (e.g., ink input, touch input, mouse input, etc.), for instance. At 518 the method includes upon detecting actuation of the login selector, identifying a user based on credentials of the user. Identifying the user based on the credential of the user may include at 520 prompting user to input a username and password associated with a user account on a cloud-based storage system. Additionally or alternatively, identifying the user based on the credentials of the user may include at 522 determining the identity of the user based on

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a facial recognition. Additionally or alternatively, identifying the user based on the credential of the user may include at 524 wirelessly detecting the credentials of the user stored in a linked portable device and at 526 determining the identity of the user based on the credentials. In one example, the linked portable device is one of a stylus, mobile computing device, and security token device. Thus, the credentials may be supplied by at least one of a stylus, mobile computing device, and security token device via wireless communication. In this way, a device associated with the user may be used to quickly identify the identity of the user.

[0030] Now turning to FIG. 5B, the method includes at 528-534 in response to identifying the user (i) retrieving preview of stored whiteboard files from a user account in a cloud-based storage system corresponding to the identity of the user, (ii) displaying the previews on the interactive display device, and (iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account. In this way, whiteboard data may be quickly pushed and pulled from the user account in the cloud-based storage system. In one example, the uploaded whiteboard data only includes a selected portion of data presented on the interactive touch sensitive display associated with the whiteboard application. For instance, a user may select a portion of the data via an ink input, touch gesture, etc., indicating the portion of data they would like to be uploaded. Still further in other examples, a stylus may be associated with a user and only the portion of whiteboard data generated by the specific stylus may be uploaded to the cloud-based storage system. However, in other examples all of the whiteboard data presented on the interactive display may be uploaded to the cloud-based storage system.

[0031] At 536 the method includes receiving a selection input of one of the previews via the interactive display device. Next at 538 the method includes retrieving the stored whiteboard file corresponding to the selected preview from the cloud-based storage system. At 540 the method includes displaying the stored whiteboard file on the interactive display and at 542 the method includes displaying a second login selector on the interactive display. At 544 the method includes detecting actuation of the second login selector. At 546 the method includes upon detection of actuation of the second login selector, identifying a second user based on credentials of the second user. Next at 548 the method includes in response to identifying the second user, uploading the whiteboard data from the memory of the computing system to a second user account in the cloud-based storage system, the second user account distinct from the first user account. At 550 the method includes displaying a logout selector on the interactive display device. Next at

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552 the method includes upon detecting actuation of the logout selector, revoking access to the user account and removing the previews of the stored whiteboard files from the interactive display device.

[0032] The above described systems and methods provide the potential advantage that a user can quickly pull and push data to and from a cloud-based storage system. As a result, the users can quickly and intuitively acquire relevant data during a collaborative session for use at a later time. Furthermore, previously stored files are presented during the current whiteboard session for use during the current whiteboard session, if desired, further expanding the content that can be used is a single session. In this way, data from multiple whiteboard sessions can be provided in a single interface further enhancing the current whiteboard session by providing greater amount of collaborative content. As a result, the functionality of the whiteboard is expanded to provide a user with quick and efficient access to cloud-based content. In this way, content from more than one whiteboard session may be linked via a cloud-based storage system enabling the user to link content from multiple whiteboard sessions, if desired.

[0033] In some embodiments, the methods and processes described herein may be tied to a computing system of one or more computing devices. In particular, such methods and processes may be implemented as a computer-application program or service, an application-programming interface (API), a library, and/or other computer-program product. Specifically, the methods and processing herein may be tied to the computing system discussed above with regard to FIGS. 1-4.

[0034] FIG. 6 schematically shows a non-limiting embodiment of a computing system 600 that can enact one or more of the methods and processes described above. Computing system 600 is shown in simplified form. Computing system 600 may take the form of a touch-screen display device, as well as any other suitable computing system, including but not limited to game consoles, one or more personal computers, server computers, tablet computers, home-entertainment computers, network computing devices, gaming devices, mobile computing devices, mobile communication devices (e.g., smart phone), and/or other computing devices.

[0035] Computing system 600 includes a logic machine 602 and a storage machine 604. Computing system 600 may also include a display subsystem 606, input subsystem 608, communication subsystem 610, and/or other components not shown in FIG. 6.

[0036] Logic machine 602 includes one or more physical devices configured to execute instructions. For example, the logic machine may be configured to execute

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instructions that are part of one or more applications, services, programs, routines, libraries, objects, components, data structures, or other logical constructs. Such instructions may be implemented to perform a task, implement a data type, transform the state of one or more components, achieve a technical effect, or otherwise arrive at a desired result.

[0037] The logic machine may include one or more processors configured to execute software instructions. Additionally or alternatively, the logic machine may include one or more hardware or firmware logic machines configured to execute hardware or firmware instructions. Processors of the logic machine may be single-core or multi-core, and the instructions executed thereon may be configured for sequential, parallel, and/or distributed processing. Individual components of the logic machine optionally may be distributed among two or more separate devices, which may be remotely located and/or configured for coordinated processing. Aspects of the logic machine may be virtualized and executed by remotely accessible, networked computing devices configured in a cloud-computing configuration.

[0038] Storage machine 604 includes one or more physical devices configured to hold instructions executable by the logic machine to implement the methods and processes described herein. When such methods and processes are implemented, the state of storage machine 604 may be transformed—e.g., to hold different data.

[0039] Storage machine 604 may include removable and/or built-in devices. Storage machine 604 may include optical memory (e.g., CD, DVD, HD-DVD, Blu-Ray Disc, etc.), semiconductor memory (e.g., RAM, EPROM, EEPROM, etc.), and/or magnetic memory (e.g., hard-disk drive, floppy-disk drive, tape drive, MRAM, etc.), among others. Storage machine 604 may include volatile, nonvolatile, dynamic, static, read/write, read-only, random-access, sequential-access, location-addressable, file-addressable, and/or content-addressable devices.

[0040] It will be appreciated that storage machine 604 includes one or more physical devices. However, aspects of the instructions described herein alternatively may be propagated by a communication medium (e.g., an electromagnetic signal, an optical signal, etc.) that is not held by a physical device for a finite duration.

[0041] Aspects of logic machine 602 and storage machine 604 may be integrated together into one or more hardware-logic components. Such hardware-logic components may include field-programmable gate arrays (FPGAs), program- and application-specific integrated circuits (PASIC / ASICs), program- and application-specific standard products

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(PSSP / ASSPs), system-on-a-chip (SOC), and complex programmable logic devices (CPLDs), for example.

[0042] The terms "module," "program," and "engine" may be used to describe an aspect of computing system 600 implemented to perform a particular function. In some cases, a module, program, or engine may be instantiated via logic machine 602 executing instructions held by storage machine 604. It will be understood that different modules, programs, and/or engines may be instantiated from the same application, service, code block, object, library, routine, API, function, etc. Likewise, the same module, program, and/or engine may be instantiated by different applications, services, code blocks, objects, routines, APIs, functions, etc. The terms "module," "program," and "engine" may encompass individual or groups of executable files, data files, libraries, drivers, scripts, database records, etc.

[0043] When included, display subsystem 606 may be used to present a visual representation of data held by storage machine 604. This visual representation may take the form of a graphical user interface (GUI). As the herein described methods and processes change the data held by the storage machine, and thus transform the state of the storage machine, the state of display subsystem 606 may likewise be transformed to visually represent changes in the underlying data. Display subsystem 606 may include one or more display devices utilizing virtually any type of technology. Such display devices may be combined with logic machine 602 and/or storage machine 604 in a shared enclosure, or such display devices may be peripheral display devices.

[0044] When included, input subsystem 608 may comprise or interface with one or more user-input devices such as a keyboard, mouse, touch screen, or game controller. In some embodiments, the input subsystem may comprise or interface with selected natural user input (NUI) componentry. Such componentry may be integrated or peripheral, and the transduction and/or processing of input actions may be handled on- or off-board. Example NUI componentry may include a microphone for speech and/or voice recognition; an infrared, color, stereoscopic, and/or depth camera for machine vision and/or gesture recognition; a head tracker, eye tracker, accelerometer, and/or gyroscope for motion detection and/or intent recognition; as well as electric-field sensing componentry for assessing brain activity.

[0045] When included, communication subsystem 610 may be configured to communicatively couple computing system 600 with one or more other computing devices. Communication subsystem 610 may include wired and/or wireless

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communication devices compatible with one or more different communication protocols. As non-limiting examples, the communication subsystem may be configured for communication via a wireless telephone network, or a wired or wireless local- or wide-area network. In some embodiments, the communication subsystem may allow computing system 600 to send and/or receive messages to and/or from other devices via a network such as the Internet.

[0046] It will be understood that the configurations and/or approaches described herein are exemplary in nature, and that these specific embodiments or examples are not to be considered in a limiting sense, because numerous variations are possible. The specific routines or methods described herein may represent one or more of any number of processing strategies. As such, various acts illustrated and/or described may be performed in the sequence illustrated and/or described, in other sequences, in parallel, or omitted. Likewise, the order of the above-described processes may be changed.

[0047] The subject matter of the present disclosure includes all novel and nonobvious combinations and subcombinations of the various processes, systems and configurations, and other features, functions, acts, and/or properties disclosed herein, as well as any and all equivalents thereof.

[0048] The subject matter of the present disclosure is further described in the following paragraphs. According to one aspect, a method of storing data from a whiteboard application executed on a computing system including an interactive display device is provided. The method includes, storing, in a memory of the computing system, whiteboard data input to the whiteboard application in response to user interaction with the interactive display device, displaying a login selector on the interactive display device, and upon detecting actuation of the login selector; identifying the user based on credentials of the user; in response to identifying the user, (i) retrieving previews of stored whiteboard files from a user account in a cloud-based storage system corresponding to the identity of the user, (ii) displaying the previews on the interactive display device, and (iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

[0049] In this aspect, the method may further include displaying a logout selector on the interactive display device; and upon detecting actuation of the logout selector, revoking access to the user account and removing the previews of the stored whiteboard files from the interactive display device.

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[0050] In this aspect, identifying the user based on credentials of the user may further comprise: prompting the user to input a username and a password associated with a user account on a cloud-based storage system.

[0051] In this aspect, identifying the user based on credentials of the user may further comprise: determining the identity of the user based on a facial recognition.

[0052] In this aspect, identifying the user based on credentials of the user may further comprise: wirelessly detecting the credentials of the user stored in a linked portable device; and determining the identity of the user based on the credentials.

[0053] In this aspect, the linked portable device may be one of a stylus, mobile computing device, and security token device.

[0054] In this aspect, the method may further include receiving a selection input of one of the previews via the interactive display device; retrieving the stored whiteboard file corresponding to the selected preview from the cloud-based storage system; and displaying the stored whiteboard file on the interactive display device.

[0055] In this aspect, the method may further include displaying a second login selector on the interactive display device; upon detecting actuation of the second login selector, identifying a second user based on credentials of the second user; and in response to identifying the second user, uploading the whiteboard data from the memory of the computing system to a second user account in the cloud-based storage system, the second user account distinct from the first user account.

[0056] In this aspect, the method may further include detecting a privacy keyword via handwriting recognition on the interactive display device; assigning a privacy level to the whiteboard data based on the privacy keyword; and restricting access to the whiteboard data based on the privacy level.

[0057] In this aspect, the whiteboard data may be in a data format specific to the whiteboard application.

[0058] In this aspect, the uploaded whiteboard data may only include a selected portion of data presented on the interactive touch sensitive display associated with the whiteboard application.

[0059] According to another aspect, a computing system is provided which includes an interactive touch sensitive display device; code stored in memory executable by a processor to: store, in a memory of the computing system, whiteboard data input to the whiteboard application in direct response to user interaction with the interactive touch sensitive display device; display a login selector on the interactive touch sensitive display

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device; upon detecting actuation of the login selector, identifying the user based on credentials of the user; and in response to identifying the user, (i) retrieve previews of stored whiteboard files from the user account on the cloud-based storage system, (ii) display the previews on the interactive touch sensitive display device, and (iii) upload the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

[0060] In this aspect, the whiteboard data may be in a data format specific to the whiteboard application.

[0061] In this aspect, the whiteboard data may include at least one of modifiable ink input data, touch input data, and sticky-note data associated with a location or another element in the whiteboard data.

[0062] In this aspect, the computing system may further include code stored in memory executable by a processor to; detect a privacy keyword via handwriting recognition on the interactive touch sensitive display device; assign a privacy level to the whiteboard data based on the privacy keyword; and restrict access to the whiteboard data based on the privacy level.

[0063] In this aspect, the credentials may be supplied by at least one of a stylus, mobile computing device, and security token device via wireless communication.

[0064] In this aspect, the whiteboard data may be uploaded in direct response to identifying the user.

[0065] According to another aspect, a method of storing data from a whiteboard application executed on a computing system including an interactive touch sensitive display device is provided. The method includes storing, in a memory of the computing system, whiteboard data input to the whiteboard application in direct response to user interaction with the interactive touch sensitive display device, the whiteboard data includes at least one of modifiable ink input data, touch input data, and sticky-note data associated with a location or another element in the whiteboard data; displaying a login selector on the interactive touch sensitive display device; upon detecting actuation of the login selector, identifying the user based on credentials of the user; and in response to identifying the user, (i) retrieving previews of stored whiteboard files from the user account on the cloud-based storage system, (ii) displaying the previews on the interactive touch sensitive display device, and (iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

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[0066] In this aspect, the whiteboard data may be uploaded in direct response to identifying the user.

[0067] In this aspect, the uploaded whiteboard data may only include a selected portion of data presented on the interactive touch sensitive display associated with the whiteboard application.

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CLAIMS:

1. A method of storing data from a whiteboard application executed on a computing system including an interactive display device, the method comprising:

storing, in a memory of the computing system, whiteboard data input to the whiteboard application in response to user interaction with the interactive display device;

displaying a login selector on the interactive display device; and

upon detecting actuation of the login selector, identifying the user based on credentials of the user;

in response to identifying the user,

(i) retrieving previews of stored whiteboard files from a user account in a cloud-based storage system corresponding to the identity of the user,

(ii) displaying the previews on the interactive display device, and

(iii) uploading the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

2. The method of claim 1, further comprising:

displaying a logout selector on the interactive display device; and

upon detecting actuation of the logout selector, revoking access to the user account and removing the previews of the stored whiteboard files from the interactive display device.

3. The method of claim 1, wherein identifying the user based on credentials of the user further comprises:

prompting the user to input a username and a password associated with a user account on a cloud-based storage system.

4. The method of claim 1, wherein identifying the user based on credentials of the user further comprises:

determining the identity of the user based on a facial recognition.

5. The method of claim 1, wherein identifying the user based on credentials of the user further comprises:

wirelessly detecting the credentials of the user stored in a linked portable device; and

determining the identity of the user based on the credentials.

6. The method of claim 5, wherein the linked portable device is one of a stylus, mobile computing device, and security token device.

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7. The method of claim 1, further comprising:

receiving a selection input of one of the previews via the interactive display device;

retrieving the stored whiteboard file corresponding to the selected preview from the cloud-based storage system; and

displaying the stored whiteboard file on the interactive display device.

8. The method of claim 1, further comprising:

displaying a second login selector on the interactive display device;

upon detecting actuation of the second login selector, identifying a second user based on credentials of the second user; and

in response to identifying the second user, uploading the whiteboard data from the memory of the computing system to a second user account in the cloud-based storage system, the second user account distinct from the first user account.

9. The method of claim 1, further comprising:

detecting a privacy keyword via handwriting recognition on the interactive display device;

assigning a privacy level to the whiteboard data based on the privacy keyword; and

restricting access to the whiteboard data based on the privacy level.

10. The method of claim 1, wherein the whiteboard data is in a data format specific to the whiteboard application and wherein the uploaded whiteboard data only includes a selected portion of data presented on the interactive touch sensitive display associated with the whiteboard application.

11. A computing system comprising:

an interactive touch sensitive display device;

code stored in memory executable by a processor to:

store, in a memory of the computing system, whiteboard data input to the whiteboard application in direct response to user interaction with the interactive touch sensitive display device;

display a login selector on the interactive touch sensitive display device;

upon detecting actuation of the login selector, identifying the user based on credentials of the user; and

in response to identifying the user,

(i) retrieve previews of stored whiteboard files from the user account on the cloud-based storage system,

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(ii) display the previews on the interactive touch sensitive display device, and

(iii) upload the whiteboard data as a whiteboard file from the memory of the computing system to the user account.

12. The computing system of claim 11, wherein the whiteboard data is in a data format specific to the whiteboard application.

13. The computing system of claim 11, wherein the whiteboard data includes at least one of modifiable ink input data, touch input data, and sticky-note data associated with a location or another element in the whiteboard data.

14. The computing system of claim 11, further comprising code stored in memory executable by a processor to;

detect a privacy keyword via handwriting recognition on the interactive touch sensitive display device;

assign a privacy level to the whiteboard data based on the privacy keyword; and

restrict access to the whiteboard data based on the privacy level.

15. The computing system of claim 11, wherein the credentials are supplied by at least one of a stylus, mobile computing device, and security token device via wireless communication and the whiteboard data is uploaded in direct response to identifying the user.

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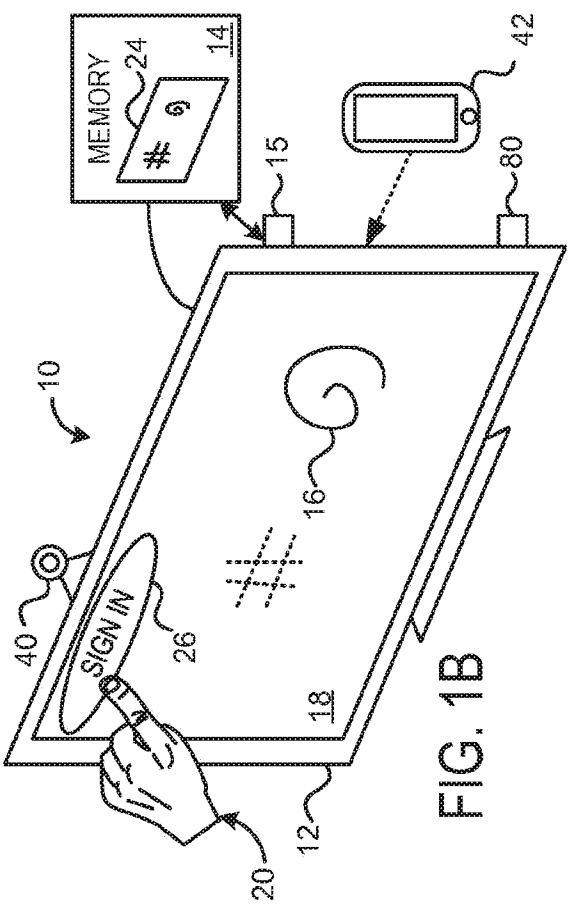


FIG. 1B

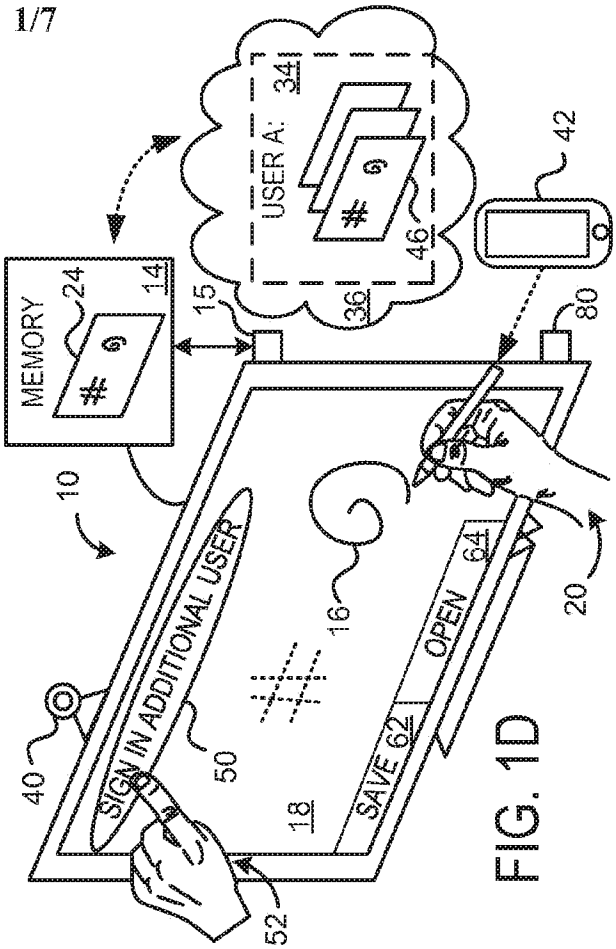


FIG. 1D

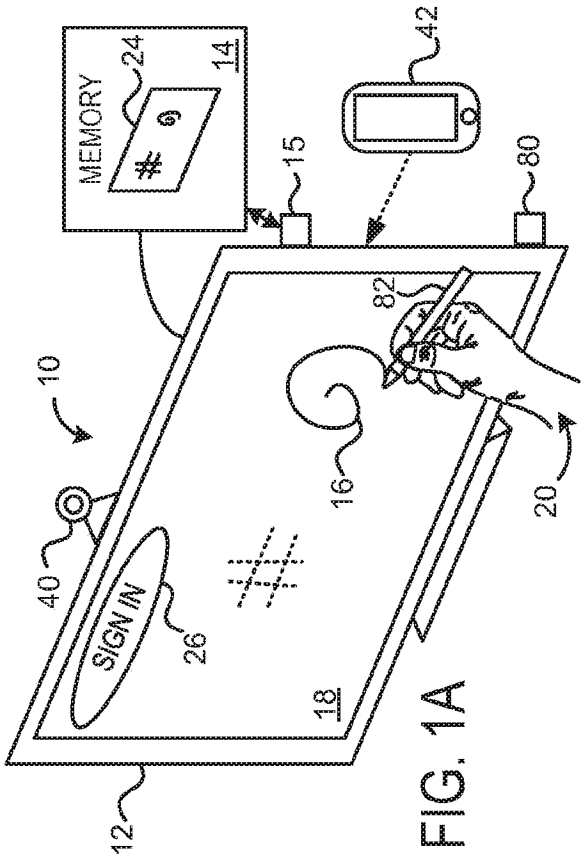


FIG. 1A

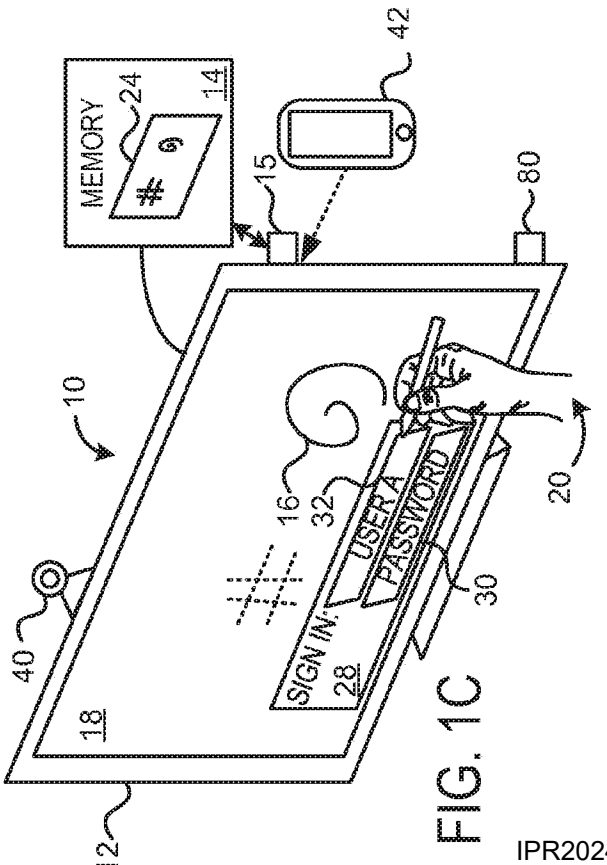


FIG. 1C

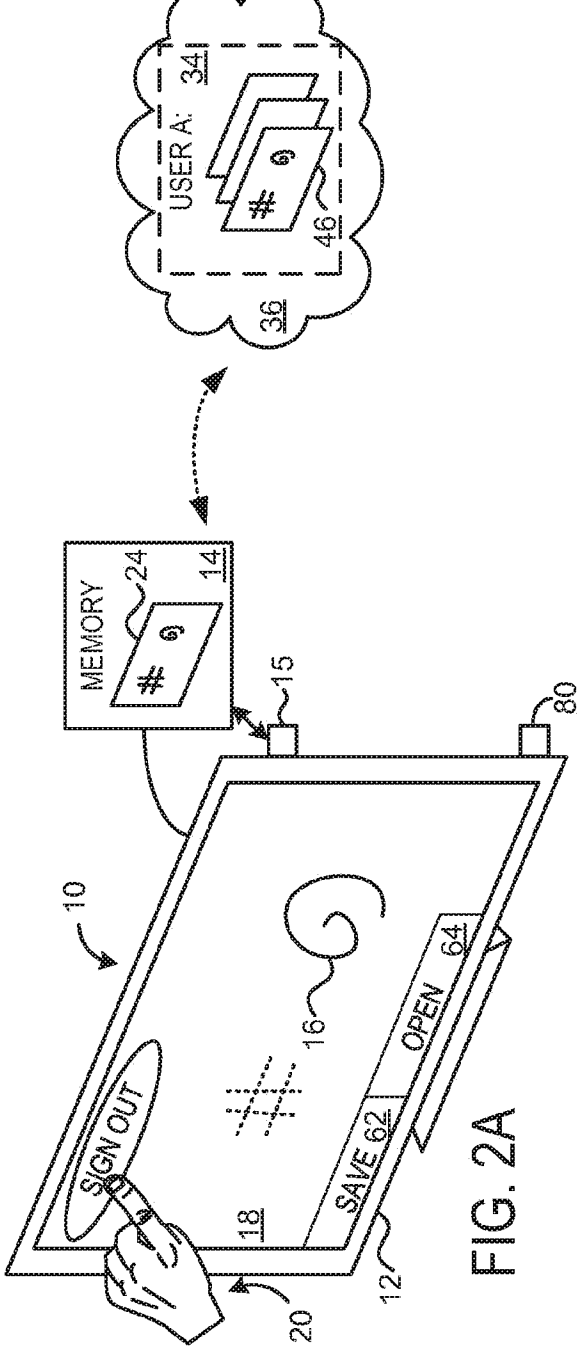

USER A:
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46
36
MEMORY
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14
15
80
10
16
SIGN OUT
OPEN
64
SAVE 62
18
12
20

FIG. 2A

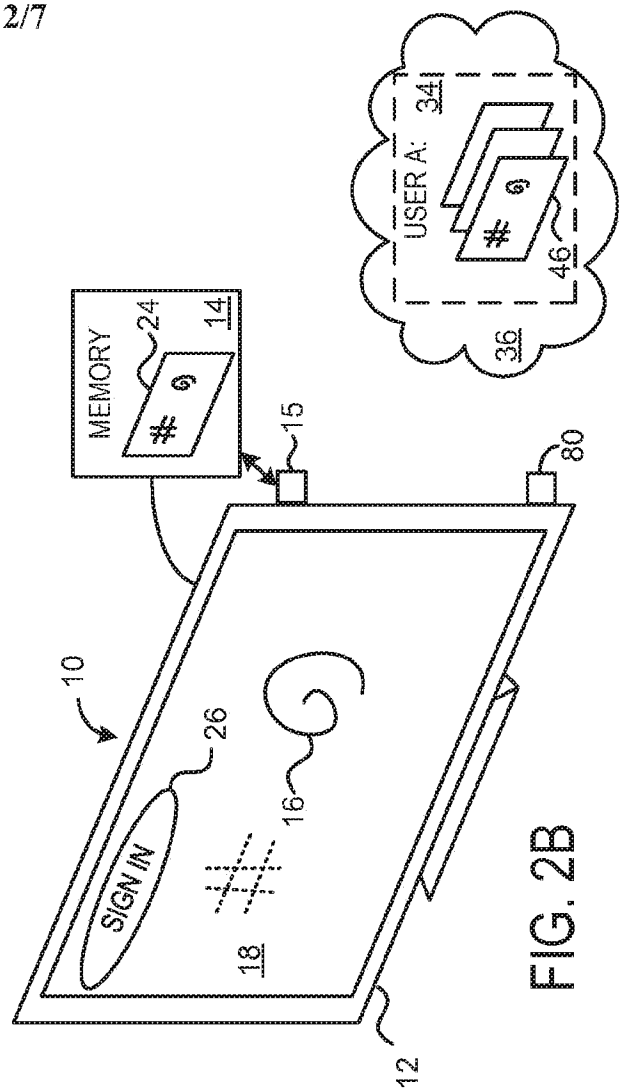

USER A:
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MEMORY
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80
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26
16
SIGN IN
18
12

FIG. 2B

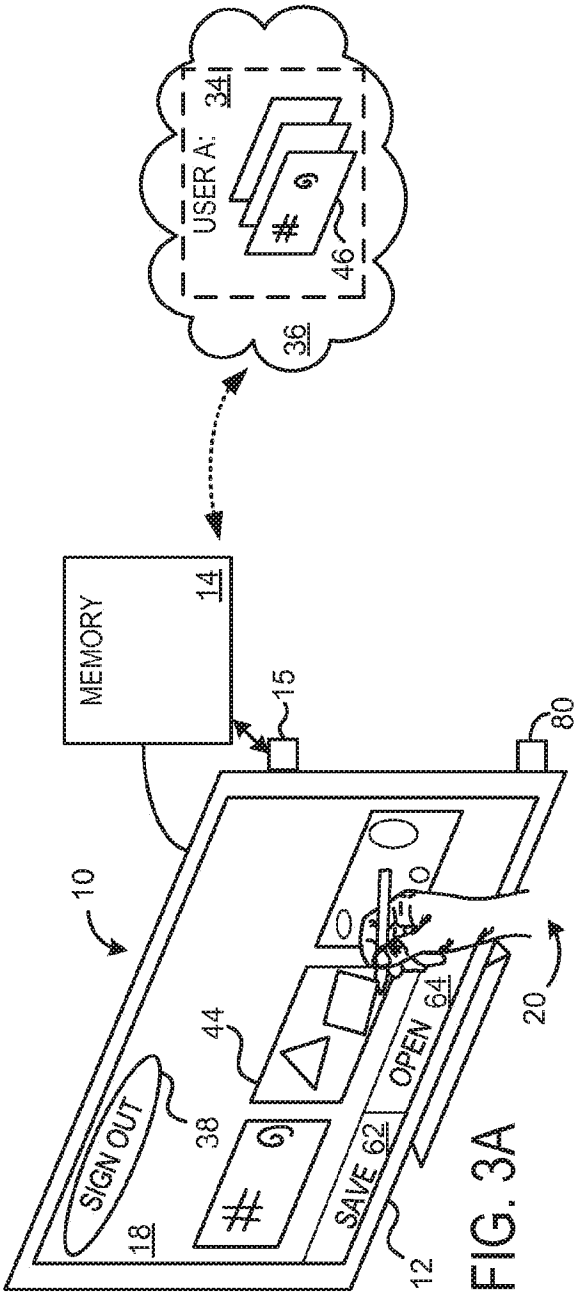

MEMORY
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SIGN OUT
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SAVE 62
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12

FIG. 3A

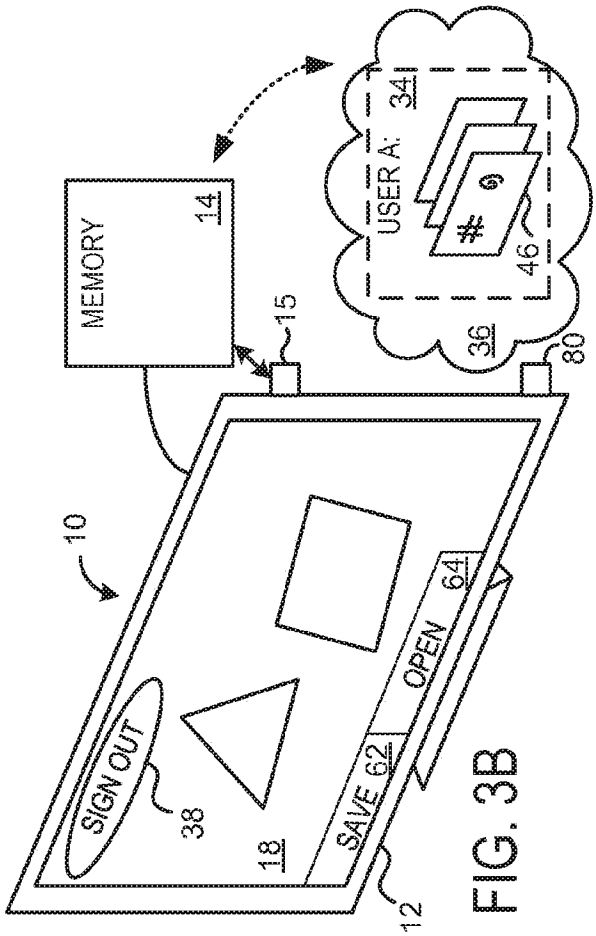

MEMORY
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USER A:
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#
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SIGN OUT
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SAVE 62
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FIG. 3B

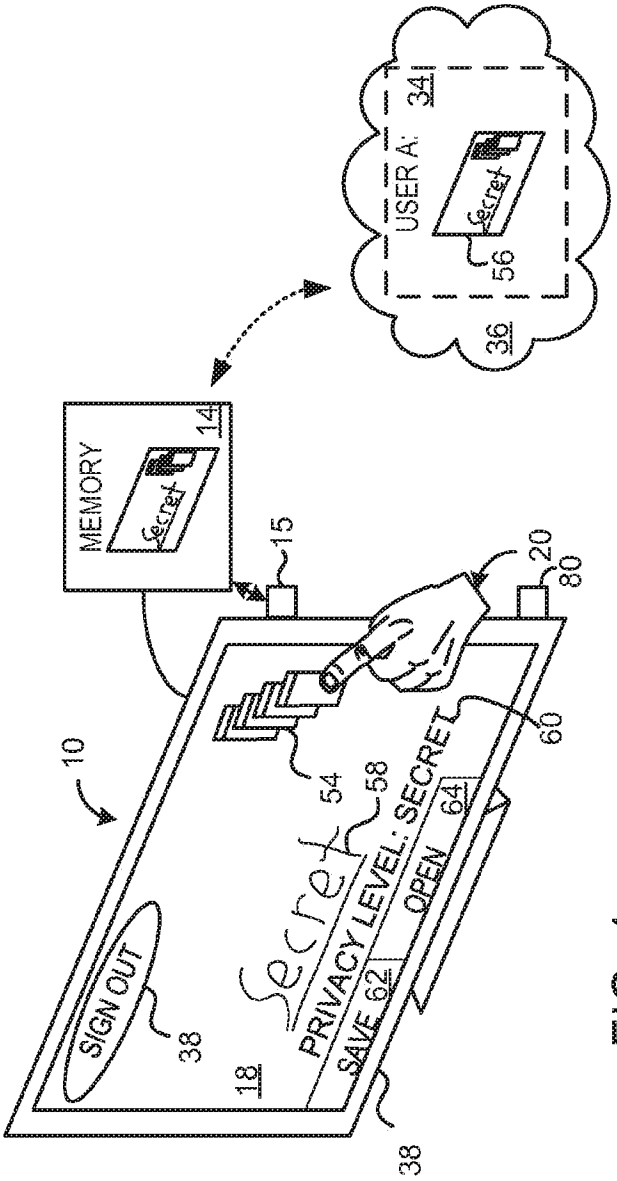

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MEMORY
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Secret
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60
64
Secret
PRIVACY LEVEL: SECRET
OPEN
SAVE 62
SIGN OUT
38
18
38

