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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

(54) **Title:** FOLDABLE DISPLAY

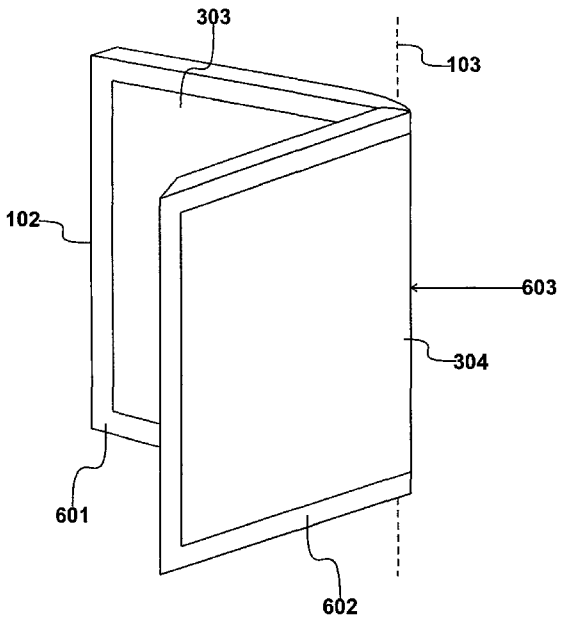

Fig. 6

(57) **Abstract:** A foldable electronic device (101) comprises a display device (102) moveable from an unfolded configuration to a folded configuration in which the display device folds along a fold axis (103). The electronic foldable device further comprises a force sensing device (603) responsive to a manual interaction on the surface of the display device. The force sensing device is positioned on the fold axis of the display device.

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Foldable Display

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from United States Provisional Patent Application number 62/812,303, filed on 01 March 2019, the whole contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a foldable electronic device, method of manufacturing a foldable electronic device and method of determining a mechanical interaction in a foldable electronic device.

Recent developments in electrical technology have resulted in foldable or flexible electronic devices becoming available. Increasingly, foldable or flexible displays have become available which allow the display to bend during use. Beyond this, there is a need for developments to enable increased functionality addressing problems which exist with foldable displays which are not present in conventional non-folding displays or electronic devices.

BRIEF SUMMARY OF THE INVENTION

According to an aspect of the present invention, there is provided a foldable electronic device, comprising: a display device moveable from an unfolded configuration to a folded configuration in which said display device folds along a fold axis; a force sensing device responsive to a manual interaction on a surface of said display device; wherein said force sensing device is positioned on said fold axis of said display device.

According to a further aspect of the present invention, there is provided a method of manufacturing a foldable electronic device, comprising the steps of: providing a force sensing device responsive to a manual interaction; attaching said force sensing device to a display device configured to move from an unfolded configuration to a folded configuration along a fold axis; wherein: said step of attaching comprises positioning said force sensing device on said fold axis of said display device.

According to a still further aspect of the present invention, there is provided a method of determining a mechanical interaction in a foldable electronic device, said foldable electronic device comprising a display device and a force sensing device on a surface of said display device, said method comprising the steps of: folding said display device along a fold axis such that said display device moves from an unfolded configuration to a folded configuration; applying a manual interaction to said force sensing device positioned on said fold axis.

Embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings. The detailed embodiments show the best mode known to the inventor and provide support for the invention as claimed. However, they are only exemplary and should not be used to interpret or limit the scope of the claims. Their purpose is to provide a teaching to those skilled in the art. Components and processes distinguished by ordinal phrases such as "first" and "second" do not necessarily define an order or ranking of any sort.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 shows an example foldable electronic device in accordance with the invention;

Figure 2 shows a cross-sectional exploded view of a corner of the edge of a foldable electronic device;

Figures 3A and 3B show the foldable electronic device in an unfolded configuration and use of force sensing devices positioned along the edge of the surface of the display from the front and back of the foldable electronic device;

Figure 4 shows an example force sensing device;

Figure 5 shows an alternative example force sensing device;

Figure 6 shows a foldable electronic device having an in-folding and out-folding display surface;

Figure 7 shows an embodiment of the foldable electronic device in a

folded configuration in which a force sensing device is positioned on the fold axis of the display device; and

Figure 8 shows an alternative view of the configuration of the foldable electronic device as shown in Figure 7.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Figure 1

An example foldable electronic device is shown in use in Figure 1. Foldable electronic device **101** comprises a display device **102** which is configured to be moveable from an unfolded configuration (as depicted in the examples of Figure 1 and 3) to a folded configuration (as depicted in the examples of Figures 6 to 8) about a fold axis **103**.

In the embodiment, user **104** holds foldable electronic device **101** in the unfolded configuration so as to view the display of display device **102**. In the embodiment, display device **102** comprises a touch screen in which user **104** may provide a mechanical interaction to display device **102** to receive an output on the display of foldable electronic device.

In the embodiment, foldable electronic device **101** is shown as a tablet computer, however, it is appreciated that alternative foldable electronic devices fall within the scope of invention, and include other display devices, mobile telephones, personal computers, televisions, media players or similar.

In the embodiment, foldable electronic device **101** comprises at least one force sensing device which is responsive to a mechanical interaction, such as an applied pressure or force from user **104** which is positioned on a surface of the display device. In the embodiment, foldable electronic device **101** comprises one or more force sensing devices positioned along the edges **105**, **106** of display device **102**. Thus, in use, user **104** can apply a pressure by means of finger or thumb **107** to edge **105** for example to provide a signal to foldable electronic device **101** to activate a predetermined output.

Figure 2

A cross sectional exploded view of the corner of edge **105** of foldable

electronic device **101** is shown in Figure 2. Display device **102** comprises a light-emitting layer **201** which provides a light output to a display device **102**. Display device **102** also comprises a touch sensitive layer **202** which is configured to measure a force in response to a mechanical interaction and provide a touch screen capacity in any suitable conventional manner.

At the edge **105** of foldable electronic device **101**, force sensing device **203** is positioned so as to enable a response to be provided to a mechanical interaction applied along edge **105**. Force sensing device **203** may comprise any suitable force sensing device capable of measuring a force in response to a mechanical interaction. In an embodiment, force sensing device **203** is configured to provide positional (x, y) and extent (z) properties in response to a mechanical interaction, such as an applied force or pressure.

