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HR, HU, ID, IL, IN, IR, IS, IT, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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(54) Title: FLEXIBLE DISPLAY DEVICES WITH A MODULAR RIGID DISPLAY

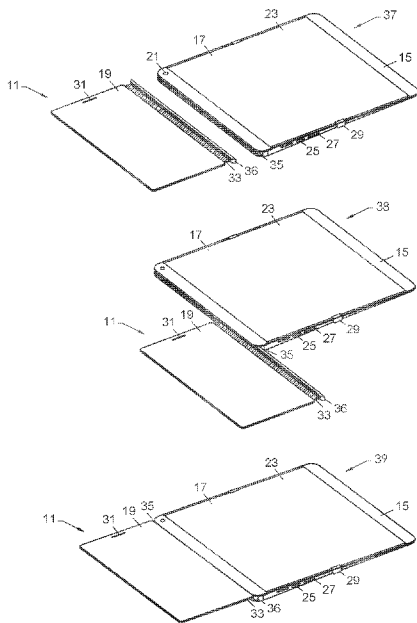
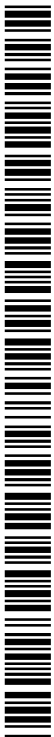


FIG. 1

(57) Abstract: Foldable touch screen display devices with a flexible display including foldable segments to configure from a compact state to an expanded state, and a fold over camera window are described. The form factor of the compact state can be the size of a handheld phone. The form factor of the expanded state can be the size of a tablet computer, and can include the mechanical functionality of a laptop. Both states include an integrated speaker and microphone. The fold over camera window allows symmetrically folding so that edges of each segment are tangent with each other in a fully folded state. The device includes sensors indicating the state of configuration and mechanisms for alignment, locking, and further structural support. A module attached to at least one segment of the flexible display or rigid display contains all processing and memory, and a communications system to be used in any state.



FLEXIBLE DISPLAY DEVICES WITH A MODULAR RIGID DISPLAY

Reference to Related Applications

[0001] The present application claims priority to U.S. Patent Application No. 62/994,161, filed March 24, 2020 and titled "FLEXIBLE DISPLAY DEVICES WITH A MODULAR RIGID DISPLAY," which is incorporated herein by reference in its entirety.

Field of the Invention

[0002] The present invention relates generally to computing devices, and more particularly, to a computing device with a touch screen display that can be folded from a compact state to an expanded state.

Background of the Invention

[0003] The use of handheld computing devices today has been significantly enabled by a number of advancements in electronics, including the miniaturization of components, an increase in processing speeds, improved memory capacity, and the optimization of battery efficiency. Advancements in touch screen display technology have also enabled interfaces to become more adaptable and intuitive to use on a small scale. Because of these enormous improvements over the last decade, the differences in the performance between handheld computing devices, such as mobile phones, and larger computing devices, have become increasingly subtle.

[0004] One of the great difficulties in using a small-scale touch screen device, however, is in the fact that it can often be cumbersome to physically interact with. This is especially apparent when selecting and manipulating features and inputting text, which can sometimes be imprecise for a user. Additionally, in such handheld computing devices as a touch screen mobile phone, the limited size of the display can significantly reduce the viewing capacity while watching videos, using graphic-intensive applications, and reading text. The rigid nature of a standard touch screen display can also limit the portability of a device when its form factor is on the larger size range for a phone, or at the scale of a tablet, which makes folding a desirable feature.

[0005] There is therefore a need for touch screen displays having increased size without sacrificing the convenience of a small device

Summary of Embodiments of the Invention

[0006] To mitigate the difficulties associated with having a single rigid touch screen display device, variations on flexible displays and the implementation of multiple screen displays have been proposed and implemented to enable the transformation of a display from a compact state to an expanded state. Although the use of flexible displays and multiple screen displays offer the advantages of a transformation in scale, there are still a number of limitations as to how they can be implemented. For example, when a flexible display device can fold to a compact state such that it is closed like a book, a rigid display must be integrated on the back side of the device so that the device can be further used as a phone or for notifications depending on how small the device's folded state is. However, having a rigid display on the back side can be extraneous when the flexible display portion of the device is unfolded and being

used. To overcome this limitation, providing modularity and a connection interface between the flexible display and the rigid display to be used within a single device provides greater capacity in terms of folding configurations and use cases, i.e., the flexible display or rigid display can be used within separate standalone devices or integrated together within one device.

[0007] There is a need for a computing device that can retain the form factor and functionality of a phone, while also providing a touch screen display that can be reconfigured from a compact state to an expanded state. Furthermore, there is a need for a foldable device that provides modularity when the device integrates both flexible displays and rigid displays. A modular interface between displays would ultimately bring greater adaptability to such devices.

[0008] Foldable touch screen display devices with a flexible display unit made up of segments that can be reconfigured from a compact state to an expanded state which includes a modular rigid display that may be attached to the flexible display unit is disclosed. The form factor of the compact state is roughly the size of a typical handheld phone or smaller. The form factor of the expanded state is roughly the size of a larger phone or tablet computer, which may also include the mechanical functionality of a laptop. A third state whereby the attached rigid display is folded out such that its top surface is aligned with the top surface of the unfolded flexible display, may provide the use of both displays simultaneously. All folded states may include an integrated speaker and microphone. The devices may further include sensors to indicate the state of configuration and mechanisms for alignment, locking, and structural support. In one embodiment, a module attached to, situated within, or otherwise associated with at least one segment of the flexible display or rigid display may contain all or substantially

all processing and memory, along with a communications system, which may be used in any state.