FIG. 4

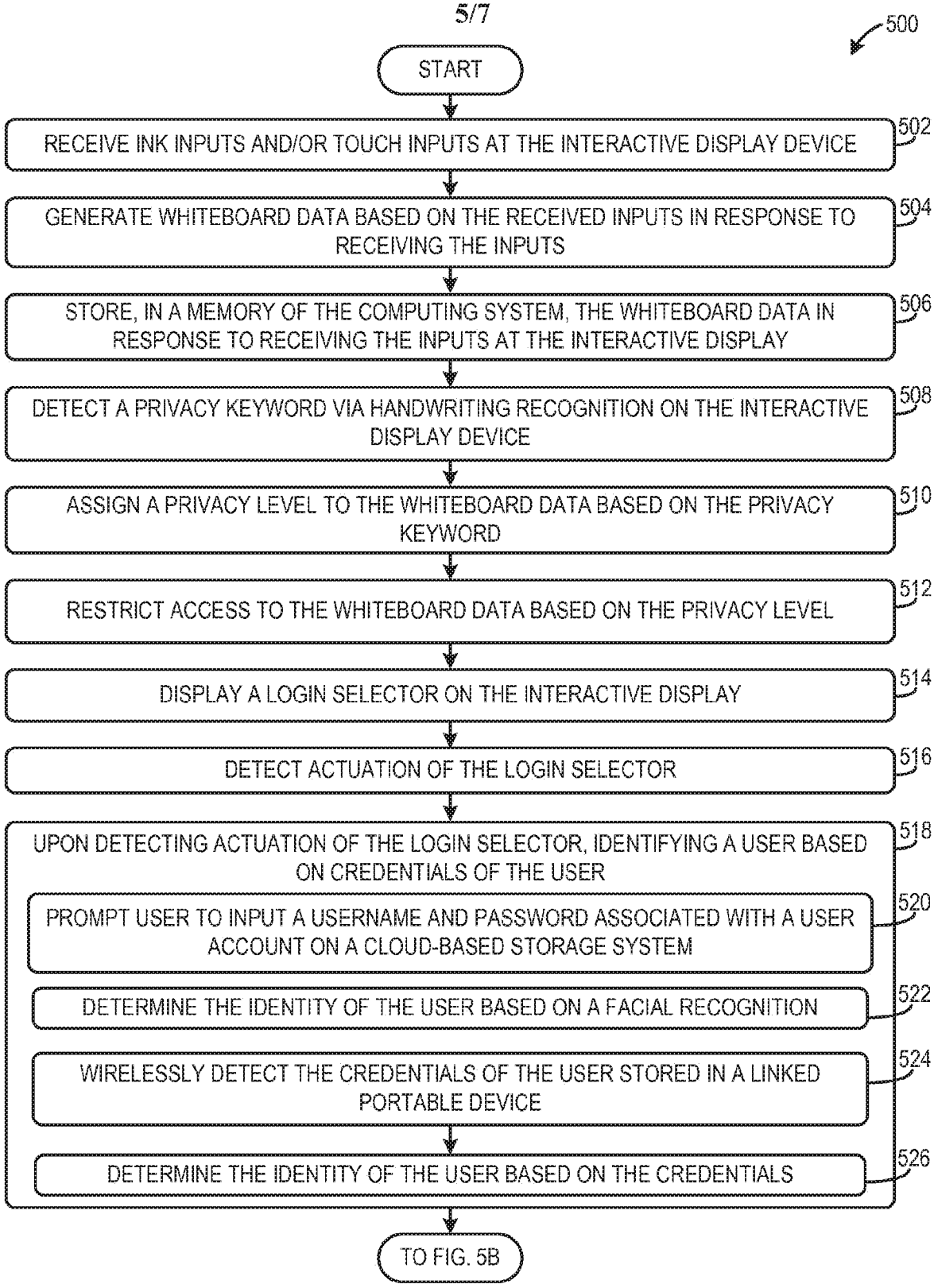

500
START
RECEIVE INK INPUTS AND/OR TOUCH INPUTS AT THE INTERACTIVE DISPLAY DEVICE
502
GENERATE WHITEBOARD DATA BASED ON THE RECEIVED INPUTS IN RESPONSE TO RECEIVING THE INPUTS
504
STORE, IN A MEMORY OF THE COMPUTING SYSTEM, THE WHITEBOARD DATA IN RESPONSE TO RECEIVING THE INPUTS AT THE INTERACTIVE DISPLAY
506
DETECT A PRIVACY KEYWORD VIA HANDWRITING RECOGNITION ON THE INTERACTIVE DISPLAY DEVICE
508
ASSIGN A PRIVACY LEVEL TO THE WHITEBOARD DATA BASED ON THE PRIVACY KEYWORD
510
RESTRICT ACCESS TO THE WHITEBOARD DATA BASED ON THE PRIVACY LEVEL
512
DISPLAY A LOGIN SELECTOR ON THE INTERACTIVE DISPLAY
514
DETECT ACTUATION OF THE LOGIN SELECTOR
516
UPON DETECTING ACTUATION OF THE LOGIN SELECTOR, IDENTIFYING A USER BASED ON CREDENTIALS OF THE USER
518
PROMPT USER TO INPUT A USERNAME AND PASSWORD ASSOCIATED WITH A USER ACCOUNT ON A CLOUD-BASED STORAGE SYSTEM
520
DETERMINE THE IDENTITY OF THE USER BASED ON A FACIAL RECOGNITION
522
WIRELESSLY DETECT THE CREDENTIALS OF THE USER STORED IN A LINKED PORTABLE DEVICE
524
DETERMINE THE IDENTITY OF THE USER BASED ON THE CREDENTIALS
526
TO FIG. 5B

FIG. 5A

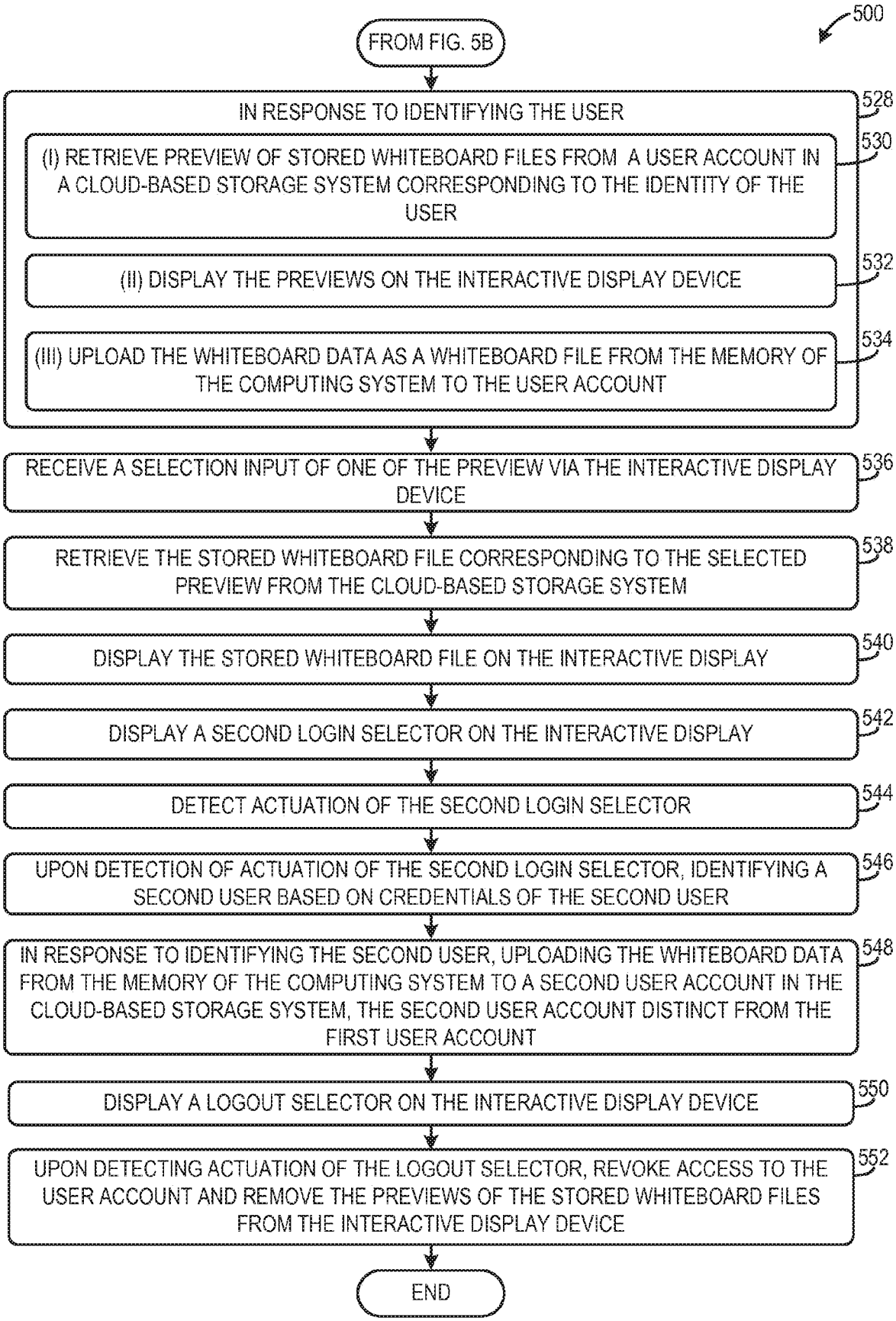

500
FROM FIG. 5B
IN RESPONSE TO IDENTIFYING THE USER
528
(I) RETRIEVE PREVIEW OF STORED WHITEBOARD FILES FROM A USER ACCOUNT IN A CLOUD-BASED STORAGE SYSTEM CORRESPONDING TO THE IDENTITY OF THE USER
530
(II) DISPLAY THE PREVIEWS ON THE INTERACTIVE DISPLAY DEVICE
532
(III) UPLOAD THE WHITEBOARD DATA AS A WHITEBOARD FILE FROM THE MEMORY OF THE COMPUTING SYSTEM TO THE USER ACCOUNT
534
RECEIVE A SELECTION INPUT OF ONE OF THE PREVIEW VIA THE INTERACTIVE DISPLAY DEVICE
536
RETRIEVE THE STORED WHITEBOARD FILE CORRESPONDING TO THE SELECTED PREVIEW FROM THE CLOUD-BASED STORAGE SYSTEM
538
DISPLAY THE STORED WHITEBOARD FILE ON THE INTERACTIVE DISPLAY
540
DISPLAY A SECOND LOGIN SELECTOR ON THE INTERACTIVE DISPLAY
542
DETECT ACTUATION OF THE SECOND LOGIN SELECTOR
544
UPON DETECTION OF ACTUATION OF THE SECOND LOGIN SELECTOR, IDENTIFYING A SECOND USER BASED ON CREDENTIALS OF THE SECOND USER
546
IN RESPONSE TO IDENTIFYING THE SECOND USER, UPLOADING THE WHITEBOARD DATA FROM THE MEMORY OF THE COMPUTING SYSTEM TO A SECOND USER ACCOUNT IN THE CLOUD-BASED STORAGE SYSTEM, THE SECOND USER ACCOUNT DISTINCT FROM THE FIRST USER ACCOUNT
548
DISPLAY A LOGOUT SELECTOR ON THE INTERACTIVE DISPLAY DEVICE
550
UPON DETECTING ACTUATION OF THE LOGOUT SELECTOR, REVOKE ACCESS TO THE USER ACCOUNT AND REMOVE THE PREVIEWS OF THE STORED WHITEBOARD FILES FROM THE INTERACTIVE DISPLAY DEVICE
552
END

FIG. 5B

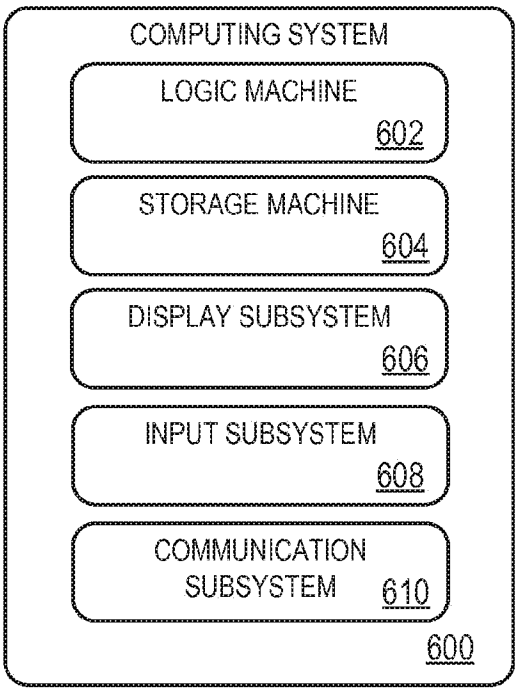

COMPUTING SYSTEM
LOGIC MACHINE
602
STORAGE MACHINE
604
DISPLAY SUBSYSTEM
606
INPUT SUBSYSTEM
608
COMMUNICATION SUBSYSTEM
610
600

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/030452

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F21/31 G06F21/32 G06F21/35
ADD.

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)
G06F G06K

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2007/216660 A1 (SPOSATO STEVE [US] ET AL) 20 September 2007 (2007-09-20) paragraphs [0012], [0019] - [0024], [0026], [0029], [0043] - [0051], [0054] - [0056] figures 1, 2, 3, 6	1-7,11, 13,15 8-10,12, 14
X Y	US 2004/128354 A1 (HORIKIRI KAZUNORI [JP] ET AL) 1 July 2004 (2004-07-01) paragraphs [0002], [0007], [0091] - [0093], [0100] - [0116], [0121], [0122], [0126] - [0146], [0224] - [0264] figures 3, 5	1-7,11, 13,15 8

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" documentwhich may throw doubts on priority claim(s) orwhich is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
28 October 2015	05/11/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Volpato, Gian Luca

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/083109 A1 (HILDEBRANDT PETER W [US] ET AL) 7 April 2011 (2011-04-07) paragraphs [0003], [0008], [0013] - [0015], [0022], [0029] - [0032], [0054] - [0058], [0158] - [0161], [0197], [0229] - [0237] figures 26, 27, 30 -----	1-8, 11, 13, 15
Y	US 2011/179352 A1 (TREADWELL WILLIAM S [US] ET AL) 21 July 2011 (2011-07-21) paragraphs [0002] - [0007], [0020] - [0022], [0026] - [0027], [0031], [0034], [0037], [0039] - [0044], [0060] figure 2 -----	9, 14
Y	"IMS GLC IWB/CFF Specification Version 1.0 Final Specification", , 1 February 2012 (2012-02-01), XP055224018, Retrieved from the Internet: URL:https://www.imsglobal.org/specificationdownload.cfm [retrieved on 2015-10-28] the whole document -----	10, 12
A	"Blackboard collaborate web conferencing Version 12.6", , 1 November 2013 (2013-11-01), XP055224027, Retrieved from the Internet: URL:www.blackboard.com/docs/documentation.htm?DocID=611004PDF [retrieved on 2015-10-28] page 71 - page 94 -----	10, 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/030452

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos. :

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos. :

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

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Flatfrog Laboratories AB, Ex. 2002
Page 1046 of 1254

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8, 11, 13, 15

   Method and system for claiming data from a virtual whiteboard

   ---

2. claims: 9, 14

   Method and system for classifying user input

   ---

3. claims: 10, 12

   Definition of data format for whiteboard applications

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/030452

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
US 2007216660 A1	20-09-2007	NONE			
US 2004128354 A1	01-07-2004	CN	1499841	A	26-05-2004
		JP	4321203	B2	26-08-2009
		JP	2004171526	A	17-06-2004
		US	2004128354	A1	01-07-2004
us 2011083109 A1	07-04-2011	AU	2004246630	A1	16-12-2004
		CA	2526306	A1	16-12-2004
		EP	1636688	A2	22-03-2006
		JP	2006526958	A	24-11-2006
		US	2004070616	A1	15-04-2004
		US	2011083109	A1	07-04-2011
		Wo	2004109496	A2	16-12-2004
us 2011179352 A1	21-07-2011	US	2011179352	A1	21-07-2011
		Wo	2011090871	A1	28-07-2011

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 1048 of 1254

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 May 2018 (31.05.2018)

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(10) International Publication Number
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(51) International Patent Classification:
G06F 3/042 (2006.01)

(21) International Application Number:
PCT/IB20 17/057201

(22) International Filing Date:
17 November 2017 (17.11.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1630274-7 24 November 2016 (24.11.2016) SE

(71) Applicant: **FLATFROG LABORATORIES AB** [SE/SE]; Scheelevagen 15 A, Alfa 2, S-223 63 Lund (SE).

(72) Inventors: **CHRISTIANSSON, Tomas;** Prastvagen 8, 247 45 Torna-Hallestad (SE). **WALL, Henrik;** Kottestigen 7, 247 51Dalby (SE). **OHLSSON, Nicklas;** Strandgardsgrand 12, 218 38 Bunkeflostrand (SE). **KRUS, Mattias;** Byggglovsgranden 1, 226 47 Lund (SE). **SVENSSON, Tomas;** Attention/ c/o FlatFrog Laboratories, Scheelevagen 15 A, 223 63 Lund (SE).

(74) Agent: **EVENT HORIZON IP AB;** Barometergatan 16B, 211 17 Malmo (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *with amended claims (Art. 19(1))*

(54) Title: AUTOMATIC OPTIMISATION OF TOUCH SIGNAL

(57) Abstract: A method of operating an optical touch apparatus is described wherein, the optical touch apparatus comprising a panel, a plurality of emitters and a plurality of detectors arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples of light transmitted between pairs of emitters and detectors. The optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of: generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise, wherein the touch apparatus is configured to perform the following steps: operating according to the ambient light evaluation mode for a plurality of repetitions.

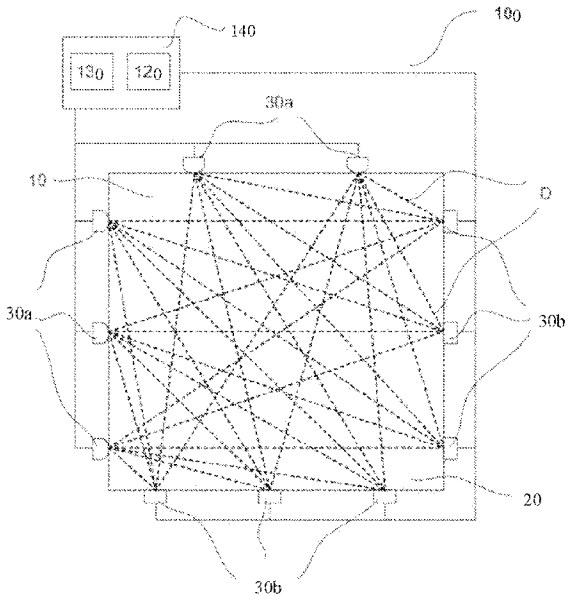


Figure 1

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AUTOMATIC OPTIMISATION OF TOUCH SIGNAL

Technical Field

The present invention relates to a method and apparatus for reducing the effects of ambient light noise resulting from incident ambient light on an optical touch system.

Background Art

Touch sensing systems ("touch systems") are in widespread use in a variety of applications. Typically, the touch sensing systems are actuated by a touch object such as a finger or stylus, either in direct contact, or through proximity (i.e. without contact), with a touch surface. Touch sensing systems are for example used as touch pads of laptop computers, in control panels, and as overlays to displays on e.g. hand held devices, such as mobile telephones and interactive whiteboards. A touch panel that is overlaid on or integrated in a display is also denoted a "touch screen". Many other applications are known in the art.

WO2010/064983 discloses a multi-touch system, which is based on frustrated total internal reflection (FTIR). Light sheets are coupled into a panel to propagate inside the panel by total internal reflection (TIR). When an object comes into contact with a touch surface of the panel, the propagating light will be attenuated at the point of touch. Arrays of light sensors are located around the perimeter of the touch surface to detect the received light for each light sheet and generate a signal value for each light path across the touch surface. The signal values of the light sensors are normalized by respective reference values and input into an image reconstruction algorithm that generates a two-dimensional distribution of attenuation values across the touch surface. This enables repeated determination of current position/size/shape of touches while one or more users interact with the touch surface. In FTIR systems, the touches need to be detected against a background of interferences, e.g. originating from fingerprints and other types of smear on the touch surface. The influence of interferences may vary not only over time but also across the touch surface, making it difficult to properly detect the touches on the touch surface at all times. WO2011/028169 proposes manipulating the reference values to compensate for the influence of contaminations in the attenuation pattern, and

WO2011/049512 proposes tracking a two-dimensional background pattern of the contamination contribution and using the background pattern to generate an attenuation pattern that is compensated for contaminations.

Optical touch systems often need to be designed with a high sensitivity, since a touching object may result in only a small attenuation of the propagating light, e.g. less than 1%. Certain systems may therefore be designed to detect attenuations on the order of 0.1% - 0.01 %. To ensure proper touch detection, WO2011/078769 proposes monitoring the temporal variability of the signal values to identify potential causes for reduced performance of the touch system, e.g. due to component failure, and implementing corrective measures to account for unreliable signal values.

WO2013/115710 describes processing the output signal of an optical touch system to generate a set of data samples comprises ON energy values when the light signal is being transmitted and OFF energy value when no light signal is being transmitted. An estimated ambient value is determined from the OFF energy value. An ambient-compensated energy value is generated by subtracting an estimated ambient value from the ON energy value for each actual detection line. However, this technique only provides significant improvements for light noise sources that are unmodulated (e.g. Sunlight) or modulated with a low frequency (e.g. Incandescent lamps). This technique provides poor results with respect to modulated noise sources like fluorescent lighting.

Therefore, what is needed is a way of improving performance of an optical touch system in an environment that comprises various types of ambient light noise.

Summary

It is an objective of the invention to at least partly overcome one or more limitations of the prior art.

A first embodiment of the invention describes a method of operating an optical touch apparatus, the optical touch apparatus comprising: a panel (10), a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors, a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal, the optical touch apparatus being configured to operate in a data

sampling mode operating in a sequence of repetitions, each repetition comprising the steps of: turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value, processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and processing the set of data samples to detect an interaction with the panel, the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of: generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise, wherein the method comprises the steps of: operating the optical touch apparatus according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions, selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and operating the optical touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time. The filter may be configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between the second set of samples and the first set of samples. The optimal residual ambient light value may correspond to the residual ambient light value having the lowest magnitude. The first integration time may be the same length as the second integration time. A first settling period may occur between the first integration time and the second integration time.

The ambient light evaluation mode may further comprising the steps of: generating a first set of samples over a first integration time, a second set of samples over a second integration time, and a third set of samples over a third integration time using at least one detector (30b'), and applying an ambient light filter to the first, second, and third set of samples to generate a residual ambient light value indicative of ambient light noise, wherein the touch apparatus is configured to operate in the data sampling mode with a timing configuration corresponding to the first, second, and third integration time of the determined the ambient light evaluation mode repetition. The first integration time may be the same length as the third integration

time. A second settling period may occur between the second integration time and the third integration time. The second integration time may correspond to the integration time of the ON signal, the first integration time corresponds to integration time of the OFF signal preceding the ON signal, and the third integration time corresponds to integration time of the OFF signal following the ON signal. The ambient light filter may be configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and an average of the signal sampled over the first integration time and the signal sampled over the third integration time. The ambient light filter may be configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and a linear interpolation of the signal sampled over the first integration time and the signal sampled over the third integration time. The steps of the ambient light evaluation mode may be performed once per frame, more than once per frame, or less often than every frame. The ambient light evaluation mode steps may be performed at the beginning, middle or end of every frame. The residual ambient light value may be determined for a plurality of the detectors of the touch apparatus and wherein the optimal residual ambient light value is determined as a function of the plurality of residual ambient light values. The function may be an average or maximum of the residual ambient light values. A total of number of different configurations of the first, second, and third integration times may be greater than 2 and wherein the apparatus being configured to cycle through the total of number of configurations in subsequent ambient light evaluation mode repetitions. Preferably, between 1 and 10 configurations of the total number of configurations may be tested each frame. Preferably, the first second or third integration time may have a length of between 3ps to 30ps. Preferably, the first second or third integration times are changed in steps of between 0.1 μs and 20μs each ambient light evaluation mode repetition. The optimal residual ambient light value may also be selected as a function of the first and second integration times as well as the residual ambient light value. The residual ambient light value exceeding a performance threshold value and having the shortest first and second integration times may be selected as the optimal residual ambient light value. The system may be configured to not alter the first, second and third integration times used by the

optical touch apparatus whilst operating in the data sampling mode whilst a touch interaction with the touch system is occurring.

A second embodiment of the invention describes An optical touch apparatus (100) comprising: a panel (10), a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors, a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal, the optical touch apparatus being configured to operate in a data sampling mode operating in a sequence of repetitions, each repetition comprising the steps of: turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value, processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and processing the set of data samples to detect an interaction with the panel, the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of: generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise,
wherein the touch apparatus is configured to perform the following steps: operating according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions, selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and operating the touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time.

Still other objectives, features, aspects and advantages of the present invention will appear from the following detailed description, from the attached claims as well as from the drawings.

Brief Description of Drawings

Embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings.

Figure 1 is a top plan view of a touch sensing apparatus with light beams.

Figure 2 is a side view of the apparatus in figure 1 in which light propagates from emitters to detectors by total internal reflection through a glass panel.

Figure 3 is a side view of the apparatus in figure 1 in which light travels from emitters to detectors along a path largely above a glass panel.

Figures 4a to 4e show a portion of the scan scheme sequence.

Figure 5 shows a signal detected at a single detector. An uncompensated signal with ambient disturbances and an uncompensated signal without ambient disturbances is shown.

Figure 6 shows typical power spectrum received by a detector with no ambient electrical light source present.

Figure 7 shows a typical ambient filter kernel.

Figure 8 shows an ambient light filter response function where N=44.

Figure 9 shows an ambient light filter response function where N=32.

Figure 10 shows an ambient light filter response function where N=20.

Figure 11 shows a normalised ambient performance magnitude.

Figure 12 shows typical power spectrum received by a detector with a compact fluorescent lamp light source present.

Figure 13a shows an ambient light filter response function where N=20 with respect to the compact fluorescent lamp light source.

Figure 13b shows an ambient light filter response function where N=32 with respect to the compact fluorescent lamp light source.

Figure 14 shows an ambient light filter response function where N=44 with respect to the compact fluorescent lamp light source.

Figure 15 shows a normalised ambient performance magnitude with a compact fluorescent lamp light source present.

Figure 16 is a flow chart of an embodiment of the ambient light evaluation mode and data sampling mode.

Figure 17 is a flow chart of another embodiment of the ambient light evaluation mode and data sampling mode.

Detailed Description of Example Embodiments

Below follows a description of example embodiments of a technique for enabling extraction of touch data for objects in contact with a touch surface of a touch-sensitive apparatus. Throughout the following description, the same reference numerals are used to identify corresponding elements.

Terms

Before describing embodiments of the invention, a few definitions will be given.

A "touch object" or "touching object" is a physical object that touches, or is brought in sufficient proximity to, a touch surface so as to be detected by one or more sensors in the touch system. The physical object may be animate or inanimate.

An "interaction" occurs when the touch object affects a parameter measured by the sensor.

An "interaction strength" is a relative or absolute measure of the degree of interaction. The "interaction strength" may be represented as an "attenuation".

An "interaction map" or "interaction pattern" is a two-dimensional (2D) distribution of interaction strength across the touch surface, or a portion thereof. If the interaction is presented as attenuation, the interaction map/pattern is also denoted an "attenuation map" or "attenuation pattern".

A "touch" denotes a point of interaction as seen in the interaction pattern.

A "frame" or "iteration" denotes a repeated event comprising an ambient light evaluation, data collection, and determination of touch data.

As used herein, a "trace" is information about the temporal history of an interaction. Touches from an interaction detected in a sequence of frames, i.e. at different points in time, are collected into a trace.

Embodiments of the inventions relate to signal processing in relation to a touch-sensitive apparatus which is based on the concept of transmitting energy of some form across a touch surface, such that an object that is brought into close vicinity of, or in contact with, the touch surface causes a local decrease in the transmitted energy. The apparatus may be configured to permit transmission of energy in one of many different forms. The emitted signals may be any radiation or wave energy that can travel in and/or across the touch surface including, without limitation, light waves in the visible or infrared or ultraviolet spectral regions. Example embodiments of the

invention will be described in relation to a touch-sensitive apparatus 100, which is shown in Figures 1-3 and is based on the concept of transmitting the light through a glass panel via TIR (Total Internal Reflection) or transmission of the light above the touch surface. The apparatus 100 operates by transmitting light across a panel 10, from light emitters 30a, 31a, 32a to light sensors or detectors 30b, 31b, 32b. In the embodiment shown in figure 2, the transmitted light illuminates a touch surface 20 from within the panel 10. The panel 10 is made of solid material in one or more layers and may have any shape. The panel 10 defines an internal radiation propagation channel, in which light propagates by internal reflections. The propagation channel is defined between the boundary surfaces 5, 6 of the panel 10, where the top surface 5 allows the propagating light to interact with touching objects 7 and thereby defines the touch surface 20. This is achieved by injecting the light into the panel 10 such that the light is reflected by total internal reflection (TIR) in the touch surface 20 as it propagates through the panel 10. The light may be reflected by TIR in the bottom surface 6 or against a reflective coating thereon. It is also conceivable that the propagation channel is spaced from the bottom surface 6, e.g. if the panel comprises multiple layers of different materials. The apparatus 100 may be designed to be overlaid on or integrated into a display device or monitor.

The apparatus 100 allows an object 7 that is brought in contact with the touch surface 20 to interact with the propagating light at the point of touch. In this interaction, part of the light may be scattered by the object 7, part of the light may be absorbed by the object 7, and part of the light may continue to propagate in its original direction across the panel 10. Thus, the touching object 7 causes a local frustration of the total internal reflection, which leads to a decrease in the energy (or, equivalently, power or intensity) of the transmitted light.

In the embodiment shown in figure 3, light is passed above the surface of the panel instead of within the panel. Such a configuration of an optical touch system may be described as an 'above surface' optical touch system. In this configuration, the apparatus 100 allows an object 7 that is brought in contact with the touch surface 20 to interact with the light travelling above the surface of the panel at the point of touch on the panel. In this interaction, a portion of the light travelling above the surface of the panel will be interrupted by the object, which leads to a decrease in the energy (or, equivalently, power or intensity) of the transmitted light received at detectors downstream of the touching objects 7.

The emitters 30a, 31a, 32a are distributed along the perimeter of the touch surface 20 to generate a corresponding number of light sheets inside or above the panel 10. In the example of figure 2, each emitter 31a generates a beam of light that expands in the plane of the panel 10 while propagating in the panel 10. Each beam propagates from one or more entry or incoupling points on the panel 10. The detectors 31b are distributed along the perimeter of the touch surface 20 to receive the light from the emitters 31a at a number of spaced-apart outcoupling points on the panel 10. It should be understood that the incoupling and outcoupling points merely refer to the position where the beam enters and leaves, respectively, the panel 10. Thus, although not shown in figure 2, one emitter/detector may be optically coupled to a number of incoupling/outcoupling points.

While various configurations for an above surface system exist, figure 3 describes an embodiment in which a portion of the light emitted by emitters 32a is transmitted through transmissive panel 100. The light exits transmissive panel 100 through touch surface 20 and is reflected by reflector surface 80 of edge reflector 70 to travel along paths 90a and 90b in a plane parallel with touch surface 20. The light will then continue until deflected by reflector surface 80 of the edge reflector 70 at an opposing edge of the transmissive panel 100, wherein the light will be deflected back down through transmissive panel 100 and onto detectors 32b. In another embodiment, the emitters and detectors may be positioned to emit and receive light directly above the surface of the panel. Alternatively, the light from emitters positioned below the panel may be directed around the edge of the panel by means of a light guide or other optical arrangement. A corresponding arrangement may convey the light from above the surface of the panel to the detectors positioned beneath the panel.

The detectors 30b, 31b, 32b collectively provide an output signal, which is received and sampled by a signal processor 130. The output signal contains a number of sub-signals, also denoted "projection signals", each representing the energy of light emitted by a certain light emitter and received by a certain detector. Depending on implementation, the signal processor 130 may need to process the output signal for separation of the individual projection signals. Conceptually, the touch apparatus 100 is considered to define a grid of detection lines D on the touch surface 20, where each detection line D corresponds to a light propagation path from an emitter to a detector, as projected onto the touch surface 20. Thus, the projection

signals represent the received energy or power of light on the individual detection lines D. It is realised that the touching object 7 results in a decrease (attenuation) of the received energy on one or more detection lines D.

As will be explained below, the signal processor 130 may be configured to process the projection signals so as to determine a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 20, where each attenuation value represents a local attenuation of light. The attenuation pattern may be represented in many different ways, e.g. as attenuation values arranged in a regular x-y-grid, such as in an ordinary digital image, although other types of grids are conceivable, e.g. hexagonal patterns or triangular meshes. The attenuation pattern may be further processed by the signal processor 130 or by a separate device (not shown) for touch determination, which may involve extraction of touch data, such as a position (e.g. x,y coordinates), a shape or an area of each touching object. In the following, a "frame" denotes a repeated event starting with ambient light evaluation and data collection and ending with determination of touch data.

The signal processor 130 may be configured to process the projection signals so as to determine a property of the touching objects, such as a position (e.g. in an x,y coordinate system), a shape, or an area. This determination may involve a straight-forward triangulation based on the attenuated detection lines, e.g. as disclosed in US7432893 and WO2010/015408, or a more advanced processing to recreate a distribution of attenuation values (for simplicity, referred to as an "attenuation pattern") across the touch surface 20, where each attenuation value represents a local degree of light attenuation. The attenuation pattern may be further processed by the signal processor 130 or by a separate device (not shown) for determination of a position, shape or area of touching objects. The attenuation pattern may be generated e.g. by any available algorithm for image reconstruction based on projection signal values, including tomographic reconstruction methods such as Filtered Back Projection, FFT-based algorithms, ART (Algebraic Reconstruction Technique), SART (Simultaneous Algebraic Reconstruction Technique), etc. Alternatively, the attenuation pattern may be generated by adapting one or more basis functions and/or by statistical methods such as Bayesian inversion. Examples of such reconstruction functions designed for use in touch

determination are found in WO2009/077962, WO201 1/04951 1, WO201 1/139213, WO201 2/050510, and WO201 3/062471 .

In the illustrated example, the apparatus 100 also includes a controller 120 (also called a which is connected to selectively control the activation of the emitters 30a, 31a, 32a and, possibly, the readout of data from the detectors 30b, 31b, 32b. The signal processor 130 and the controller 120 may be configured as separate units, or they may be incorporated in a single unit. One or both of the signal processor 130 and the controller 120 may be at least partially implemented by software executed by a processing unit 140.

In one embodiment, the different emitters 30a, 31a, 32a are activated in sequence within a frame, such that each individual emitter is activated separately, whereby the transmitted light energy can be measured at each detector that receives light from the activated emitter. Thereby, an energy value is measured for each detection line during the frame.

In an alternative embodiment, groups of emitters 30a, 31a, 32a are activated concurrently, wherein each emitter is controlled to transmit a code by way of the emitted light such that the code identifies the respective emitter. Based on the transmitted codes, the energy measured by each detector in the light detection arrangement can be separated into energy values for each detection line. Such an emitter activation scheme is denoted "multiplexing" and is further described in PCT publication WO201 0/064983.

Embodiments of the invention utilise the energy values measured by the detectors 30b, 31b, 32b while the emitters 30a, 31a, 32a are OFF and ON. In the following, an "ON value" denotes detected energy when a signal is conducted from the emitter to the detector, and an "OFF value" denotes detected energy without a signal being conducted.

The OFF values are conventionally used for so-called ambient compensation, which aims at removing or at least suppressing signal components originating from ambient light and detector dark level, including any analog-to-digital conversion (ADC) offset. Ambient light refers to light that is received by a detector while not originating from the emitters. The ON/OFF activation scheme of the emitters may enable each detector to measure an OFF value one or several times during a frame. As described in WO20131 15710A2, an ambient-compensated energy value each for

detection line may then be obtained. The ON value or an average of ON values is recorded for each detection line, i.e. the energy measured by the detector associated with detection line when the emitter associated with detection line is ON, and OFF value or an average of OFF values, i.e. the energy measured by the detector associated with detection line is recorded when all emitters are OFF. The OFF values, obtained during one or plural frames, are processed to generate a current estimate of the noise level for each individual detector, and hence for each detection line. The ambient-compensated energy value of each detection line is then determined to be the difference between the ON value and OFF value. By using the ambient measurements for validation, all influence from touching objects on the estimated noise level is avoided. Furthermore, the validation process may be designed to operate on the same data as the ambient compensation. In one embodiment, the noise estimate is continuously updated using the latest OFF values. In another embodiment, the noise estimate is given by an exponential forget estimation of the variance (standard deviation) of the OFF values.

It was realised that the above technique was insufficient to handle ambient noise having a variety of different power spectra. Although unmodulated or modulated light at low frequencies may be adequately addressed by the above technique, light modulated at a frequency higher than the frequency at which the emitters are turned ON and OFF is effectively unfiltered and may cause significant detrimental effects to performance of the touch system. Therefore, the following text describes a dynamic ambient light filter configured to respond to the characteristics of ambient light sources and filter to the ambient light source in an optimal way, taking into account restraints including touch accuracy, frame rate, and power usage.