In an embodiment, the total height **204** of force sensing device **203** is between one hundred and one hundred and fifty micrometres (100 – 150 μm). In a particular embodiment, the height **204** is one hundred micrometres (100 μm). Force sensing device **203** is configured to conform to these dimensions to enable display device **102** to be made as thin as possible.

Display device **102** further comprises a top cover **205**, shown in exploded view, and, in this illustrated embodiment, an edge portion **206** of top cover **205** is configured to cover force sensing device **203**. Portion **207** of top cover **205** comprises a transparent area which allows light output from light-emitting layer **201** to be transmitted through the display.

It is appreciated that any number of force sensing devices may be positioned around any part of the edges of display device **102** to provide an input device to user **104**. As will now be described, Figure 3 illustrates an example embodiment of positioning of force sensing devices on the edge of foldable electronic device **101**.

Figures 3A and 3B

In the embodiment of Figure 3A foldable electronic device **101** comprises a plurality of force sensing devices positioned along front edges **105** and **106** of the surface of foldable electronic device **101**. Figure 3A therefore

illustrates foldable electronic device from a front side of display device **102**.

In contrast, Figure 3B, foldable electronic device **101** is shown from a rear side of display device **102** and comprises a plurality of force sensing devices along rear edges **301** and **302**.

In the embodiment, foldable electronic device **101** comprises a first display **303** on the front side as per Figure 3A and a second display **304** on a rear side as per Figure 3B. In the embodiment, front side and rear side are substantially opposite to each other as illustrated.

In the embodiment, user **104** grips foldable electronic device **101** in a conventional manner, such that the thumbs of both the right and left hands are proximate to the front side of Figure 3A and the fingers of the right and left hands are proximate to the rear side of Figure 3B. In this way, when the display device is in the unfolded configuration of Figure 3, user **104** is able to ergonomically operate any force sensing devices arranged along front edges **105**, **106** with their thumbs, and rear edges **301**, **302** with their fingers.

The force sensing devices along any of the edges may be configured to provide navigation, scrolling, selection of applications (apps), launch of applications (apps), control volume, control zoom, or any number of any other required functions specific to applications in use. The use of force sensing devices in this way may augment other sensing devices present in the foldable electronic device, for example, capacitive touch sensors forming the touch screen or other sensing devices.

The configuration described in Figure 3 provides many advantages for folding displays which are of a size which require a two-handed grip. In this case, the user does not usually have a free hand to interact with the display or touch screen in a conventional manner. In addition, the placement of force sensing devices on the rear side enables improved user interface for certain applications, such as in gaming. Any of the force sensing devices may also be utilised for operation of the foldable electronic device from either the front side of Figure 3A or the rear side of Figure 3B.

Figure 4

An example force sensing device which may be utilised along the edges of foldable electronic device **101** is shown in Figure 4. It is appreciated that the force sensing device **401** of Figure 4 may also be utilised in any other capacity in the foldable electronic device, such as the force sensing devices shown in the embodiments of Figures 6 to 8.

A schematic exploded view of force sensing device **401** is shown in Figure 4. Force sensing device **401** comprises a first conductive layer **402** and a second conductive layer **403**. A pressure sensitive layer **404** is positioned between conductive layer **402** and conductive layer **403**.

In the embodiment, the first conductive layer **402**, second conductive layer **403** and pressure sensitive layer **404** are sequentially printed as inks onto a substrate **204** to form a force sensing device. Thus, each of the layers are printed in close proximity rather than the exploded view of Figure 4. Conductive layers **402** and **403** may comprise a carbon-based material and/or a silver-based material. Pressure sensitive layer **404** comprises a pressure sensitive material such as the type supplied by the applicant Peratech Holdco Limited, Brompton-on-Swale, United Kingdom, under the trade mark QTC®. The pressure sensitive material therefore may comprise a quantum tunnelling composite material which is configured to exhibit a change in electrical resistance based on a change in applied force. The quantum tunnelling composite material may be supplied as a printable ink or film.

In use, when a pressure is applied to the layers, a conductive path is created which enables calculation of an extent property or intensity of a force applied, in a substantially conventional manner by interpretation of the electrical outputs. In this way, the layers of force sensing device **401** can be arranged to form a single point sensor, which can subsequently be applied to foldable electronic device **101** where force sensing devices are required.

Figure 5

An alternative example force sensing device which may be utilised in foldable electronic device **101** in any manner discussed herein is shown in

Figure 5.

Force sensing device **501** is shown in a partially exploded view and comprises a first conductive layer **502** and a second conductive layer **503**. In this diagrammatic illustration, first conductive layer **502** and second conductive layer **503** are shown in an exploded form such that there is a gap **504** between them. It is appreciated that, in practice, first conductive layer **502** and second conductive layer **503** are positioned closer together than shown and in some embodiments, gap **504** is negligible.

In combination, conductive layer **502** and conductive layer **503** combine to define a sensing region which can determine a mechanical interaction such as a force or pressure applied by means of a user's finger, thumb or stylus press. In the embodiment, conductive layer **502** and conductive layer **503** are configured to be substantially flexible such that they are able to bend or flex in use. In addition, the layers may be suitably constrained to allow movement to provide a flexible sensor which does not suffer from false triggering. An example of such a sensor is described in GB 2 **557 894** in the name of the present applicant.

Conductive layer **502** comprises a substrate **505** which comprises a plurality of conductive rows **506** printed onto substrate **505**. In a similar way, conductive layer **503** comprises substrate **507** onto which a plurality of conductive columns **508** are printed. Each row is electrically insulated from the others, and similarly, each column is electrically insulated from the others.

The conductive rows and columns of each of the conductive layers are configured to cooperate in the manner of a matrix sensor such that positional (x, y) and extent (z) properties of a mechanical interaction can be determined. Thus, in response to a mechanical interaction, the rows and columns are brought together which allows an electrical potential gradient to be established and position to be determined.

In the embodiment, conductive rows **506** comprise a layer of silver-loaded ink and a layer of carbon loaded ink. Similarly, conductive columns **508** comprise a layer of silver-loaded ink which is then overprinted with a

conductive carbon loaded ink. Conductive layer **503** further comprises a pressure sensitive material such as a quantum tunnelling material. Again, this may be a material of the type supplied by the present applicant Peratech Holdco Limited under the trade mark QTC®. In the embodiment, the quantum tunnelling material is overprinted over the conductive carbon ink with the silver, carbon and quantum tunnelling material in combination forming the plurality of conductive columns **508**.

