PTO/SB/80 (11-08)
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I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

☑ Practitioners associated with the Customer Number: 12323

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

☑ The address associated with Customer Number: 12323

OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address:

Atmel Corporation
2325 Orchard Parkway
San Jose, CA 95131

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	1/13/11
Name	Scott Wornow	Telephone	408-436-4229
Title	Senior Vice President and Chief Legal Officer		

This collection of information is required by 37 CFR 1.31, 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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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.

PTO/SB/96 (07-09)
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Harald Philipp 080900.1118

Application No./Patent No.: Unknown Filed/Issue Date: Herewith

Titled: Capacitive Position Sensor

Atmel Corporation , a Delaware corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] the assignee of the entire right, title, and interest in;

2. [ ] an assignee of less than the entire right, title, and interest in (The extent (by percentage) of its ownership interest is _____ %); or

3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. [ ] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy therefore is attached.

OR

B. [X] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Harald Philipp To: QRG Limited

The document was recorded in the United States Patent and Trademark Office at
Reel 021791 , Frame 0040 , or for which a copy thereof is attached.

2. From: QRG Limted To: Atmel Corporation

The document was recorded in the United States Patent and Trademark Office at
Reel 022608 , Frame 0130 , or for which a copy thereof is attached.

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____ , Frame _____ , or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[ ] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/travis w. thomas/ REG. NO. 48667 — Signature

27 May 2011 — Date

Travis W. Thomas — Printed or Typed Name

Attorney of Record — Title

This collection of information is required by 37 CFR 3.73(b). 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 12 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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Privacy Act Statement

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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

First Named Inventor:	Harald Philipp
Application No.:	Unassigned
Filing Date:	Herewith
Confirmation No.:	Unassigned
Title:	*Capacitive Position Sensor*

Information Disclosure Statement

Applicant submits this Information Disclosure Statement under 37 C.F.R. § 1.97(b)(3). Applicant respectfully requests the Examiner to consider and cite in the examination of this Application the documents listed in the attached Form PTO/SB/08. This Application is a continuing application under 35 U.S.C. § 120 of U.S. Patent Application No. 12/703614, filed 10 February 2010. Under 37 C.F.R. § 1.98(d), Applicant has not provided copies of references previously submitted to or cited by the Office in U.S. Patent Application No. 12/703614. Moreover, under 37 C.F.R. § 1.98(a)(2)(ii), Applicant has not provided copies of U.S. patents and U.S. patent application publications.

Under 37 C.F.R. § 1.97(g), the filing of this IDS shall not be construed as a representation that a search has been made. Moreover, under 37 C.F.R. § 1.97(h), the filing of this IDS shall not be construed to be an admission that the information cited in this IDS is or is considered to be material to patentability as defined by 37 C.F.R. §1.56(b). Furthermore, the filing of this IDS shall not be construed to be an admission that any information cited in this IDS is or is considered to be prior art under 35 U.S.C. §§ 102-103.

The Commissioner may charge any fee due and credit any overpayment in this Application to Deposit Account No. 02-0384 of Baker Botts L.L.P.

Respectfully submitted,

BAKER BOTTS L.L.P.
Attorneys for Applicant

Travis Thomas
Reg. No. 48,667

Date: 27 May 2011

PTO/SB/08 **INFORMATION DISCLOSURE STATEMENT BY APPLICANT**	**Application Number:** Unassigned		**First Named Inventor:** Harald Philipp
	Attorney Docket No: 080900.1118	**Art Unit:** Unassigned	**Filing Date:** Herewith

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**FIRST NAMED INVENTOR**
	A	4,121,204	10-17-1978	Welch et al.
	B	4,264,903	04-28-1981	Bigelow
	C	2003/0043174	03-06-2003	Hinckley et al.
	D	2004/0027395	02-12-2004	Lection et al.
	E	2004/0196267	10-07-2004	Kawai et al.
	F	2004/0207605	10-21-2004	Mackey
	G	2005/0052429	03-10-2005	Philipp
	H	2005/0078027	04-14-2005	Philipp
	I	2006/0016800	01-26-2006	Paradiso et al.
	J	2008/0094077	04-24-2008	Philipp
	K	2009/0051660	02-26-2009	Feland et al.
	L	2009/0115431	05-07-2009	Philipp