Figures 4a-4e and figure 5 provide an example of the measurement of OFF and ON samples. Figures 4a-4e show a portion of a scan scheme sequence in which a sequence of emitters are used to transmit a signal with rest periods in between. Figure 5 shows an uncompensated signal 210 with ambient disturbances and uncompensated signal 200 without ambient disturbances. Figure 5 shows a received signal at detector 30b' over a portion of the scan scheme sequence. In figure 4a, no signal is being transmitted by any emitter for a first period of time. Figure 5 shows a corresponding received signal at detector 30b' over the first period of time marked AO. In figure 4b, emitter 30a' emits a signal for a second period of time. Figure 5 shows a corresponding received signal at detector 30b' over the second period of

time marked S'. In figure 4c, no signal is being transmitted by any emitter for a third period of time. Figure 5 shows a corresponding received signal at detector 30b' over the third period of time marked A1. In figure 4d, emitter 30a" emits a signal for a fourth period of time. Figure 5 shows a corresponding received signal at detector 30b' over the fourth period of time marked S". In figure 4e, no signal is being transmitted by any emitter for a fifth period of time. Figure 5 shows a corresponding received signal at detector 30b' over the third period of time marked A2.

Figure 6 shows typical power spectrum received by a detector with no ambient electrical light source present and no emitter turned on.

Figure 16 shows a flow chart for a system according to an embodiment of the present invention. The flow chart shown in figure 16 may describe a sequence of steps performed by the optical touch System of the present invention in each frame. In one embodiment, the steps of the ambient light evaluation mode are performed once per frame. In alternative embodiments, the ambient light evaluation mode steps may be performed more than once per frame or once every number of frames. The ambient light evaluation mode steps may be performed at the beginning, middle or end of every frame. In the following embodiment, the ambient light evaluation mode steps are executed once per frame and at the start of every frame.

According to the embodiment shown in figure 16, the optical touch system begins the frame in an ambient light evaluation mode. Whilst in the ambient light evaluation mode, the system executes the following steps:

1 - A sample AO is recorded over a first integration time from a single detector 30b'.

2 - A sample S' is recorded over a second integration time, subsequent to the first integration time, from detector 30b'.

3 - A sample A1 is recorded over a third integration time, subsequent to the second integration time, from detector 30b'.

4 - An ambient light filter function is applied to samples AO, A1 and S' to generate a residual ambient light value.

5 - Record the first, second, and third integration time and corresponding residual ambient light value in a memory as a 'filter configuration'.

6 - (Repeat at least once) Modify the length of the first, second, and/or third integration time and repeat steps 1-5.

7 - Determine the filter configuration in the memory having the optimal residual ambient light value.

8 - Operating the optical touch system in a data sampling mode using the first, second, and third integration time of the filter configuration having the optimal residual ambient light value.

The above steps will now be described in detail.

1 - A sample A0 is recorded over a first integration time from a single detector 30b'.

The sample A0 may be a single data value recorded from a detector over the first integration time. In this case, the first integration time describes a period of time over which an analogue filtering and/or integration of the received signal is generated. Alternatively, A0 may be a series of data samples.

2 - A sample S' is recorded over a second integration time, subsequent to the first integration time, from detector 30b'.

The sample S' may be a single data value recorded from a detector over the second integration time. In this case, the second integration time describes a period of time over which an analogue filtering and/or integration of the received signal is generated. Alternatively, S' may be a series of data samples.

Preferably, a settling time is used between the first integration time and second integration time in order to minimise distortions resulting from the rise and/or fall times of the emitter and detector components between the first integration time and second integration time.

Preferably, the same settling time is used between the second integration time and third integration time as that used between the first integration time and second integration time.

3 - A sample A1 is recorded over a third integration time, subsequent to the second integration time, from detector 30b'.

The sample A1 may be a single data value recorded from a detector over the third integration time. In this case, the third integration time describes a period of time over which an analogue filtering and/or integration of the received signal is generated. Alternatively, A1 may be a series of data samples.

In one embodiment, instead of sampling values from a single detector 30b', a plurality or all of the detectors are sampled and an average of the sampled values is used for each of A0, A1, and S'.

4 - An ambient light filter function is applied to samples A0, A1 and S' to generate a residual ambient light value.

In a preferred embodiment, the ambient light filter function calculates the residual ambient light value according to the following equation:

A = Average of A0 and A1

5 = Average of S'

Residual ambient light value = Magnitude of difference between A and S.

In an embodiment, the ambient light filter function calculates the residual ambient light value according to a linear interpolation of A0 and A1 evaluated at the centre of S'. If S' is a collection of data samples, S' may be digitally integrated and normalised by the number of samples in S' to generate S.

The ambient light filter function may be executed on signal processor 12. Other digital filters as known in the art may be used.

Figure 7 shows a typical ambient filter kernel. The ambient filter kernel is applied to the samples recorded at a detector 30b'. Settling times are used in which samples are set to 0 in order to minimise distortions resulting from any signal changes between the first integration time and second integration time. Detector and emitter components typically have a rise and fall time in which output or detection stabilises to a correct value.

Figure 8 shows an ambient light filter response function where N=44 and P=15. Figure 8 is a Fourier transform of the ambient filter kernel shown in figure 7, wherein N is the number of digitally accumulated samples used for each of the first, second, and third integration times and P is the number of samples used during the settling times. The ADC in this example is running at 2.5 MHz, i.e. each data sample is 0.4 microseconds long. The left side lobe of figure 8 shows that low frequency components are somewhat filtered by filter. At the first singularity, frequencies are not filtered at all. The multiple lobes on the right of the graph at the higher frequencies are a result of the settling times used in between the integration times.

It is clear that from figure 8 that shorter integration times (i.e. first, second, and third integration times with fewer samples) can compensate low-frequencies better, i.e. moving the main lobe of figure 8 higher up in frequency.

It should be noted that the ambient filter may actually worsen the residual for some frequencies. If the filter response magnitude is 1.0, the ambient filter does not reduce the ambient light impact at all. If it is above 1.0 it will make matters worse. A desired outcome is one with the lowest filter output values possible. It is important that the main and side lobes do not line up with peaks in the power spectral density of high-frequency noise from lamps.

Figure 9 shows an ambient light filter response function where N=32 and P=15.

Figure 10 shows an ambient light filter response function where N=20 and P=15.

5 - Record the first, second, and third integration time and corresponding residual ambient light value in a memory as a 'filter configuration'.

The data may be stored in a datastore on signal processor 120. Each filter configuration comprises a first integration time, a second integration time, a third integration time and a residual ambient light value.

In one embodiment, steps 1-3 are repeated a multiple number of times using the same first, second, and third integration times, with the recorded residual ambient light value being the average value of the residual ambient light values calculated each repetition.

6 - (Repeat at least once) Modify the length of the first, second, and/or third integration time and repeat steps 1-5.

Preferably, the first integration time, second integration time, and third integration time are all of the same length. Alternatively, both the first and third integration time may be the same length whilst varying in length in proportion to the second integration time. For example, if the first and third integration time are made longer by 5%, the second integration time is made longer by 5% also. However, in some embodiments, the length of the first, second, and third integration times may all be varied independently of each other.

The number of repeats of steps 1-4 may be chosen in dependence on the number of different residual ambient light values that are needed.

In one embodiment, a number of different configurations of the first integration time and second integration time are tested to determine an optimal residual ambient light value. Depending on the number of variables, the number of configurations may be between 5 and 5000. In a preferred embodiment, 3 configurations of 300 possible configurations are tested each frame. This way, all configurations of the first integration time and second integration time may be tested over 100 frames. For an

optical touch system operating at 120 frames per second, this allows all 300 configurations to be tested in under a second. Once all 300 configurations have been tested, the system preferably restarts the cycle. This allows the optical touch system to rapidly react to changes in the ambient lighting conditions.

Figure 11 shows a normalised ambient performance magnitude with no significant ambient light noise. The normalisation is achieved by dividing the value by the integration time to compensate for the fact that the actual signal becomes higher when more samples are accumulated. In figure 11, where the number of accumulation samples (n) is 20, the residual ambient light value is 1.3. White noise causes the performance magnitude to curve downwards to the right of the graph.

In one embodiment, the residual ambient light value of each filter configuration may be formed from an averaging of residual ambient light values over a number of cycles. In one example, the residual ambient light values of a particular filter configuration may be calculated as the average of the residual ambient light values of the filter configuration of the previous three cycles. As this average is for samples taken at different times with respect to the ambient noise, the samples are more likely to be recorded at different phases of the modulated ambient noise, reducing the effect and likelihood of aliasing between the high-frequency component of the lamp and the ambient filter kernel. Doing an average over several values make sure that the difference in phase between lamp and filter gets averaged.

In a preferred embodiment where the first integration time and second integration time are the same length, the system is configured to test a second integration time over a range of 6µs to 30µs, and incremented in steps of between 0.4µs and 20µs.

In one embodiment of the invention, the length of the settling times can be varied in a similar manner to the first, second, and third integration times.

7 - Determine the filter configuration in the memory having the optimal residual ambient light value.

In an embodiment, the system is configured to review the filter configurations stored in the datastore to determine an optimal filter configuration. In one embodiment, the optimal filter configuration is determined to be the filter configuration having the residual ambient light value with the lowest magnitude. The lowest magnitude indicates that any modulated ambient light is modulated at a frequency which has less effect on the sampled signal when sampled according to the first and second integration times of the filter configuration.

Figure 12 shows typical power spectrum received by a detector with a compact fluorescent lamp light source present. We can see that the lamp has a very strong modulation frequencies around 45 kHz, including overtones at 90, 135, 180, 225, 265 kHz.

Figure 13a shows an ambient light filter response function where N=20 with respect to the compact fluorescent lamp light source. We can see that the 45 kHz signal falls within the main lobe and that the first overtone at 90 kHz lines up with one of side lobes. This filter configuration provides a bad response with a substantial amount of the ambient noise remaining unfiltered.

Figure 13b shows an ambient light filter response function where N=32 with respect to the compact fluorescent lamp light source. This filter configuration provides a similarly bad response the N=20 filter configuration with a substantial amount of the ambient noise remaining unfiltered.

Figure 14 shows an ambient light filter response function where N=44 with respect to the compact fluorescent lamp light source. In this figure we see that the 45 kHz peak lies between the main lobe and the first side lobe. The 90 kHz peak also lies between two side lobes. This means that the ambient filter is very good at reducing the ambient residual error from this lamp.

Figure 15 shows a normalised ambient performance magnitude with a compact fluorescent lamp light source present. For short integration times ($N < 25$) we see that the 45 kHz peak become amplified by the filter since it falls within the region where the frequency response of the filter is greater than 1.0, see new figure. As the integration time increases we see that we have an optimal alignment between power spectral density of the current lamp and ambient filter response when N is around 44.

The optimal filter configuration may also be selected as a function of the first and second integration times as well as the residual ambient light value. In one embodiment shown in figure 15, a threshold value 300 exists wherein all filter configurations having a residual ambient light value below the threshold qualify as suitable candidates for usage. i.e. The touch accuracy of the optical touch system when operating according to the first and second integration times of each of the candidates filter configurations is likely to be adequate. In this embodiment, the system may therefore select which filter configuration to use in dependence on characteristics other than the residual ambient light values. Preferably, the filter

configuration having the shortest first and second integration times may be selected in order to allow the optical touch system to perform at the fastest frame rate in order to reduce touch latency. Alternatively, whilst the frame rate is maintained at a standard rate (e.g. 150 frames per second), the filter configuration having the shortest first and second integration times may be selected in order to allow the touch system to operate using the lowest power consumption possible. In figure 15, the system may select between a value of N at 44 for optimal performance, or N at 29 for shortest sampling periods (for optimal power consumption or shortest frame length).

8 - Operating the optical touch system in a data sampling mode using the first, second, and third integration time of the filter configuration having the optimal residual ambient light value.

In the data sampling mode, the system is configured to activate each of the emitters 30a in sequence, whereby the transmitted light energy can be measured at each detector that receives light from the activated emitter. Thereby, an energy value is measured for each detection line during the frame. According to the present embodiment, the system is configured to activate each emitter ON for a period of time corresponding to the second integration time. The period of time for which the emitter is activated ON is typically slightly longer (e.g. 1-20µs) than the second integration time to allow for rise and/or fall times of the emitter and detector. During the ON period, the system generates an ON sample value at each detector over the second integration time. The system is then configured to ensure that all emitters are OFF for a period of time corresponding to the first/third integration times between ON activations. During the OFF period, the system generates an OFF sample value at each detector over the first integration time. Preferably, a settling time is used between the ON and OFF periods corresponding to the rest period used between the sampling periods of the ambient light evaluation mode. An ambient-compensated energy value of each detection line is then determined to be the difference between the ON sample value and an average of the OFF sample value preceding the ON sample value and the OFF sample value recorded after the ON sample value. Alternatively, ambient-compensated energy value of each detection line may be determined according to a linear interpolation of A0 and A1 evaluated at the centre of S'.

In an alternative embodiment, the system is configured to activate each emitter ON for a period of time corresponding to but shorter than the second integration time. The period of time for which the emitter is activated ON is slightly shorter (e.g. 1-20 μs) than the second integration time to allow for sampling the complete pulse including the rise and/or fall time of the pulse.

In one embodiment, the length of the first, second and third integration times affect the length of the frame, as the longer the first, second and third integration times are, the longer it takes to complete activation of all the emitters and the interspaced OFF periods. In some embodiments, the frame comprises a period of time reserved as slack, so that the variation of the first, second and third integration times does not require the frame length to be altered. Preferably, the third integration time can be reused as the first integration for the next detection line recorded for the same single detector.

In a preferred embodiment, the system is configured to not alter the first, second and third integration times used by the optical touch system whilst in the data sampling mode whilst a touch interaction with the touch system is occurring. As any touch interaction will necessarily significantly alter the detected touch signal during the interaction, the results of the ambient light evaluation mode can be disregarded or postponed for use until the touch interaction has finished.

In an embodiment in which the touch system utilises multiplexing of several emitters, the main difference is that the signal captured during the ON period comes from several emitters. The ambient reduction filter works in the same way as for non-multiplexing systems. In a multiplexing system there is an extra de-multiplexing step between ambient compensation and the transmission/interpolation/reconstruction steps.

Figure 17 shows a flow chart for a system according to a simpler variation of the embodiment shown in figure 16 in which two samples are recorded instead of three. According to this embodiment, the system executes the following steps whilst in ambient light evaluation mode:

1 - A sample A0 is recorded over a first integration time from a single detector 30b'.

2 - A sample S' is recorded over a second integration time, subsequent to the first integration time, from detector 30b'.

3 - An ambient light filter function is applied to samples AO and S' to generate a residual ambient light value.

4 - Record the first integration time and second integration time and corresponding residual ambient light value in a memory as a 'filter configuration'.

5 - (Repeat at least once per frame) Modify the length of the first integration time and/or second integration time and repeat steps 1-4.

6 - Determine the filter configuration in the memory having the optimal residual ambient light value.

7 - Operating the optical touch system in a data sampling mode using the first integration time and second integration time of the filter configuration having the optimal residual ambient light value.

The above steps will now be described in detail.

1 - A sample AO is recorded over a first integration time from a single detector 30b' substantially as described in the previous embodiment.

2 - A sample S' is recorded over a second integration time, subsequent to the first integration time, from detector 30b' substantially as described in the previous embodiment.

3 - An ambient light filter function is applied to samples AO and S' to generate a residual ambient light value.

In a preferred embodiment, the ambient light filter function calculates the residual ambient light value according to the following equation:

A = Average of AO

S = Average of S'

Residual ambient light value = Magnitude of difference between A and S.

4 - Record the first integration time and second integration time and corresponding residual ambient light value in a memory as a 'filter configuration'.

The data may be stored in a datastore on signal processor 12. Each filter configuration comprises a first integration time, a second integration time, and a residual ambient light value.

5 - (Repeat at least once) Repeat steps 1-4 whilst modifying the length of the first integration time and/or second integration time.

Preferably, the first integration time and second integration time are the same length. Alternatively, both the first integration time and second integration time are

varied in length in proportion to each other. For example, if the first integration time is made longer by 5%, the second integration time is made longer by 5% also. However, in some embodiments, the length of the first integration time may be varied independently of the length of the second integration time. Alternatively, the length of the second integration time may be varied independently of the length of the first integration time.

The number of repeats of steps 1-4 may be chosen in dependence on the number of different residual ambient light values that are needed.

6 - Determine the filter configuration in the memory having the optimal residual ambient light value.

As with the previous embodiment, the optimal filter configuration may also be selected as a function of the first, second and third integration times as well as the residual ambient light value.

7 - Operating the optical touch system in a data sampling mode using the first integration time and second integration time of the filter configuration having the optimal residual ambient light value.

According to the present embodiment, the system is configured to activate each emitter ON for a period of time corresponding to the second integration time. During the ON period, the system generates an ON sample value at each detector over the second integration time. The system is then configured to ensure that all emitters are OFF for a period of time corresponding to the first integration time between ON activations. During the OFF period, the system generates an OFF sample value at each detector over the first integration time. Preferably, a settling time is used between the ON and OFF periods corresponding to the rest period used between the sampling periods of the ambient light evaluation mode. An ambient-compensated energy value of each detection line is then determined to be the difference between the ON sample value and OFF sample value.

The touch determination process and the validation process according to the various embodiments disclosed herein may be implemented by a data processing device which is connected to sample measurement values from the detectors 30b, 31b, 32b. The device 140 may include an input for receiving the output signal. The device 140 may further include a data collection element (or means) for obtaining the

current projection values, a generation element (or means) for generating absolute values, an interpolation element (or means) for generating a matched sinogram with absolute values, an error correction element for maintaining the relative signal transmission of affected interpolation points, a conversion element (or means) for converting the absolute values of the interpolation points into relative values, a reconstruction element (or means) for generating a current interaction pattern, and an output for outputting the current interaction pattern. The device 140 may include an input for receiving the output signal. The device 140 may further include an element (or means) for obtaining the ON values, an element (or means) for obtaining the OFF values, a compensation element (or means) for generating ambient-compensated ON values, a noise estimation element (or means) for computing a noise estimate, and a datastore.

The device 140 may be implemented by special-purpose software (or firmware) run on one or more general-purpose or special-purpose computing devices. In this context, it is to be understood that each "element" or "means" of such a computing device refers to a conceptual equivalent of a method step; there is not always a one-to-one correspondence between elements/means and particular pieces of hardware or software routines. One piece of hardware sometimes comprises different means/elements. For example, a processing unit may serve as one element/means when executing one instruction, but serve as another element/means when executing another instruction. In addition, one element/means may be implemented by one instruction in some cases, but by a plurality of instructions in some other cases. Naturally, it is conceivable that one or more elements (means) are implemented entirely by analog hardware components.

The software controlled device 140 may include one or more processing units, e.g. a CPU ("Central Processing Unit"), a DSP ("Digital Signal Processor"), an ASIC ("Application-Specific Integrated Circuit"), discrete analog and/or digital components, or some other programmable logical device, such as an FPGA ("Field Programmable Gate Array"). The device 140 may further include a system memory and a system bus that couples various system components including the system memory to the processing unit. The system bus may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory may include computer storage media in the form of volatile and/or non-volatile memory such as

read only memory (ROM), random access memory (RAM) and flash memory. The special-purpose software, the exclusion data, the reference values, and any other data needed during execution, may be stored in the system memory, or on other removable/non-removable volatile/non-volatile computer storage media which is included in or accessible to the computing device, such as magnetic media, optical media, flash memory cards, digital tape, solid state RAM, solid state ROM, etc. The data processing device 140 may include one or more communication interfaces, such as a serial interface, a parallel interface, a USB interface, a wireless interface, a network adapter, etc, as well as one or more data acquisition devices, such as an *A/D* converter. The special-purpose software may be provided to the device 140 on any suitable computer-readable medium, including a record medium, and a read-only memory.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and the scope of the appended claims.

CLAIMS

1. A method of operating an optical touch apparatus (100), the optical touch apparatus comprising:

- a panel (10),
- a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors,
- a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal,

the optical touch apparatus being configured to operate in a data sampling mode operating in a sequence of repetitions, each repetition comprising the steps of:

- turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value,
- processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and
- processing the set of data samples to detect an interaction with the panel,
- the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of:
- generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and
- applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the method comprises the steps of:

- operating the optical touch apparatus according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions,
- selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and

- operating the optical touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time.

2. The method of claim 1, wherein the filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between the second set of samples and the first set of samples.

3. The method of claim 2, wherein the optimal residual ambient light value corresponds to the residual ambient light value having the lowest magnitude.

4. The method of any preceding claim, wherein the first integration time is the same length as the second integration time.

5. The method of any preceding claim, wherein a first settling period occurs between the first integration time and the second integration time.

6. The method of any preceding claim, wherein the ambient light evaluation mode comprising the steps of:

- generating a first set of samples over a first integration time, a second set of samples over a second integration time, and a third set of samples over a third integration time using at least one detector (30b'), and
- applying an ambient light filter to the first, second, and third set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the touch apparatus is configured to operate in the data sampling mode with a timing configuration corresponding to the first, second, and third integration time of the determined the ambient light evaluation mode repetition.

7. The method of claims 6, wherein the first integration time is the same length as the third integration time.

8. The method of claims 6-7, wherein a second settling period occurs between the second integration time and the third integration time.

9. The method of claims 6-8, wherein the second integration time corresponds to the integration time of the ON signal, the first integration time corresponds to integration time of the OFF signal preceding the ON signal, and the third integration time corresponds to integration time of the OFF signal following the ON signal.

10. The method of claims 6-9, wherein the ambient light filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and an average of the signal sampled over the first integration time and the signal sampled over the third integration time.

11. The method of claims 6-10, wherein the ambient light filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and a linear interpolation of the signal sampled over the first integration time and the signal sampled over the third integration time.

12. The method of any preceding claim wherein the steps of the ambient light evaluation mode are performed once per frame, more than once per frame, or less often than every frame.

13. The method of any preceding claim wherein the ambient light evaluation mode steps may be performed at the beginning, middle or end of every frame.

14. The method of any preceding claim wherein the residual ambient light value is determined for a plurality of the detectors of the touch apparatus and wherein the optimal residual ambient light value is determined as a function of the plurality of residual ambient light values.

15. The method of claim 14 wherein the function is an average or maximum of the residual ambient light values.

16. The method of any preceding claim wherein a total of number of different configurations of the first, second, and third integration times is greater than 2 and

wherein the apparatus being configured to cycle through the total of number of configurations in subsequent ambient light evaluation mode repetitions.

17. The method of claim 16 wherein between 1 and 10 configurations of the total number of configurations are tested each frame.

18. The method of any preceding claim wherein the first, second or third integration time have a length of between 3μs to 30μs

19. The method of any preceding claim wherein first second or third integration times are changed in steps of between 0.1 μs and 20μs each ambient light evaluation mode repetitions.

20. The method of any preceding claim wherein the optimal residual ambient light value may also be selected as a function of the first and second integration times as well as the residual ambient light value.

21. The method of claim 20 wherein the residual ambient light value exceeding a performance threshold value and having the shortest first and second integration times may be selected as the optimal residual ambient light value.

22. The method of any preceding claim wherein the system is configured to not alter the first, second and third integration times used by the optical touch apparatus whilst operating in the data sampling mode whilst a touch interaction with the touch system is occurring.

23. An optical touch apparatus (100) comprising:

- a panel (10),
- a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors,
- a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal,

the optical touch apparatus being configured to operate in a data sampling mode operating in a sequence of repetitions, each repetition comprising the steps of:

- turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value,
- processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and
- processing the set of data samples to detect an interaction with the panel,
- the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of:
- generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and
- applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the touch apparatus is configured to perform the following steps:

- operating according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions,
- selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and
- operating the touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time.

AMENDED CLAIMS
received by the International Bureau on 23.04.2018

CLAIMS

1. A method of operating an optical touch apparatus (100), the optical touch apparatus comprising:

- a panel (10),
- a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors,
- a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal,

the optical touch apparatus being configured to operate in a data sampling mode operating in a sequence of repetitions, each repetition comprising the steps of:

- turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value,
- processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and
- processing the set of data samples to detect an interaction with the panel,

the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of:

- generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and
- applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the method comprises the steps of:

- operating the optical touch apparatus according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions,
- selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and
- operating the optical touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time.

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2. The method of claim 1, wherein the filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between the second set of samples and the first set of samples.

3. The method of claim 2, wherein the optimal residual ambient light value corresponds to the residual ambient light value having the lowest magnitude.

4. The method of any preceding claim, wherein the first integration time is the same length as the second integration time.

5. The method of any preceding claim, wherein a first settling period occurs between the first integration time and the second integration time.

6. The method of any preceding claim, wherein the ambient light evaluation mode comprising the steps of:

- generating a first set of samples over a first integration time, a second set of samples over a second integration time, and a third set of samples over a third integration time using at least one detector (30b'), and
- applying an ambient light filter to the first, second, and third set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the touch apparatus is configured to operate in the data sampling mode with a timing configuration corresponding to the first, second, and third integration time of the determined the ambient light evaluation mode repetition.

7. The method of claims 6, wherein the first integration time is the same length as the third integration time.

8. The method of claims 6-7, wherein a second settling period occurs between the second integration time and the third integration time.

9. The method of claims 6-8, wherein the second integration time corresponds to the integration time of the ON signal, the first integration time corresponds to integration time of

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the OFF signal preceding the ON signal, and the third integration time corresponds to integration time of the OFF signal following the ON signal.

10. The method of claims 6-9, wherein the ambient light filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and an average of the signal sampled over the first integration time and the signal sampled over the third integration time.

11. The method of claims 6-10, wherein the ambient light filter is configured to generate a residual ambient light value indicative of ambient light in dependence on the difference between a signal sampled over the second integration time and a linear interpolation of the signal sampled over the first integration time and the signal sampled over the third integration time.

12. The method of any preceding claim wherein the steps of the ambient light evaluation mode are performed once per frame, more than once per frame, or less often than every frame.

13. The method of any preceding claim wherein the ambient light evaluation mode steps may be performed at the beginning, middle or end of every frame.

14. The method of any preceding claim wherein the residual ambient light value is determined for a plurality of the detectors of the touch apparatus and wherein the optimal residual ambient light value is determined as a function of the plurality of residual ambient light values.

15. The method of claim 14 wherein the function is an average or maximum of the residual ambient light values.

16. The method of any preceding claim wherein a total of number of different configurations of the first, second, and third integration times is greater than 2 and wherein the apparatus being configured to cycle through the total of number of configurations in subsequent ambient light evaluation mode repetitions.

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17. The method of claim 16 wherein between 1 and 10 configurations of the total number of configurations are tested each frame.

18. The method of any preceding claim wherein the first, second or third integration time have a length of between 3μs to 30μs

19. The method of any preceding claim wherein first second or third integration times are changed in steps of between 0.1μs and 20μs each ambient light evaluation mode repetitions.

20. The method of any preceding claim wherein the optimal residual ambient light value may also be selected as a function of the first and second integration times as well as the residual ambient light value.

21. The method of claim 20 wherein the residual ambient light value exceeding a performance threshold value and having the shortest first and second integration times may be selected as the optimal residual ambient light value.

22. The method of any preceding claim wherein the system is configured to not alter the first, second and third integration times used by the optical touch apparatus whilst operating in the data sampling mode whilst a touch interaction with the touch system is occurring.

23. An optical touch apparatus (100) comprising:

- a panel (10),
- a plurality of emitters (30a, 31a, 32a) and a plurality of detectors (30b, 31b, 32b) arranged with respect to the panel, the plurality of detectors configured to receive light from the plurality of emitters thereby defining detection samples (D) of light transmitted between pairs of emitters and detectors,
- a controller coupled to the plurality of emitters to generate the signals and wherein each detector is configured to generate an output signal,

the optical touch apparatus being configured to operate in a data sampling mode operating in a sequence of repetitions, each repetition comprising the steps of:

- turning the emitters ON and OFF according to a timing configuration during each repetition such that the output signal for each detector is generated to comprise ON energy values for the detection samples (D) and at least one OFF energy value,

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- processing the output signals to generate a set of data samples, each data sample being generated to represent detected energy for one of the detection samples (D), and
- processing the set of data samples to detect an interaction with the panel,

the optical touch apparatus being further configured to operate in an ambient light evaluation mode comprising the steps of:

- generating a first set of samples over a first integration time and a second set of samples over a second integration time using at least one detector, and
- applying a filter to at least the first and second set of samples to generate a residual ambient light value indicative of ambient light noise,

wherein the touch apparatus is configured to perform the following steps:

- operating according to the ambient light evaluation mode for a plurality of repetitions, wherein the length of at least one of the first integration time and second integration time vary between repetitions,
- selecting the first integration time and/or second integration time that generated an optimal residual ambient light value, and
- operating the touch apparatus in the data sampling mode with a timing configuration corresponding to the selected first integration time and/or second integration time.

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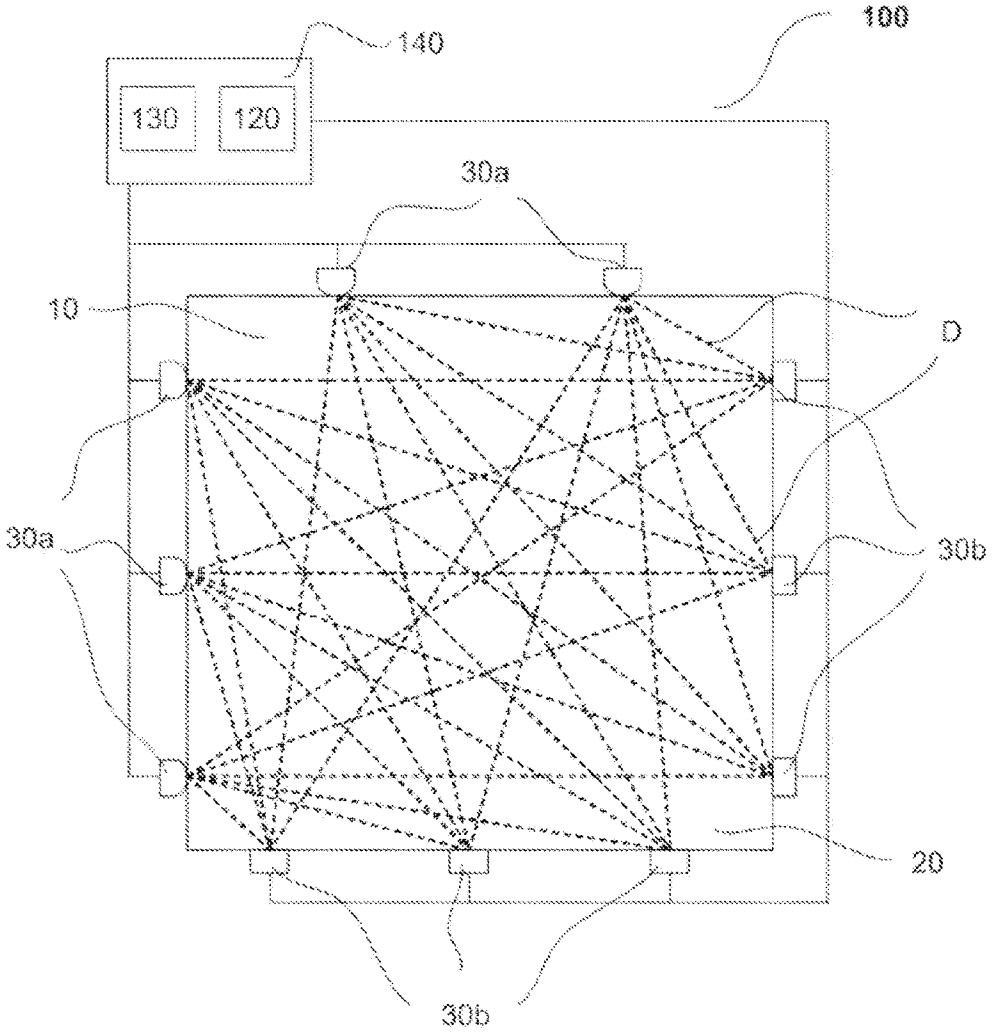