It is appreciated that, in alternative embodiments, the quantum tunnelling material is printed on substrate **505** and forms part of conductive layer **502** rather than conductive layer **503**. It is further appreciated that in a further embodiment both conductive layer **502** and conductive layer **503** both comprise layers of quantum tunnelling material.

With respect to the use of the terminology "rows" and "columns", it is appreciated that rows **506** and columns **508** are positioned parallel to one another within the first conductive layer **502** and second conductive layer **503** respectively. The plurality of rows are also positioned substantially perpendicularly to the plurality of columns, albeit in separate planes relating to the first conductive layer **502** and the second conductive layer **503** respectively.

Figure 6

Foldable electronic device **101** comprising display device **102** has been moved from the unfolded configuration (as depicted in the examples of Figure 1 and 3 described previously) to the folded configuration shown in Figure 6.

In the embodiment, display device **102** have been folded along fold axis **103**. In this way, foldable electronic device **101** operates in a manner similar to that of the unfolded configuration, allowing user **104** to provide input by means of mechanical interactions such as a force or pressure input arising from a finger press or similar.

In the embodiment, foldable electronic device **101** comprises first display **303** and second display **304**. As described previously, first display **303** is positioned on a front side **601** of display device **102** and second display

device **304** is positioned on a rear side **602** of display device **102** which is substantially opposite to the front side **601**.

In the embodiment, foldable electronic device **101** comprises at least one force sensing device which is responsive to a manual interaction on the surface of display device **102**. As explained previously, foldable electronic device comprises force sensing devices positioned along the front and rear edges of display device **102**. In this way, when the foldable electronic device is in the folded configuration, the force sensing device(s) along the front and rear edges the edge may be configured to serve secondary display(s) that appear on the folded surface. Thus, use of the foldable electronic device can be made in either folded or unfolded form.

In this embodiment, in addition to the force sensing devices positioned along the front and rear edges of display device **102**, foldable electronic device further comprises at least one force sensing device **603** on fold axis **103**, as will be explained further with respect to Figure 6.

In the embodiment, when display device **102** is in the unfolded configuration of Figure 1, a signal may be provided from force sensing device **603** by application of a pressure or other mechanical interaction directly to the surface of display device and force sensing device **603**. However, in the folded configuration, an alternative signal may be provided from force sensing device **603** which provides an alternative output to a processor of the foldable electronic device in response to the folding of display device and alteration of the configuration. Additionally, the first signal in the unfolded configuration may provide a control signal to display **303** and the second signal in the folded configuration may provide a control signal to display **304**.

As shown, display **303** is inward-folding and in contrast, display **304** is outward-folding in the sense that display **304** extends across an outer surface of display device **102** and display **303** extends across an inner surface of display device **102**, and fold axis **103** extends along the edge of the outer surface.

Figure 7

A side view of foldable electronic device **101** in the folded configuration of Figure 6 is illustrated in Figure 7. A plurality of force sensing devices **603**, such as for example force sensing devices **401** or **501** are provided and attached along fold axis **103** which extends into the page as shown.

When foldable electronic device **101** is in the folded configuration, the folded surface **701** to which the force sensing devices **603** are attached thereto enables surface **701** to utilised as an additional input control surface. By providing suitably flexible force sensing devices, these can be utilised without false triggering.

In addition, with the force sensing devices positioned on the fold axis **103**, when the foldable electronic device **101** is folded into the folded configuration, the sensitivity of the force sensing device on the folded surface can be taken advantage of.

In the embodiment, force sensing devices **603** are positioned on the rear side of the display device. It is appreciated however, that in alternative embodiments, force sensing devices **603** may be positioned on the front side of the display device to provide a varied function.

While the embodiment also indicates a plurality of force sensing devices, it is appreciated that, in alternative embodiments, a single force sensing device may be utilised, for example, such as a force sensing device as described herein but mounted along the entire length of fold axis **103** of foldable electronic device **101**. Alternatively, a single force sensing device may also be utilised that only exists on part of the length of fold axis **103**. It is anticipated that further alternative embodiments having varying arrangements and numbers of force sensing devices along fold axis **103** may also be provided.

Figure 8

The folded configuration previously described with respect to Figures 6 and 7 is shown further in Figure 8. It is appreciated that, in the unfolded configuration, the display device **102** extends in a single plane such that the

foldable electronic device **101** extends substantially horizontally. As the two halves of the foldable electronic device are brought together by folding along fold axis **103**, the folded configuration is entered and may extend from the zero-degree position of the unfolded configuration to a ninety-degree position in which each of the two halves are brought entirely together, as shown in Figure 8.

In this embodiment, display **303**, being inward-folding, is no longer visible to a user, however, display **304** is visible and is configured to present any required outputs from foldable electronic device **101**. In this embodiment therefore, force sensing devices positioned along edge **302** can be utilised to operate output onto display **304**. In addition, force sensing device **603** can be used along fold axis **103** to provide further output to display **304**.

In particular, it is envisaged that this feature may be suitable to provide further capacity in gaming applications, in which a user may apply a force directly to the folded surface **701** to give an ergonomic response.

CLAIMS

The invention claimed is:

1. A foldable electronic device, comprising:

a display device moveable from an unfolded configuration to a folded configuration in which said display device folds along a fold axis;

a force sensing device responsive to a manual interaction on a surface of said display device; wherein

said force sensing device is positioned on said fold axis of said display device.

2. A foldable electronic device according to claim 1, wherein said foldable electronic device comprises a first display on a front side of said display device, and a second display on a rear side of said display device, said front side being substantially opposite to said rear side.

3. A foldable electronic device according to claim 1 or claim 2, wherein said force sensing device is configured to provide a signal in response to said manual interaction, and

a first signal is provided from said force sensing device when said display device is in said unfolded configuration; and

a second signal is provided from said force sensing device when said display device is in said folded configuration.

4. A foldable electronic device according to claim 3 when dependent on claim 2, wherein said first signal provides a control signal to said first display and said second signal provides a control signal to said second display.

5. A foldable electronic device according to claim 3 or claim 4, wherein said first display is inward-folding and said second display is outward-folding.

6. A foldable electronic device according to any one of claims 2 to 5, wherein said force sensing device is positioned on said front side.

7. A foldable electronic device according to any one of claims 2 to 5, wherein said force sensing device is positioned on said rear side.