Brief Description of the Drawings

[0009] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

[0010] FIG. 1 is a diagram showing a rigid display being attached to the flexible display portion of a foldable computing device through a sliding connector interface;

[0011] FIG. 2 is a sectional side view and top view of a locking mechanism and supporting magnetic connections for the sliding connector interface illustrated in FIG. 1

[0012] FIG. 3 is a view of a release button situated on the back side of the interface shown in FIG. 1 and FIG. 2 that unlocks the sliding connector;

[0013] FIG. 4 is a diagram showing three sectional views of the release button and locking mechanism from FIG. 2 and FIG. 3 transitioning from a locked state to an unlocked state;

[0014] FIG. 5 is a perspective view of a folding sequence for the foldable display device illustrated in FIG. 1 transitioning from an unfolded state to a folded state;

[0015] FIG. 6 is a perspective view of one embodiment for a foldable display device with a flexible display portion shown detached and then attached to a modular rigid display portion having interface tabs and a sliding connector;

[0016] FIG. 7 is a perspective view of one embodiment for a foldable display device with a flexible display portion shown detached and then attached to a modular rigid display having flat interface pads and a sliding connector;

[0017] FIG. 8 is a perspective view of one embodiment for a foldable display device with a flexible display portion shown detached and then attached to a modular rigid display having interface tabs;

[0018] FIG. 9 is a perspective view of one embodiment for a foldable display device with a flexible display portion shown detached and then attached to a modular rigid display having flat interface pads;

[0019] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

Detailed Description of the Embodiments

[0020] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0021] Although embodiments of the invention are not limited in this regard, discussions utilizing terms such as, for example, “processing,” “computing,” “calculating,”

“determining,” “establishing,” “analyzing,” “checking,” or the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulates and/or transforms data represented as physical (e.g., electronic) quantities within the computer's registers and/or memories into other data similarly represented as physical quantities within the computer's registers and/or memories or other information non-transitory storage medium that may store instructions to perform operations and/or processes. Although embodiments of the invention are not limited in this regard, the terms “plurality” and “a plurality” as used herein may include, for example, “multiple” or “two or more”. The terms “plurality” or “a plurality” may be used throughout the specification to describe two or more components, devices, elements, units, parameters, or the like. Unless explicitly stated, the method embodiments described herein are not constrained to a particular order or sequence. Additionally, some of the described method embodiments or elements thereof can occur or be performed simultaneously, at the same point in time, or concurrently.

[0022] In accordance with the exemplary embodiment shown in FIG. 1, a foldable computing device **15** is shown with a single flexible display made up of a first flexible display segment **17** and a second flexible display segment **23** that can both fold flat against each other through hinge **29**, which is situated below and in between both segments. The diagram of FIG. 1 further illustrates a rigid display module **11** being attached to the left side of first flexible display segment shown with foldable computing device **15** through sliding channel interface **35**. The top image shows rigid display module **11** detached from foldable computing device **15**, while the middle image shows rigid display module **11** slid partially into sliding channel interface **35** on the left side of foldable computing device **15**. Rigid display module **11** is then shown in the

bottom image fully engaged with foldable computing device **15**. Rigid display module **11** is made up of rigid display **19** and a speaker opening **31**. Sliding connector **36** is attached to rigid display **11** through a flexible material **33** which allows rigid display **11** to fold along the edge of foldable device **15** when sliding connector **36** is attached to sliding channel interface **35**. Flexible material **33** could also be replaced with a rigid mechanism that might be hinged together in sections, or through other means, so that rigid display **11** can be folded from the position it is shown in FIG. 1, to the back side of foldable device **15** which is further illustrated in FIG. 5. A peripheral port **25** is situated at the bottom of foldable device **15** along with speaker and microphone openings **27**. It is important to note that the sliding channel interface and the sliding connector could be swapped such that the sliding channel interface is integrated along the edge of rigid display module **11** while the sliding connector is integrated along the edge of foldable computing device **15**.

[0023] To elaborate on sliding channel interface **35** and sliding connector **36** which engages with it, FIG. 2 illustrates a sectional detailed view of this configuration and the locking mechanism **57** that locks sliding connector **36** within sliding channel interface **35**. Ultimately, for locking mechanism **57** to hold sliding connector in place, a spring **65** which surrounds post **63** attached with locking mechanism **57** forces it forward to engage with opening **55** where interface pins for communicating data and transferring power between rigid display module **11** and foldable computing device **15**. Magnet **51**, which is attached to sliding connector **36** connects with magnet **53**, which is attached to the inside of sliding channel interface **35** to allow both parts to be coupled together when sliding connector **36** is slid within sliding channel interface **35**. Magnets are shown populated throughout each side of the interface next to magnet **51** and magnet **53** to allow for greater connection strength between sliding connector

36 and sliding channel interface **35**. Release button **59** is attached to locking mechanism **57** so that it can be accessed by a user of the device from the bottom side of the folding computing device **15**. Release button **59** is also shown on the bottom side of folding computing device **15** in FIG. 3 where it is situated within a channel so that it can slide inward to release sliding connector **36**. FIG. 4 further illustrates locking mechanism **57** with three sectional drawings of the locking sequence. The top section shows the device in a locked state where locking mechanism **57** is engaged with opening **55** from sliding connector **35** allowing the two parts to be in a fixed position. In the middle sectional drawing, release button **59** and locking mechanism are shown in a retracted position which releases sliding connector **35** so that it can freely slide inward or outward to be attached or detached from foldable computing device **15**. The final sectional drawing at the bottom of FIG. 4 shows sliding connector **35** repositioned to illustrate how it is free to slide outward so that rigid display module **11** can be fully unlocked and detached. It should be noted that while rigid display module **11** is shown as a separate component that is being attached to mobile computing device **15** which contains the flexible display, core electronics, and peripheral interfaces of the device, rigid display module **11** may carry the core electronics and peripherals of the device with the flexible display acting as the module instead. Sliding connector **35** could also be used implemented to attach to foldable mobile device **15** such that it doesn't require a sliding mechanism. It could instead simply plug into the side of foldable mobile device **15** or connect to it with magnets and interface pads.