Figure 1

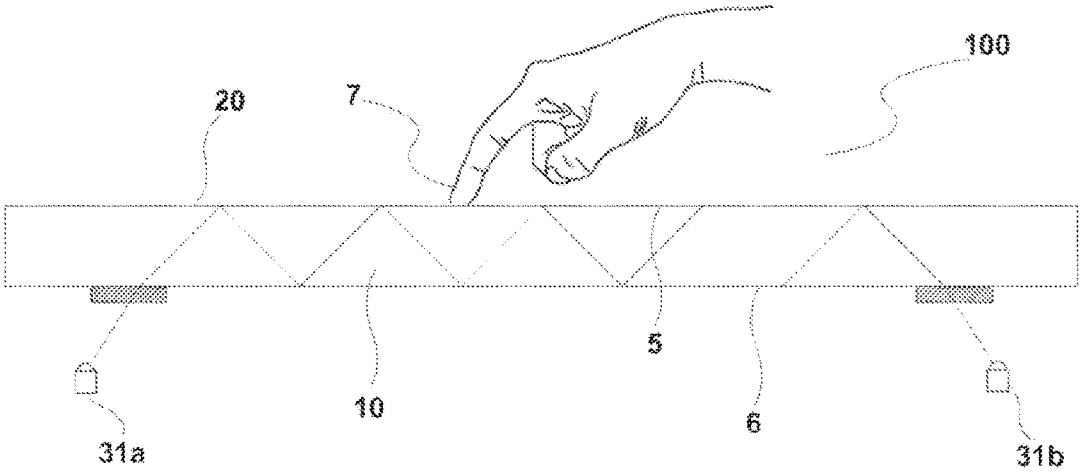


Figure 2

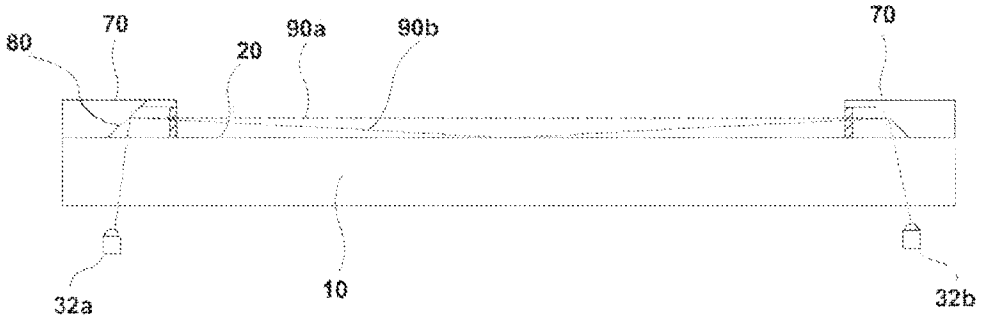


Figure 3

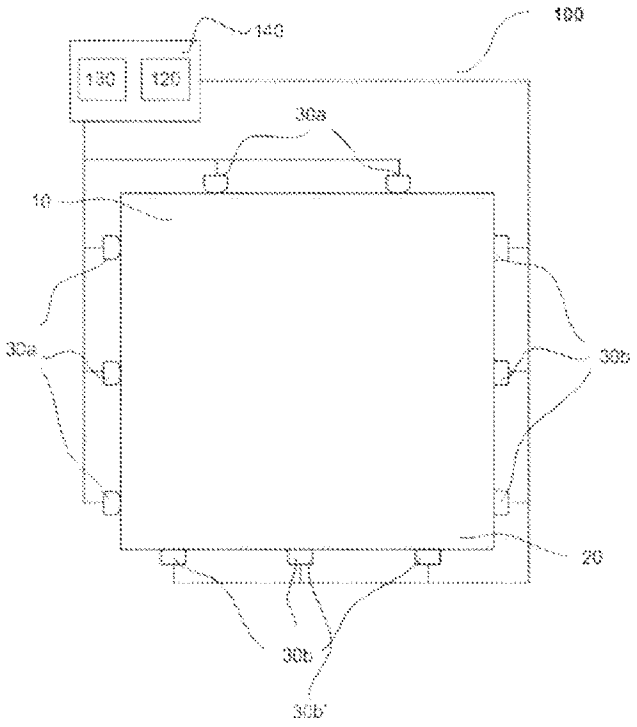


Figure 4a

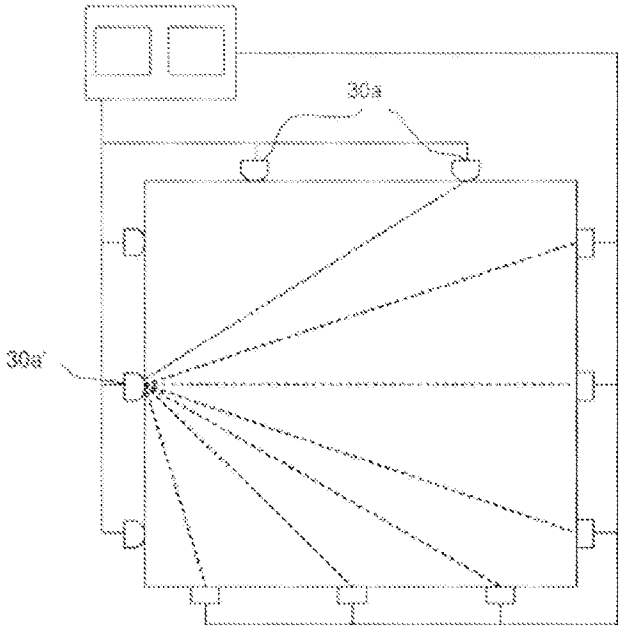


Figure 4b

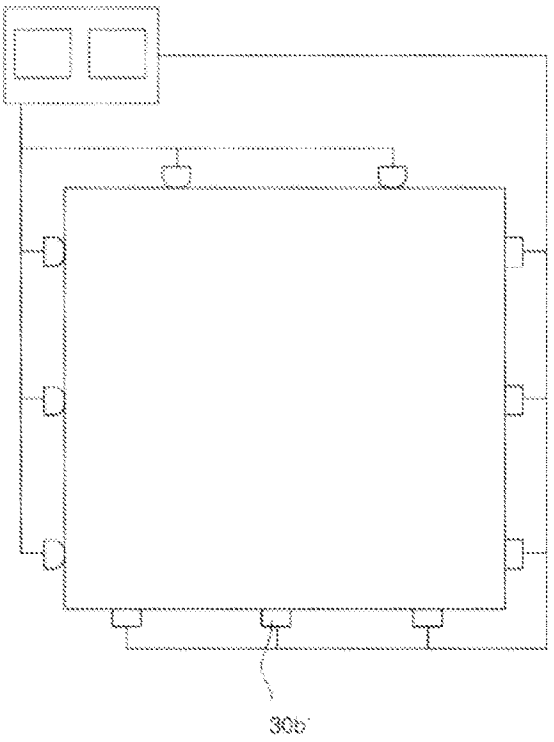


Figure 4c

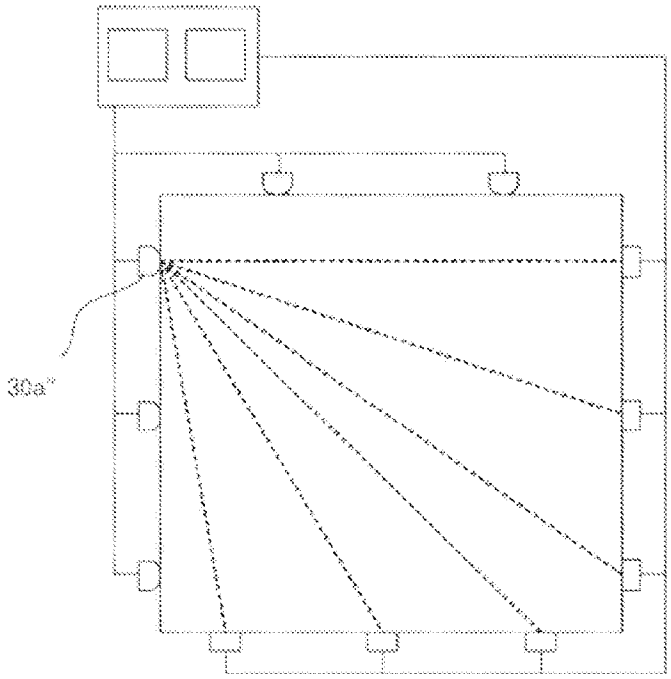


Figure 4d

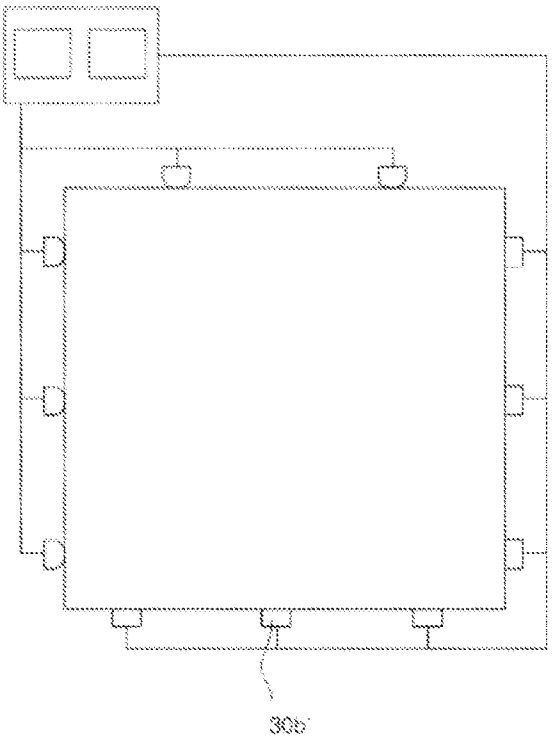


Figure 4e

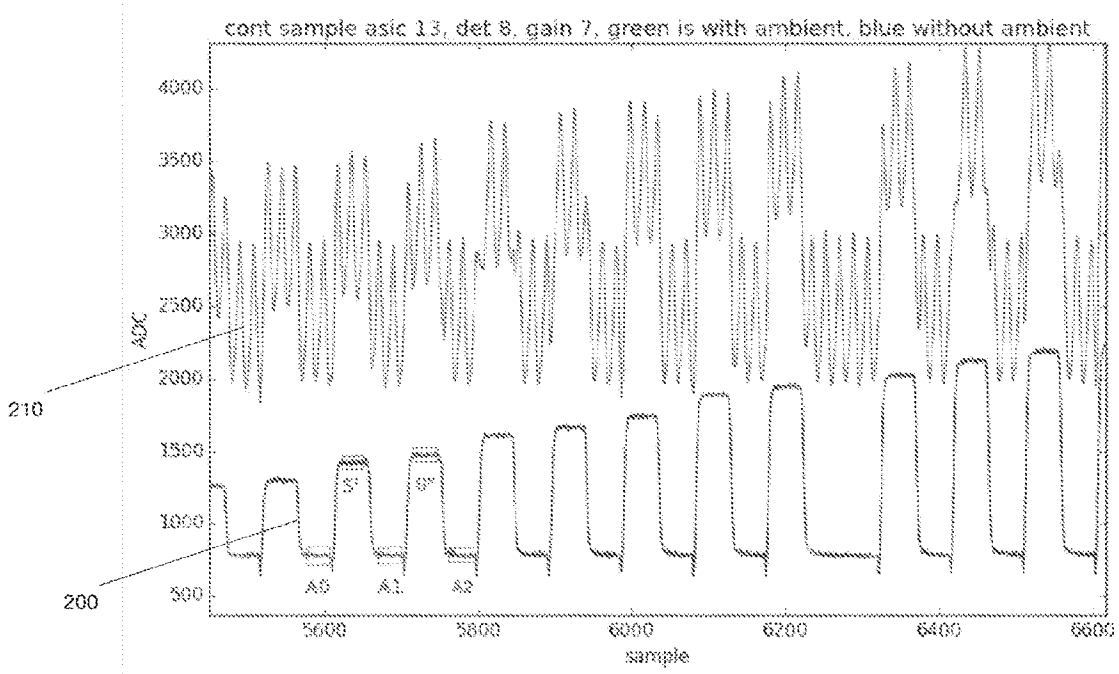

cont sample asic 13, det 8, gain 7, green is with ambient, blue without ambient
4000
3500
3000
2500
2000
1500
1000
500
ADC
210
200
A0
A1
A2
5600
5800
6000
6200
6400
6600
sample

Figure 5

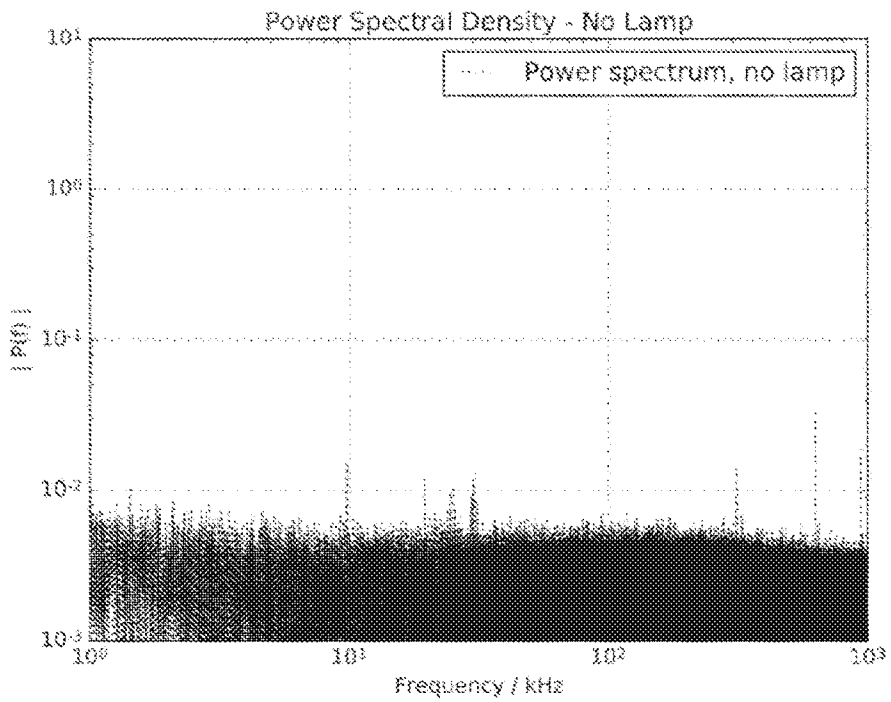

Power Spectral Density - No Lamp
Power spectrum, no lamp
10¹
10⁰
10⁻¹
10⁻²
10⁻³
|P(f)|
10⁰
10¹
10²
10³
Frequency / kHz

Figure 6

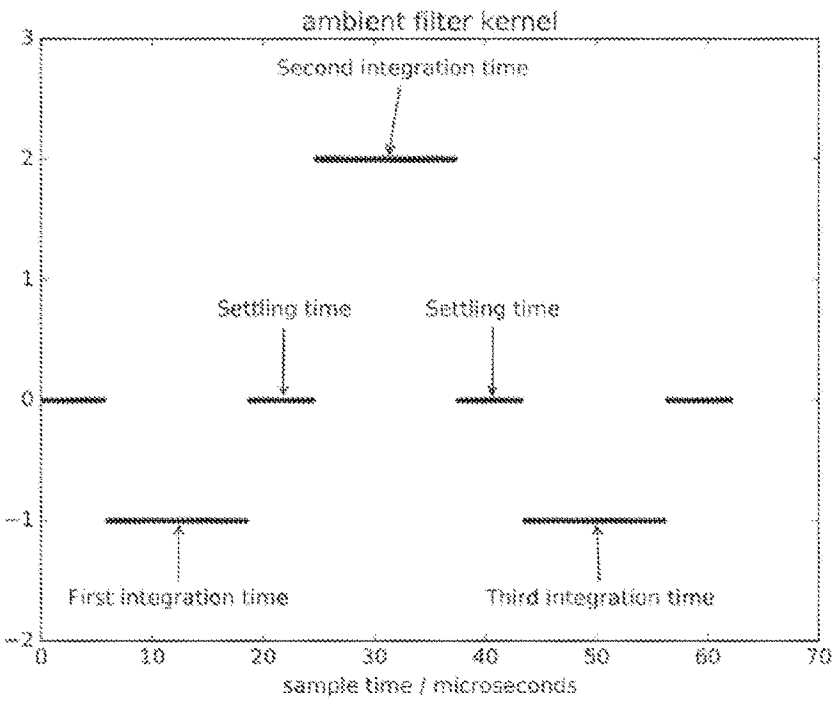

ambient filter kernel
Second integration time
Settling time
Settling time
First integration time
Third integration time
3
2
1
0
−1
−2
0
10
20
30
40
50
60
70
sample time / microseconds

Figure 7

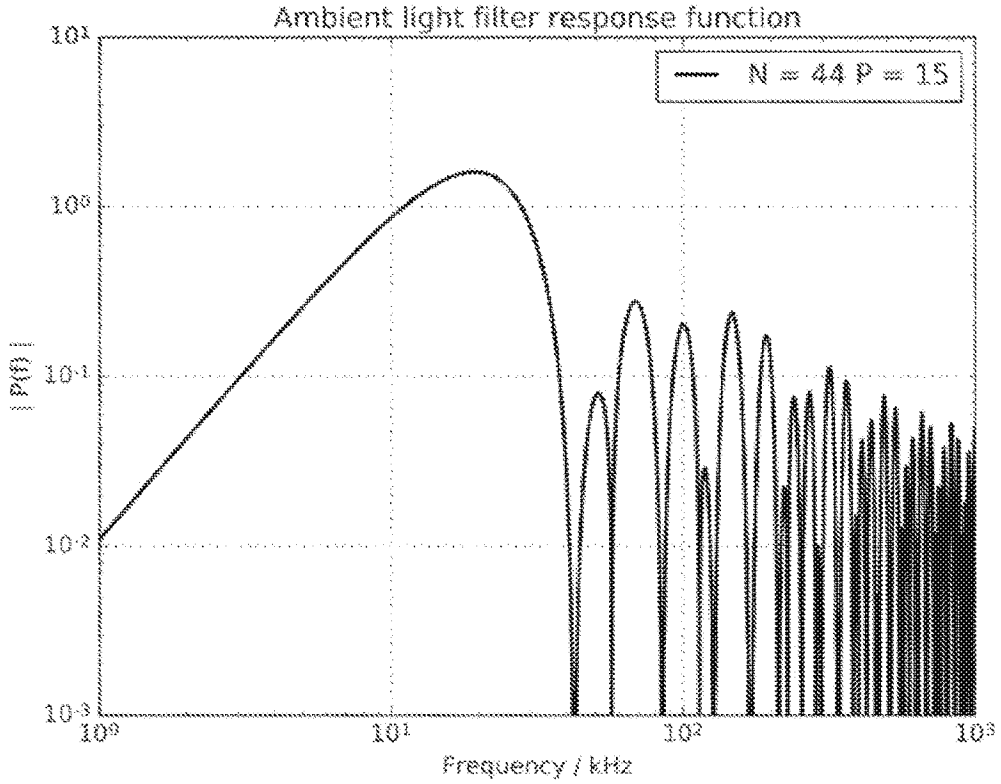

Ambient light filter response function
N = 44 P = 15
|P(f)|
Frequency / kHz
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁰
10¹
10²
10³

Figure 8

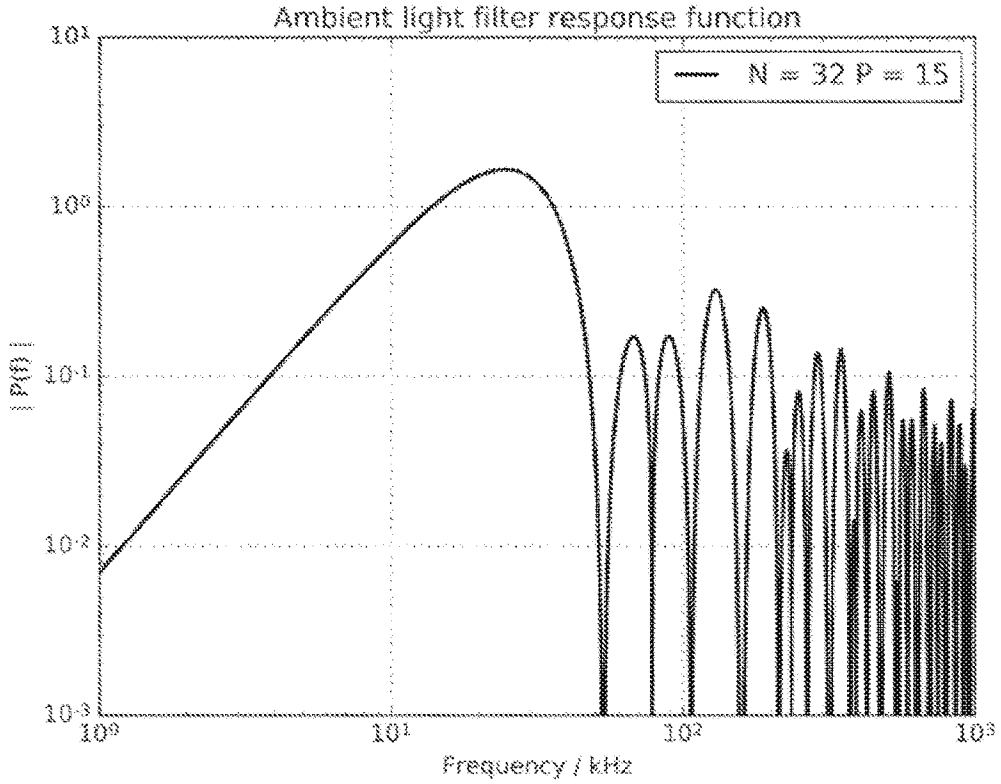

Ambient light filter response function
N = 32 P = 15
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
|P(f)|
10^{0}
10^{1}
10^{2}
10^{3}
Frequency / kHz

Figure 9

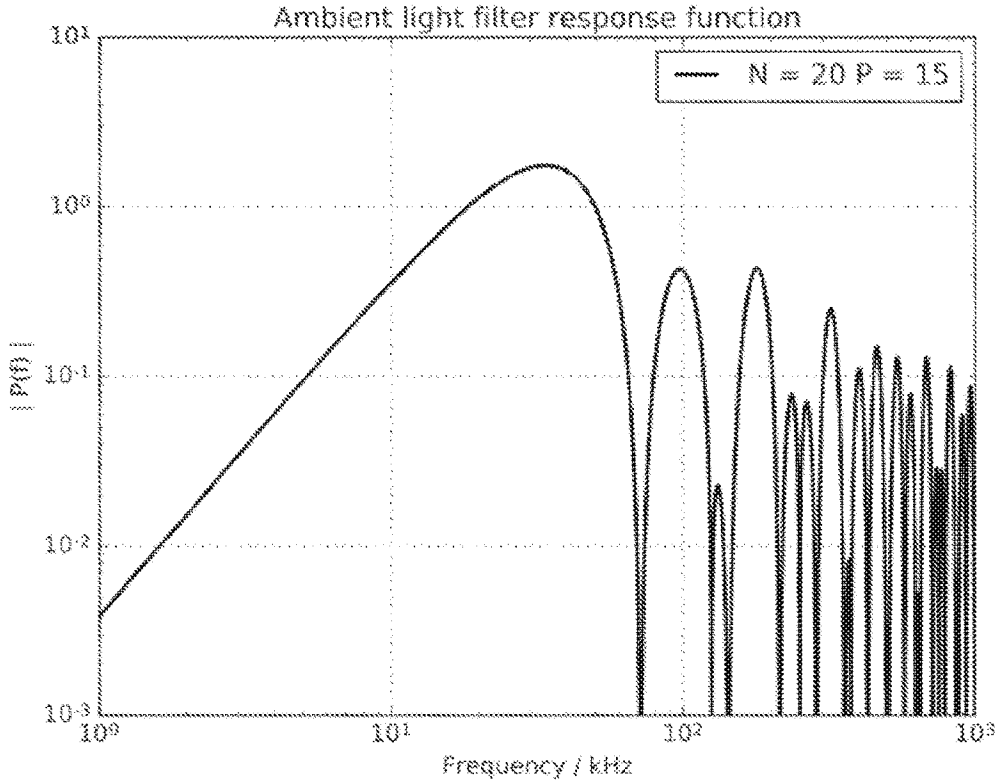

Ambient light filter response function
N = 20 P = 15
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
|P(f)|
10^{0}
10^{1}
10^{2}
10^{3}
Frequency / kHz

Figure 10

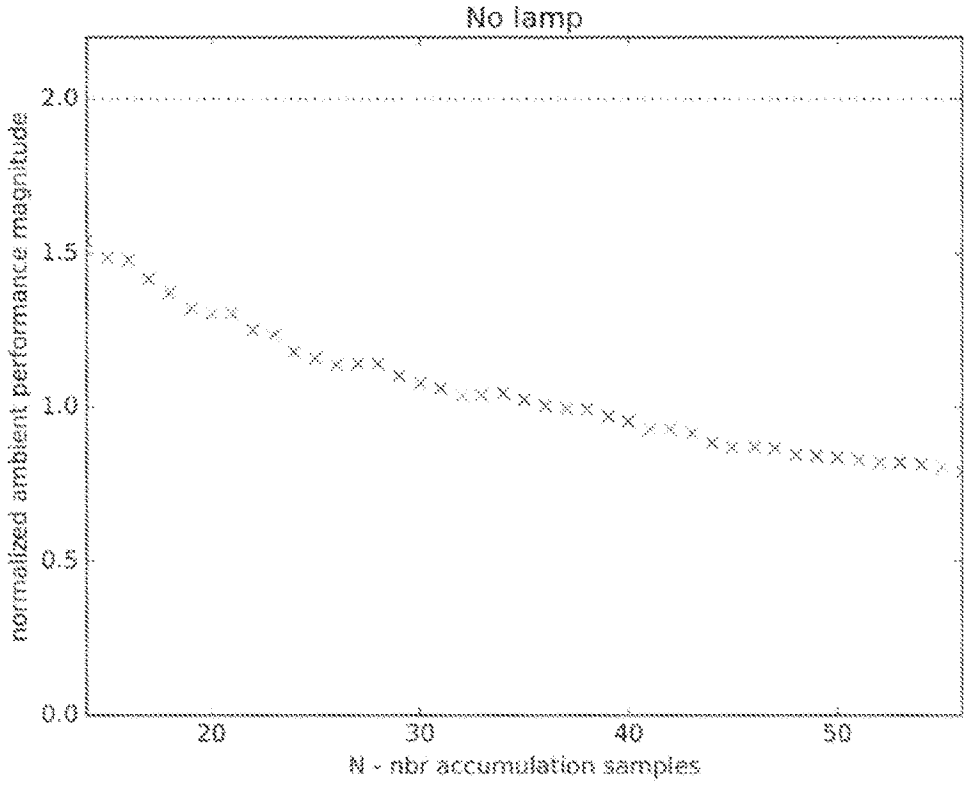

No lamp
normalized ambient performance magnitude
2.0
1.5
1.0
0.5
0.0
20
30
40
50
N - nbr accumulation samples

Figure 11

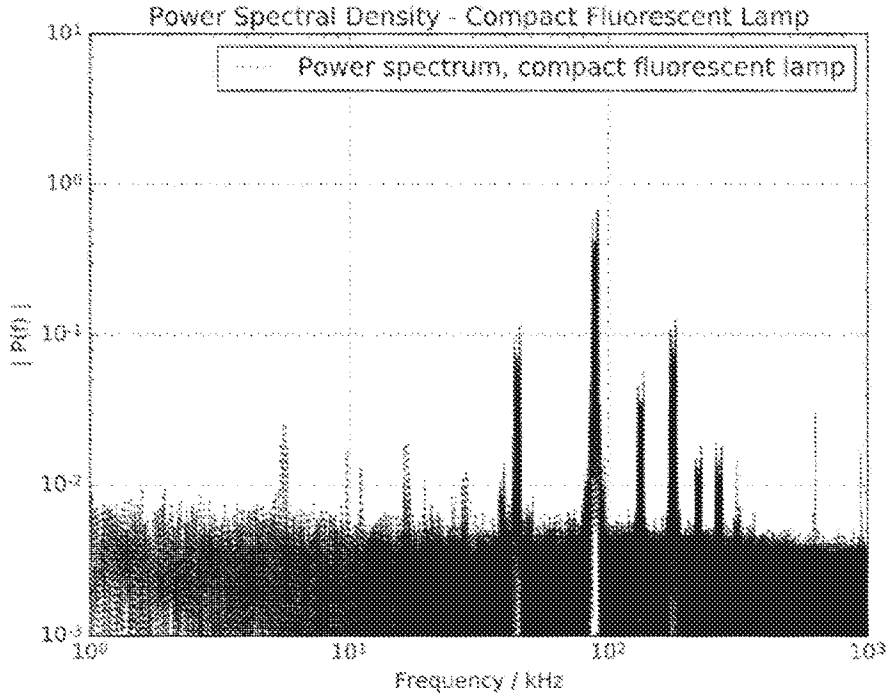

Power Spectral Density - Compact Fluorescent Lamp
Power spectrum, compact fluorescent lamp
|P(f)|
Frequency / kHz

Figure 12

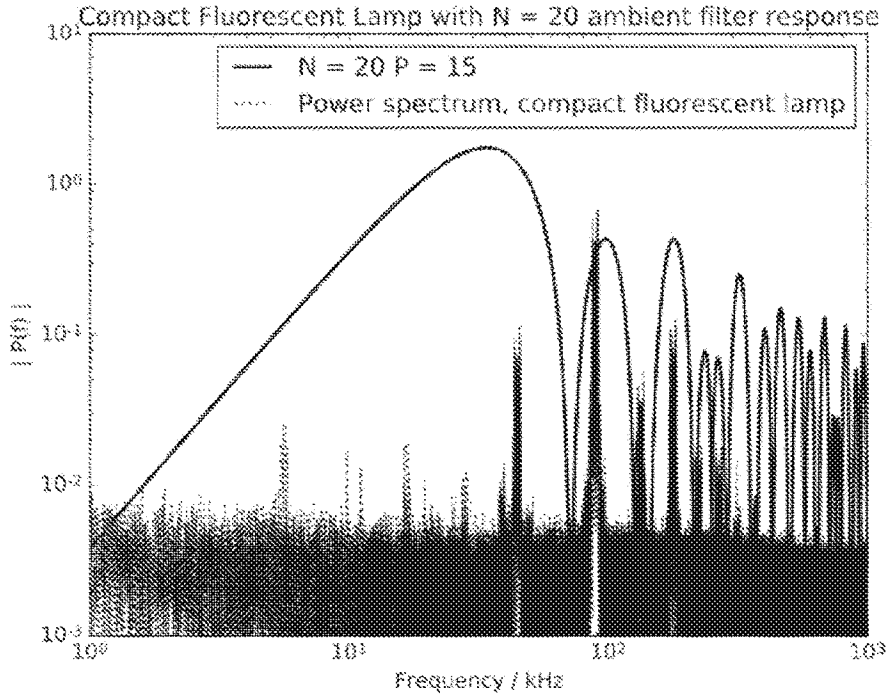


Figure 13a

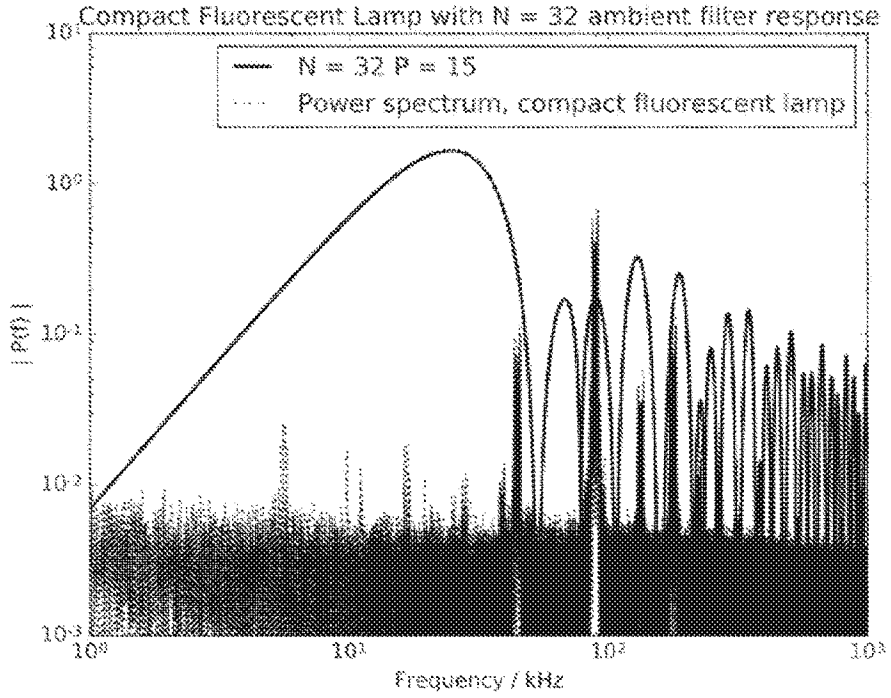


Figure 13b

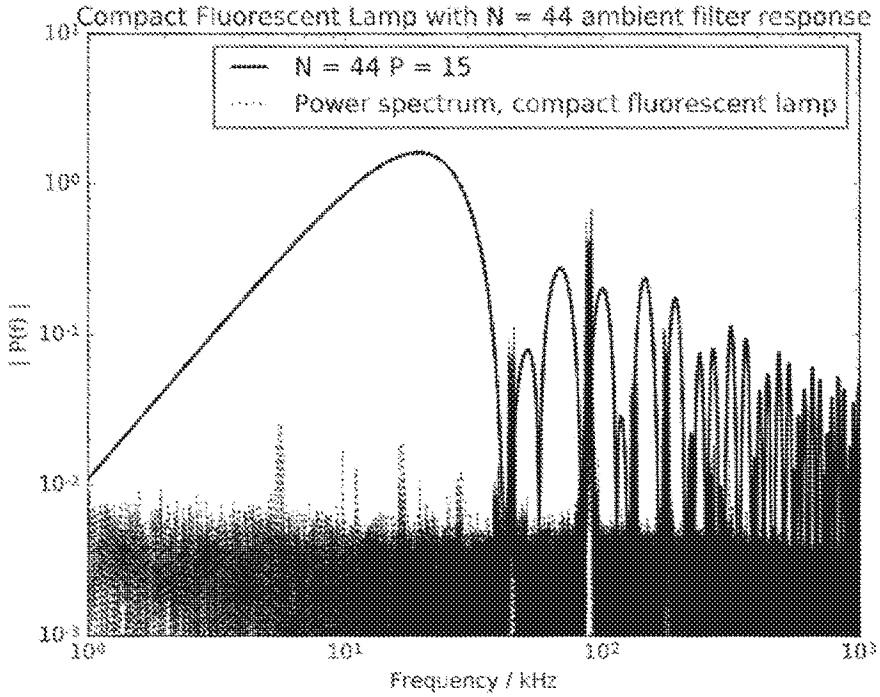

Compact Fluorescent Lamp with N = 44 ambient filter response
N = 44 P = 15
Power spectrum, compact fluorescent lamp
|P(f)|
Frequency / kHz

Figure 14

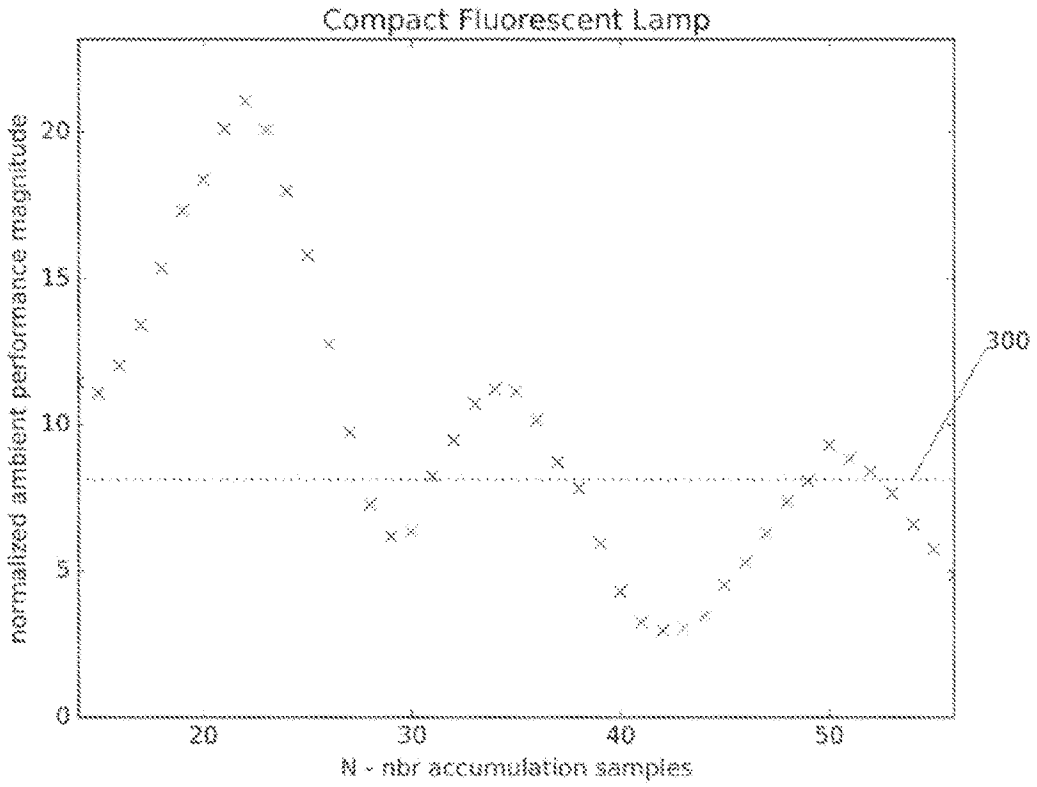

Compact Fluorescent Lamp
normalized ambient performance magnitude
0
5
10
15
20
20
30
40
50
N - nbr accumulation samples
300

Figure 15

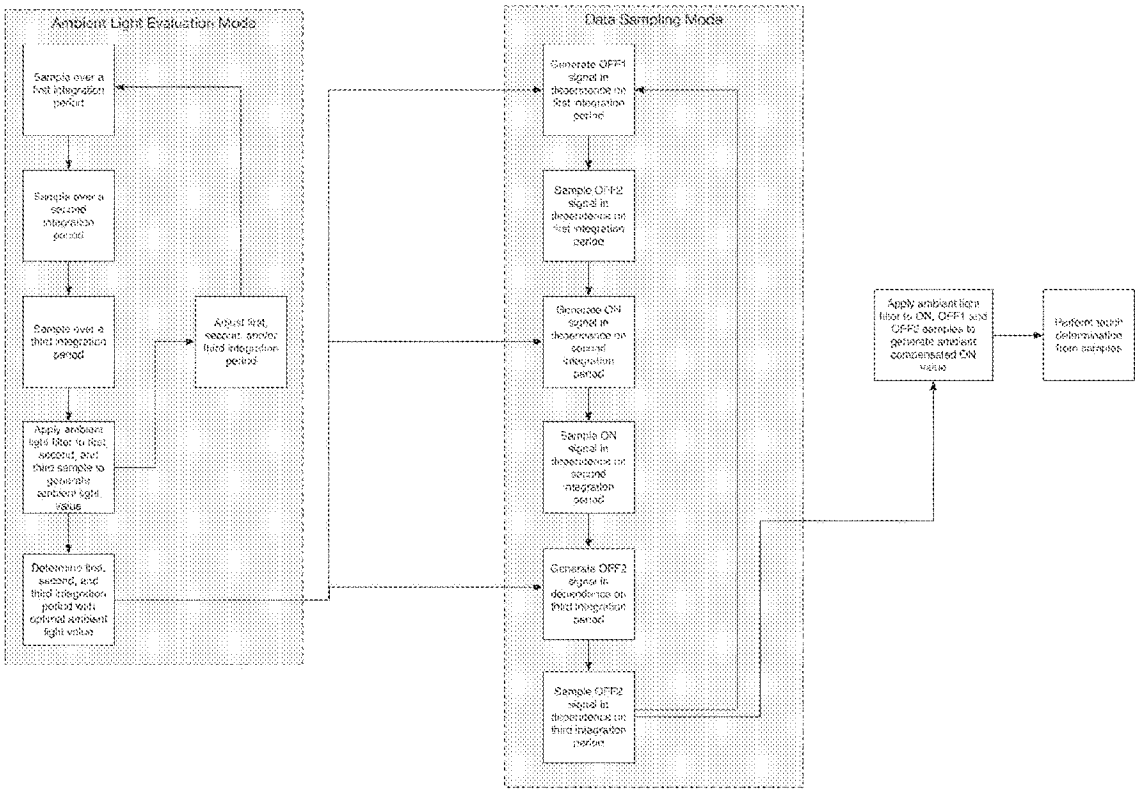

Ambient Light Evaluation Mode
Sample over a first integration period
Sample over a second integration period
Sample over a third integration period
Adjust first, second, and/or third integration period
Apply ambient light filter to first, second, and third sample to generate ambient light value
Determine first, second, and third integration period with optimal ambient light value
Data Sampling Mode
Generate OFF1 signal in dependence on first integration period
Sample OFF2 signal in dependence on first integration period
Generate ON signal in dependence on second integration period
Sample ON signal in dependence on second integration period
Generate OFF2 signal in dependence on third integration period
Sample OFF2 signal in dependence on third integration period
Apply ambient light filter to ON, OFF1 and OFF2 samples to generate ambient compensated ON value
Perform touch determination from samples