8. A foldable electronic device according to any preceding claim, further comprising a further force sensing device, wherein said further force sensing device is positioned on at least one edge of said surface.

9. A foldable electronic device according to any preceding claim, wherein said foldable electronic device comprises a mobile telephone.

10. A foldable electronic device according to any preceding claim, wherein said force sensing device comprises a quantum tunnelling material.

11. A foldable electronic device according to any one of claims 1 to 10, wherein said force sensing device comprises a matrix sensor comprising a plurality of rows and a plurality of columns.

12. A foldable electronic device according to any one of claims 1 to 10, wherein said force sensing device comprises a single point sensor.

13. A foldable electronic device according to any preceding claim, further comprising a plurality of force sensing devices.

14. A method of manufacturing a foldable electronic device, comprising the steps of:

providing a force sensing device responsive to a manual interaction;

attaching said force sensing device to a display device configured to

move from an unfolded configuration to a folded configuration along a fold axis; wherein:

said step of attaching comprises positioning said force sensing device on said fold axis of said display device.

15. A method of manufacturing according to claim 14, wherein said step of attaching comprises attaching said force sensing device to an outer surface of said display device.

16. A method of determining a mechanical interaction in a foldable electronic device, said foldable electronic device comprising a display device and a force sensing device on a surface of said display device, said method comprising the steps of:

folding said display device along a fold axis such that said display device moves from an unfolded configuration to a folded configuration;

applying a manual interaction to said force sensing device positioned on said fold axis.

17. A method of determining a mechanical interaction in a foldable electronic device according to claim 16, further comprising the steps of:

providing a first signal from said force sensing device when said display device is in said unfolded configuration; and

providing a second signal from said force sensing device when said display device is in said folded configuration.

18. A method of determining a mechanical interaction in a foldable electronic device according to claim 16 or claim 17, further comprising the step of:

calculating positional and extent properties of said mechanical interaction by means of said force sensing device.