[0024] In accordance with the exemplary embodiment shown in FIG. 5, position **81** shows foldable computing device **15** situated with rigid display module **11** in a similar position as shown in the final embodiment of FIG. 1 where both parts are attached with each other and fully unfolded. This shows how rigid display module **11** can be situated in an unfolded position

so that both rigid display **19** and the flexible display with its segments **21** and **17** from foldable mobile device **15** can be used simultaneously. Positions **83** and **85** show rigid display module **11** folded to the back side of the device, while positions **87** and **89** show the full assembly and flexible display segments **21** and **17** being folded flat against each other such that rigid display **19** from rigid display module **11** can be used as the core display when the device is being used as a handheld phone. This concept is further illustrated in FIGS. 6-9 where each embodiment shows a different interface for modular rigid display **11**. In FIG. 6, the embodiment for foldable computing device **15** with an integrated flexible display is shown detached in the top drawing and then attached to modular rigid display **11** in the bottom drawing, which in this case has interface tabs **75** and **77** that connect to slots **93** and **95** and a sliding connector **35**. In FIG. 7 the sequence is shown, but in this case modular rigid display **11** is illustrated having flat interface pads **97** that connects to flat interface pads **95** while sliding connector **35** engages with sliding channel interface **36** on foldable mobile device **15**. In FIG. 8 the same sequence is shown again but modular rigid display **11** uses only interface tabs **75** and **77** to attach to slots **93** and **95** on the back side of foldable computing device **15**, but doesn't include sliding connector **35**. Finally, in FIG. 9, rigid display module is shown having flat interface pads **97** that connect to flat interface pads **95** from the back side **73** of foldable computing device **15**. Pins may also be used to make the electrical connection between the rigid display module and the flexible display portion. Additionally, camera **90** situated on back side **73** of foldable computing device **15**, is able to penetrate a transparent window that sits along the surface of rigid display **19** when it is folded flat and integrated with foldable computing device **15**, which is the same case for each embodiment shown in FIGS. 6-9. It is important to note that the rigid display module in each embodiment can also communicate with the flexible display device's primary electronics

through a wireless connection, such as with Bluetooth, rather than a physical electronic connection.

[0025] The flexible display integrated with foldable computing device 15 may also be implemented with different aspect ratios beyond what is shown in the drawings and through different types of flexible display technologies. The ratios may include ranges that would result in a rectangular unfolded state shape when flexible display segments 17 and 23 are approximately square in shape, and a square unfolded state shape, when flexible display 17 and 23 segments are rectangular in shape, as shown in the drawings. These aspect ratios may range from approximately 22:9 to 1:1 and are applicable to the full flexible display, the segments that make up the flexible display, and the rigid display as well. The flexible display technology may include, but is not limited to OLED, Mini-LED, and Micro-LED technology.

Claims

What is claimed is:

1. An apparatus comprising:
 - (a) a rigid touch-sensitive display;
 - (b) a flexible touch-sensitive display comprising a first flexible touch-sensitive display component and a second flexible touch-sensitive display component;wherein:
 - (1) the first flexible touch-sensitive display component is attached to a first structural support segment;
 - (2) the second flexible touch-sensitive display component is attached to a second structural support segment;
 - (3) the flexible touch-sensitive display further comprises having a fully folded state;
 - (4) the flexible touch-sensitive display further comprises having a partially expanded state;
 - (5) the flexible touch-sensitive display further comprises having a fully expanded state;
 - (c) a first connection interface integrated with the first structural support or the second structural support, and a second connection interface integrated with the rigid touch-sensitive display, wherein the first connection interface and the second connection interface can be attached and detached from each other.

2. The apparatus of claim 1 wherein:

the first connection interface and the second connection interface can be attached to each other through magnets.

3. The apparatus of claim 1 wherein:
the first connection interface and the second connection interface can be attached to each other through a tab and a slot where the tab is situated on one interface such that it can engage with a slot situated on the other interface.
4. The apparatus of claim 1 wherein:
the first connection interface and the second connection interface can be attached to each other through a locking mechanism.
5. The apparatus of claim 4 wherein:
the locking mechanism comprises a spring-loaded release button.
6. The apparatus of claim 1 wherein:
the first connection interface and the second connection interface provide an electrical connection between each other once they are attached.
7. The apparatus of claim 6 wherein:
the first connection interface and the second connection interface provide an electrical connection between each other through conductive pads once they are attached.
8. The apparatus of claim 6 wherein:
the first connection interface and the second connection interface provide an electrical connection between each other once they are attached through conductive pins.
9. The apparatus of claim 1 wherein:

the rigid touch-sensitive display and the flexible touch-sensitive display and their supporting electronics can communicate with each other through a wireless connection.

10. The apparatus of claim 1 wherein:

the fully folded state comprises a fully folded angle between the first flexible touch-sensitive display component and the second flexible touch-sensitive display component that is less than 10 degrees; and

the fully expanded state comprises a fully expanded angle between the first flexible touch-sensitive display component and the second flexible touch-sensitive display component that is between 170 and 190 degrees; and

the partially expanded state comprises an angle that falls between the fully folded state and the fully expanded state.

11. The apparatus of claim 1 wherein:

the first connection interface is situated along at least one edge of the flexible touch-sensitive display's first structural support or second structural support; and

the second connection interface is situated along at least one edge of the rigid touch-sensitive display.

12. The apparatus of claim 11 wherein:

the first connection interface is comprised of a channel situated along the edge of the flexible touch sensitive display's first structural support or the second structural support; and

the second connection interface is comprised of a sliding connector that can slide within the channel such that the structural segment of the flexible touch-sensitive display can be attached to the edge of the rigid touch-sensitive display.

13. The apparatus of claim 11 wherein:

the second connection interface is comprised of a channel situated along the edge of the rigid touch-sensitive display; and

the first connection interface is comprised of a sliding connector that can slide within the channel such that the edge of the rigid touch-sensitive display can be attached to the flexible touch-sensitive display's first structural segment or second structural segment.

14. The apparatus of claim 11 wherein:

a flexible material is situated between the second connection interface and the edge of the rigid touch-sensitive display such that when the second connection interface is attached to the first connection interface, the rigid touch-sensitive display can rotate about edge of the flexible touch-sensitive display structural segment edge.