Figure 16

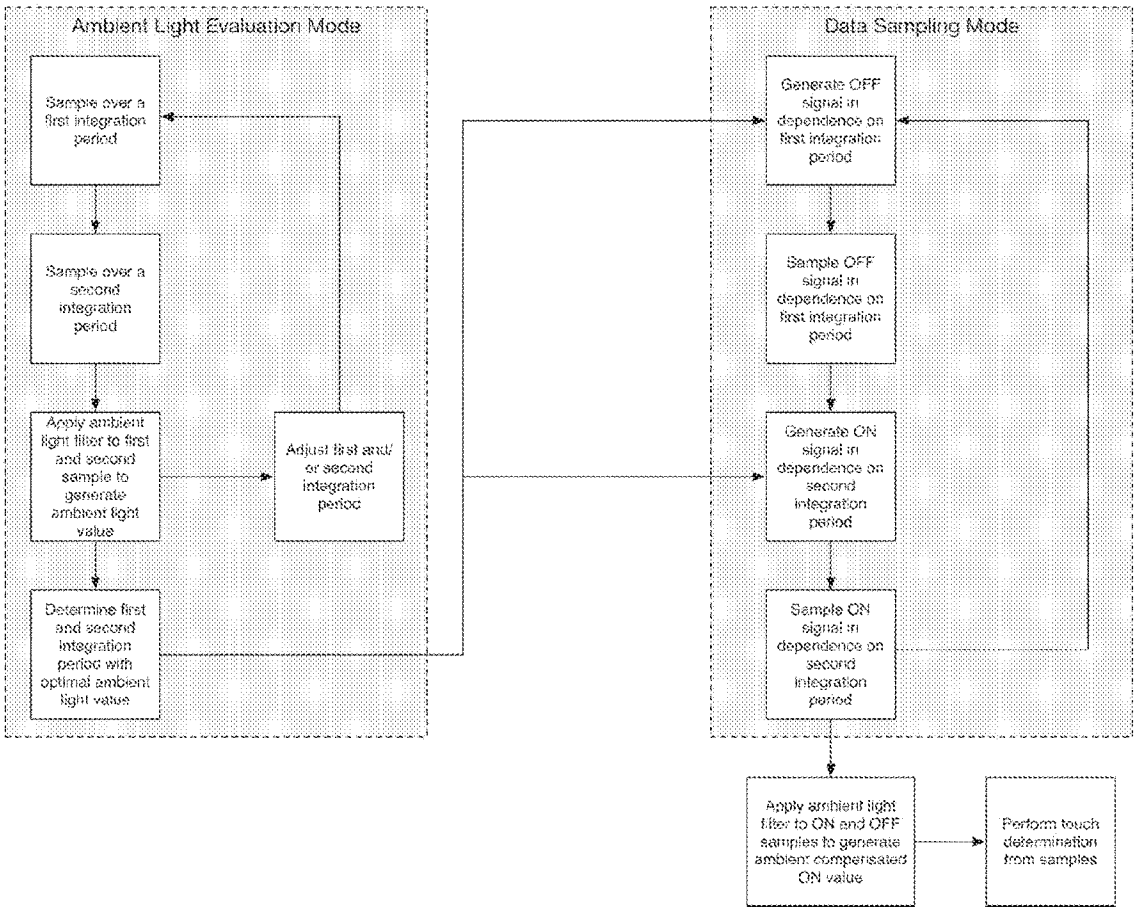

Ambient Light Evaluation Mode
Sample over a first integration period
Sample over a second integration period
Apply ambient light filter to first and second sample to generate ambient light value
Adjust first and/or second integration period
Determine first and second integration period with optimal ambient light value
Data Sampling Mode
Generate OFF signal in dependence on first integration period
Sample OFF signal in dependence on first integration period
Generate ON signal in dependence on second integration period
Sample ON signal in dependence on second integration period
Apply ambient light filter to ON and OFF samples to generate ambient compensated ON value
Perform touch determination from samples

Figure 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB201 7/057201

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category' *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 201 10084939 A 1 (GEPNER JOSEPH E ET AL), 14 April 201 1 (201 1-04-14); abstract; paragraphs [0003]-[0005] --	1-23
A	WO 201 3 1 1571 0 A2 (FLATFROG LAB AB), 8 August 201 3 (201 3-08-08); abstract; page 26, line 9 - page 29, line 14 --	1-23
A	WO 20141 04967 A 1 (FLATFROG LAB AB), 3 July 2014 (2014-07-03); abstract; page 2, line 16 - page 4, line 5 --	1-23
A	US 201 301 35258 A 1 (KING JEFFREY STAPLETON ET AL), 30 May 2013 (201 3-05-30); abstract; paragraphs [0007]-[001 2] --	1-23

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
06-03-201 8	06-03-201 8

Name and mailing address of the ISA/SE	Authorized officer
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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.
A	US 20090091554 A1 (KEAM NIGEL), 9 April 2009 (2009-04-09); abstract; paragraphs [0003]-[0004]	1-23

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Continuation of: second sheet

International Patent Classification (IPC)

G06F 3/042 (2006.01)

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				US	8373679	B2	12/02/201 3
WO	20131 15710	A2	08/08/201 3	EP	2810146	A4	16/09/201 5
				TW	201346683	A	16/1 1/201 3
				US	20140368471	A 1	18/12/2014
				US	201 70139541	A 1	18/05/201 7
				US	958861 9	B2	07/03/201 7
WO	20141 04967	A 1	03/07/2014	US	201 50332655	A 1	19/1 1/201 5
US	201301 35258	A 1	30/05/201 3	TW	201337687	A	16/09/201 3
				US	9213445	B2	15/12/201 5
				WO	201 3081 894	A 1	06/06/201 3
US	20090091 554	A 1	09/04/2009	CA	2698623	C	11/03/2014
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				KR	201 00063765	A	11/06/201 0
				KR	101465835	B 1	26/1 1/2014
				US	8004502	B2	23/08/201 1
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(74) Agent: **EVENT HORIZON IP;** Barometergatan 16B, 2 1117 Malmo (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: ACTIVE PEN TRUE ID

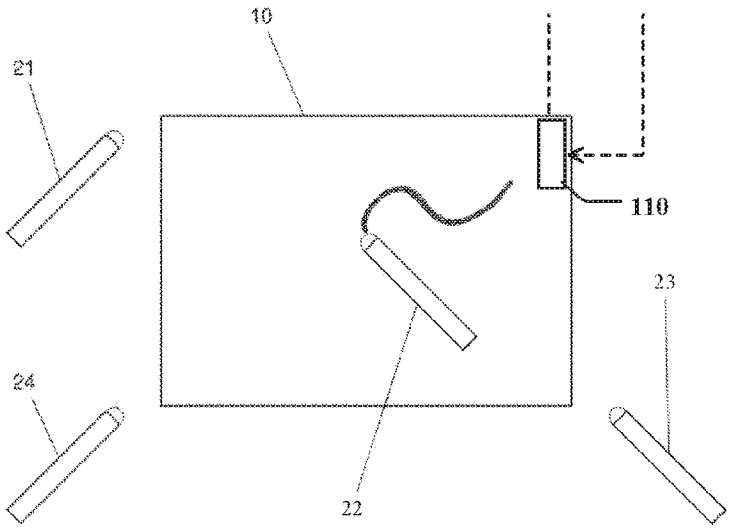


Fig. 1b

(57) Abstract: A method of controlling an interaction between a stylus and a touch sensitive device is disclosed. The stylus comprises a unique identifier and a wireless transmitter for wireless transmission of the unique identifier. The touch sensitive device comprises a wireless receiver for wirelessly receiving the unique identifier of one or more styluses. The method comprises transmitting the unique identifier from a first stylus to the touch sensitive device, determining from a database, a set of controls associated with the unique identifier, and controlling the interaction between the touch sensitive device and the user of the first stylus according to the set of controls. A touch interaction system is also disclosed.

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[Continued on next page]

GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

ACTIVE PEN TRUE ID

Technical Field

The present invention relates to techniques for detecting and uniquely identifying styluses and other objects to be used with a touch sensitive device.

Background

Various user identification techniques are employed in touch applications in order to distinguish different users, such as biometric techniques, or techniques based on distinguishing different gestures. By being able to distinguish different users, it is also possible to control the interaction with the touch application depending on the identified user. This allows for customizing the touch interaction to the specific user. This also opens up for user authentication procedures. A problem with previous techniques such as those using a fingerprint scanner, is increased complexity and costs. Also, gesture control can be cumbersome and slow down the user experience. In many situations, the user may also refrain from using such identification procedures due to the added complexity. This will hinder the development with respect to user customization or user security in touch applications.

Hence, an improved method of identifying unique styluses and users would be advantageous and in particular allowing for avoiding more of the above-mentioned problems and compromises.

Summary

Accordingly, examples of the present invention preferably seek to mitigate, alleviate or eliminate one or more deficiencies, disadvantages or issues in the art, such as the above-identified, singly or in any combination by providing a device according to the appended patent claims.

According to a first aspect a method of controlling an interaction between a stylus and a touch sensitive device is provided. The stylus comprises a unique identifier and a wireless transmitter for wireless transmission of the unique identifier. The touch sensitive device comprises a wireless receiver for wirelessly receiving the unique identifier of one or more styluses, and an interactive display controllable with touch interactions. The method comprises transmitting the unique identifier from a

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first stylus to the touch sensitive device; determining from a database, a set of controls associated with the unique identifier; and controlling the interaction between the touch sensitive device and the user of the first stylus according to the set of controls.

According to a second aspect a touch interaction system is provided, comprising a first stylus comprising a wireless transmitter adapted to transmit a unique identifier. The touch interaction system further comprises a touch sensitive device comprising a receiver adapted to receive the unique identifier from the first stylus, and an interactive display controllable with touch interactions. The touch interaction system further comprises a control unit adapted to transmit the unique identifier from the first stylus to the touch sensitive device; determine from a database, a set of controls associated with the unique identifier, and control the interaction between the touch sensitive device and the user of the first stylus according to the set of controls.

Further examples of the invention are defined in the dependent claims, wherein features for the second and subsequent aspects of the invention are as for the first aspect mutatis mutandis.

Some examples of the disclosure provide for a simpler stylus- or user identification system.

Some examples of the disclosure provide for stylus- or user identification which is more intuitive.

Some examples of the disclosure provide for a less costly stylus- or user identification system.

Some examples of the disclosure provide for a more reliable and robust stylus- or user identification system.

Some examples of the disclosure provide for a more flexible and adaptable stylus- or user identification system.

Some examples of the disclosure provide for a stylus- or user identification system which is quicker to use.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

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Brief Description of the Drawings

These and other aspects, features and advantages of which embodiments of the invention are capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings:

Fig. 1 is a schematic illustration of a touch interaction system according to one example, in which;

Fig. 1a is a schematic illustration of a stylus according to one example; and

Fig. 1b is a schematic illustration of a touch device and styluses according to one example.

Fig. 2 is a schematic illustration of a touch interaction system according to one example.

Fig. 3 is a schematic illustration of different users of a touch interaction system according to one example.

Detailed Description

Specific examples of the invention will now be described with reference to the accompanying drawings. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

Figs. 1a-b show a touch interaction system 100 comprising a first stylus 22 and a touch sensitive device 10. The stylus 22 comprises a wireless transmitter 70 adapted to transmit a unique identifier 90, and the touch sensitive device 10 comprises a receiver 110 adapted to receive the unique identifier 90 from the first stylus 22. The stylus 22 may be a first stylus among a plurality of styluses 21, 22, 23, 24, in the touch interaction system 100. The receiver 110 may be adapted to receive a unique identifier 90 from each of the plurality of styluses 21, 22, 23, 24. The touch interaction system 100 comprises a control unit 120 adapted to transmit the unique identifier 90 from the first stylus 22 to the touch sensitive device 10. The control unit 120 communicates with the first stylus 22 and the touch sensitive device 10, and is

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further adapted to determine, from a database 130, a set of controls associated with the unique identifier 90. The communication between the control unit 120 and the mentioned components in the touch interaction system 100 may be wireless communication. It is conceivable that the stylus 22 or the touch sensitive device 10 may comprise the control device 120. In case the touch sensitive device 10 comprise the control device 120, the stylus may have a stylus control device 60 adapted to communicate with the control device 120, via the transmitter 70 and receiver 110. Upon receiving a first unique identifier 90 the control unit 120 is adapted to identify a first set of controls stored in the database 130 that are associated with the first unique identifier 90. The control unit 120 is further adapted to control the interaction between the touch sensitive device 10 and the user of the first stylus 22 according to the set of controls that has been identified for the received unique identifier 90. Thus, this provides for a simple and effective procedure to associate a set of rules, i.e. a set of controls, to a particular stylus and user thereof. Several users may accordingly have their personal styluses 21, 22, 23, 24, each having a unique identifier 90, that will have an associated set of controls stored in the database 130, allowing for the control unit 120 to distinguish and associate each of the users to the particular set of controls to customize and regulate the particular user's interaction with the touch sensitive device 10. This allows, for example, setting different authorization levels for a plurality of styluses and users. E.g. an administrator 301 (Fig. 3) may have a stylus 21 that transmits a first unique identifier 90 associated with a set of controls that allows administrator interaction with the touch sensitive device 10, whereas a sub-user 302 has a stylus 22 that transmits a second unique identifier 90' which is associated with another set of controls that allows restricted or different interaction with the touch sensitive device 10.

Thus, a method of controlling an interaction between a stylus 22 and a touch sensitive device 10 is provided. The method comprises transmitting the unique identifier 90 from a first stylus 22 to the touch sensitive device 10, determining from a database 130, a set of controls associated with the unique identifier 90, and controlling the interaction between the touch sensitive device 10 and the user of the first stylus 22 according to the set of controls.

The unique identifier 90 may be transmitted upon contact between the first stylus 22 and the touch sensitive device 10. It is thus possible to synchronize the user's interaction with the touch sensitive device 10 and the unique set of controls that

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should apply to that particular event of interaction. I.e. once a user engages a first stylus 22 in contact with the touch sensitive device 10, the first unique identifier 90 is transmitted, received and associated with the corresponding set of first controls that dictates the rules that should apply to the interaction detected at the time of sensing the user's contact with the touch sensitive device 10. This allows for a simple and effective distinguishing between several users that may, for example, have different authorization levels. E.g., any control setting associated with an administrator- or higher authorization level applies only to the interactions, i.e. events of contact in time, carried out by a user having a stylus identified as authorized to interact at such level.

A time stamp may be transmitted from the first stylus 22 to the touch sensitive device upon contact between the first stylus 22 and the touch sensitive device 10. The method may comprise comparing this time stamp with the time of a registered touch event of the first stylus 22 at the touch sensitive display. It is thus possible to distinguish touch events occurring in fast sequences in time and synchronise these events with the set of controls that should apply for each event, depending on which of the styluses, among the plurality of styluses 22, 23, 24, 25, that contacts the touch sensitive device 10, and send the unique identifier 90 at that particular event.

Thus, the control unit 120 may be adapted to transmit the unique identifier 90 upon contact between the first stylus 22 and the touch sensitive device 10, and adapted to generate a time stamp that is transmitted from the first stylus 22 to the touch sensitive display 10 upon said contact. The control unit 120 may be further adapted to compare the time stamp with the time of a registered touch event of the first stylus 22 at the touch sensitive display 10.

The touch event may be registered based on a passive touch interaction between the first stylus 22 and the touch sensitive display 10. Thus, is not needed to have active detection of the stylus 22 touch event to register the input on the touch sensitive display 10. It is sufficient to detect the point in time the stylus contacts, or possibly come in to close contact, with the touch sensitive display 10. This reduces the complexity of the stylus 22, while still being able to distinguish input as described above. The time of contact may be registered by a distal detection unit 80 at the stylus 22, such as a mechanical, electrical or optical sensor. The distal detection unit 80 may for example comprise a pressure sensor or any electro-mechanical actuator

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being adapted to register a pushing action of the stylus against the touch sensitive device 10.

Controlling the interaction between the touch sensitive device 10 and the first stylus 22 may comprise providing access to the user of the first stylus 22 to an operating system account or application account identified by the set of controls. It is thus possible for a user to get access to designated accounts that are approved for the user's particular stylus 22.

Access for the user of the first stylus 22 to the operating system account or application account may be disabled a set period of time after the last interaction between the first stylus and the touch sensitive device. This may be advantageous in certain authorization environments, where a time limited access to the accounts is desirable, which may be the case when styluses are re-used after a certain period of time.

Access for the user of the first stylus to the operating system account or application account may be disabled a set period of time after the last received wireless transmission between the first stylus and the touch sensitive device. This further improves security since proximity to the touch sensitive device 10 may be required to maintain the set authorization level and access.

Controlling the interaction between the touch sensitive device and the first stylus may comprise controlling characteristics of the interaction input provided by the first stylus. Thus, characteristics of the input can be tailored to the different needs of the user. This may be advantageous when several users interact with a shared touch sensitive device 10, such as schematically illustrated in Fig. 2.

Controlling characteristics of the interaction input provided by the first stylus may for example comprise one or more of the following; i) controlling the colour of a digital ink applied using the first stylus 22 on the touch sensitive device 10; ii) controlling a brush configuration of a digital ink applied using the first stylus 22 on the touch sensitive device 10; iii) controlling a latency of interaction input provided by the first stylus 22 on the touch sensitive device 10; iv) controlling post processing of interaction input provided by the first stylus 22 on the touch sensitive device 10; or v) controlling a function of a secondary stylus tip 23 with respect to the touch sensitive device 10.

Controlling characteristics of the interaction input provided by the first stylus 22 may comprise visibly and distinctly associating input from each stylus 22, 23, 24, 25,

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to the respective stylus. It is thus possible to easily distinguish the input provided by the different styluses 22, 23, 24, 25.

Controlling the interaction between the touch sensitive device 10 and the first stylus 22 may comprise limiting editing of digital objects, created by or associated with the first stylus, to the first stylus. Limiting the editing of objects may be desirable in, for example, digital authentication procedures where a signature is required, e.g. when digitally signing a contract. I.e. once the authorization is given, by providing a signature, there is no possibility to cancel the authorization or signing. This provides for a more secure and reliable digital signing procedure to the users involved.

Controlling the interaction between the touch sensitive device 10 and the first stylus 22 may comprise limiting interaction input from the first stylus 22 to a first portion of the interactive display, wherein the first portion is defined by the set of controls. This advantageously provides for the possibility to restrict or grant access to interact with certain portions of the touch display device 10 for a particular stylus user. Each user may then have the ability to interact with different portions of the display depending on the set of controls associated with each of the styluses and users. It may for example be desirable to limit the interaction in a transactional application, used by a seller and buyer, so that the buyer may interact with a signing portion or field of the display only, and not with the remaining interaction fields such as the amounts payable.

Controlling the interaction between the touch sensitive device 10 and the first stylus 22 may comprise providing a first portion of the interactive display with one or more applications or UI elements customised in dependence on the set of controls. This further provides for the ability to customize the user experience or authorization level to the particular stylus and user.

The location and/or size of the first portion of the interactive display may be dependent on an interaction position of the first stylus 22 on the touch sensitive device 10. Thus, it is possible to adapt the first portion depending on the interaction with the first stylus.

The transmission of the unique identifier from the first stylus 22 to the touch sensitive device 10 may occur only in response to an indication from a biometric sensor 50 located on the pen identifying an authorised user. This provides for further increasing the security level, since the set of controls defining the rules for interaction with the touch sensitive device is linked to the particular user's biometric data.

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The method may further comprise transmitting a biometric value from a biometric sensor located on the pen to the touch sensitive device in combination with the unique identifier, and wherein the set of controls is determined in dependence on the unique identifier and the biometric value. As mentioned, this provides for uniquely associating the interaction with the touch sensitive device 10 with a user' biometrical input, such as a fingerprint.

The method may further comprise transmitting the unique identifier 90 from a second stylus 23 to the touch sensitive device, and determining from the database, a set of controls associated with the unique identifier of the first stylus 22 in combination with the unique identifier of the second stylus 23. It is thus possible to have a different set of controls and rules for the interaction when more than one user interacts with the touch sensitive device 10. This provides for adapting the above-mentioned interaction to a plurality of users, such as the style or features of the UI or applications, or authorisation requirements, e.g. signing or access to an application is only possible when two users are present.

Controlling the interaction between the touch sensitive device and the first stylus may comprise, in dependence on the set of controls, identifying a user ID and providing an authentication interface to allow the user of the first stylus to authenticate against the identified user ID. Thus, a user may have a personal stylus 22, which transmit a user ID with the unique identifier 90. But in order for the set of controls associated with the unique identifier to be activated, the user is required to sign or otherwise authenticate that he or she is in fact owner of the user ID.

The step of providing an authentication interface may comprise enabling the user of the first stylus 22 to provide a signature using the first stylus to authenticate themselves. As elucidated above, this provides increased security and reliability, without having to incorporate biometric sensing etc.

The step of providing an authentication interface may comprise enabling the user of the first stylus to provide a passcode using the first stylus to authenticate themselves. This is one possibility for user ID confirmation. Alternatively, or in addition, the step of providing an authentication interface may comprise enabling the user of the first stylus to provide a geometric pattern using the first stylus to authenticate themselves. Alternatively, or in addition, the step of providing an authentication interface may comprise enabling the user of the first stylus to provide a tap sequence using the first stylus to authenticate themselves.

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The authentication interface may be configured to not display the input interaction from the first stylus. The provides for increased security and privacy, since it will be more difficult for other nearby users to identify the input.

In any of the above embodiments, public-key cryptography or equivalent system may be used to ensure secure communication between a stylus and the touch sensitive device. The use of a cryptography system such as public-key cryptography also ensures that the unique identifier of a stylus cannot be replayed at a later date to allow authorisation to an attacker.

In any of the above embodiments, database 130 may be stored locally to control unit 120, i.e. as part of the same device. Alternatively, database 130 may be stored remotely, e.g. on a remote server. In such an embodiment, touch interaction system 100 comprises a network connection to allow control unit 120 to contact and retrieve data from remote database 130. The network connection may comprise a wireless or wired network connection, provided either directly to component 120 or to a device hosting component 120. This embodiment allows remote database 130 to be shared between more than one touch interaction system e.g. via the internet. This allows the portability of styluses, their unique identifiers, and the corresponding interaction controls and/or authentications between different touch interaction systems. In one example, a single administrator stylus may be provided with a same set of controls across a plurality of touch systems that allow administrator interaction.

The present invention has been described above with reference to specific embodiments. However, other embodiments than the above described are equally possible within the scope of the invention. The different features and steps of the invention may be combined in other combinations than those described. The scope of the invention is only limited by the appended patent claims.

More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the teachings of the present invention is/are used.

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CLAIMS:

1. A method of controlling an interaction between a stylus and a touch sensitive device,

the stylus comprising a unique identifier and a wireless transmitter for wireless transmission of the unique identifier,

the touch sensitive device comprising a wireless receiver for wirelessly receiving the unique identifier of one or more styluses, and an interactive display controllable with touch interactions,

wherein the method comprises:

transmitting the unique identifier from a first stylus to the touch sensitive device,

determining from a database, a set of controls associated with the unique identifier,

controlling the interaction between the touch sensitive device and the user of the first stylus according to the set of controls.

2. The method of claim 1, wherein the unique identifier is transmitted upon contact between the first stylus and the touch sensitive device.

3. The method of claim 2, wherein a time stamp is transmitted from the first stylus to the touch sensitive device upon said contact, the method further comprising comparing the time stamp with the time of a registered touch event of the first stylus at the touch sensitive display.

4. The method of claim 3, wherein the touch event is registered based on a passive touch interaction between the first stylus and the touch sensitive display.

5. The method of claim 1, wherein controlling the interaction between the touch sensitive device and the first stylus comprises providing access to the user of the first stylus to an operating system account or application account identified by the set of controls.

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6.The method of claim 5, wherein access for the user of the first stylus to the operating system account or application account is disabled a set period of time after the last interaction between the first stylus and the touch sensitive device.

7.The method of claim 5, wherein access for the user of the first stylus to the operating system account or application account is disabled a set period of time after the last received wireless transmission between the first stylus and the touch sensitive device.

8.The method of any preceding claim, wherein controlling the interaction between the touch sensitive device and the first stylus comprises controlling characteristics of the interaction input provided by the first stylus.

9.The method of claim 8, wherein controlling characteristics of the interaction input provided by the first stylus comprises one or more of the following:

controlling the colour of a digital ink applied using the first stylus on the touch sensitive device,

controlling a brush configuration of a digital ink applied using the first stylus on the touch sensitive device,

controlling a latency of interaction input provided by the first stylus on the touch sensitive device,

controlling post processing of interaction input provided by the first stylus on the touch sensitive device,

controlling a function of a secondary stylus tip with respect to the touch sensitive device.

10. The method of claim 8, wherein controlling characteristics of the interaction input provided by the first stylus comprises visibly and distinctly associating input from each stylus to the respective stylus.

11.The method of any preceding claim, wherein controlling the interaction between the touch sensitive device and the first stylus comprises limiting editing of digital objects created by or associated with the first stylus to the first stylus.

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12. The method of any preceding claim, wherein controlling the interaction between the touch sensitive device and the first stylus comprises limiting interaction input from the first stylus to a first portion of the interactive display, wherein the first portion is defined by the set of controls.

13. The method of any preceding claim, wherein controlling the interaction between the touch sensitive device and the first stylus comprises providing a first portion of the interactive display with one or more applications or UI elements customised in dependence on the set of controls.

14. The method of claim 13, wherein the location and/or size of the first portion of the interactive display is dependent on an interaction position of the first stylus on the touch sensitive device.

15. The method of any preceding claim, wherein transmission of the unique identifier from the first stylus to the touch sensitive device occurs only in response to an indication from a biometric sensor located on the pen identifying an authorised user.

16. The method of any preceding claim, wherein the method further comprises transmitting a biometric value from a biometric sensor located on the pen to the touch sensitive device in combination with the unique identifier, and wherein the set of controls is determined in dependence on the unique identifier and the biometric value.

17. The method of any preceding claim, wherein the method further comprises:

transmitting the unique identifier from a second stylus to the touch sensitive device,

determining from the database, a set of controls associated with the unique identifier of the first stylus in combination with the unique identifier of the second stylus.

18. The method of any preceding claim, wherein controlling the interaction between the touch sensitive device and the first stylus comprises, in dependence on

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the set of controls, identifying a user ID and providing an authentication interface to allow the user of the first stylus to authenticate against the identified user ID.

19. The method of claim 18, wherein the step of providing an authentication interface comprises enabling the user of the first stylus to provide a signature using the first stylus to authenticate themselves.

20. The method of claim 18, wherein the step of providing an authentication interface comprises enabling the user of the first stylus to provide a passcode using the first stylus to authenticate themselves.

21. The method of claim 18, wherein the step of providing an authentication interface comprises enabling the user of the first stylus to provide a geometric pattern using the first stylus to authenticate themselves.

22. The method of claim 18, wherein the step of providing an authentication interface comprises enabling the user of the first stylus to provide a tap sequence using the first stylus to authenticate themselves.

23. The method of claim 18, wherein the authentication interface is configured to not display the input interaction from the first stylus.

24. A touch interaction system (100), comprising

a first stylus (22) comprising a wireless transmitter (70) adapted to transmit a unique identifier (90),

a touch sensitive device (10) comprising a receiver (110) adapted to receive the unique identifier from the first stylus, and an interactive display controllable with touch interactions, the touch interaction system further comprising

a control unit (120) adapted to

transmit the unique identifier from the first stylus to the touch sensitive device,

determine from a database (130), a set of controls associated with the unique identifier, and

control the interaction between the touch sensitive device and the user of the first stylus according to the set of controls.

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25. The touch interaction system according to claim 24, wherein the control unit is adapted to

transmit the unique identifier upon contact between the first stylus and the touch sensitive device,

generate a time stamp that is transmitted from the first stylus to the touch sensitive display upon said contact, and

compare the time stamp with the time of a registered touch event of the first stylus at the touch sensitive display.

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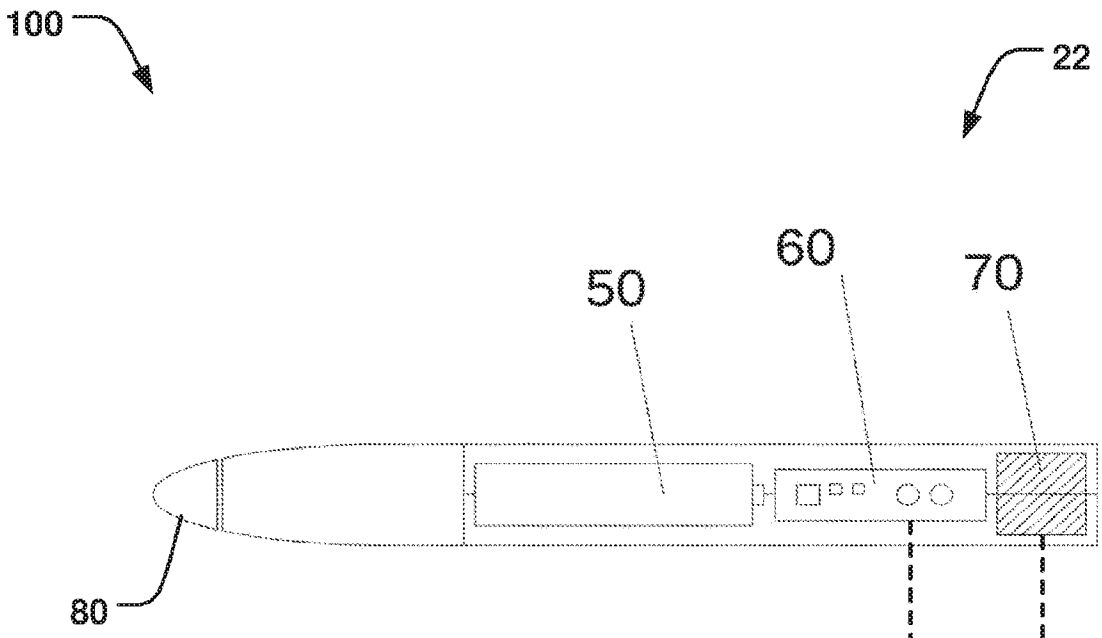


Fig. 1a

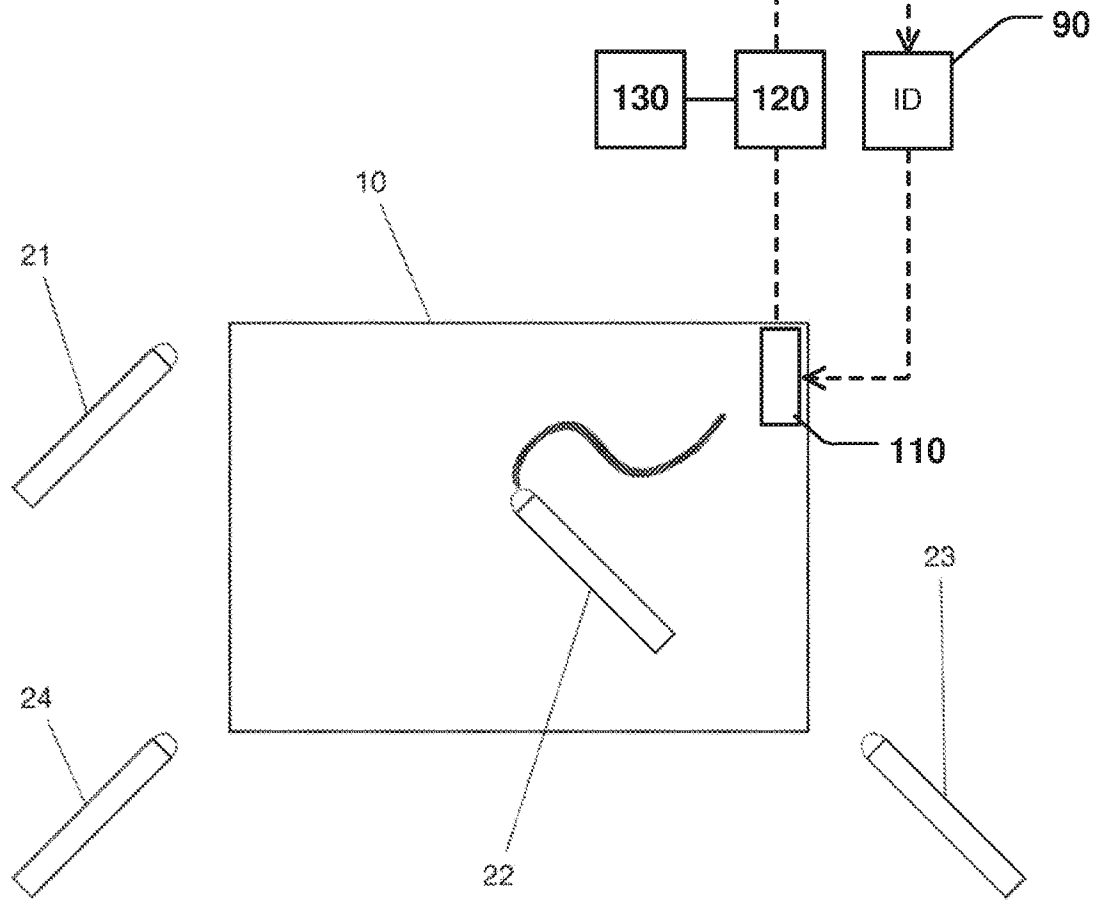


Fig. 1b

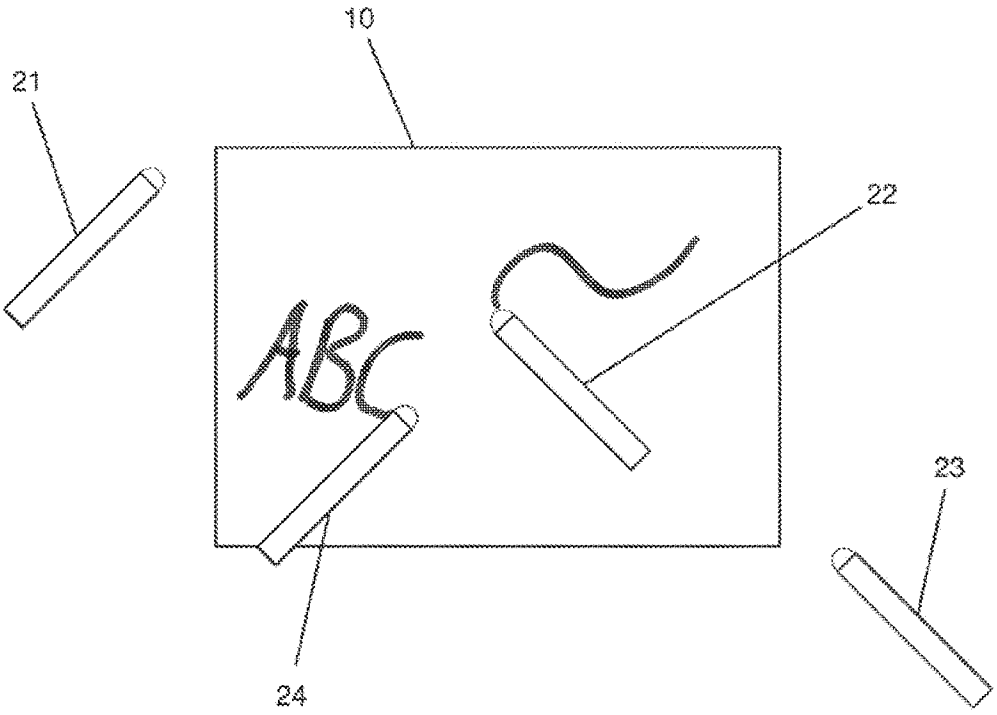


Fig. 2

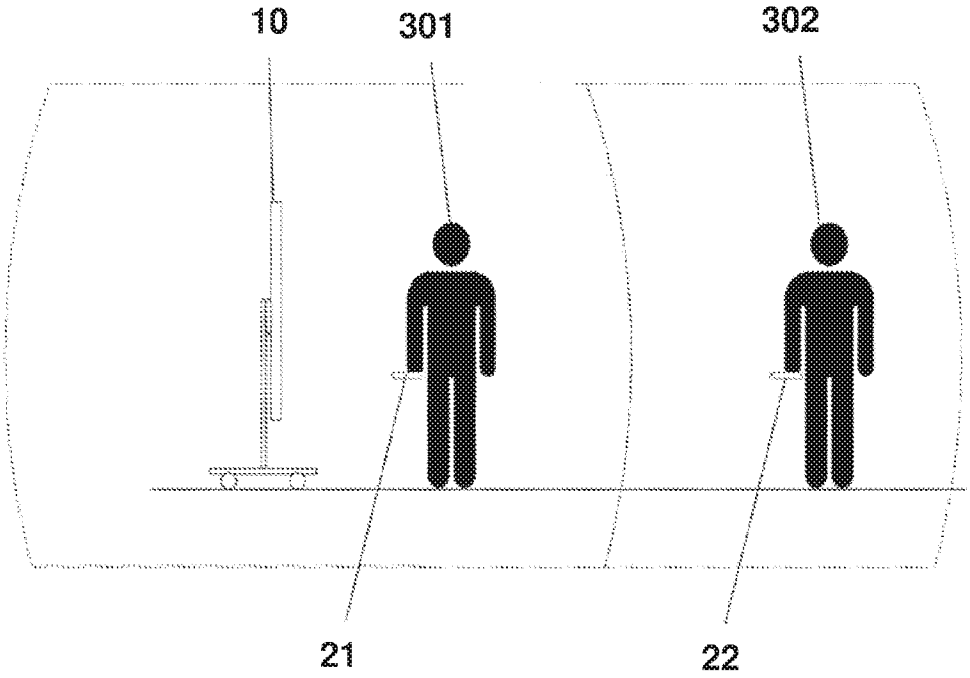


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 7/051 224

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category' *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 201 301 06709 A 1 (SIMMONS MARTIN JOHN), 2 May 2013 (201 3-05-02); abstract; paragraphs [0020], [0028], [0030], [0032], [0036]-[0038], [0040]-[0041], [0045]; figure 4A; claim 15	1-2, 5, 8-1 1, 17-18, 24
Y	--	3-4, 6-7, 12-1 6, 19-23, 25
Y	US 201 60004898 A 1 (HOLZ CHRISTIAN), 7 January 201 6 (201 6-01 -07); abstract; paragraphs [0031], [0033]-[0035], [0037], [0046]-[0047], [0050]; figure 4; claims 15-1 6	3-4, 6-7, 15-1 6, 25
A	--	1-2, 5, 8-14, 17-24