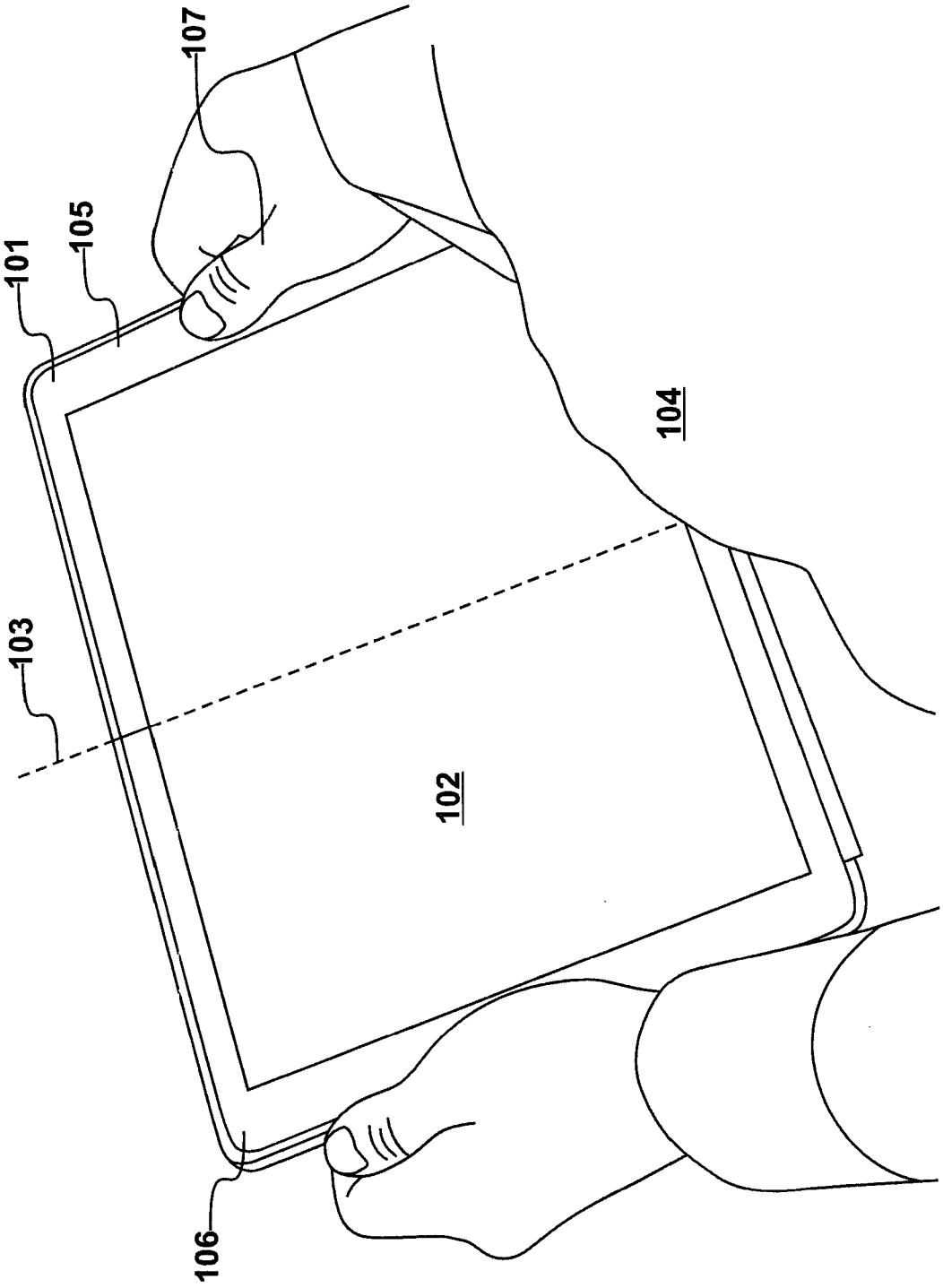

Fig. 1

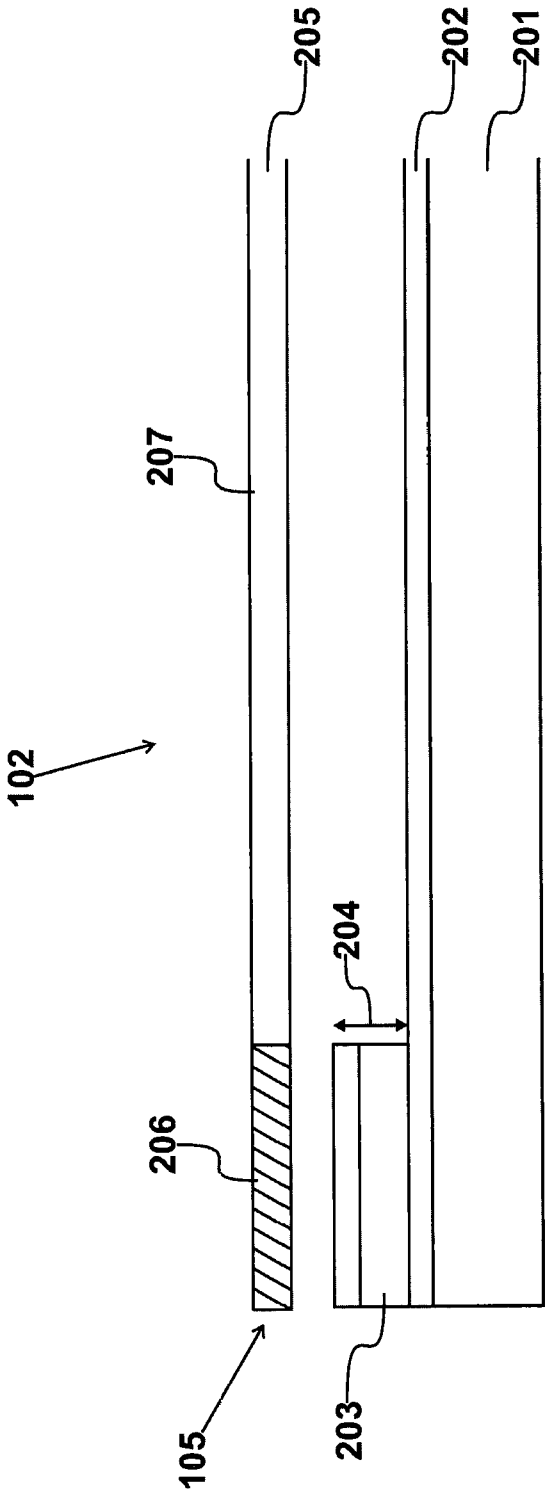

Fig. 2

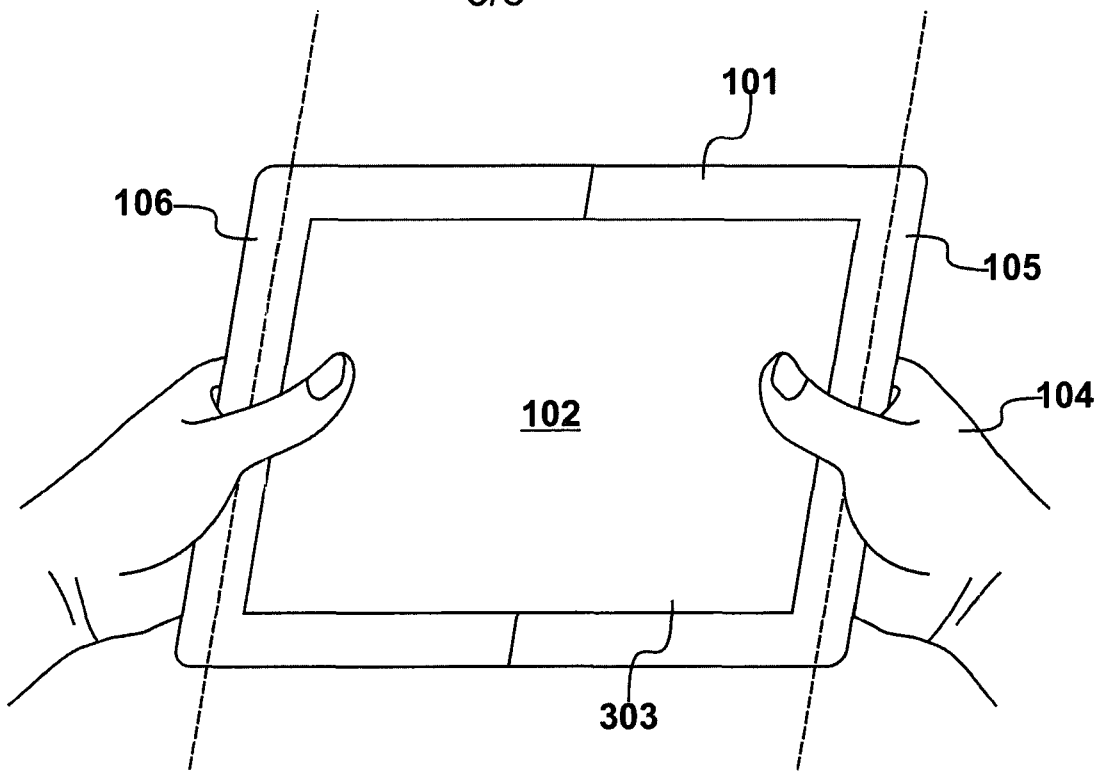

Fig. 3A

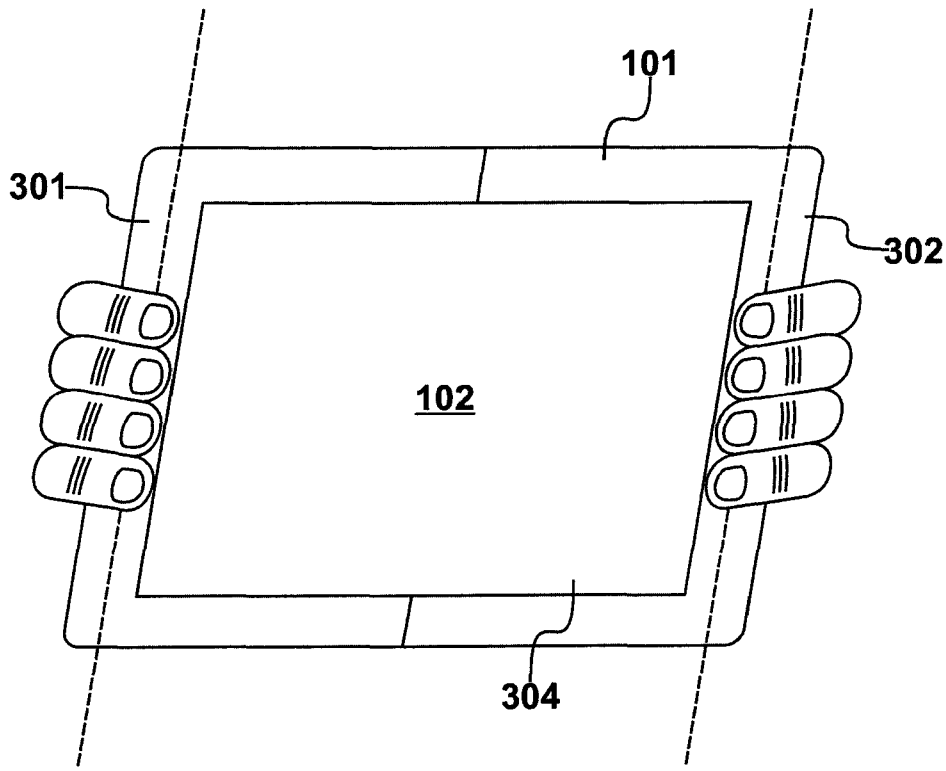

Fig. 3B

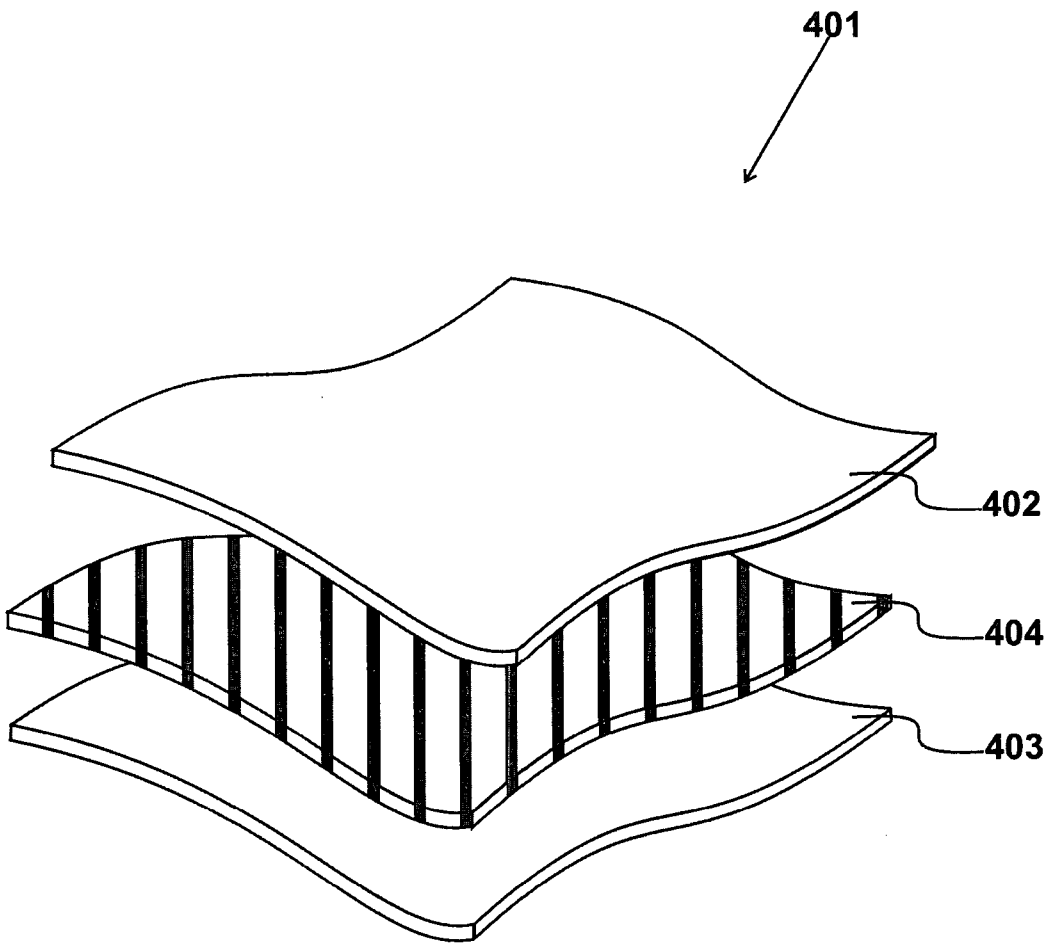

Fig. 4

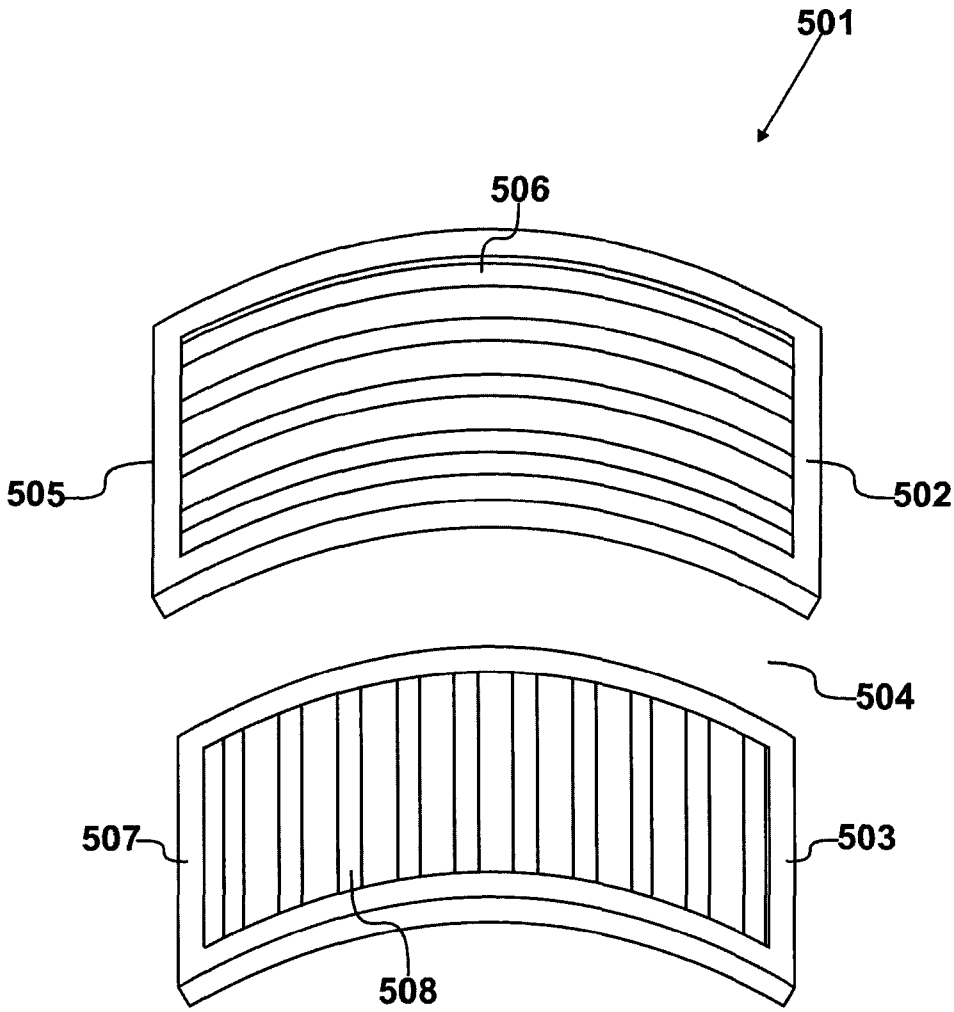

Fig. 5

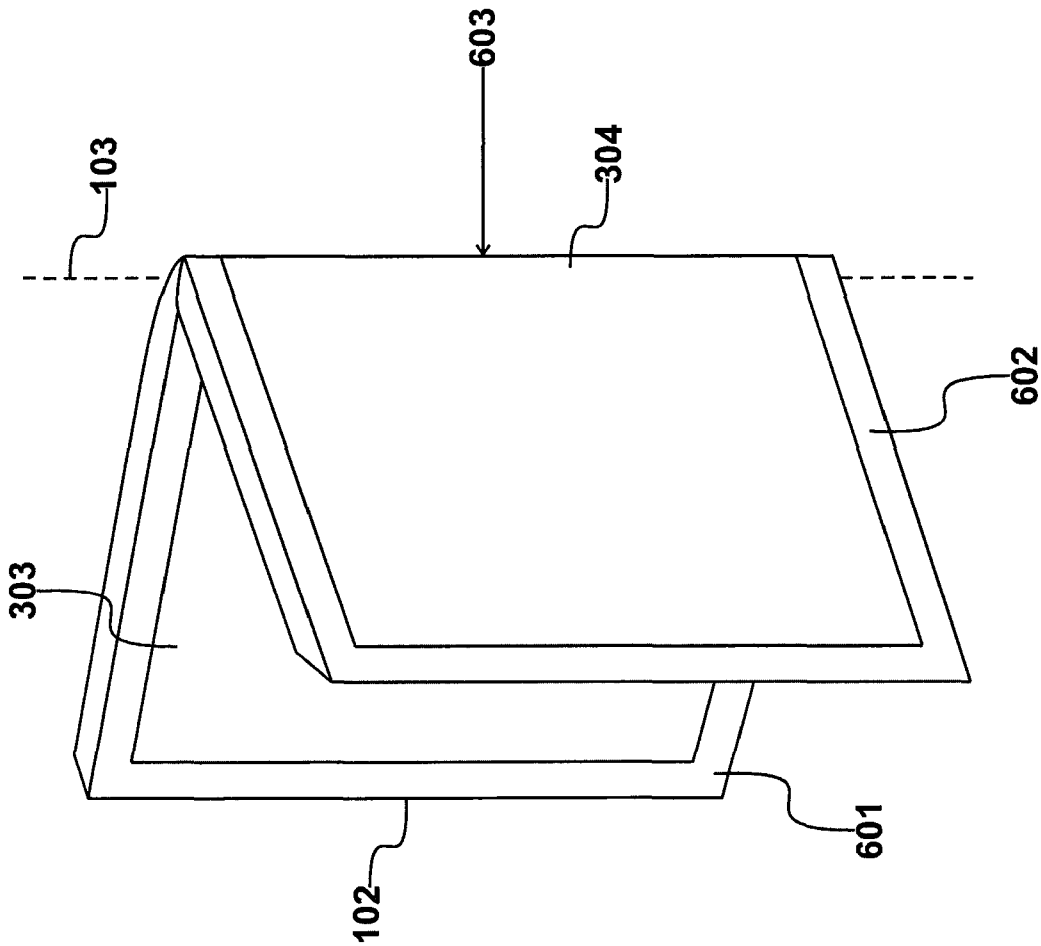

Fig. 6

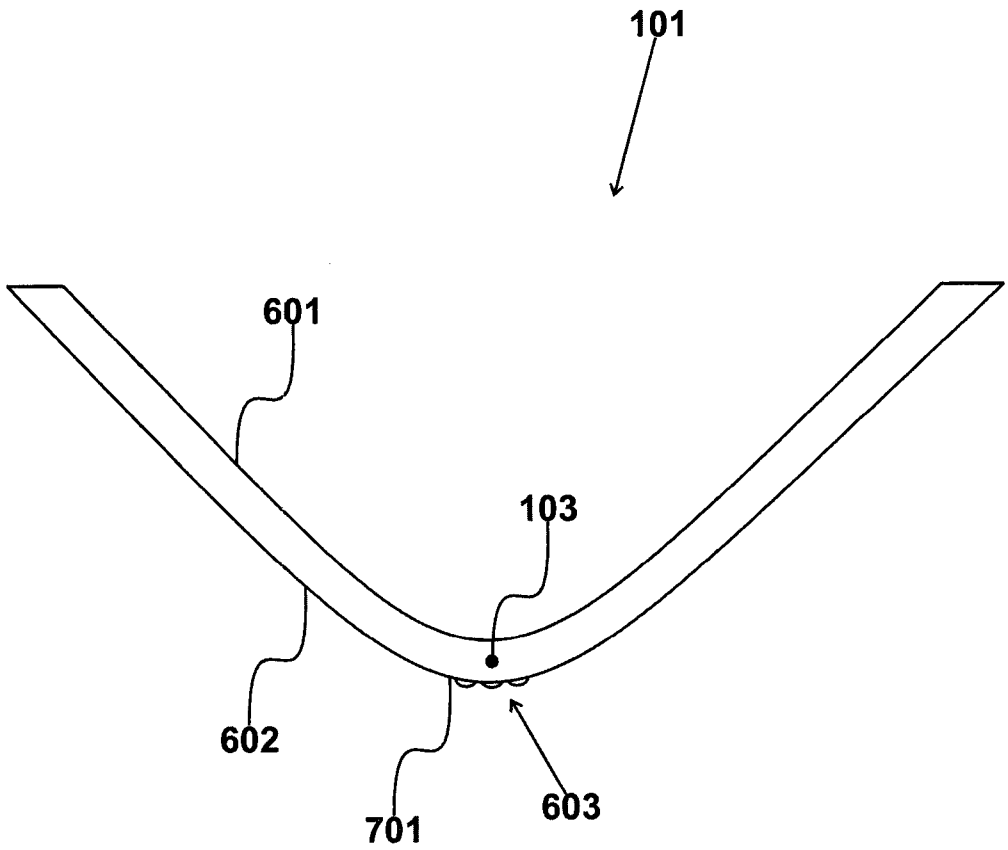

Fig. 7

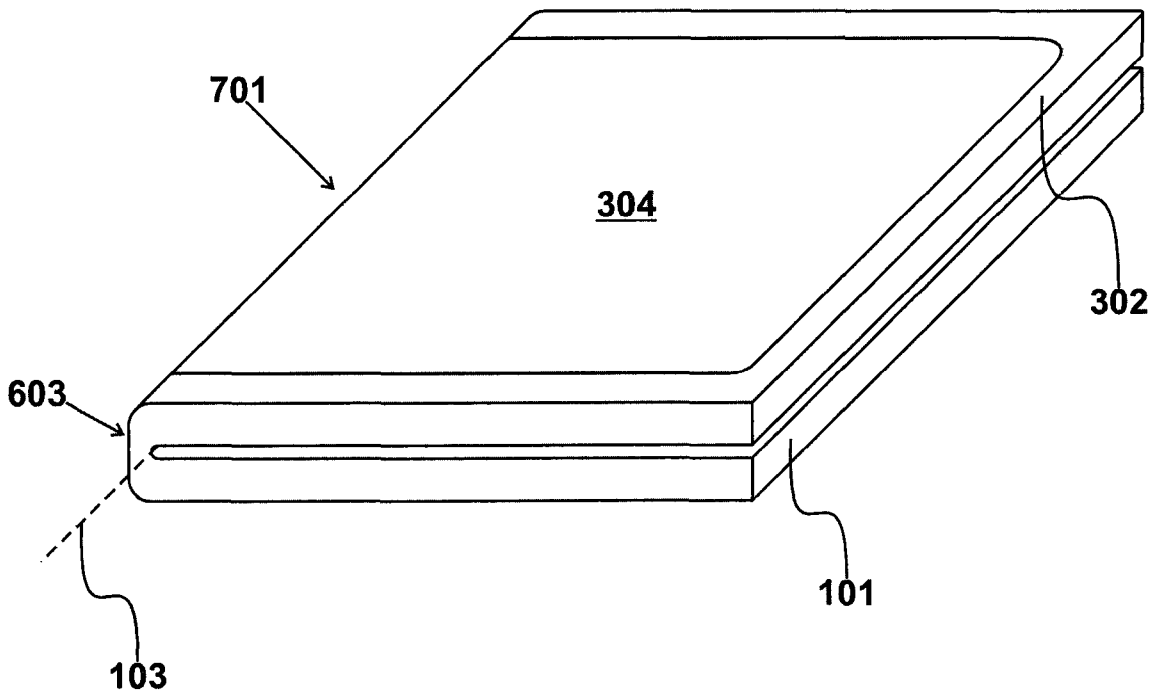

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2020/000025

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F1/16
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