15. The apparatus of claim 11 wherein:

a flexible material is situated between the first connection interface and the edge of the of the flexible touch-sensitive display structural segment such that when the second connection interface is attached to the first connection interface, the rigid touch-sensitive display can rotate about the edge of the flexible touch-sensitive display structural segment edge.

16. The apparatus of claim 11 wherein:
a mechanism is situated between the second connection interface and the edge of the rigid touch-sensitive display such that when the second connection interface is attached to the first connection interface, the rigid touch-sensitive display can rotate about edge of the flexible touch-sensitive display structural segment edge.

17. The apparatus of claim 11 wherein:
a mechanism is situated between the first connection interface and the edge of the of the flexible touch-sensitive display structural segment such that when the second connection interface is attached to the first connection interface, the rigid touch-sensitive display can rotate about the edge of the flexible touch-sensitive display structural segment edge.

18. The apparatus of claim 1 wherein:
the first connection interface is situated along the back side of the flexible touch-sensitive display's first structural support or second structural support; and
the second connection interface is situated along the back side of the rigid touch-sensitive display.

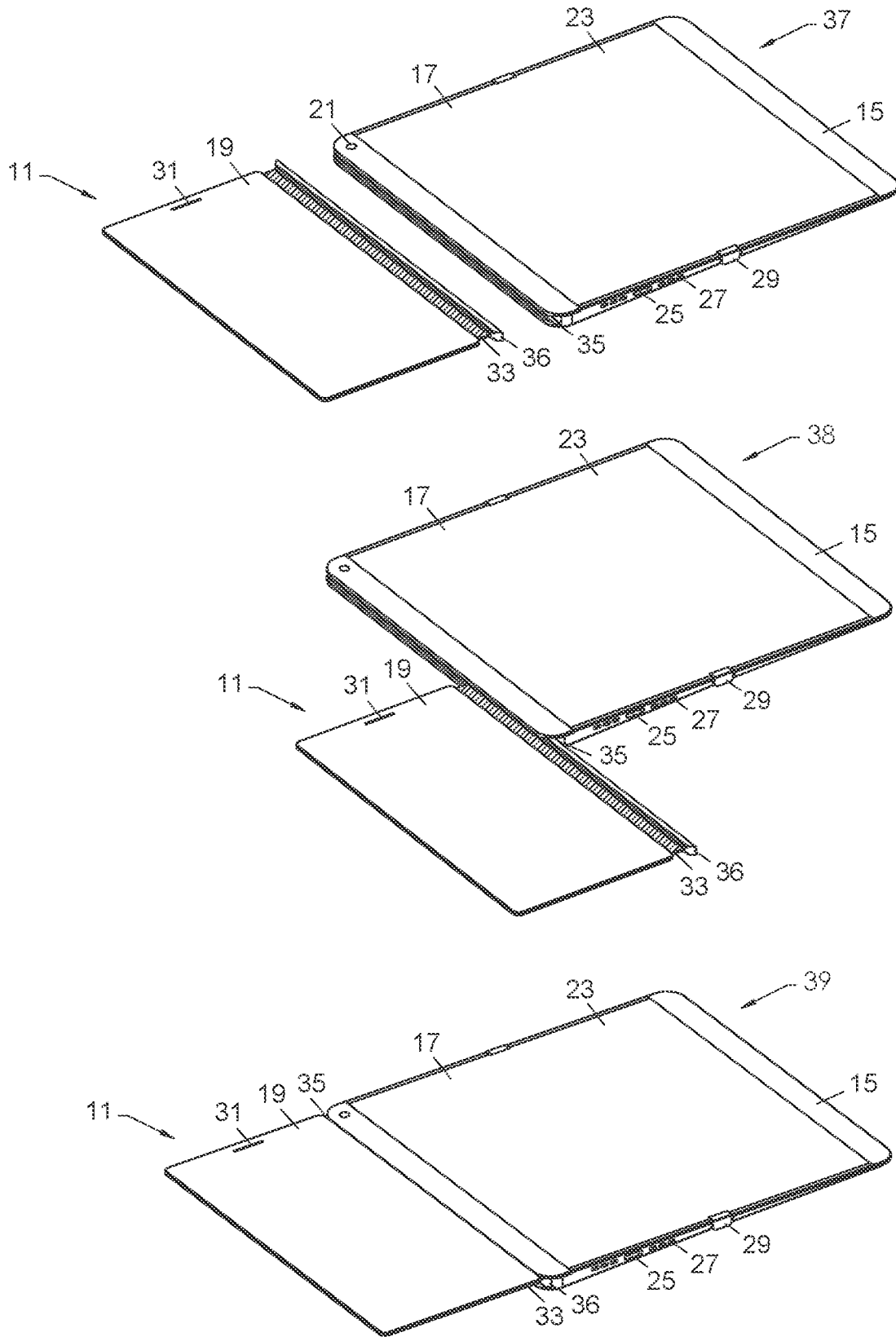


FIG. 1

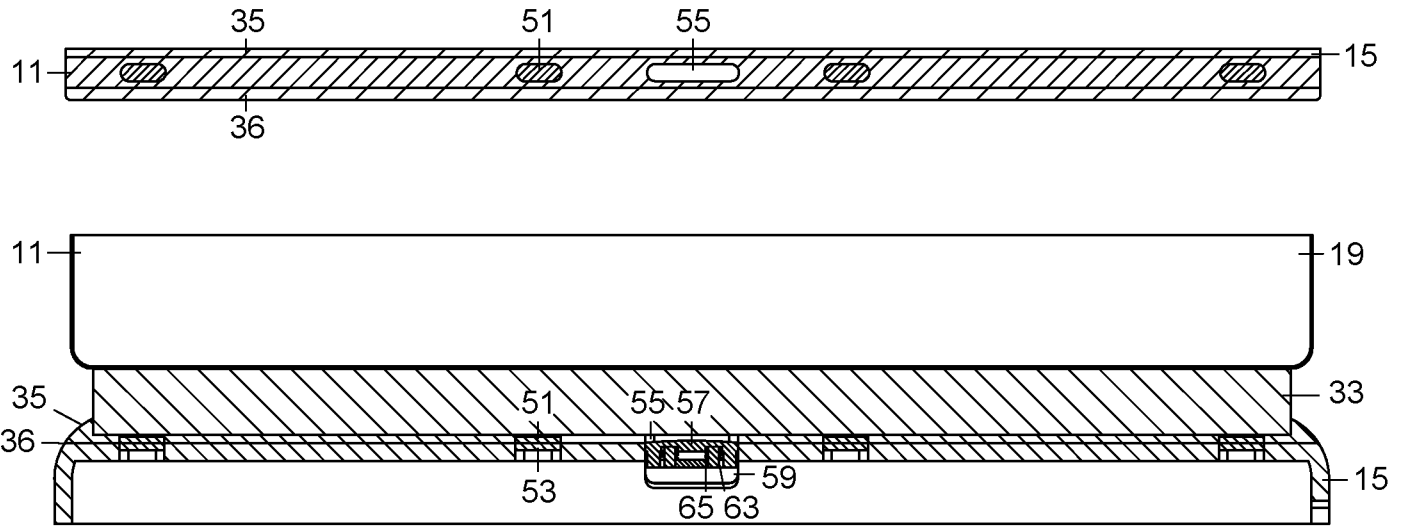


FIG. 2

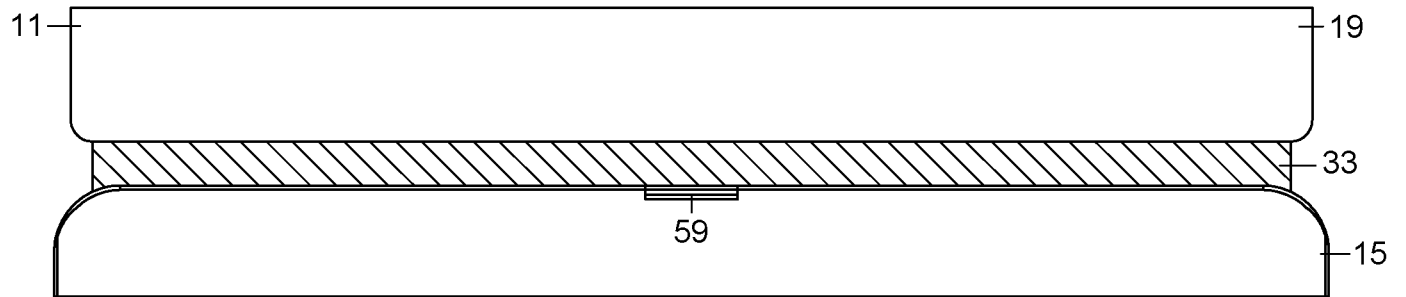


FIG. 3

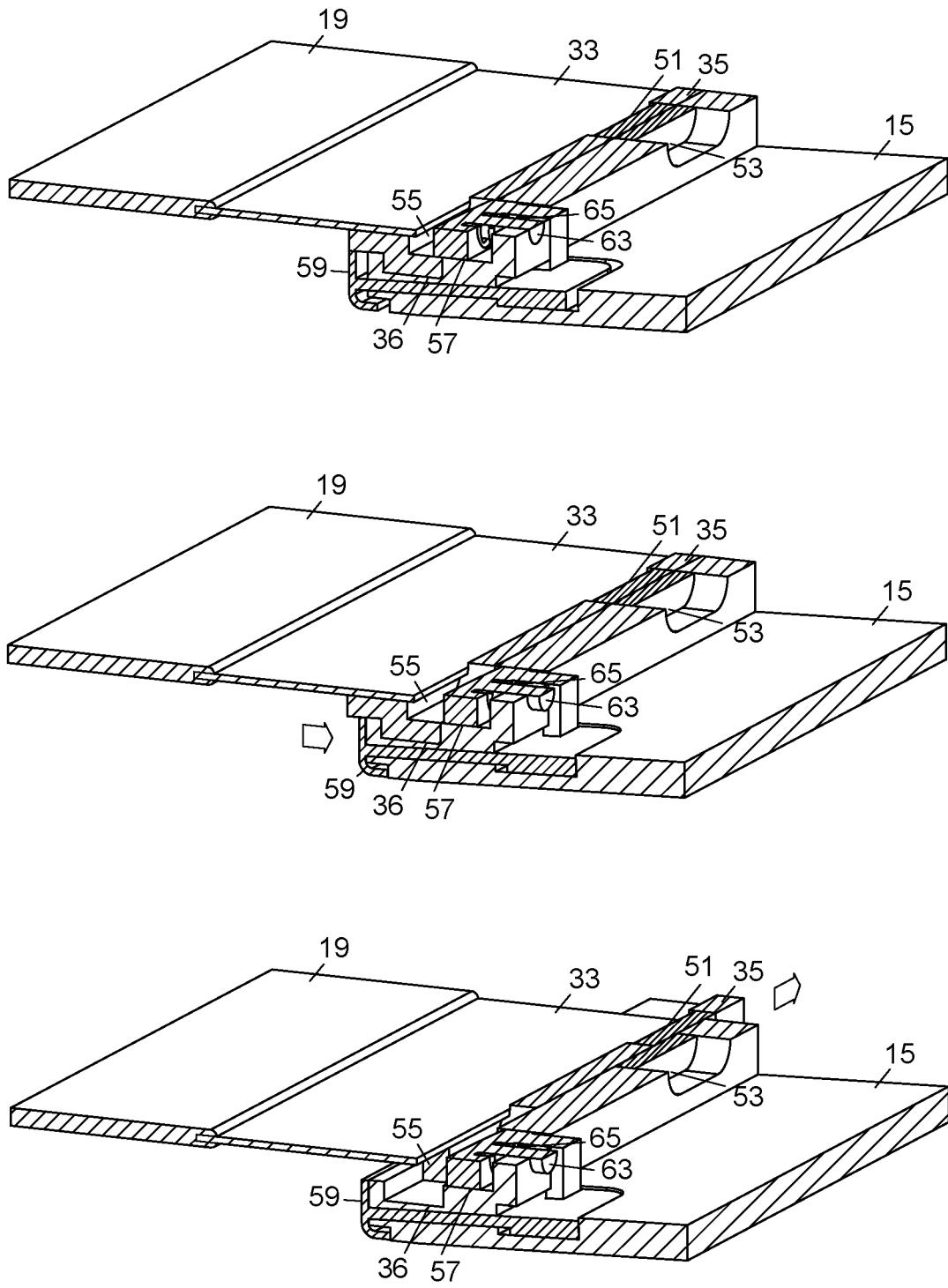


FIG. 4

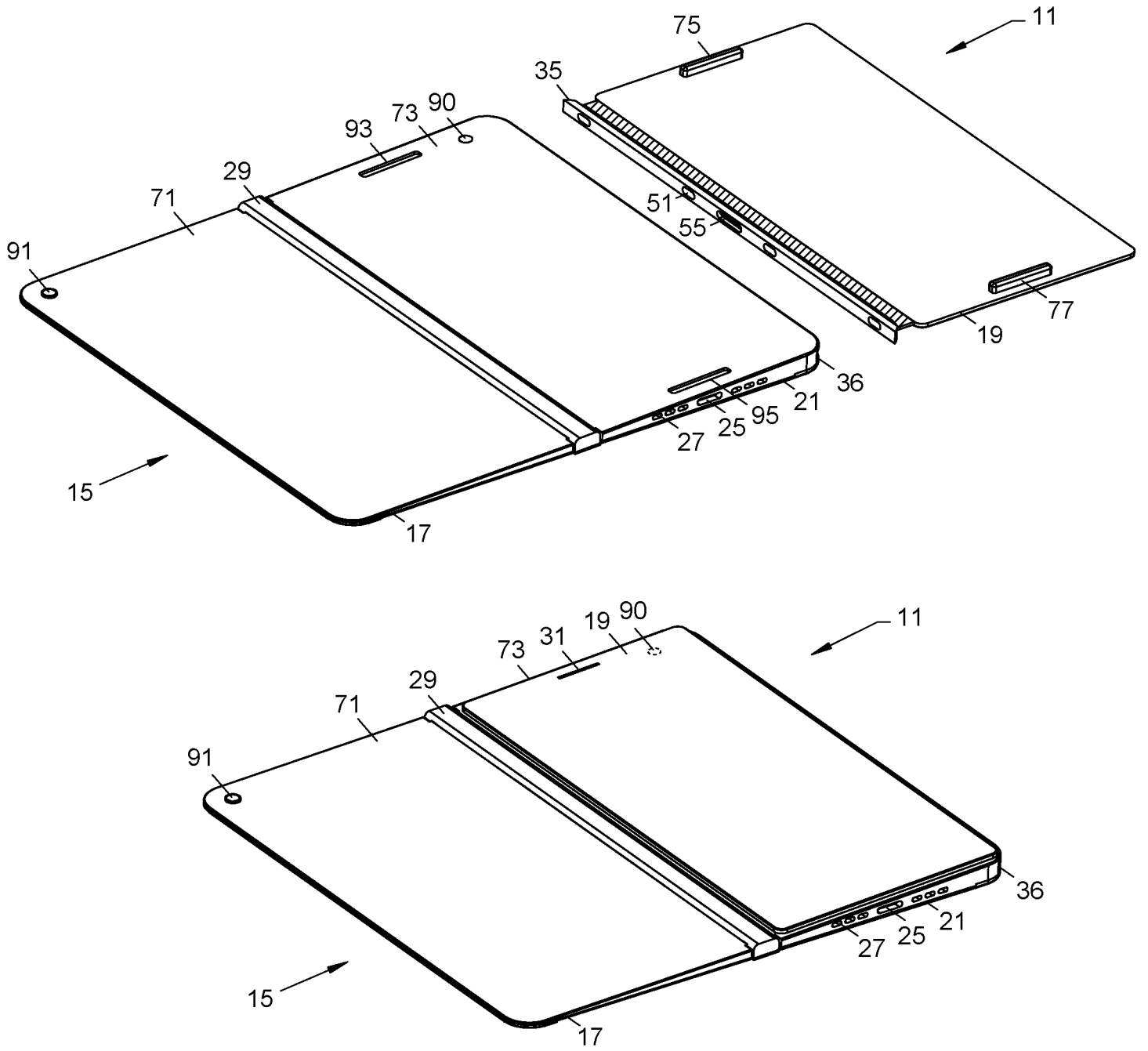


FIG. 6

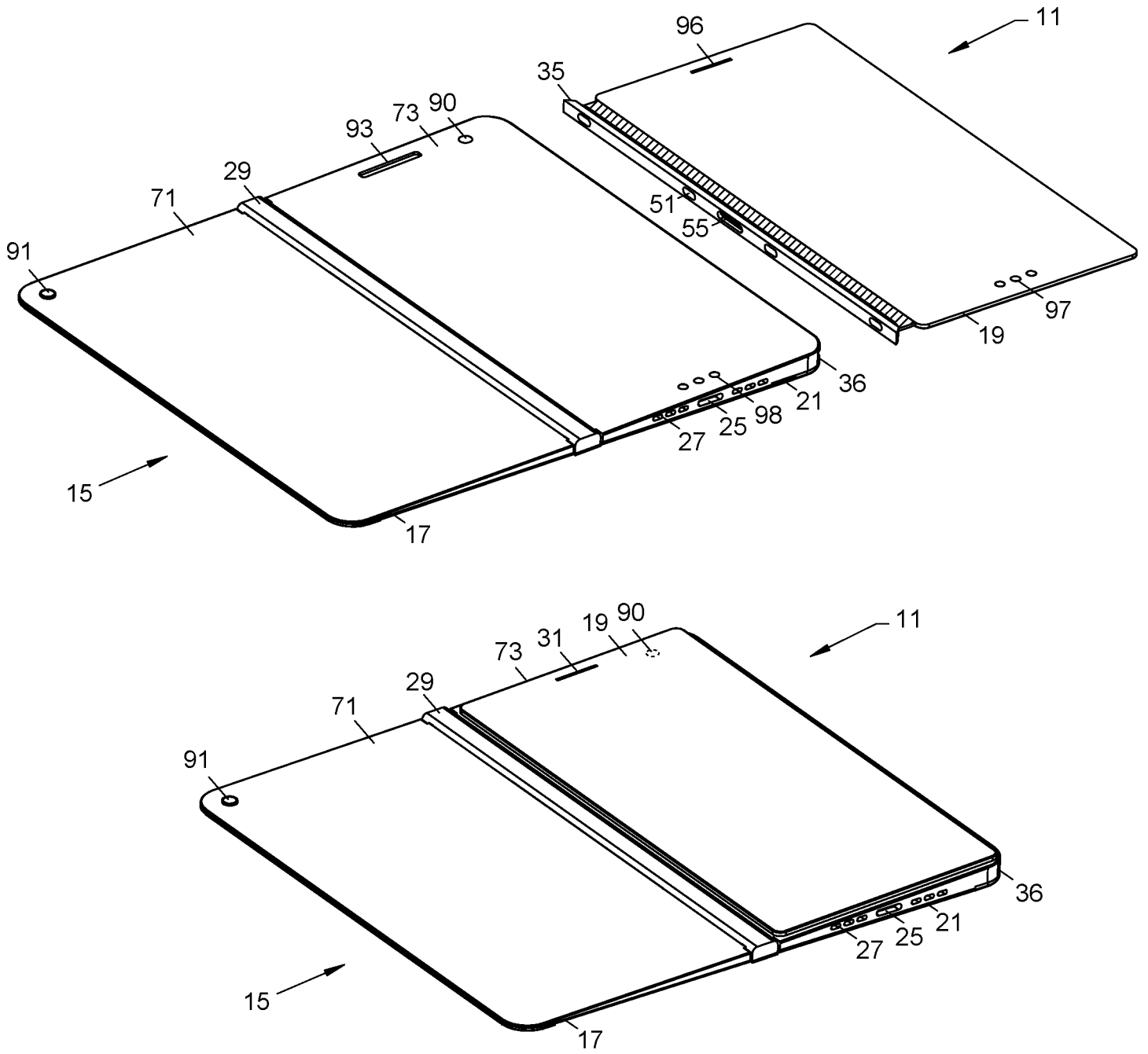


FIG. 7

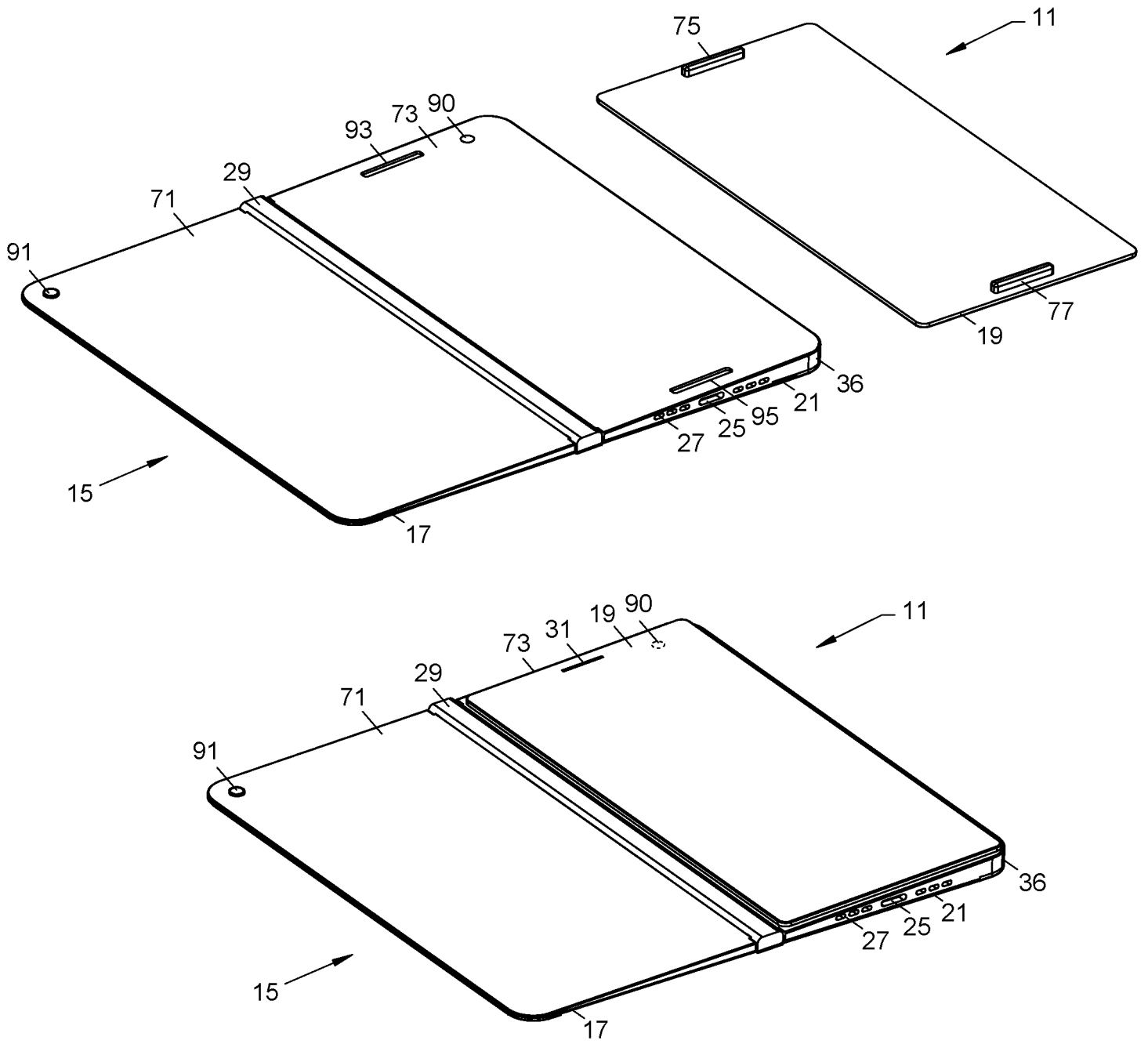


FIG. 8