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"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
23-02-201 8	23-02-201 8

Name and mailing address of the ISA/SE	Authorized officer
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International application No.
PCT/SE201 7/051 224

Continuation of: second sheet

International Patent Classification (IPC)

G06F 3/0354 (201 3.01)
G06F 3/041 (2006.01)
G06F 21/32 (201 3.01)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 7/051 224

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

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Y	--	3-4, 6-7, 12-1 6, 19-23, 25
Y	US 201 60004898 A 1 (HOLZ CHRISTIAN), 7 January 201 6 (201 6-01 -07); abstract; paragraphs [0031], [0033]-[0035], [0037], [0046]-[0047], [0050]; figure 4; claims 15-1 6	3-4, 6-7, 15-1 6, 25
A	--	1-2, 5, 8-14, 17-24

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"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
23-02-201 8	23-02-201 8

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Jimmie Femzen Telephone No. +46 8 782 28 00

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International Patent Classification (IPC)

G06F 3/0354 (201 3.01)
G06F 3/041 (2006.01)
G06F 21/32 (201 3.01)

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				KR	201 7005551 8	A	19/05/201 7
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				US	9626020	B2	18/04/201 7
				WO	201 604071 9	A 1	17/03/201 6
US	20140259029	A 1	11/09/2014	AU	2014201 293	A 1	25/09/2014
				CN	104049732	A	17/09/2014
				EP	2778881	A3	17/12/2014
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IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 1135 of 1254

WO	20151 75586	A 1	19/1 1/201 5	CN	106462679	A	22/02/201 7
				EP	3143544	A 1	22/03/201 7
				KR	201 70008780	A	24/01/201 7
				US	9552473	B2	24/01/201 7
				US	201 7001 1227	A 1	12/01/201 7
				US	201 50332037	A 1	19/1 1/201 5

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Flatfrog Laboratories AB, Ex. 2002
Page 1136 of 1254

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB201 7/057201

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category' *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 201 10084939 A 1 (GEPNER JOSEPH E ET AL), 14 April 201 1 (201 1-04-14); abstract; paragraphs [0003]-[0005] --	1-23
A	WO 201 3 1 1571 0 A2 (FLATFROG LAB AB), 8 August 201 3 (201 3-08-08); abstract; page 26, line 9 - page 29, line 14 --	1-23
A	WO 20141 04967 A 1 (FLATFROG LAB AB), 3 July 2014 (2014-07-03); abstract; page 2, line 16 - page 4, line 5 --	1-23
A	US 201 301 35258 A 1 (KING JEFFREY STAPLETON ET AL), 30 May 2013 (201 3-05-30); abstract; paragraphs [0007]-[001 2] --	1-23

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
06-03-201 8	06-03-201 8

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Per Karlsson Telephone No. +46 8 782 28 00

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 1137 of 1254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20090091 554 A 1 (KEAM NIGEL), 9 April 2009 (2009-04-09); abstract; paragraphs [0003]-[0004]	1-23

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Continuation of: second sheet

International Patent Classification (IPC)

G06F 3/042 (2006.01)

US	201 10084939	A 1	14/04/201 1	US	201 30127763	A 1	23/05/201 3
				US	8373679	B2	12/02/201 3
WO	20131 15710	A2	08/08/201 3	EP	2810146	A4	16/09/201 5
				TW	201346683	A	16/1 1/201 3
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US	201301 35258	A 1	30/05/201 3	TW	201337687	A	16/09/201 3
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				CN	10181 5979	B	29/05/201 3
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				JP	201 1501 841	A	13/01/201 1
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				KR	201 00063765	A	11/06/201 0
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				US	8004502	B2	23/08/201 1
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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference P3135PC00	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/SE2017/051233	International filing date *(day/month/year)* 07 December 2017 (07.12.2017)	Priority date *(day/month/year)* 07 December 2016 (07.12.2016)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant FLATFROG LABORATORIES AB		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 11 June 2019 (11.06.2019)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Simin Baharlou e-mail: pct.team9@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
EVENT HORIZON IP
Barometergatan 16B
211 17 Malmö

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

	Date of mailing *(day/month/year)* 12-03-2018
Applicant's or agent's file reference P3135PC00	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SE2017/051233	07-12-2017	07-12-2016

International Patent Classification (IPC) or both national classification and IPC
See Supplemental Box

Applicant
FLATFROG LABORATORIES AB

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [x] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/SE	Date of completion of this opinion	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	12-03-2018	Emil Bäcklund Telephone No. + 46 8 782 28 66

Form PCT/ISA/237 (cover sheet) (January 2015)

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: cover sheet

International Patent Classification (IPC)

G06F 1/16 (2006.01)
G06F 3/01 (2006.01)
G06F 3/03 (2006.01)
G06F 3/041 (2006.01)

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Flatfrog Laboratories AB, Ex. 2002
Page 1143 of 1254

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/SE2017/051233

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Flatfrog Laboratories AB, Ex. 2002
Page 1144 of 1254

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/SE2017/051233

Box No. V **Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-24	YES
	Claims		NO
Inventive step (IS)	Claims	1-24	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-24	YES
	Claims		NO

2. Citations and explanations

Documents cited in the International Search Report:

D1: US2016295711 A1
D2: EP3043242 A1
D3: WO2016177592 A1
D4: US2012062492 A1
D5: US2012045170 A1
D6: US6031524 A1

The cited documents represents the general state of the art.

The invention defined in claims 1-24 is not disclosed by these documents.

The cited prior art does not give any indication that would lead a person skilled in the art to the claimed assembly and touch sensing apparatus in order to obtain a improved assembly for holding and controlling the touch screen. Therefore, the claimed invention is not obvious to a person skilled in the art.

Accordingly, the invention defined in claims 1-24 is novel and is considered to involve an inventive step. The invention is industrially applicable

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Flatfrog Laboratories AB, Ex. 2002
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Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

The features of the claims 16-24 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

Claims 1, 3-4 and 15 are missing a reference to the drawing for the spacing element. However, it is clear from the description that said spacing element should have the reference 116. Furthermore, claim 4 incorrectly disclose spacing element (112, 112a and 112b).

According to the requirements of Rule 10.2 PCT, the terminology and the signs shall be consistent throughout the application. This requirement has not been met in view of the use of the expressions "an assembly" in claims 1-12, and the expression "a frame assembly" in claims 13-14 for the same feature. The same claim category must be used for those claims.

Claims 1-19 area missing a reference to an assembly and the frame assembly

Claim 15, what is performing the method ?

Claim 21 discloses the expression " the mathematical parabola" is unclear since it is in definite form. The first time an object is mention it should be in indefinite form.

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Flatfrog Laboratories AB, Ex. 2002
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 8/050070

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, EMBASE, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category' *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2565770 A2 (SAMSUNG ELECTRONICS CO LTD), 6 March 201 3 (201 3-03-06); abstract; paragraphs [0023]-[0024], [0039], [0066]-[0071]; figures 1,4,5A-B,9A-B,1 1A-G,1 2,13A-B	1-3, 5-1 2
A	--	4
Y	US 201 601 1701 9 A 1 (TAKEDA MICHIAKI), 28 April 201 6 (201 6-04-28); abstract; paragraphs [0076]-[0084]; figure 4	1-3, 5-1 2
A	--	4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
25-04-201 8	25-04-201 8

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Per Karlsson Telephone No. +46 8 782 28 00

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 1147 of 1254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20140253520 A 1 (CUETO GERALD B ET AL), 11 September 2014 (2014-09-1 1); abstract; paragraphs [0023]-[0027]; figures 1A-C --	1-12
A	US 20090000831 A 1 (MILLER THURMAN ET AL), 1 January 2009 (2009-01 -01); abstract; paragraphs [001 9]-[0026] -- --------	1-12

Continuation of: second sheet

International Patent Classification (IPC)

G06F 3/0354 (201 3.01)
G06F 3/041 (2006.01)

EP	2565770	A2	06/03/201 3	CN	102968206	A	13/03/201 3
				JP	201 3054745	A	21/03/201 3
				KR	201 30024220	A	08/03/201 3
				US	201 30050141	A 1	28/02/201 3
US	201601 1701 9	A 1	28/04/201 6	JP	WO201 4 188973	A 1	23/02/201 7
				JP	5872738	B2	01/03/201 6
				US	9495056	B2	15/1 1/201 6
				WO	20141 88973	A 1	27/1 1/2014
US	20140253520	A 1	11/09/2014	US	9785259	B2	10/10/201 7
US	20090000831	A 1	01/01/2009	US	9389709	B2	12/07/201 6
				US	201 5021 2607	A 1	30/07/201 5
				US	9019245	B2	28/04/201 5

Electronic Acknowledgement Receipt

EFS ID:	39724402
Application Number:	16834905
International Application Number:	
Confirmation Number:	1516
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Customer Number:	20995
Filer:	Harnik Shukla/Jenny Kim
Filer Authorized By:	Harnik Shukla
Attorney Docket Number:	FFOG.054C5
Receipt Date:	15-JUN-2020
Filing Date:	30-MAR-2020
Time Stamp:	18:45:13
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		FFOG054C5_IDS.pdf	59277 d2bd9cff08ca0dd2eb89c48d30c6873a9de15f2f	yes	4

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	1	
	Information Disclosure Statement (IDS) Form (SB08)		2	4	
Warnings:					
Information:					
2	Foreign Reference	AU2008280952A1.PDF	1000692 204e99b3671fa23bdf36b420466f6b1e8d9ef5c9	no	26
Warnings:					
Information:					
3	Foreign Reference	CN101174191A.PDF	2185664 85021a5a50c275653b477a5e59ecc56aff6f0b9d	no	17
Warnings:					
Information:					
4	Foreign Reference	CN101882034A.PDF	1866746 9241adf8dd3daf231f941beba6eb21bd2ca14b8f	no	15
Warnings:					
Information:					
5	Foreign Reference	CN_201465071U_wAbs.pdf	737665 15c9ca31ddf475e8d9d13e1dd95a68e68e61602f	no	12
Warnings:					
Information:					
6	Foreign Reference	CN_203189466U_wAbs.pdf	790704 40e191450447e6a9712608d4732690b47641901e	no	12
Warnings:					
Information:					
7	Foreign Reference	CN_203224848U_wAbs.pdf	2143506 adb7cbe7fa1b9e9cb1be77717c746634f30b51f	no	35
Warnings:					

Information:					
8	Foreign Reference	CN101174191.PDF	2185664 85021a5a50c275653b477a5e59ecc56aff6f0b9d	no	17
Warnings:					
Information:					
9	Foreign Reference	CN_205015574U_wAbs.pdf	1405840 6eacca14ebf095b19284d979b049ac668224a322	no	21
Warnings:					
Information:					
10	Foreign Reference	EP_2565770A2_.pdf	1196640 3f61e56ac660f04ae4ae1b9d71a00024c7438cd5	no	47
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Information:					
11	Foreign Reference	WO_2008034184A1.pdf	1025452 f04c8c3b56310fa2f60806af231e3ce051097b6d	no	52
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Information:					
12	Foreign Reference	WO_2012018176A2.pdf	2670133 c3def4610ff744596dc0f69855cf2285004d9947	no	24
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Information:					
13	Foreign Reference	WO_2013115710A2.pdf	1975223 1260dda66874e1806715f3059a503f0913b5a9b7	no	46
Warnings:					
Information:					
14	Foreign Reference	WO_2014086084A1_Abs.pdf	619352 a7da3231e957b5cea79c94c29b34b7a1103fc15f	no	26
Warnings:					
Information:					

15	Foreign Reference	WO_2014098744A1.pdf	13080892 b0ebd3dfddab39f750a195df9b03b64ea0c37c63	no	53
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Information:					
16	Foreign Reference	WO_2014104967A1.pdf	7466559 b057df4700c1882f70a34bc483a113b37e56461c	no	28
Warnings:					
Information:					
17	Foreign Reference	WO_2015175586A1.pdf	9457252 894547ca36e4d768764119c7363cbfde0d35b2f8	no	32
Warnings:					
Information:					
18	Foreign Reference	WO_2018096430A1_FFOG058.pdf	16584072 2dbe93681e38a4f60c7ff6294883147f4fb86ec4	no	60
Warnings:					
Information:					
19	Foreign Reference	WO_2018106172A1_FFOG057.pdf	4515446 f1dbea1f0442f076ce01e4c5b72b876957da606b	no	23
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Information:					
20	Non Patent Literature	SuppESR_EP16759213_10-4-2018.pdf	2178762 03613ba69d0101def26e79462132336a0644e4c1	no	9
Warnings:					
Information:					
21	Non Patent Literature	EESR_EP16743795_09-11-2018.pdf	141967 1303a571fb119d0b7f26df3249aecd8f7677f316	no	5
Warnings:					
Information:					

22	Non Patent Literature	ISR_FFOG057_FEB-23-2018_PCT-SE-2017-051224.pdf	1268420 ac03d9f6fe7c3ecd348712fd4acbb4a7d039423b	no	5
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Information:					
23	Non Patent Literature	ISR_PCT_IB2017_057201_Mar_6_2018.PDF	35148 e13e59cb6028411572ae19e4667b5d0980c88de8	no	4
Warnings:					
Information:					
24	Non Patent Literature	EESR_EP19165019_07-18-2019.pdf	1812249 962d9e1a672409d76943edfa55752d6fec239fec	no	8
Warnings:					
Information:					
25	Non Patent Literature	IPRP_PCT-SE2017-051233_Jun_11_2019.pdf	1109061 df56004b7aaf49c339b7784f1e8fc8d0d5a8bec5	no	6
Warnings:					
Information:					
26	Non Patent Literature	ISR_PCTSE2018050070_Apr_25_2018.PDF	32645 f0b46a59527f1d99ac4e3aad37c7b1a3390fd048	no	4
Warnings:					
Information:					
27	Non Patent Literature	EESR_EP17750516_Jul_16_2019.pdf	176603 1567424f01bb2a4cb76abce1302077144f7e2c75	no	4
Warnings:					
Information:					
28	Non Patent Literature	SuppESR_EP16873465_06-25-2019.pdf	1584654 24e75515b6455e55d281041eeb730632ff17fce6	no	9
Warnings:					
Information:					
		Total Files Size (in bytes):	79306288		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT

First Inventor	:	Daniel Skagmo
App. No.	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted.

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed before the receipt of a First Office Action on the merits, and presumably no fee is required. If a First Office Action on the merits was mailed before the mailing date of this Statement, the Commissioner is authorized to charge the fee set forth in 37 CFR 1.17(p) to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 15, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 760-0404

32982535

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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NOTICE OF ALLOWANCE AND FEE(S) DUE

20995 7590 06/26/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER
GIESY, ADAM

ART UNIT	PAPER NUMBER
2694	

DATE MAILED: 06/26/2020

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

TITLE OF INVENTION: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	09/28/2020

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 06/26/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

TITLE OF INVENTION: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	09/28/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
GIESY, ADAM	2694	345-175000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
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UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

20995 7590 06/26/2020

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2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
GIESY, ADAM	

ART UNIT	PAPER NUMBER
2694	

DATE MAILED: 06/26/2020

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 16/834,905	Applicant(s) Skagmo et al.	
	Examiner ADAM R GIESY	Art Unit 2694	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 6/15/2020.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 6-9 and 22-26 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☑ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/ADAM R. GIESY/
Primary Examiner, Art Unit 2694

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

EXAMINER'S AMENDMENT

2. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in an interview with Harnik Shukla on 6/22/2020.

The application has been amended as follows:

Claims 6-9 have been replaced in their entirety (see below).

Claims 10-21 have been cancelled.

Claims 22-26 have been added.

6. A touch sensing apparatus, comprising:

a panel that defines a touch surface;

a plurality of light emitters and detectors arranged along a perimeter of the panel;

a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a first projection extending downwards from said first portion and a second projection extending downwards from said first portion, wherein a gap between the first projection and the second projection forms a receptacle having a first cross-sectional shape; and

an optical element fitted in the space between the panel and the first portion and configured to seal the plurality of light emitters from contaminants from the touch surface, said optical element comprises a mating portion having a second cross-section shape that is substantially reciprocal to the first cross-sectional shape, said mating portion engaged with the receptacle of the first portion.

7. The touch sensing apparatus according to claim 6, wherein the support structure further comprises a second portion extending from the first portion, wherein the second portion is configured to enable mounting of the plurality of emitters and wherein the second portion is oriented perpendicular to the first portion.

8. The touch sensing apparatus according to claim 7, wherein the plurality of emitters are mounted on an electronics board that is supported by the second portion, said plurality of emitters configured to emit light above the touch surface.

9. The touch sensing apparatus according to claim 6, wherein the optical element is configured to slide in a direction parallel to a plane of the touch surface.

10. – 21. (CANCELED)

22. The touch sensing apparatus according to claim 6, wherein the optical element comprises a first surface facing the plurality of light emitters and a second surface opposite the first surface, said first surface angled between a top portion of the optical element and a base portion of the optical element and configured to form an offset between a first end of the top portion and a second end of the base portion.

23. The touch sensing apparatus according to claim 7, wherein the support structure comprises an inner wall supporting the plate, and wherein the first portion, the second portion, a third portion extending from the second portion, and the inner wall of the support structure together form a cavity.

24. The touch sensing apparatus according to claim 23, wherein the cavity secures an electronics substrate that mounts the plurality of light emitters.

25. The touch sensing apparatus according to claim 6, wherein the mating portion is engaged with the receptacle responsive to the optical element slidably fitted in a direction perpendicular to the first portion during assembly.

26. The touch sensing apparatus according to claim 6, wherein the mating portion is engaged with the receptacle responsive to the optical element slidably fitted in a direction parallel to the first portion during assembly.

Allowable Subject Matter

3. The following is an examiner's statement of reasons for allowance:

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Claims 6-9 and 22-26 are allowed over the prior art of record.

Independent claim 6 is allowed since the claim recites a touch sensing apparatus, comprising: a panel that defines a touch surface; a plurality of light emitters and detectors arranged along a perimeter of the panel; a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a first projection extending downwards from said first portion and a second projection extending downwards from said first portion, wherein a gap between the first projection and the second projection forms a receptacle having a first cross-sectional shape; and an optical element fitted in the space between the panel and the first portion and configured to seal the plurality of light emitters from contaminants from the touch surface, said optical element comprises a mating portion having a second cross-section shape that is substantially reciprocal to the first cross-sectional shape, said mating portion engaged with the receptacle of the first portion.

Claims 8, 9, and 22-26 are allowed as being dependent upon aforementioned independent claim 1.

The closest prior art by Eriksson (US Doc. No. 20140210793) discloses a touch surface with a plurality of emitters comprising a support structure. Eriksson does not disclose a touch sensing apparatus, comprising: a panel that defines a touch surface; a plurality of light emitters and detectors arranged along a perimeter of the panel; *a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a first projection extending downwards from said first portion and a second projection extending downwards from said first portion, wherein a gap between the first projection and the second projection forms a receptacle having a first cross-sectional shape; and an optical element fitted in the space between the panel and the first portion and configured to seal the plurality of light emitters from contaminants from the touch surface, said optical element comprises a mating portion having a second cross-section shape that is substantially reciprocal to the first cross-sectional shape, said mating portion engaged with the receptacle of the first portion.*

Conclusion

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ADAM R GIESY whose telephone number is (571)272-7555. The examiner can normally be reached on Mon-Fri 8-6.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Patrick Edouard can be reached on 5712727603. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ADAM R. GIESY/
Primary Examiner, Art Unit 2694

Applicant-Initiated Interview Summary	**Application No.** 16/834,905	**Applicant(s)** Skagmo et al.	
	Examiner ADAM R GIESY	**Art Unit** 2694	**AIA (FITF) Status** Yes

All participants (applicant, applicants representative, PTO personnel):

(1) ADAM R. GIESY. (3) _____.

(2) Harnik Shukla. (4) _____.

Date of Interview: 22 June 2020.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☐ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☑102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 6.

Identification of prior art discussed: NA.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

6/11/2020: Claim amendments to further clarify the claims over the prior art were discussed. Examiner agreed to enter the amendments via Examiner's Amendment. Applicant's Representative is going to seek Applicant's permission before agreeing to final amendments.
6:22:2020: Applicant's Representative confirmed that the amendments are agreeable..

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☑ Attachment

/ADAM R. GIESY/ Primary Examiner, Art Unit 2694	

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
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Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiners responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicants correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,-
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicants record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiners version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, Interview Record OK on the paper recording the substance of the interview along with the date and the examiners initials.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/834,905	Skagmo et al.
	Examiner	Art Unit
	ADAM R GIESY	2694

CPC - Searched*		
Symbol	Date	Examiner
(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	06/22/2020	ARG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Updated EAST	06/22/2020	ARG
EAST search included	04/27/2020	ARG

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Interference search performed (see search history)	06/22/2020	ARG

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Flatfrog Laboratories AB, Ex. 2002
Page 1171 of 1254

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/834,905	Skagmo et al.
	Examiner	**Art Unit**
	ADAM R GIESY	2694

CPC								
Symbol							**Type**	**Version**
G06F	/	3	/	0428			F	2013-01-01
G06F	/	3	/	0421			I	2013-01-01
G06F	/	2203	/	04108			A	2013-01-01
G06F	/	2203	/	04103			A	2013-01-01
G06F	/	2203	/	04107			A	2013-01-01
G06F	/	3	/	0412			A	2013-01-01

CPC Combination Sets								
Symbol							**Type**	**Set**	**Ranking**	**Version**
	/		/							

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	9	
/ADAM R. GIESY/ Primary Examiner, Art Unit 2694	22 June 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	12

U.S. Patent and Trademark Office

Part of Paper No.: 20200622

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Flatfrog Laboratories AB, Ex. 2002
Page 1172 of 1254

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/834,905	Skagmo et al.
	Examiner	**Art Unit**
	ADAM R GIESY	2694

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G06F	/	3	/	042

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
345	175

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	9	
/ADAM R. GIESY/ Primary Examiner, Art Unit 2694	22 June 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	12

U.S. Patent and Trademark Office

Part of Paper No.: 20200622

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/834,905	Skagmo et al.
	Examiner	**Art Unit**
	ADAM R GIESY	2694

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 9	
/ADAM R. GIESY/ Primary Examiner, Art Unit 2694 (Primary Examiner)	22 June 2020 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 12

U.S. Patent and Trademark Office

Part of Paper No.: 20200622

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	9,207,800 B1	12-08-2015	Eriksson et al.	
	2	2015/0339000 A1	11-26-2015	Lee et al.	
	3	2016/0306501 A1	10-20-2016	Drumm et al.	
	4	3,440,426	04-22-1969	Bush	
	5	3,553,680	01-05-1971	Cooreman	
	6	3,673,327	06-27-1972	Johnson et al.	
	7	4,129,384	12-12-1978	Walker et al.	
	8	4,180,702	12-25-1979	Sick et al.	
	9	4,209,255	06-24-1980	Heynau et al.	
	10	4,213,707	07-22-1980	Evans, Jr.	
	11	4,254,333	03-03-1981	Bergström	
	12	4,254,407	03-03-1981	Tipon	
	13	4,294,543	10-13-1981	Apple et al.	
	14	4,346,376	08-24-1982	Mallos	
	15	4,420,261	12-13-1983	Barlow et al.	
	16	4,484,179	11-20-1984	Kasday	
	17	4,507,557	03-26-1985	Tsikos	
	18	4,521,112	06-04-1985	Kuwabara et al.	
	19	4,542,375	09-17-1985	Alles et al.	
	20	4,550,250	10-29-1985	Mueller et al.	
	21	4,593,191	06-03-1986	Alles	
	22	4,673,918	06-16-1987	Adler et al.	
	23	4,688,933	08-25-1987	Lapeyre	
	24	4,688,993	08-25-1987	Ferris et al.	
	25	4,692,809	09-08-1987	Beining et al.	
	26	4,710,760	12-01-1987	Kasday	
	27	4,736,191	04-05-1988	Matzke et al.	
	28	4,737,626	04-12-1988	Hasegawa	
	29	4,746,770	05-24-1988	McAvinney	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

PTO/SB/08 Equivalent

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	4,752,655	06-21-1988	Tajiri et al.	
	31	4,772,763	09-20-1988	Garwin et al.	
	32	4,782,328	11-01-1988	Denlinger	
	33	4,812,833	03-14-1989	Shimauchi	
	34	4,837,430	06-06-1989	Hasegawa	
	35	4,868,912	09-19-1989	Doering	
	36	4,891,829	01-02-1990	Deckman et al.	
	37	4,916,712	04-10-1990	Bender	
	38	4,933,544	06-12-1990	Tamaru	
	39	4,949,079	08-14-1990	Loebner	
	40	4,986,662	01-22-1991	Bures	
	41	4,988,983	01-29-1991	Wehrer	
	42	5,065,185	11-12-1991	Powers et al.	
	43	5,073,770	12-17-1991	Lowbner	
	44	5,105,186	04-14-1992	May	
	45	5,159,322	10-27-1992	Loebner	
	46	5,166,668	11-24-1992	Aoyagi	
	47	5,227,622	07-13-1993	Suzuki	
	48	5,248,856	09-28-1993	Mallicoat	
	49	5,254,407	10-19-1993	Sergerie et al.	
	50	5,345,490	09-06-1994	Finnigan et al.	
	51	5,383,022	01-17-1995	Kaser	
	52	5,483,261	01-09-1996	Yasutake	
	53	5,484,966	01-16-1996	Segen	
	54	5,499,098	03-12-1996	Ogawa	
	55	5,502,568	03-26-1996	Ogawa et al.	
	56	5,525,764	06-11-1996	Junkins et al.	
	57	5,526,422	06-11-1996	Keen	
	58	5,539,514	07-23-1996	Shishido et al.	

Examiner Signature /ADAM R. GIESY/	Date Considered 06/22/2020

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PTO/SB/08 Equivalent

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(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 3 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	59	5,570,181	10-29-1996	Yasuo et al.	
	60	5,572,251	11-05-1996	Ogawa	
	61	5,577,501	11-26-1996	Flohr et al.	
	62	5,600,105	02-04-1997	Fukuzaki et al.	
	63	5,608,550	03-04-1997	Epstein et al.	
	64	5,672,852	09-30-1997	Fukuzaki et al.	
	65	5,679,930	10-21-1997	Katsurahira	
	66	5,686,942	11-11-1997	Ball	
	67	5,688,933	11-18-1997	Evans et al.	
	68	5,729,249	03-17-1998	Yasutake	
	69	5,736,686	04-07-1998	Perret, Jr. et al.	
	70	5,740,224	04-14-1998	Müller et al.	
	71	5,764,223	06-09-1998	Chang et al.	
	72	5,767,517	06-16-1998	Hawkins	
	73	5,775,792	07-07-1998	Wiese	
	74	5,945,980	08-31-1999	Moissev et al.	
	75	5,945,981	08-31-1999	Paull et al.	
	76	5,959,617	09-28-1999	Bird et al.	
	77	6,061,177	05-09-2000	Fujimoto	
	78	6,067,079	05-23-2000	Shieh	
	79	6,122,394	09-19-2000	Neukermans et al.	
	80	6,141,104	10-31-2000	Schulz et al.	
	81	6,172,667	01-09-2001	Sayag	
	82	6,175,999	01-23-2001	Sloan et al.	
	83	6,227,667	05-08-2001	Halldorsson et al.	
	84	6,229,529	05-08-2001	Yano et al.	
	85	6,333,735	12-25-2001	Anvekar	
	86	6,366,276	04-02-2002	Kunimatsu et al.	
	87	6,380,732	04-30-2002	Gilboa	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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PTO/SB/08 Equivalent

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	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 4 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	88	6,380,740	04-30-2002	Laub	
	89	6,390,370	05-21-2002	Plesko	
	90	6,429,857	08-06-2002	Masters et al.	
	91	6,452,996	09-17-2002	Hsieh	
	92	6,476,797	11-05-2002	Kurihara et al.	
	93	6,492,633	12-10-2002	Nakazawa et al.	
	94	6,495,832	12-17-2002	Kirby	
	95	6,504,143	01-07-2003	Koops et al.	
	96	6,529,327	03-04-2003	Graindorge	
	97	6,538,644	03-25-2003	Muraoka	
	98	6,587,099	07-01-2003	Takekawa	
	99	6,648,485	11-18-2003	Colgan et al.	
	100	6,660,964	12-09-2003	Benderly	
	101	6,664,498	12-16-2003	Forsman et al.	
	102	6,664,952	12-16-2003	Iwamoto et al.	
	103	6,690,363	02-10-2004	Newton	
	104	6,707,027	03-16-2004	Liess et al.	
	105	6,738,051	05-18-2004	Boyd et al.	
	106	6,748,098	06-08-2004	Rosenfeld	
	107	6,784,948	08-31-2004	Kawashima et al.	
	108	6,799,141	09-28-2004	Stoustrup et al.	
	109	6,806,871	10-19-2004	Yasue	
	110	6,927,384	08-09-2005	Reime et al.	
	111	6,940,286	09-06-2005	Wang et al.	
	112	6,965,836	11-15-2005	Richardson	
	113	6,972,753	12-06-2005	Kimura et al.	
	114	6,985,137	01-10-2006	Kaikuranta	
	115	7,042,444	05-09-2006	Cok	
	116	7,084,859	08-01-2006	Pryor	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 5 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	117	7,087,907	08-08-2006	Lalovic et al.	
	118	7,133,031	11-07-2006	Wang et al.	
	119	7,176,904	02-13-2007	Satoh	
	120	7,199,932	04-03-2007	Sugiura	
	121	7,359,041	04-15-2008	Xie et al.	
	122	7,397,418	07-08-2008	Doerry et al.	
	123	7,432,893	10-07-2008	Ma et al.	
	124	7,435,940	10-14-2008	Eliasson et al.	
	125	7,436,443	10-14-2008	Hirunuma et al.	
	126	7,442,914	10-28-2008	Eliasson et al.	
	127	7,465,914	12-16-2008	Eliasson et al.	
	128	7,613,375	11-03-2009	Shimizu	
	129	7,629,968	12-08-2009	Miller et al.	
	130	7,646,833	01-12-2010	He et al.	
	131	7,653,883	01-26-2010	Hotelling et al.	
	132	7,655,901	02-02-2010	Idzik et al.	
	133	7,705,835	04-27-2010	Eikman	
	134	7,729,056	06-01-2010	Hwang et al.	
	135	7,847,789	12-07-2010	Kolmykov-Zotov et al.	
	136	7,855,716	12-21-2010	McCreary et al.	
	137	7,859,519	12-28-2010	Tulbert	
	138	7,924,272	04-12-2011	Boer et al.	
	139	7,932,899	04-26-2011	Newton et al.	
	140	7,969,410	06-28-2011	Kakarala	
	141	7,995,039	08-09-2011	Eliasson et al.	
	142	8,013,845	09-06-2011	Ostergaard et al.	
	143	8,031,186	10-04-2011	Ostergaard	
	144	8,077,147	12-13-2011	Krah et al.	
	145	8,093,545	01-10-2012	Leong et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 6 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	146	8,094,136	01-10-2012	Eliasson et al.	
	147	8,094,910	01-10-2012	Xu	
	148	8,149,211	04-03-2012	Hayakawa et al.	
	149	8,218,154	07-10-2012	Østergaard et al.	
	150	8,274,495	09-25-2012	Lee	
	151	8,325,158	12-04-2012	Yatsuda et al.	
	152	8,339,379	12-25-2012	Goertz et al.	
	153	8,350,827	01-08-2013	Chung et al.	
	154	8,384,010	02-26-2013	Hong et al.	
	155	8,407,606	03-26-2013	Davidson et al.	
	156	8,441,467	05-14-2013	Han	
	157	8,445,834	05-21-2013	Hong et al.	
	158	8,466,901	06-18-2013	Yen et al.	
	159	8,482,547	07-09-2013	Cobon et al.	
	160	8,542,217	09-24-2013	Wassvik et al.	
	161	8,567,257	10-29-2013	Van Steenberge et al.	
	162	8,581,884	11-12-2013	Fåhraeus et al.	
	163	8,624,858	01-07-2014	Fyke et al.	
	164	8,686,974	04-01-2014	Christiansson et al.	
	165	8,692,807	04-08-2014	Føhraeus et al.	
	166	8,716,614	05-06-2014	Wassvik	
	167	8,727,581	05-20-2014	Saccomanno	
	168	8,745,514	06-03-2014	Davidson	
	169	8,780,066	07-15-2014	Christiansson et al.	
	170	8,830,181	09-09-2014	Clark et al.	
	171	8,860,696	10-14-2014	Wassvik et al.	
	172	8,872,098	10-28-2014	Bergström et al.	
	173	8,872,801	10-28-2014	Bergström et al.	
	174	8,884,900	11-11-2014	Wassvik	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	First Named Inventor	Daniel Skagmo
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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	175	8,890,843	11-18-2014	Wassvik et al.	
	176	8,890,849	11-18-2014	Christiansson et al.	
	177	8,928,590	01-06-2015	El Dokor	
	178	8,963,886	02-24-2015	Wassvik	
	179	8,982,084	03-17-2015	Christiansson et al.	
	180	9,024,916	05-05-2015	Christiansson	
	181	9,035,909	05-19-2015	Christiansson	
	182	9,063,617	06-23-2015	Eliasson et al.	
	183	9,086,763	07-21-2015	Johansson et al.	
	184	9,134,854	09-15-2015	Wassvik et al.	
	185	9,158,401	10-13-2015	Christiansson	
	186	9,158,415	10-13-2015	Song et al.	
	187	9,213,445	12-15-2015	King et al.	
	188	9,274,645	03-01-2016	Christiansson et al.	
	189	9,317,168	04-19-2016	Christiansson et al.	
	190	9,323,396	04-26-2016	Han et al.	
	191	9,366,565	06-14-2016	Uvnäs	
	192	9,377,884	06-28-2016	Christiansson et al.	
	193	9,389,732	07-12-2016	Craven-Bartle	
	194	9,411,444	08-09-2016	Christiansson et al.	
	195	9,411,464	08-09-2016	Wallander et al.	
	196	9,430,079	08-30-2016	Christiansson et al.	
	197	9,442,574	09-13-2016	Fåhraeus et al.	
	198	9,547,393	01-17-2017	Christiansson et al.	
	199	9,552,103	01-24-2017	Craven-Bartle et al.	
	200	9,557,846	01-31-2017	Baharav et al.	
	201	9,588,619	03-07-2017	Christiansson et al.	
	202	9,594,467	03-14-2017	Christiansson et al.	
	203	9,618,682	04-11-2017	Yoon et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	204	9,626,018	04-18-2017	Christiansson et al.	
	205	9,626,040	04-18-2017	Wallander et al.	
	206	9,639,210	05-02-2017	Wallander et al.	
	207	9,678,602	06-13-2017	Wallander	
	208	9,684,414	06-20-2017	Christiansson et al.	
	209	9,710,101	07-18-2017	Christiansson et al.	
	210	9,874,978	01-23-2018	Wall	
	211	10,013,107	007-03-2018	Christiansson et al.	
	212	10,019,113	07-10-2018	Christiansson et al.	
	213	2001/0002694	06-07-2001	Nakazawa et al.	
	214	2001/0005004	06-28-2001	Shiratsuki et al.	
	215	2001/0005308	06-28-2001	Oishi et al.	
	216	2001/0030642	10-18-2001	Sullivan et al.	
	217	2002/0067348	06-06-2002	Masters et al.	
	218	2002/0075243	06-20-2002	Newton	
	219	2002/0118177	08-29-2002	Newton	
	220	2002/0158823	10-31-2002	Zavracky et al.	
	221	2002/0158853	10-31-2002	Sugawara et al.	
	222	2002/0163505	11-07-2002	Takekawa	
	223	2003/0016450	01-23-2003	Bluemel et al.	
	224	2003/0034439	02-20-2003	Reime et al.	
	225	2003/0034935	02-20-2003	Amanai et al.	
	226	2003/0048257	03-13-2003	Mattila	
	227	2003/0052257	03-20-2003	Sumriddetchkajorn	
	228	2003/0095399	05-22-2003	Grenda et al.	
	229	2003/0107748	06-12-2003	Lee	
	230	2003/0137494	07-24-2003	Tulbert	
	231	2003/0156100	08-21-2003	Gettemy	
	232	2003/0160155	08-28-2003	Liess	

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	233	2003/0210537	11-13-2003	Engelmann	
	234	2003/0214486	11-20-2003	Roberts	
	235	2004/0027339	02-12-2004	Schulz	
	236	2004/0032401	02-19-2004	Nakazawa et al.	
	237	2004/0090432	05-13-2004	Takahashi et al.	
	238	2004/0130338	07-08-2004	Wang et al.	
	239	2004/0174541	09-09-2004	Freifeld	
	240	2004/0201579	10-14-2004	Graham	
	241	2004/0212603	10-28-2004	Cok	
	242	2004/0238627	12-02-2004	Silverbrook et al.	
	243	2004/0239702	12-02-2004	Kang et al.	
	244	2004/0245438	12-09-2004	Payne et al.	
	245	2004/0252091	12-16-2004	Ma et al.	
	246	2004/0252867	12-16-2004	Lan et al.	
	247	2005/0012714	01-20-2005	Russo et al.	
	248	2005/0041013	02-24-2005	Tanaka	
	249	2005/0057903	03-17-2005	Choi	
	250	2005/0073508	04-07-2005	Pittel et al.	
	251	2005/0083293	04-21-2005	Dixon	
	252	2005/0128190	06-16-2005	Ryynanen	
	253	2005/0143923	06-30-2005	Keers et al.	
	254	2005/0156914	07-21-2005	Lipman et al.	
	255	2005/0162398	07-28-2005	Eliasson et al.	
	256	2005/0179977	08-18-2005	Chui et al.	
	257	2005/0200613	09-15-2005	Kobayashi et al.	
	258	2005/0212774	09-29-2005	Ho et al.	
	259	2005/0248540	11-10-2005	Newton	
	260	2005/0253834	11-17-2005	Sakamaki et al.	
	261	2005/0276053	12-15-2005	Nortrup et al.	