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	US 2010/053073 A1 (COHEN ALEXANDER J [US] ET AL) 4 March 2010 (2010-03-04) paragraphs [0188] - [0193], [0096]; figures 20, 22, 23	1-18
X	US 2016/246559 A1 (JUNG SUNG GON [KR]) 25 August 2016 (2016-08-25) [0029], [0055]-[0056], [0078]-[0079], [0084]; figure 1A to 6	1-18
X	US 9 959 030 B2 (SAMSUNG DISPLAY CO LTD [KR]) 1 May 2018 (2018-05-01) see figs. 1 to 12B, and cf. [0060]-[0072]	1-18
X	US 2016/085319 A1 (KIM SAMSICK [KR] ET AL) 24 March 2016 (2016-03-24) paragraphs [0039] - [0040]; figures 1-18B	1-18

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[X] Further documents are listed in the continuation of Box C.

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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.
X	US 2018/242446 A1 (CHO SHIYUN [KR] ET AL) 23 August 2018 (2018-08-23) the whole document	1-18
X	US 2015/338888 A1 (KIM SO-YOUNG [KR] ET AL) 26 November 2015 (2015-11-26) the whole document	1-18
A	EP 2 196 077 A2 (EADS DEFENCE AND SECURITY SYST [GB]) 16 June 2010 (2010-06-16) paragraph [0021]	10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2020/000025

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010053073 A1	04-03-2010	NONE	
US 2016246559 A1	25-08-2016	KR 20160103599 A	02-09-2016
		US 2016246559 A1	25-08-2016
		US 2017337029 A1	23-11-2017
		US 2019026060 A1	24-01-2019
		US 2020125315 A1	23-04-2020
US 9959030 B2	01-05-2018	CN 105938426 A	14-09-2016
		EP 3065025 A1	07-09-2016
		EP 3480676 A1	08-05-2019
		JP 2016162447 A	05-09-2016
		KR 20160108705 A	20-09-2016
		US 2016259514 A1	08-09-2016
		US 2018246628 A1	30-08-2018
		US 2019155475 A1	23-05-2019
US 2016085319 A1	24-03-2016	CN 105843464 A	10-08-2016
		EP 2998851 A1	23-03-2016
		KR 20160033507 A	28-03-2016
		US 2016085319 A1	24-03-2016
US 2018242446 A1	23-08-2018	CN 108508967 A	07-09-2018
		EP 3367207 A1	29-08-2018
		KR 20180097356 A	31-08-2018
		US 2018242446 A1	23-08-2018
US 2015338888 A1	26-11-2015	EP 2965184 A1	13-01-2016
		US 2015338888 A1	26-11-2015
		WO 2015178714 A1	26-11-2015
EP 2196077 A2	16-06-2010	AT 546036 T	15-03-2012
		EP 2196077 A2	16-06-2010
		GB 2452746 A	18-03-2009
		WO 2009034347 A2	19-03-2009