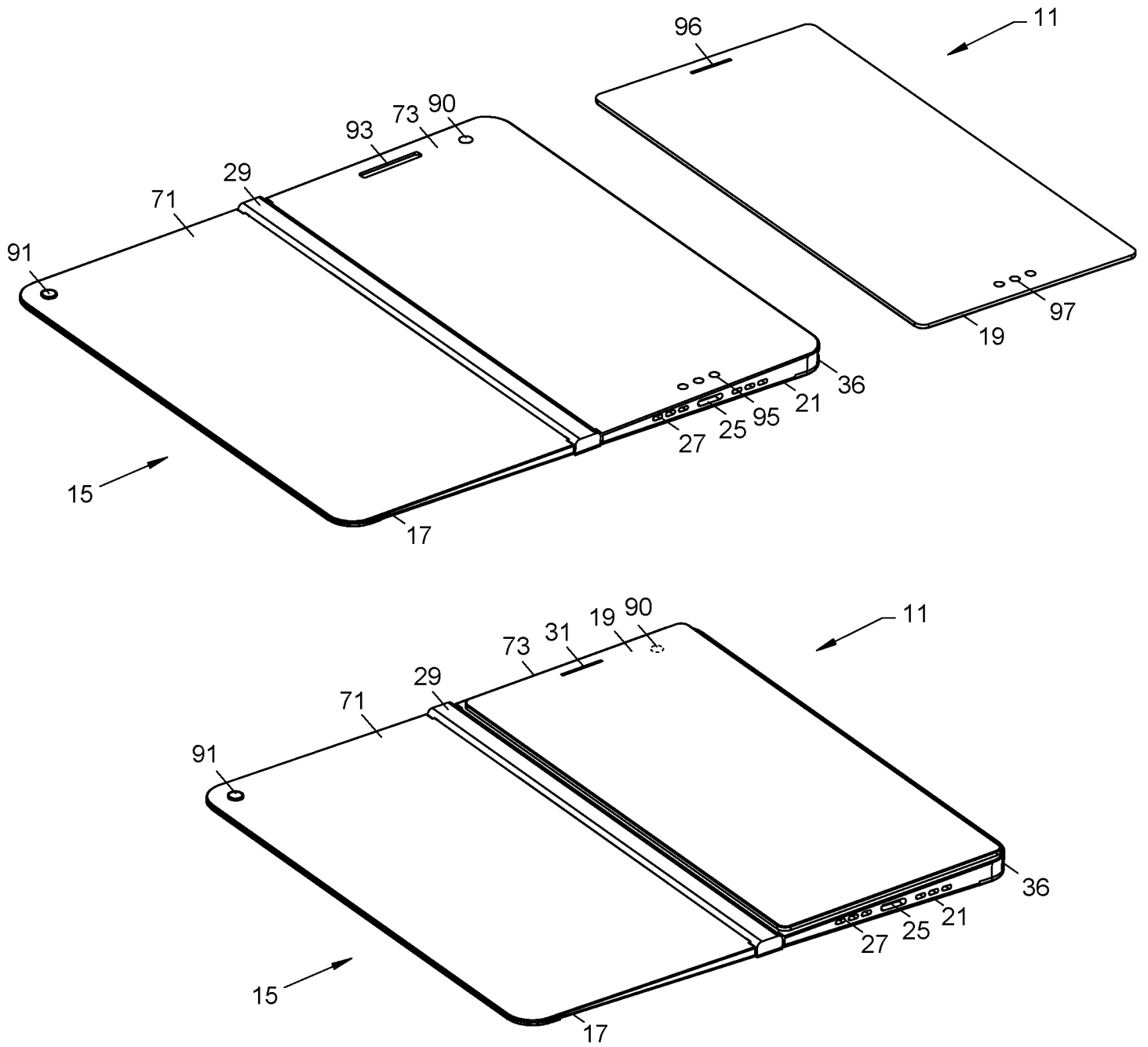


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/023992

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G06F 1/16; G06F 1/00; G06F 3/00; G06F 3/03 (2021.01)
CPC - G06F 1/16; G06F 1/00; G06F 1/1601; G06F 1/1616; G06F 1/162; G06F 1/1641; G06F 1/1643; G06F 1/1679; G06F 1/1683; G06F 3/00; G06F 3/03 (2021.05)

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)

see Search History document

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

see Search History document

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

see Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2020/0012318 A1 (LEPTON COMPUTING LLC) 09 January 2020 (09.01.2020) entire document	1-18
A	US 2003/0071832 A1 (BRANSON) 17 April 2003 (17.04.2003) entire document	1-18
A	US 2010/0060664 A1 (KILPATRICK, II et al) 11 March 2010 (11.03.2010) entire document	1-18
A	US 2003/0160735 A1 (LEE et al) 28 August 2003 (28.08.2003) entire document	1-18
E	US 2021/0132660 A1 (LEPTON COMPUTING LLC) 06 May 2021 (06.05.2021) entire document	1-18

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

27 May 2021

Date of mailing of the international search report

JUN 25 2021

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