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	262	2006/0001650	01-05-2006	Robbins et al.	
	263	2006/0001653	01-05-2006	Smits	
	264	2006/0007185	01-12-2006	Kobayashi	
	265	2006/0008164	01-12-2006	Wu et al.	
	266	2006/0017706	01-26-2006	Cutherell et al.	
	267	2006/0017709	01-26-2006	Okano	
	268	2006/0033725	02-16-2006	Marggraff et al.	
	269	2006/0038698	02-23-2006	Chen	
	270	2006/0061861	03-23-2006	Munro et al.	
	271	2006/0114237	06-01-2006	Crockett et al.	
	272	2006/0132454	06-22-2006	Chen et al.	
	273	2006/0139340	06-29-2006	Geaghan	
	274	2006/0158437	07-20-2006	Blythe et al.	
	275	2006/0170658	08-03-2006	Nakamura et al.	
	276	2006/0202974	09-14-2006	Thielman	
	277	2006/0227120	10-12-2006	Eikman	
	278	2006/0255248	11-16-2006	Eliasson	
	279	2006/0256092	11-16-2006	Lee	
	280	2006/0279558	12-14-2006	Van Delden et al.	
	281	2006/0281543	12-14-2006	Sutton et al.	
	282	2006/0290684	12-28-2006	Giraldo et al.	
	283	2007/0014486	01-18-2007	Schiwietz et al.	
	284	2007/0024598	02-01-2007	Miller et al.	
	285	2007/0034783	02-15-2007	Eliasson et al.	
	286	2007/0038691	02-15-2007	Candes et al.	
	287	2007/0052684	03-08-2007	Gruhlke et al.	
	288	2007/0070056	03-29-2007	Sato et al.	
	289	2007/0075648	04-05-2007	Blythe et al.	
	290	2007/0120833	05-31-2007	Yamaguchi et al.	

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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	291	2007/0125937	06-07-2007	Eliasson et al.	
	292	2007/0152985	07-05-2007	Ostergaard et al.	
	293	2007/0201042	08-30-2007	Eliasson et al.	
	294	2007/0296688	12-27-2007	Nakamura et al.	
	295	2008/0006766	01-10-2008	Oon et al.	
	296	2008/0007540	01-10-2008	Ostergaard	
	297	2008/0007541	01-10-2008	Eliasson et al.	
	298	2008/0007542	01-10-2008	Eliasson et al.	
	299	2008/0011944	01-17-2008	Chua et al.	
	300	2008/0029691	02-07-2008	Han	
	301	2008/0036743	02-14-2008	Westerman et al.	
	302	2008/0062150	03-13-2008	Lee	
	303	2008/0068691	03-20-2008	Miyatake	
	304	2008/0074401	03-27-2008	Chung et al.	
	305	2008/0088603	04-17-2008	Eliasson et al.	
	306	2008/0121442	05-29-2008	Boer et al.	
	307	2008/0122792	05-29-2008	Izadi et al.	
	308	2008/0122803	05-29-2008	Izadi et al.	
	309	2008/0130979	06-05-2008	Run et al.	
	310	2008/0150846	06-26-2008	Chung et al.	
	311	2008/0150848	06-26-2008	Chung et al.	
	312	2008/0151126	06-26-2008	Yu	
	313	2008/0158176	07-03-2008	Land et al.	
	314	2008/0189046	08-07-2008	Eliasson et al.	
	315	2008/0192025	08-14-2008	Jaeger et al.	
	316	2008/0238433	10-02-2008	Joutsenoja et al.	
	317	2008/0246388	10-09-2008	Cheon et al.	
	318	2008/0252619	10-16-2008	Crockett et al.	
	319	2008/0266266	10-30-2008	Kent et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	320	2008/0278460	11-13-2008	Arnett et al.	
	321	2008/0284925	11-20-2008	Han	
	322	2008/0291668	11-27-2008	Aylward et al.	
	323	2008/0297482	12-04-2008	Weiss	
	324	2008/0133265	06-05-2008	Silkaitis et al.	
	325	2009/0002340	01-01-2009	Van Genechten	
	326	2009/0006292	01-01-2009	Block	
	327	2009/0040786	02-12-2009	Mori	
	328	2009/0066647	03-12-2009	Kerr et al.	
	329	2009/0067178	03-12-2009	Huang et al.	
	330	2009/0073142	03-19-2009	Yamashita et al.	
	331	2009/0077501	03-19-2009	Partridge et al.	
	332	2009/0085894	04-02-2009	Gandhi et al.	
	333	2009/0091554	04-09-2009	Keam	
	334	2009/0115919	05-07-2009	Tanaka et al.	
	335	2009/0122020	05-14-2009	Eliasson et al.	
	336	2009/0122027	05-14-2009	Newton	
	337	2009/0128508	05-21-2009	Sohn et al.	
	338	2009/0135162	05-28-2009	Van De Wijdeven et al.	
	339	2009/0143141	06-04-2009	Wells et al.	
	340	2009/0153519	06-18-2009	Suarez Rovere	
	341	2009/0161026	06-25-2009	Wu et al.	
	342	2009/0168459	07-02-2009	Holman et al.	
	343	2009/0187842	07-23-2009	Collins et al.	
	344	2009/0189857	07-30-2009	Benko et al.	
	345	2009/0189874	07-30-2009	Chene et al.	
	346	2009/0189878	07-30-2009	Goertz et al.	
	347	2009/0219256	09-03-2009	Newton	
	348	2009/0229892	09-17-2009	Fisher et al.	

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	349	2009/0251439	10-08-2009	Westerman et al.	
	350	2009/0256817	10-15-2009	Perlin et al.	
	351	2009/0259967	10-15-2009	Davidson et al.	
	352	2009/0267919	10-29-2009	Chao et al.	
	353	2009/0273794	11-05-2009	Østergaard et al.	
	354	2009/0278816	11-12-2009	Colson	
	355	2009/0297009	12-03-2009	Xu et al.	
	356	2010/0033444	02-11-2010	Kobayashi	
	357	2010/0045629	02-25-2010	Newton	
	358	2010/0060896	03-11-2010	Van De Wijdeven et al.	
	359	2010/0066016	03-18-2010	Van De Wijdeven et al.	
	360	2010/0066704	03-18-2010	Kasai	
	361	2010/0073318	03-25-2010	Hu et al.	
	362	2010/0078545	04-01-2010	Leong et al.	
	363	2010/0079407	04-01-2010	Suggs et al.	
	364	2010/0079408	04-01-2010	Leong et al.	
	365	2010/0097345	04-22-2010	Jang et al.	
	366	2010/0097348	04-22-2010	Park et al.	
	367	2010/0097353	04-22-2010	Newton	
	368	2010/0125438	05-20-2010	Audet	
	369	2010/0127975	05-27-2010	Jensen	
	370	2010/0134435	06-03-2010	Kimura et al.	
	371	2010/0142823	06-10-2010	Wang et al.	
	372	2010/0187422	07-29-2010	Kothari et al.	
	373	2010/0193259	08-05-2010	Wassvik	
	374	2010/0229091	09-09-2010	Homma et al.	
	375	2010/0238139	09-23-2010	Goertz et al.	
	376	2010/0245292	09-30-2010	Wu	
	377	2010/0265170	10-21-2010	Norieda	

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	378	2010/0277436	11-04-2010	Feng et al.	
	379	2010/0283785	11-11-2010	Satulovsky	
	380	2010/0284596	11-11-2010	Miao et al.	
	381	2010/0289754	11-18-2010	Sleeman et al.	
	382	2010/0295821	11-25-2010	Chang et al.	
	383	2010/0302196	12-02-2010	Han et al.	
	384	2010/0302209	12-02-2010	Large	
	385	2010/0302210	12-02-2010	Han et al.	
	386	2010/0302240	12-02-2010	Lettvin	
	387	2010/0315379	12-16-2010	Allard et al.	
	388	2010/0321328	12-23-2010	Chang et al.	
	389	2010/0322550	12-23-2010	Trott	
	390	2011/0043490	02-24-2011	Powell et al.	
	391	2011/0049388	03-03-2011	Delaney et al.	
	392	2011/0050649	03-03-2011	Newton et al.	
	393	2011/0051394	03-03-2011	Bailey	
	394	2011/0068256	03-24-2011	Hong et al.	
	395	2011/0069039	03-24-2011	Lee et al.	
	396	2011/0069807	03-24-2011	Dennerlein et al.	
	397	2011/0074725	03-31-2011	Westerman et al.	
	398	2011/0074734	03-31-2011	Wassvik et al.	
	399	2011/0074735	03-31-2011	Wassvik et al.	
	400	2011/0090176	04-21-2011	Christiansson et al.	
	401	2011/0102374	05-05-2011	Wassvik et al.	
	402	2011/0115748	05-19-2011	Xu	
	403	2011/0121323	05-26-2011	Wu et al.	
	404	2011/0122075	05-26-2011	Seo et al.	
	405	2011/0122091	05-26-2011	King et al.	
	406	2011/0122094	05-26-2011	Tsang et al.	

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	407	2011/0134079	06-09-2011	Stark	
	408	2011/0147569	06-23-2011	Drumm	
	409	2011/0157095	06-30-2011	Drumm	
	410	2011/0157096	06-30-2011	Drumm	
	411	2011/0163996	07-07-2011	Wassvik et al.	
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	417	2011/0216042	09-08-2011	Wassvik et al.	
	418	2011/0221705	09-15-2011	Yi et al.	
	419	2011/0221997	09-15-2011	Kim et al.	
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	421	2011/0227874	09-22-2011	Fåhraeus et al.	
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	423	2011/0254864	10-20-2011	Tsuchikawa et al.	
	424	2011/0261020	10-27-2011	Song et al.	
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	429	2011/0310045	12-22-2011	Toda et al.	
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	433	2012/0062474	03-15-2012	Weishaupt et al.	
	434	2012/0068973	03-22-2012	Christiansson et al.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 16 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	436	2012/0089348	04-12-2012	Perlin et al.	
	437	2012/0110447	05-03-2012	Chen	
	438	2012/0131490	05-24-2012	Lin et al.	
	439	2012/0141001	06-07-2012	Zhang et al.	
	440	2012/0146930	06-14-2012	Lee	
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	443	2012/0162142	06-28-2012	Christiansson et al.	
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	445	2012/0169672	07-05-2012	Christiansson	
	446	2012/0181419	07-19-2012	Momtahan	
	447	2012/0182266	07-19-2012	Han	
	448	2012/0188206	07-26-2012	Sparf et al.	
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	450	2012/0200532	08-09-2012	Powell et al.	
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	454	2012/0249478	10-04-2012	Chang et al.	
	455	2012/0256882	10-11-2012	Christiansson et al.	
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	457	2012/0268427	10-25-2012	Slobodin	
	458	2012/0274559	11-01-2012	Mathai et al.	
	459	2012/0305755	12-06-2012	Hong et al.	
	460	2013/0021300	01-24-2013	Wassvik	
	461	2013/0021302	01-24-2013	Drumm	
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	463	2013/0044073	02-21-2013	Christiansson et al.	
	464	2013/0055080	02-28-2013	Komer et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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U.S. PATENT DOCUMENTS					
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	465	2013/0076697	03-28-2013	Goertz et al.	
	466	2013/0082980	04-04-2013	Gruhlke et al.	
	467	2013/0107569	05-02-2013	Suganuma	
	468	2013/0113715	05-09-2013	Grant et al.	
	469	2013/0120320	05-16-2013	Liu et al.	
	470	2013/0125016	05-16-2013	Pallakoff et al.	
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	472	2013/0135258	05-30-2013	King et al.	
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	474	2013/0141388	06-06-2013	Ludwig et al.	
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	482	2013/0241887	09-19-2013	Sharma	
	483	2013/0249833	09-26-2013	Christiansson et al.	
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	485	2013/0275082	10-17-2013	Follmer et al.	
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	488	2013/0300716	11-14-2013	Craven-Bartle et al.	
	489	2013/0307795	11-21-2013	Suarez Rovere	
	490	2013/0342490	12-26-2013	Wallander et al.	
	491	2014/0002400	01-02-2014	Christiansson et al.	
	492	2014/0028575	01-30-2014	Parivar et al.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	494	2014/0028629	01-30-2014	Drumm et al.	
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	500	2014/0092052	04-03-2014	Grunthaner et al.	
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	504	2014/0125633	05-08-2014	Fåhraeus et al.	
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	506	2014/0160762	06-12-2014	Dudik et al.	
	507	2014/0192023	07-10-2014	Hoffman	
	508	2014/0232669	08-21-2014	Ohlsson et al.	
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	510	2014/0237408	08-21-2014	Ohlsson et al.	
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	512	2014/0253831	09-11-2014	Craven-Bartle	
	513	2014/0267124	09-18-2014	Christiansson et al.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
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U.S. PATENT DOCUMENTS					
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	523	2015/0015497	01-15-2015	Leigh	
	524	2015/0035774	02-05-2015	Christiansson et al.	
	525	2015/0035803	02-05-2015	Wassvik et al.	
	526	2015/0053850	02-26-2015	Uvnäs	
	527	2015/0054759	02-26-2015	Christiansson et al.	
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	529	2015/0103013	04-16-2015	Huang	
	530	2015/0130769	05-14-2015	Björklund	
	531	2015/0138105	05-21-2015	Christiansson et al.	
	532	2015/0138158	05-21-2015	Wallander et al.	
	533	2015/0138161	05-21-2015	Wassvik	
	534	2015/0205441	07-23-2015	Bergström et al.	
	535	2015/0215450	07-30-2015	Seo et al.	
	536	2015/0242055	08-27-2015	Wallander	
	537	2015/0271481	09-24-2015	Guthrie et al.	
	538	2015/0286698	10-08-2015	Gagnier et al.	
	539	2015/0317036	11-05-2015	Johansson et al.	
	540	2015/0324028	11-12-2015	Wassvik et al.	
	541	2015/0331544	11-19-2015	Bergström et al.	
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	543	2015/0331546	11-19-2015	Craven-Bartle et al.	
	544	2015/0331547	11-19-2015	Wassvik et al.	
	545	2015/0332655	11-19-2015	Krus et al.	
	546	2015/0346856	12-03-2015	Wassvik	
	547	2015/0346911	12-03-2015	Christiansson	
	548	2015/0363042	12-17-2015	Krus et al.	
	549	2016/0026337	01-28-2016	Wassvik et al.	
	550	2016/0034099	02-04-2016	Christiansson et al.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 20 OF 28	Attorney Docket No.	FFOG.054C5

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Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	552	2016/0070415	03-10-2016	Christiansson et al.	
	553	2016/0070416	03-10-2016	Wassvik	
	554	2016/0124546	05-05-2016	Chen et al.	
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	556	2016/0154531	06-02-2016	Wall	
	557	2016/0154532	06-02-2016	Campbell	
	558	2016/0202841	07-14-2016	Christiansson et al.	
	559	2016/0216844	07-28-2016	Bergström	
	560	2016/0224144	08-04-2016	Klinghult et al.	
	561	2016/0299593	10-13-2016	Christiansson et al.	
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	563	2016/0328091	11-10-2016	Wassvik et al.	
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	566	2016/0357348	12-08-2016	Wallander	
	567	2017/0010688	01-12-2017	Fahraeus et al.	
	568	2017/0090090	03-30-2017	Craven-Bartle et al.	
	569	2017/0102827	04-13-2017	Christiansson et al.	
	570	2017/0115235	04-27-2017	Ohlsson et al.	
	571	2017/0115823	04-27-2017	Huang et al.	
	572	2017/0139541	05-18-2017	Christiansson et al.	
	573	2017/0177163	06-22-2017	Wallander et al.	
	574	2017/0185230	06-29-2017	Wallander et al.	
	575	2017/0293392	10-12-2017	Christiansson et al.	
	576	2017/0344185	11-30-2017	Ohlsson et al.	
	577	2018/0031753	02-01-2018	Craven-Bartle et al.	
	578	2018/0129354	05-10-2018	Christiansson et al.	
	579	2018/0210572	07-26-2018	Wallander et al.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 21 OF 28	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	581	2018/0267672	09-20-2018	Wassvik et al.	
	582	2018/0275788	09-27-2018	Christiansson et al.	
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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	604	EP 2 325 735 A2	05-25-2011	Samsung Electronics Co., Ltd.		

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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SHEET 22 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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	606	CN 101019071 B	06-13-2012	QUALCOMM MEMS TECHNOLOGIES INC		
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	620	EP 0897161 B1	10-10-2007	FUJITSU LTD		
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	622	EP 1126236 B1	12-15-2010	RICOH COMPANY LTD		
	623	EP 1457870 B1	08-22-2012	SMART TECHNOLOGIES INC		
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 24 OF 28	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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Examiner Signature	/ADAM R. GIESY/	Date Considered

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 25 OF 28	Attorney Docket No.	FFOG.054C5

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 26 OF 28	Attorney Docket No.	FFOG.054C5

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	724	WO 2014/055809 A1	04-10-2014	CORNING INC		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	725	AHN, Y., et al., "A slim and wide multi-touch tabletop interface and its applications," BigComp2014, IEEE, 2014, in 6 pages.	
	726	CHOU, N., et al., "Generalized pseudo-polar Fourier grids and applications in regfersting optical coherence tomography images," 43rd Asilomar Conference on Signals, Systems and Computers, Nov. 2009, in 5 pages.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 28 OF 28	Attorney Docket No.	FFOG.054C5

NON PATENT LITERATURE DOCUMENTS			
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	735	NATTERER, F., "The Mathematics of Computerized Tomography", Society for Industrial and Applied Mathematics, 2001, in 240 pages.	
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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	33	((optical adj2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light adj2 source)) and (support$3 frame mount$3)) and (engag$5 coupl$3 mat$3 fitted)).clm.	US-PGPUB	OR	ON	2020/06/22 13:37
S1	0	16/191251	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/25 13:24
S2	28,284	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 08:33
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("20120153134") or ("20120154338") or
("20120162142") or ("20120162144") or
("20120169672") or ("20120181419") or
("20120182266") or
("20120188206")).PN. or
(("20120191993") or ("20120200532") or
("20120200538") or ("20120212441") or
("20120217882") or ("20120249478") or
("20120256882") or ("20120268403") or
("20120268427") or ("20120274559") or
("20120305755") or ("20130021300") or
("20130021302") or ("20130027404") or
("20130044073") or ("20130055080") or
("20130076697") or ("20130082980") or
("20130107569") or ("20130113715") or
("20130120320") or ("20130125016") or
("20130127790") or ("20130135258") or
("20130135259") or ("20130141388") or
("20130154983") or ("20130155027") or
("20130158504") or ("20130181896") or
("20130187891") or ("20130201142") or
("20130222346") or ("20130241887") or
("20130249833") or ("20130269867") or

		("20130275082") or ("20130285920") or ("20130285968") or ("20130300716") or ("20130307795") or ("20130342490") or ("20140002400") or ("20140028575") or ("20140028604") or ("20140028629") or ("20140036203") or ("20140055421") or ("20140063853") or ("20140071653") or ("20140085241") or ("20140092052") or ("20140098032") or ("20140098058") or ("20140109219") or ("20140125633") or ("20140139467") or ("20140160762") or ("20140192023") or ("20140232669") or ("20140237401") or ("20140237408") or ("20140237422") or ("20140253831") or ("20140267124") or ("20140292701") or ("20140300572") or ("20140320460") or ("20140347325") or ("20140362046") or ("20140368471") or ("20140375607") or ("20150002386") or ("20150009687") or ("20150015497") or ("20150035774") or ("20150035803") or ("20150053850") or ("20150054759") or ("20150083891") or ("20150103013") or ("20150130769") or ("20150138105") or ("20150138158") or ("20150138161") or ("20150205441") or ("20150215450") or ("20150242055") or ("20150271481") or ("20150286698") or ("20150317036") or ("20150324028") or ("20150331544") or ("20150331545") or ("20150331546") or ("20150331547") or ("20150332655") or ("20150346856") or ("20150346911") or ("20150363042") or ("20160026337") or ("20160034099") or ("20160050746") or ("20160070415") or ("20160070416") or ("20160124546") or ("20160124551") or ("20160154531") or ("20160154532") or ("20160202841") or ("20160216844") or ("20160224144") or ("20160299593") or ("20160328090") or ("20160328091") or ("20160334942") or ("20160342282") or ("20160357348")).PN. or (("20170010688") or ("20170090090") or ("20170102827") or ("20170115235") or ("20170115823") or ("20170139541") or ("20170177163") or ("20170185230") or ("20170293392") or ("20170344185") or ("20180031753") or ("20180129354") or ("20180210572") or ("20180225006") or ("20180267672") or ("20180275788") or ("20180275830") or ("20180275831")).PN.				

S5	4,272	(G06F3/0421).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:35
S6	260	S5 and (collimat$3 near2 beam)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:35
S7	65	S5 and ((collimat$3 near2 beam) same parallel same surface)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 09:48
S8	55	S5 and ((collimat$3 near2 beam) same (across parallel) with surface) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 10:51
S9	55	S5 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 10:51
S10	42	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2019/04/29 11:11
S11	56	S2 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 11:13
S12	1	S11 not S9	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/04/29 11:21
S13	4,289	(G06F3/0421).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 09:41
S14	49	S13 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and ((emitter light) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 09:41
S16	50	S13 and ((emitter LED diode) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:05
S17	5,480	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:15
S18	52	S17 and ((emitter LED diode) near3 above near3 (surface plane))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:15
S19	169	S17 and ((emitter LED diode) with (above near3 (surface plane)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:25

S20	121	S19 not S18	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:26
S21	190	S17 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:54
S22	29,597	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:55
S23	21	S21 not S19	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:55
S24	266	S22 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:59
S25	76	S24 not S21	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 10:59
S26	29,531	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:38
S27	274	S26 and ((emitter LED diode) with ((atop (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:38
S28	266	S26 and ((emitter LED diode) with (above near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:39
S29	8	S27 not S28	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 12:39
S31	146	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 14:16
S32	153	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:04

S33	7	S32 not S31	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:18
S34	1,879	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23
S35	5,476	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23
S36	1,313	S35 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:23
S37	1,440	S34 not S36	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:24
S38	346	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:27
S39	375	S35 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:27
S40	180	S39 not S38	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/05/16 16:28
S41	2	((optical adj2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light adj2 source)) and (support$3 frame mount$3)) and ((light beam) adj5 (over across atop) adj3 (surface plane cover panel))).clm.	US-PGPUB	OR	ON	2019/05/27 18:31
S42	1	16/191177	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:47
S43	3	(("9207800") or ("20150339000") or ("20160306501")).PN.	US-PGPUB; USPAT	OR	OFF	2019/12/23 05:52

S44	154	(US-20010002694-$ | US-20010005004-$ | US-20010005308-$ | US-20010030642-$ | US-20020067348-$ | US-20020075243-$ | US-20020118177-$ | US-20020158823-$ | US-20020158853-$ | US-20020163505-$ | US-20030016450-$ | US-20030034439-$ | US-20030034935-$ | US-20030048257-$ | US-20030052257-$ | US-20030095399-$ | US-20030107748-$ | US-20030137494-$ | US-20030156100-$ | US-20030160155-$ | US-20030210537-$ | US-20030214486-$ | US-20040027339-$ | US-20040032401-$ | US-20040090432-$ | US-20040130338-$ | US-20040174541-$ | US-20040201579-$ | US-20040212603-$ | US-20040238627-$ | US-20040239702-$ | US-20040245438-$ | US-20040252091-$ | US-20040252867-$ | US-20050012714-$ | US-20050041013-$ | US-20050057903-$ | US-20050073508-$ | US-20050083293-$ | US-20050128190-$ | US-20050143923-$ | US-20050156914-$ | US-20050162398-$ | US-20050179977-$ | US-20050200613-$ | US-20050212774-$ | US-20050248540-$ | US-20050253834-$ | US-20050276053-$ | US-20060001650-$ | US-20060001653-$ | US-20060007185-$ | US-20060008164-$ | US-20060017706-$ | US-20060017709-$ | US-20060033725-$ | US-20060038698-$ | US-20060061861-$ | US-20060114237-$ | US-20060132454-$ | US-20060139340-$ | US-20060158437-$ | US-20060170658-$ | US-20060202974-$ | US-20060227120-$ | US-20060255248-$ | US-20060256092-$ | US-20060279558-$ | US-20060281543-$ | US-20060290684-$ | US-20070014486-$ | US-20070024598-$ | US-20070034783-$ | US-20070038691-$ | US-20070052684-$ | US-20070070056-$ | US-20070075648-$ | US-20070120833-$ | US-20070125937-$ | US-20070152985-$ | US-20070201042-$ | US-20070296688-$ | US-20080006766-$ | US-20080007540-$ | US-20080007541-$ | US-20080007542-$ | US-20080011944-$ | US-20080029691-$ | US-20080036743-$ | US-20080062150-$ | US-20080068691-$ | US-20080074401-$ | US-20080088603-$	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		| US-20080121442-$ | US-20080122792-$ | US-20080122803-$ | US-20080130979-$ | US-20080133265-$ | US-20080150846-$ | US-20080150848-$ | US-20080151126-$ | US-20080158176-$ | US-20080189046-$ | US-20080192025-$ | US-20080238433-$ | US-20080246388-$ | US-20080252619-$ | US-20080266266-$ | US-20080278460-$ | US-20080284925-$ | US-20080291668-$ | US-20080297482-$ | US-20090002340-$ | US-20090006292-$ | US-20090040786-$ | US-20090066647-$ | US-20090067178-$ | US-20090073142-$ | US-20090077501-$ | US-20090085894-$ | US-20090091554-$ | US-20090115919-$ | US-20090122020-$ | US-20090122027-$ | US-20090128508-$ | US-20090135162-$ | US-20090143141-$ | US-20090153519-$ | US-20090161026-$ | US-20090168459-$ | US-20090187842-$ | US-20090189857-$ | US-20090189874-$ | US-20090189878-$ | US-20090219256-$ | US-20090229892-$ | US-20090251439-$ | US-20090256817-$ | US-20090259967-$ | US-20090267919-$ | US-20090273794-$ | US-20090278816-$ | US-20090297009-$ | US-20100033444-$ | US-20100045629-$ | US-20100060896-$ | US-20100066016-$ | US-20100066704-$ | US-20100073318-$ | US-20100078545-$ | US-20100079407-$ | US-20100079408-$ | US-20100097345-$ | US-20100097348-$).DID.				
S45	154	(US-20100097353-$ | US-20100125438-$ | US-20100127975-$ | US-20100134435-$ | US-20100142823-$ | US-20100187422-$ | US-20100193259-$ | US-20100229091-$ | US-20100238139-$ | US-20100245292-$ | US-20100265170-$ | US-20100277436-$ | US-20100283785-$ | US-20100284596-$ | US-20100289754-$ | US-20100295821-$ | US-20100302196-$ | US-20100302209-$ | US-20100302210-$ | US-20100302240-$ | US-20100315379-$ | US-20100321328-$ | US-20100322550-$ | US-20110043490-$ | US-20110049388-$ | US-20110050649-$ | US-20110051394-$ | US-20110068256-$ |	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		US-20110069039-$ | US-20110069807-$ | US-20110074725-$ | US-20110074734-$ | US-20110074735-$ | US-20110090176-$ | US-20110102374-$ | US-20110115748-$ | US-20110121323-$ | US-20110122075-$ | US-20110122091-$ | US-20110122094-$ | US-20110134079-$ | US-20110147569-$ | US-20110157095-$ | US-20110157096-$ | US-20110163996-$ | US-20110163997-$ | US-20110163998-$ | US-20110169780-$ | US-20110175852-$ | US-20110205186-$ | US-20110216042-$ | US-20110221705-$ | US-20110221997-$ | US-20110227036-$ | US-20110227874-$ | US-20110234537-$ | US-20110254864-$ | US-20110261020-$ | US-20110267296-$ | US-20110291989-$ | US-20110298743-$ | US-20110309325-$ | US-20110310045-$ | US-20120019448-$ | US-20120026408-$ | US-20120038593-$ | US-20120062474-$ | US-20120068973-$ | US-20120086673-$ | US-20120089348-$ | US-20120110447-$ | US-20120131490-$ | US-20120141001-$ | US-20120146930-$ | US-20120153134-$ | US-20120154338-$ | US-20120162142-$ | US-20120162144-$ | US-20120169672-$ | US-20120181419-$ | US-20120182266-$ | US-20120188206-$ | US-20120191993-$ | US-20120200532-$ | US-20120200538-$ | US-20120212441-$ | US-20120217882-$ | US-20120249478-$ | US-20120256882-$ | US-20120268403-$ | US-20120268427-$ | US-20120274559-$ | US-20120305755-$ | US-20130021300-$ | US-20130021302-$ | US-20130027404-$ | US-20130044073-$ | US-20130055080-$ | US-20130076697-$ | US-20130082980-$ | US-20130107569-$ | US-20130113715-$ | US-20130120320-$ | US-20130125016-$ | US-20130127790-$ | US-20130135258-$ | US-20130135259-$ | US-20130141388-$ | US-20130154983-$ | US-20130155027-$ | US-20130158504-$ | US-20130181896-$ | US-20130187891-$ | US-20130201142-$ | US-20130222346-$ | US-20130241887-$ | US-20130249833-$ | US-20130269867-$ | US-20130275082-$ | US-20130285920-$ | US-20130285968-$			

		| US-20130300716-$ | US-20130307795-$ | US-20130342490-$ | US-20140002400-$ | US-20140028575-$ | US-20140028604-$ | US-20140028629-$ | US-20140036203-$ | US-20140055421-$ | US-20140063853-$ | US-20140071653-$ | US-20140085241-$ | US-20140092052-$ | US-20140098032-$ | US-20140098058-$ | US-20140109219-$ | US-20140125633-$ | US-20140139467-$ | US-20140160762-$ | US-20140192023-$ | US-20140232669-$ | US-20140237401-$ | US-20140237408-$ | US-20140237422-$ | US-20140253831-$ | US-20140267124-$ | US-20140292701-$ | US-20140300572-$ | US-20140320460-$ | US-20140347325-$ | US-20140362046-$ | US-20140368471-$ | US-20140375607-$).DID.				
S46	179	(US-20150002386-$ | US-20150009687-$ | US-20150015497-$ | US-20150035774-$ | US-20150035803-$ | US-20150053850-$ | US-20150054759-$ | US-20150083891-$ | US-20150103013-$ | US-20150130769-$ | US-20150138105-$ | US-20150138158-$ | US-20150138161-$ | US-20150205441-$ | US-20150215450-$ | US-20150242055-$ | US-20150271481-$ | US-20150286698-$ | US-20150317036-$ | US-20150324028-$ | US-20150331544-$ | US-20150331545-$ | US-20150331546-$ | US-20150331547-$ | US-20150332655-$ | US-20150346856-$ | US-20150346911-$ | US-20150363042-$ | US-20160026337-$ | US-20160034099-$ | US-20160050746-$ | US-20160070415-$ | US-20160070416-$ | US-20160124546-$ | US-20160124551-$ | US-20160154531-$ | US-20160154532-$ | US-20160202841-$ | US-20160216844-$ | US-20160224144-$ | US-20160299593-$ | US-20160328090-$ | US-20160328091-$ | US-20160334942-$ | US-20160342282-$ | US-20160357348-$ | US-20170010688-$ | US-20170090090-$ | US-20170102827-$ | US-20170115235-$ | US-20170115823-$ | US-20170139541-$ | US-20170177163-$ | US-20170185230-$ | US-20170293392-$ | US-20170344185-$ |	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

		US-20180031753-$ | US-20180129354-$ | US-20180210572-$ | US-20180225006-$ | US-20180267672-$ | US-20180275788-$ | US-20180275830-$ | US-0001650-$ | US-0001653-$ | US-0002340-$ | US-0002386-$ | US-0002400-$ | US-0002694-$ | US-0005004-$ | US-0005308-$ | US-0006292-$ | US-0006766-$ | US-0007185-$ | US-0007540-$ | US-0007541-$ | US-0007542-$ | US-0008164-$ | US-0009687-$ | US-0010688-$ | US-0011944-$ | US-0012714-$ | US-0014486-$ | US-0015497-$ | US-0016450-$ | US-0017706-$ | US-0017709-$ | US-0019448-$ | US-0021300-$ | US-0021302-$ | US-0024598-$ | US-0026337-$ | US-0026408-$ | US-0027339-$ | US-0027404-$ | US-0028575-$ | US-0028604-$ | US-0028629-$ | US-0029691-$ | US-0030642-$ | US-0031753-$ | US-0032401-$ | US-0033444-$ | US-0033725-$ | US-0034099-$ | US-0034439-$ | US-0034783-$ | US-0034935-$ | US-0035774-$ | US-0035803-$ | US-0036203-$ | US-0036743-$ | US-0038593-$ | US-0038691-$ | US-0038698-$ | US-0040786-$ | US-0041013-$ | US-0043490-$ | US-0044073-$ | US-0045629-$ | US-0048257-$ | US-0049388-$ | US-0050649-$ | US-0050746-$ | US-0051394-$ | US-0052257-$ | US-0052684-$ | US-0053850-$ | US-0054759-$ | US-0055080-$ | US-0055421-$ | US-0057903-$ | US-0060896-$ | US-0061861-$ | US-0062150-$ | US-0062474-$ | US-0063853-$ | US-0066016-$ | US-0066647-$ | US-0066704-$ | US-0067178-$ | US-0067348-$ | US-0068256-$ | US-0068691-$ | US-0068973-$ | US-0069039-$ | US-0069807-$ | US-0070056-$ | US-0070415-$ | US-0070416-$ | US-0071653-$ | US-0073142-$ | US-0073318-$ | US-0073508-$ | US-0074401-$ | US-0074725-$ | US-0074734-$ | US-0074735-$ | US-0075243-$ | US-0075648-$ | US-0076697-$ | US-				

		0077501-$ | US-0078545-$ | US-0079407-$ | US-0079408-$ | US-0082980-$ | US-0083293-$ | US-0083891-$ | US-0085241-$ | US-0085894-$ | US-0086673-$ | US-0088603-$ | US-0089348-$ | US-0090090-$ | US-0090176-$ | US-0090432-$ | US-0091554-$ | US-0092052-$ | US-0095399-$).DID.				
S47	194	(US-0097345-$ | US-0097348-$ | US-0097353-$ | US-0098032-$ | US-0098058-$ | US-0102374-$ | US-0102827-$ | US-0103013-$ | US-0107569-$ | US-0107748-$ | US-0109219-$ | US-0110447-$ | US-0113715-$ | US-0114237-$ | US-0115235-$ | US-0115748-$ | US-0115823-$ | US-0115919-$ | US-0118177-$ | US-0120320-$ | US-0120833-$ | US-0121323-$ | US-0121442-$ | US-0122020-$ | US-0122027-$ | US-0122075-$ | US-0122091-$ | US-0122094-$ | US-0122792-$ | US-0122803-$ | US-0124546-$ | US-0124551-$ | US-0125016-$ | US-0125438-$ | US-0125633-$ | US-0125937-$ | US-0127790-$ | US-0127975-$ | US-0128190-$ | US-0128508-$ | US-0129354-$ | US-0130338-$ | US-0130769-$ | US-0130979-$ | US-0131490-$ | US-0132454-$ | US-0133265-$ | US-0134079-$ | US-0134435-$ | US-0135162-$ | US-0135258-$ | US-0135259-$ | US-0137494-$ | US-0138105-$ | US-0138158-$ | US-0138161-$ | US-0139340-$ | US-0139467-$ | US-0139541-$ | US-0141001-$ | US-0141388-$ | US-0142823-$ | US-0143141-$ | US-0143923-$ | US-0146930-$ | US-0147569-$ | US-0150846-$ | US-0150848-$ | US-0151126-$ | US-0152985-$ | US-0153134-$ | US-0153519-$ | US-0154338-$ | US-0154531-$ | US-0154532-$ | US-0154983-$ | US-0155027-$ | US-0156100-$ | US-0156914-$ | US-0157095-$ | US-0157096-$ | US-0158176-$ | US-0158437-$ | US-0158504-$ | US-0158823-$ | US-	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:58

0160155-$ | US-0160762-$ | US-
0161026-$ | US-0162142-$ | US-
0162144-$ | US-0162398-$ | US-
0163505-$ | US-0163996-$ | US-
0163997-$ | US-0163998-$ | US-
0168459-$ | US-0169672-$ | US-
0169780-$ | US-0170658-$ | US-
0174541-$ | US-0175852-$ | US-
0177163-$ | US-0179977-$ | US-
0181419-$ | US-0181896-$ | US-
0182266-$ | US-0185230-$ | US-
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S48	196	(US-0276053-$ | US-0277436-$ | US-0278460-$ | US-0278816-$ | US-0279558-$ | US-0281543-$ | US-0283785-$ | US-0284596-$ | US-0284925-$ | US-0285920-$ | US-0285968-$ | US-0286698-$ | US-0289754-$ | US-0290684-$ | US-0291668-$ | US-0291989-$ | US-0292701-$ | US-0293392-$ | US-0295821-$ | US-0296688-$ | US-0297009-$ | US-0297482-$ | US-0298743-$ | US-0299593-$ | US-0300572-$ | US-0300716-$ | US-0302196-$ | US-0302209-$ | US-0302210-$ | US-0302240-$ | US-0305755-$ | US-0307795-$ | US-0309325-$ | US-0310045-$ | US-0315379-$ | US-0317036-$ | US-0320460-$ | US-0321328-$ | US-0322550-$ | US-0324028-$ | US-0328090-$ | US-0328091-$ | US-0331544-$ | US-0331545-$ | US-0331546-$ | US-0331547-$ | US-0332655-$ | US-0334942-$ | US-0342282-$ | US-0342490-$ | US-0344185-$ | US-0346856-$ | US-0346911-$ | US-0347325-$ | US-0357348-$ | US-0362046-$ | US-0363042-$ | US-0368471-$ | US-0375607-$ | US-1234567-$ | US-10013107-$ | US-10019113-$ | US-3440426-$ | US-3553680-$ | US-3673327-$ | US-4129384-$ | US-4180702-$ | US-4209255-$ | US-4213707-$ | US-4254333-$ | US-4254407-$ | US-4294543-$ | US-4346376-$ | US-4420261-$ | US-4484179-$ | US-4507557-$ | US-4521112-$ | US-4542375-$ | US-4550250-$ | US-4593191-$ | US-4673918-$ | US-4688933-$ | US-4688993-$ | US-4692809-$ | US-4710760-$ | US-4736191-$ | US-4737626-$ | US-4746770-$ | US-4752655-$ | US-4772763-$ | US-4782328-$ | US-4812833-$ | US-4837430-$ | US-4868912-$ | US-4891829-$ | US-4916712-$ | US-4933544-$ | US-4949079-$ | US-4986662-$ | US-	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:59

		5065185-$ | US-5073770-$ | US-5105186-$ | US-5159322-$ | US-5166668-$ | US-5227622-$ | US-5248856-$ | US-5254407-$ | US-5345490-$ | US-5383022-$ | US-5483261-$ | US-5484966-$ | US-5499098-$ | US-5502568-$ | US-5525764-$ | US-5526422-$ | US-5539514-$ | US-5570181-$ | US-5572251-$ | US-5577501-$ | US-5600105-$ | US-5608550-$ | US-5672852-$ | US-5679930-$ | US-5686942-$ | US-5688933-$ | US-5729249-$ | US-5736686-$ | US-5740224-$ | US-5764223-$ | US-5767517-$ | US-5775792-$ | US-5945980-$ | US-5945981-$ | US-5959617-$ | US-6061177-$ | US-6067079-$ | US-6122394-$ | US-6141104-$ | US-6172667-$ | US-6175999-$ | US-6227667-$ | US-6229529-$ | US-6333735-$ | US-6366276-$ | US-6380732-$ | US-6380740-$ | US-6390370-$ | US-6429857-$ | US-6452996-$ | US-6476797-$ | US-6492633-$ | US-6495832-$ | US-6504143-$ | US-6529327-$ | US-6538644-$ | US-6587099-$ | US-6648485-$ | US-6660964-$ | US-6664498-$ | US-6664952-$ | US-6690363-$ | US-6707027-$ | US-6738051-$ | US-6748098-$ | US-6784948-$ | US-6799141-$ | US-6806871-$ | US-6927384-$ | US-6940286-$ | US-6965836-$ | US-6972753-$ | US-6985137-$ | US-7042444-$ | US-7084859-$ | US-7087907-$ | US-7133031-$ | US-7176904-$ | US-7199932-$ | US-7359041-$ | US-7397418-$ | US-7432893-$ | US-7435940-$ | US-7436443-$ | US-7442914-$ | US-7465914-$ | US-7613375-$ | US-7629968-$ | US-7646833-$ | US-7653883-$ | US-7655901-$ | US-7705835-$ | US-7729056-$ | US-7847789-$ | US-7855716-$ | US-7859519-$).DID.				
S49	73	(US-7924272-$ | US-7932899-$ | US-7969410-$ | US-7995039-$ | US-8013845-$ | US-8031186-$ | US-8077147-$ | US-8093545-$ | US-	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 05:59

		8094136-$ | US-8094910-$ | US-8149211-$ | US-8218154-$ | US-8274495-$ | US-8325158-$ | US-8339379-$ | US-8350827-$ | US-8384010-$ | US-8407606-$ | US-8441467-$ | US-8445834-$ | US-8466901-$ | US-8482547-$ | US-8542217-$ | US-8567257-$ | US-8581884-$ | US-8624858-$ | US-8686974-$ | US-8692807-$ | US-8716614-$ | US-8727581-$ | US-8745514-$ | US-8780066-$ | US-8830181-$ | US-8860696-$ | US-8872098-$ | US-8872801-$ | US-8884900-$ | US-8890843-$ | US-8890849-$ | US-8928590-$ | US-8963886-$ | US-8982084-$ | US-9024916-$ | US-9035909-$ | US-9063617-$ | US-9086763-$ | US-9134854-$ | US-9158401-$ | US-9158415-$ | US-9213445-$ | US-9274645-$ | US-9317168-$ | US-9323396-$ | US-9366565-$ | US-9377884-$ | US-9389732-$ | US-9411444-$ | US-9411464-$ | US-9430079-$ | US-9442574-$ | US-9547393-$ | US-9552103-$ | US-9557846-$ | US-9588619-$ | US-9594467-$ | US-9618682-$ | US-9626018-$ | US-9626040-$ | US-9639210-$ | US-9678602-$ | US-9684414-$ | US-9710101-$ | US-9874978-$).DID.				
S50	6	(("4751379") or ("6100538") or ("20070165008") or ("20130234991") or ("8913035") or ("20130300714")).PN.	US-PGPUB; USPAT	OR	OFF	2019/12/23 06:04
S51	32,685	(G06F3/0428 or G06F3/0421 or G06F2203/04108 or G06F2203/04107 or G06F2203/04103 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:05
S52	5,737	(G06F3/0421 or G06F3/0428).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S53	378	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58

S54	397	S52 and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((light beam) near5 (over across atop) near3 (surface plane cover panel))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S55	186	S54 not S53	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S56	151	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:58
S57	31,612	(G06F3/0421 or G06F2203/04107 or G06F2203/04103 or G06F2203/04108 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:59
S58	56	S57 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 06:59
S59	53	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2019/12/23 07:08
S60	56	S51 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09
S61	158	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09
S62	7	S61 not S56	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/12/23 07:09
S63	12	(US-20080080811-$ | US-20100315379-$ | US-20110134079-$ | US-20110141062-$ | US-20120170056-$ | US-20130300714-$ | US-20150131010-$ | US-20190025984-$ | US-20190196657-$ | US-20190196658-$ | US-20190196659-$ | US-9001086-$).DID.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:45

S64	152	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode) with (support frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:51
S65	33,069	(G06F3/0428 or G06F3/0421 or G06F2203/04108 or G06F2203/04107 or G06F2203/04103 or G06F3/0412).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S66	56	S65 and ((collimat$3 near2 beam) same ((across parallel) with surface)) and (frame chasis bezel) and (glass plastic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S67	159	(optical near2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch near2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light near2 source)) with (support$3 frame mount$3)) and ((emitter LED diode) with ((atop over (on near2 top) above) near3 (surface plane panel)))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S68	7	S67 not S64	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/02/03 09:52
S69	2	((optical adj2 (touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad)))) and ((emitter LED diode (light adj2 source)) and (support$3 frame mount$3)) and ((light beam) adj5 (over across atop) adj3 (surface plane cover panel))).clm.	US-PGPUB	OR	ON	2020/02/03 09:55
S70	0	16/834905	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/26 22:26
S71	56	((("SKAGMO") near3 ("Daniel")) OR (("EHN") near3 ("Robert")) OR (("BERGSTROM") near3 ("Hakan"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2020/04/26 22:27
S72	34,265	(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/26 22:32
S73	34,265	(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 13:33

S74	30	S73 and (((optical near2 element) lens) same emitter same (surface)) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3 translat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 13:38
S75	329	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) lens) same emitter) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3 translat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:00
S76	148	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) lens) same emitter) and (((optical near2 element) lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:00
S77	198	(touchscreen touchpanel touchpad touch-screen touch-pad touch-panel (touch adj2 (screen panel display sens$3 pad))) and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) and (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) (light near2 guide) light-guide lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:11
S78	30	S73 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) and (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3 contamina$4 dust dirt)) and (((optical near2 element) (light near2 guide) light-guide lens) same (slid$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:13
S80	14	S73 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) same (((optical near2 element) (light near2 guide) light-guide lens) same (seal$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:28
S81	255	S73 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) same (((optical near2 element) (light near2 guide) light-guide lens) same (engag$5 coupl$3 mat$3))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:29

S82	12	("20080080811" | "20100315379" | "20110134079" | "20110141062" | "20120170056" | "20130300714" | "20150131010" | "20190025984" | "20190196657" | "20190196658" | "20190196659" | "9001086").PN.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/04/27 14:33
S83	1	("20140210793").PN.	US-PGPUB; USPAT	OR	OFF	2020/06/03 12:48
S84	1	("20160224300").PN.	US-PGPUB; USPAT	OR	OFF	2020/06/11 09:44
S85	34,968	(G06F3/0428 or G06F3/0421 or G06F2203/04103 or G06F3/0412 or G06F2203/04108 or G06F2203/04107).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/06/22 13:03
S86	265	S85 and (((optical near2 element) (light near2 guide) light-guide lens) same emitter) same (((optical near2 element) (light near2 guide) light-guide lens) same (engag$5 coupl$3 mat$3 fitted))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2020/06/22 13:03

6/22/2020 1:39:38 PM
C:\Users\agiesy\Documents\EAST\Workspaces\16834905.wsp

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 3	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	6,031,524	02-29-2000	Kunert	
	2	2010/0103133	04-29-2010	Park et al.	
	3	2012/0062492	03-15-2012	Katoh	
	4	2016/0026297	01-28-2016	Shinkai et al.	
	5	2016/0209886	07-21-2016	Suh et al.	
	6	2016/0255713	09-01-2016	Kim et al.	
	7	2016/0295711	10-06-2016	Ryu et al.	
	8	9,063,614	06-23-2015	Petterson et al.	
	9	9,201,520	10-03-2013	Benko et al.	
	10	9,280,237	03-08-2016	Kukulj	
	11	10,282,035	05-07-2019	Kocovksi et al.	
	12	2009/0000831	01-01-2009	Miller et al.	
	13	2010/0103133	04-29-2010	Park et al.	
	14	2011/0084939	04-14-2011	Gepner et al.	
	15	2012/0062492	03-15-2012	Katoh	
	16	2012/0218229	08-30-2012	Drumm	
	17	2012/0223916	09-06-2012	Kukulj, Dax	
	18	2012/0313865	12-13-2012	Pearce	
	19	2013/0106709	05-02-2013	Simmons	
	20	2013/0141395	06-06-2013	Holmgren et al.	
	21	2013/0181953	07-18-2013	Hinckley et al.	
	22	2014/0253520	09-11-2014	Cueto et al.	
	23	2014/0259029	09-11-2014	Choi et al.	
	24	2015/0121691	05-07-2015	Wang, Yun-Jun	
	25	2016/0004898	01-07-2016	Holz	
	26	2016/0026297	01-28-2016	Shinkai et al.	
	27	2016/0117019	04-28-2016	Michiaki	
	28	2016/0209886	07-21-2016	Suh et al.	
	29	2016/0255713	09-01-2016	Kim et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 3	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	2016/0295711	10-06-2016	Ryu et al.	
	31	2016/0299583	10-13-2016	Watanabe	
	32	2018/0253187	09-06-2018	Christiansson et al.	
	33	2019/0050074	02-14-2019	Kocovski	
	34	2013/0155655	06-20-2013	Lee et al.	

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	35	AU 2008 280 952 A1	03-19-2009	NEXT HOLDINGS INC		
	36	CN 101174191A	06-17-2009	GUANGDONG WEICHUANG VIDEO AND		
	37	CN 101882034	11-10-2010	GUANGDONG VTRON TECHNOLOGY CO		
	38	CN 201465071 U	05-12-2010	Wei, He		
	39	CN 203189466 U	09-11-2013	Wistron Corp.		
	40	CN 203224848 U	10-02-2013	CPTW Wujiang Co Ltd;Chunghwa Picture Tubes LTD.		
	41	CN 101174191	05-07-2008	GUANGDONG WEICHUANG VIDEO AND		
	42	CN 205015574 U	02-03-2016	Shenzhen Lianhesheng Electronics CO LTD.		
	43	EP 2565770 A2	03-06-2013	SAMSUNG ELECTRONICS CO LTD		
	44	WO 2008/034184 A1	03-27-2008	RPO PTY LIMITED		
	45	WO 2012/018176 A2	02-09-2012	LG Innotek CO LTD.		
	46	WO 2013/115710 A2	08-08-2013	FLATFROG LABORATORIES AB		
	47	WO 2014/086084 A1	06-12-2014	GENERALTOUCH TECHNOLOGY CO LTD		

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

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	Filing Date	March 30, 2020
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(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 3 OF 3	Attorney Docket No.	FFOG.054C5

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	48	WO 2014/098744 A1	06-26-2014	FLATFROG LABORATORIES AB		
	49	WO 2014/104967 A1	07-03-2014	FLATFROG LABORATORIES AB		
	50	WO 2015/175586 A1	11-19-2015	MICROSOFT TECHNOLOGY LICENSING LLC		
	51	WO 2018/096430 A1	05-31-2018	FLATFROG LABORATORIES AB		
	52	WO 2018/106172 A1	06-14-2018	FLATFROG LABORATORIES AB		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	53	Supplementary European Search Report for European App. No. EP 16759213, dated October 4, 2018, in 9 pages.	
	54	Extended European Search Report for European App. No. 16743795.3, dated September 11, 2018, in 5 pages.	
	55	International Search Report for International App. No. PCT/SE2017/051224, dated February 23, 2018, in 5 pages.	
	56	International Search Report for International App. No. PCT/IB2017/057201, dated March 6, 2018, in 4 pages.	
	57	Extended European Search Report in European Application Number 19165019.1, dated July 18, 2019 in 8 pages.	
	58	International Preliminary Report on Patentability received in International Application No. PCT/SE2017/051233, dated June 11, 2019, in 6 pages.	
	59	International Search Report for International App. No. PCT/SE2018/050070, dated April 25, 2018, in 4 pages.	
	60	Extended European Search Report in European Application number 17750516.1, dated July 16, 2019 in 5 pages.	
	61	Extended European Search Report in European Application number 16873465.5, date June 25, 2019 in 9 pages.	

32980459

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 2	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	2015/0373864 A1	12-24-2015	Jung	
	2	2013/0321740 A1	12-5-2013	An et al.	
	3	2016/0154533 A1	06-02-2016	Eriksson et al.	
	4	2011/0080361 A1	04-07-2011	Miller et al.	
	5	2019/0235701 A1	08-01-2019	Han et al.	
	6	9,024,896 B2	05-05-2015	Chen	
	7	4,751,379	06-14-1988	Sasaki et al.	
	8	2013/0234991 A1	09-12-2013	Sparf	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	9	WO 2014/065601	05-01-2014	LG Electronics Inc.		
	10	WO 2018/106176	06-14-2018	FlatFrog Laboratories AB		
	11	EP 3535640 A1	09-11-2019	FlatFrog Laboratories AB		
	12	EP 2765622 A2	08-13-2014	LG Electronics Inc.		
	13	WO 2013/159472	10-31-2013	Shenzhen Timelink Technology Co., LTD.		X

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	14	Report on the Filing or Determination of an Action Regarding a Patent or Trademark. For U.S. Patent No. 10,282,035, U.S. District of Delaware, dated December 10, 2019, in 1 page.	
	15	Civil Cover Sheet FLATFROG LABORATORIES AB v. PROMETHEAN LTD. and PROMETHEAN INC., dated December 10, 2019, in 1 page.	
	16	Complaint for Patent Infringement, FLATFROG LABORATORIES AB v. PROMETHEAN LTD. and PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019, in 83 pages.	
	17	Executed Summons in a Civil Action to PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	
	18	Summons in a Civil Action to PROMETHEAN INC., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 2 OF 2	Attorney Docket No.	FFOG.054C5

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	19	Summons in a Civil Action to Promethean Ltd., C.A. No. 19-2246, dated December 10, 2019 in 2 pages.	
	20	Defendants' Answer to Second Amended Complaint and Defendant Promethean Inc.'s Counterclaims Against FlatFrog Laboratories AB., C.A. No. 19-2246, dated May 22, 2020, in 29 pages.	

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Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor	:	Daniel Skagmo
App. No	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

6. (Currently Amended) A touch sensing apparatus, comprising:

a panel that defines a touch surface;

a plurality of light emitters and detectors arranged along a perimeter of the panel;

a support structure comprising a first portion that is parallel to the touch surface and separated by a space from the panel, said first portion including a first projection extending downwards from said first portion and a second projection extending downwards from said first portion, wherein a gap between the first projection and the second projection forms a receptacle having a first cross-sectional shape; and

an optical element ~~configured to be slidably~~ fitted in the space between the panel and the first portion and configured to seal[[s]] the plurality of light emitters from contaminants from the touch surface, said optical element ~~comprising~~ comprises a mating portion having a second cross-section shape that

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is substantially reciprocal to the first cross-sectional shape, said mating portion ~~configured to~~ engaged with the receptacle of the first portion.

7. (Currently Amended) The touch sensing apparatus according to claim 6, wherein the support structure further comprises a second portion extending from the first portion, wherein the second portion is configured to enable mounting of the plurality of emitters and wherein the second portion is oriented perpendicular to the first portion.

8. (Previously Presented) The touch sensing apparatus according to claim 7, wherein the plurality of emitters are mounted on an electronics board that is supported by the second portion, said plurality of emitters configured to emit light above the touch surface.

9. (Original) The touch sensing apparatus according to claim 6, wherein the optical element is configured to slide in a direction parallel to a plane of the touch surface.

10. – 21. (CANCELED)

22. (NEW) The touch sensing apparatus according to claim 6, wherein the optical element comprises a first surface facing the plurality of light emitters and a second surface opposite the first surface, said first surface angled between a top portion of the optical element and a base portion of the optical element and configured to form an offset between a first end of the top portion and a second end of the base portion.

23. (NEW) The touch sensing apparatus according to claim 7, wherein the support structure comprises an inner wall supporting the plate, and wherein the first

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portion, the second portion, a third portion extending from the second portion, and the inner wall of the support structure together form a cavity.

24. (NEW) The touch sensing apparatus according to claim 23, wherein the cavity secures an electronics substrate that mounts the plurality of light emitters.

25. (NEW) The touch sensing apparatus according to claim 6, wherein the mating portion is engaged with the receptacle responsive to the optical element slidably fitted in a direction perpendicular to the first portion during assembly.

26. (NEW) The touch sensing apparatus according to claim 6, wherein the mating portion is engaged with the receptacle responsive to the optical element slidably fitted in a direction parallel to the first portion during assembly.

SUMMARY OF INTERVIEW

Inventor	:	Daniel Skagmo
App. No	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Pursuant to the Interview Summary of June 26, 2020, Applicant submits this Summary of Interview for recording in the official file.

Attendees, Date and Type of Interview

The interview was conducted via phone on June 11 and June 22 and attended by Harnik Shukla.

Exhibits and/or Demonstrations

n/a

Identification of Claims Discussed

6

Identification of Cited/Disclosed Art Discussed

US 20140210793 (Eriksson); US 2015/0131010 Sugiyama; US 4751379 to Sasaki; WO2013159472; US 2013/023499 (Sparf).

Proposed Amendments

Mr. Shukla proposed amendments solely in the interest of expediting prosecution.

Principal Arguments and Other Matters

Mr. Shukla discussed the proposed amendments in view of the cited art and references stated above.

Results of Interview

The Examiner agreed that the proposed amendments are allowable.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: July 2, 2020 By:/Harnik Shukla/

Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 721-5278

33082440

Electronic Patent Application Fee Transmittal

Application Number:	16834905
Filing Date:	30-Mar-2020
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Filer:	Harnik Shukla/Jenny Kim
Attorney Docket Number:	FFOG.054C5

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1000**

Electronic Acknowledgement Receipt

EFS ID:	39902976
Application Number:	16834905
International Application Number:	
Confirmation Number:	1516
Title of Invention:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
First Named Inventor/Applicant Name:	Daniel Skagmo
Customer Number:	20995
Filer:	Harnik Shukla/Wendy Castorena
Filer Authorized By:	Harnik Shukla
Attorney Docket Number:	FFOG.054C5
Receipt Date:	02-JUL-2020
Filing Date:	30-MAR-2020
Time Stamp:	17:14:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
RAM confirmation Number	E202072H15166122
Deposit Account	111410
Authorized User	Wendy Castorena

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	FFOG054C5_issuefee.pdf	213865 4d274a3233f384938be8118940348d7085514811	no	1
Warnings:					
Information:					
2	Post Allowance Communication - Incoming	FFOG054C5_COMMENTS.pdf	20355 803389e1e5646cc0b6a0e4f0a9df73c2da264a51	no	2
Warnings:					
Information:					
3	Applicant summary of interview with examiner	FFOG054C5_intsumm.pdf	15448 9d0e2f486a7f8f9491b969432e64c47fdb2a9373	no	2
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30431 30dff32d49e847ca5eab19cf6fe3194f57c6bca1	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	280099		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 06/26/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

TITLE OF INVENTION: TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	09/28/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
GIESY, ADAM	2694	345-175000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 KNOBBE MARTENS
OLSON & BEAR, LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE	(B) RESIDENCE: (CITY and STATE OR COUNTRY)
FlatFrog Laboratories AB	Lund, SWEDEN

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge ~~the required fee(s),~~ any deficiency, or credit any overpayment to Deposit Account No. 11-1410

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Harnik Shukla/ Date July 2, 2020

Typed or printed name HARNIK SHUKLA Registration No. 73,097

IPR2024-00013
Flatfrog Laboratories AB, Ex. 2002
Page 1241 of 1254

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor	:	Daniel Skagmo
App. No	:	16/834905
Filed	:	March 30, 2020
For	:	TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY
Examiner	:	Giesy, Adam
Art Unit	:	2694
Conf. No.	:	1516

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Dear Commissioner:

Applicant makes the following comments in response to the Examiner's description of allowable subject matter in the Notice of Allowance mailed on June 28, 2020.

Applicant respectfully disagrees with the Examiner's statement to the extent that it may characterize the language or scope of the claims pending in this application or in any other prior art referenced in the statement. Applicant notes that it is the language of the claims, not the Examiner's characterization of the language that determines the scope of the claims. Also, to the extent that there is any implication that the patentability of the claims rests on the recitation of a single feature or subset of features, Applicant respectfully disagrees with the Examiner's statement because it is the recited combination of features that makes the claims patentable.

The claims of the present application are different and possibly broader in scope than the claims pursued in the parent application(s). To the extent any prior amendments or characterizations of the scope of any claim or referenced art could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicant hereby rescinds and retracts such disclaimer.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: July 2, 2020

By:/Harnik Shukla/_____
Harnik Shukla
Registration No. 73,097
Registered Practitioner
(949) 721-5278

33081145

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5	1516

7590 07/09/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
GIESY, ADAM	
ART UNIT	PAPER NUMBER
2694	

DATE MAILED: 07/09/2020

PRIORITY ACKNOWLEDGMENT

☑ 1. Receipt is acknowledged of priority papers submitted under 35 U.S.C. 119. The papers have been placed of record in the file.

☐ 2. Applicant's claim for priority, based on papers filed in parent Application Number _____ submitted under 35 U.S.C. 119, is acknowledged.

☐ 3. The priority papers, submitted _____, after payment of the issue fee are

- ☐ acknowledged
  While the priority claim or certified copy filed will be placed in the file record, neither will be reviewed and the patent when published will not include the priority claim.
  See 37 CFR 1.55(a)(2).
- ☐ not acknowledged since the processing fee in 37 CFR 1.17(i) has not been received.

☐ 4. For utility and plant applications filed on or after November 29, 2000, the priority claim is not entered because the claim was not presented within the time limit required by 37 CFR 1.55(a)(1). A petition to accept a delayed claim for priority under 35 U.S.C. 119(a) - (d) or (f), or 365(a) may be filed. See 37 CFR 1.55(c) and MPEP 201.14(a).

/Joe Boris/ for

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

PTOL-147 (Rev. 03/08)

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/834905
	Filing Date	March 30, 2020
	First Named Inventor	Daniel Skagmo
	Art Unit	2694
(Multiple sheets used when necessary)	Examiner	Giesy, Adam
SHEET 1 OF 3	Attorney Docket No.	FFOG.054C5

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	6,031,524	02-29-2000	Kunert	
	2	2010/0103133	04-29-2010	Park et al.	
	3	2012/0062492	03-15-2012	Katoh	
	4	2016/0026297	01-28-2016	Shinkai et al.	
	5	2016/0209886	07-21-2016	Suh et al.	
	6	2016/0255713	09-01-2016	Kim et al.	
	7	2016/0295711	10-06-2016	Ryu et al.	
	8	9,063,614	06-23-2015	Petterson et al.	
Change(s) applied to document, /J.T./ 7/10/2020	**9**	9,201,520	~~10-03-2013~~ 12/2015	Benko et al.	
	10	9,280,237	03-08-2016	Kukulj	
	11	10,282,035	05-07-2019	Kocovksi et al.	
	12	2009/0000831	01-01-2009	Miller et al.	
	13	2010/0103133	04-29-2010	Park et al.	
	14	2011/0084939	04-14-2011	Gepner et al.	
	15	2012/0062492	03-15-2012	Katoh	
	16	2012/0218229	08-30-2012	Drumm	
	17	2012/0223916	09-06-2012	Kukulj, Dax	
	18	2012/0313865	12-13-2012	Pearce	
	19	2013/0106709	05-02-2013	Simmons	
	20	2013/0141395	06-06-2013	Holmgren et al.	
	21	2013/0181953	07-18-2013	Hinckley et al.	
	22	2014/0253520	09-11-2014	Cueto et al.	
	23	2014/0259029	09-11-2014	Choi et al.	
	24	2015/0121691	05-07-2015	Wang, Yun-Jun	
	25	2016/0004898	01-07-2016	Holz	
	26	2016/0026297	01-28-2016	Shinkai et al.	
	27	2016/0117019	04-28-2016	Michiaki	
	28	2016/0209886	07-21-2016	Suh et al.	
	29	2016/0255713	09-01-2016	Kim et al.	

Examiner Signature	/ADAM R. GIESY/	Date Considered	06/22/2020

*__Examiner:__ Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.G./

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/834,905	03/30/2020	Daniel Skagmo	FFOG.054C5

CONFIRMATION NO. 1516

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

PUBLICATION NOTICE



Title:TOUCH SENSING APPARATUS AND METHOD FOR ASSEMBLY

Publication No.US-2020-0225807-A1
Publication Date:07/16/2020

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/834,905	08/11/2020	10739916	FFOG.054C5	1516

20995 7590 07/22/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Daniel Skagmo, Malmo, SWEDEN;
FlatFrog Laboratories AB, Lund, SWEDEN;
Robert Ehn, Lund, SWEDEN;
Hakan Bergstrom, Torna-Hallestad, SWEDEN;

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AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
19-2246 (MN)	12/10/2019	District of Delaware

PLAINTIFF	DEFENDANT
FLATFROG LABORATORIES AB	PROMETHEAN LTD. and PROMETHEAN INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	~~10,282,935~~	~~5/7/2019~~	~~FLATFROG LABORATORIES AB~~ 10/16/2020 - Third Amended Complaint filed. This patent is not a patent-in-suit in the Third Amended Complaint.
2			
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY
10/16/2020	☑ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	~~10,606,414~~	~~3/31/2020~~	~~FLATFROG LABORATORIES AB~~ 10/16/2020 - Third Amended Complaint filed. These patents are not patents-in-suit in the Third Amended Complaint.
2	~~10,606,416~~	~~3/31/2020~~	~~FLATFROG LABORATORIES AB~~
3	10,775,935 B2	9/15/2020	FLATFROG LABORATORIES AB
4	10,739,916 B2	8/11/2020	FLATFROG LABORATORIES AB
5			

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED 10/16/2020

INCLUDED BY ☑ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading

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4	10,739,916 B2	8/11/2020	FLATFROG LABORATORIES AB
5			

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

Dismissed - see attached

CLERK	(BY) DEPUTY CLERK	DATE
John A. Cerino	/s/ Mark D. Buckson, Jr.	4/14/2022

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Trials@uspto.gov
Tel: 571-272-7822

Paper No. 13
Entered: April 18, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PROMETHEAN LTD. and PROMETHEAN INC.,
Petitioner,

v.

FLATFROG LABORATORIES AB,
Patent Owner.

IPR2022-00061
Patent 10,739,916 B2

Before DEBRA K. STEPHENS, GARTH D. BAER, and NABEEL U. KHAN, *Administrative Patent Judges*.

BAER, *Administrative Patent Judge*.

DECISION
Settlement Prior to Institution of Trial and
Granting Joint Request to Treat Settlement Agreement
as Business Confidential Information
37 C.F.R. § 42.74

I. INTRODUCTION

With the Board's authorization, Petitioner and Patent Owner (collectively, "the Parties") filed a Joint Motion requesting termination of the above-captioned proceeding due to settlement. Paper 10 ("Joint Motion"). Along with the Joint Motion, the Parties filed a copy of a written, confidential "SETTLEMENT, RELEASE AND LICENSE AGREEMENT." Ex. 1023 ("Settlement Agreement"). The Parties also filed a Joint Request that the Settlement Agreement be treated as business confidential information and kept separate from the file of U.S. Patent No. 10,739,916 B2 ("the '916 patent"). Paper 12 ("Joint Request").

II. DISCUSSION

In the Joint Motion, the Parties represent that the Settlement Agreement resolves the Parties' disputes involving the '916 patent. Joint Motion 2.[1] The Parties also represent that the Settlement Agreement is a true copy of the agreement or understanding made in connection with, or in contemplation of, the termination of the proceeding. *Id.* The Settlement Agreement states that it "constitutes the entire agreement between the Parties with respect to settlement of the Action and supersedes all prior written or oral agreements and understandings between the Parties with respect to such subject matters." Settlement Agreement 18.

There are strong public policy reasons to favor settlement between the parties to a proceeding. *Office Patent Trial Practice Guide*, 84 Fed. Reg. 64,280 (Nov. 21, 2019). The proceeding is at an early stage, and we have

[1] The Joint Motion does not include page numbers. For reference herein, we consider the caption page as page 1 and the subsequent pages proceed in numerical order.

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not yet decided whether to institute a trial in the proceeding. In view of the early stage of the proceeding and the settlement between the Parties, we determine that good cause exists to dismiss the petition for *inter partes* review and terminate the proceeding with respect to the Parties.

In the Joint Request, the Parties request that the Settlement Agreement be treated as business confidential information and kept separate from the file of the '916 patent. Joint Request 2.[2] After reviewing the Settlement Agreement, we find that it contains confidential business information regarding the terms of settlement. Thus, we determine the the Settlement Agreement shall be treated as business confidential information pursuant to 37 C.F.R. § 42.74(c) and shall be kept separate from the files of the patents and associated proceeding.

This Order does not constitute a final written decision pursuant to 35 U.S.C. § 318(a).

III. ORDER

Accordingly, it is:

ORDERED that the Joint Motion requesting termination of the proceeding is *granted*;

FURTHER ORDERED that IPR2022-00061 is *terminated* with respect to Petitioner and Patent Owner; and

FURTHER ORDERED that the Joint Request to treat the Settlement Agreement as business confidential information is *granted*, and the

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[2] The Joint Request does not include page numbers. For reference herein, we consider the caption page as page 1 and the subsequent pages proceed in numerical order.

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Settlement Agreement shall be kept separate from the file of U.S. Patent No. 10,739,916 B2, and shall be made available only to Federal Government agencies on written request, or to any person on a showing of good cause, pursuant to 37 C.F.R. § 42.74(c).

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