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**COUNTRY**	**TRANSLATION (YES OR NO)**
	M	19645907 A1	05-20-1998	DE	
	N	19903300 A1	08-05-1999	DE	
	O	10133135 A1	01-30-2003	DE	
	P	10313401 A1	10-07-2004	DE	
	Q	212004000044 U1	06/07/2006	DE	
	R	102005002952 A1	07-27-2006	DE	
	S	102005018298 A1	10-19-2006	DE	
	T	1273851 A2	01-08-2003	EP	
	U	1602882 A1	12/07/2005	EP	
	V	2443296 A	04-30-2008	GB	
	W	2003088176 A1	10-23-2003	WO	
	X	2006133976 A1	12-21-2006	WO	
	Y	2007006624 A1	01-18-2007	WO	
	Z	2007023067 A1	03-01-2007	WO	
	AA	2007072294 A1	06-28-2007	WO	
	BB	2010075463 A4	09-02-2010	WO	

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation 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 the applicant.

U.S. PATENT AND TRADEMARK OFFICE

PTO/SB/08 **INFORMATION DISCLOSURE STATEMENT BY APPLICANT**	**Application Number:** Unassigned		**First Named Inventor:** Harald Philipp
	Attorney Docket No: 080900.1118	**Art Unit:** Unassigned	**Filing Date:** Herewith

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**FIRST NAMED INVENTOR**
	A			
	B			
	C			
	D			

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**COUNTRY**	**TRANSLATION (YES OR NO)**
	E				
	F				
	G				
	H				

NON-PATENT LITERATURE (NPL)			
		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	**DATE**
	I	UK Intellectual Property Office, Combined Search and Examination Report in Corresponding UK application.	February 22, 2008
	J	Application Serial No. 11/868566, Non-Final Office Action mailed 10-01-09, 19 pages.	October 1, 2009
	K	Application Serial No. 12/317305, Non-Final Office Action mailed 10-01-09, 15 pages.	October 1, 2009
	L	Application Serial No. 12/317305, Interview Summary and Supplemental Office Action mailed 02-09-10, 12 pages.	February 9, 2010
	M	Application Serial No. 12/317305, Response filed 03-01-10 to Non-Final Office Action mailed 10-01-09 and the Supplemental Office Action mailed 02-09-10, 14 pages.	March 1, 2010
	N	Application Serial No. 12/317305, Notice of Allowance mailed 04-12-10, 7 pages.	April 4, 2010
	O	International Application Serial No. PCT/US2009/069322, International Search Report mailed 05-07-10, 3 pages.	May 7, 2010
	P	International Application Serial No. PCT/US2009/069322, Written Opinion mailed 05/07/10, 5 pages.	May 7, 2010
	Q	German Application Serial No. 102007049559.7, Office Action mailed 01-04-11, 10 pages.	January 4, 2011

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation 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 the applicant.

CAPACITIVE POSITION SENSOR

RELATED APPLICATIONS

[1] This application is a continuation under 35 U.S.C. § 120 of U.S. Patent Application No. 12/703614, filed 10 February 2010, which is a continuation under 35 U.S.C. § 120 of U.S. Patent Application No. 11/868566, filed 8 October 2007, which claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application No. 60/862358, filed 20 October 2006.

TECHNICAL FIELD

[2] This disclosure generally relates to touch sensors.

BACKGROUND

[3] Particular embodiments relate to capacitive position sensors. Particular embodiments relate more particularly to capacitive position sensors for detecting the position of an object around a curved path.

[4] Capacitive position sensors are applicable to human interfaces as well as material displacement sensing in conjunction with controls and appliances, mechanisms and machinery, and computing.

[5] Capacitive position sensors in general have recently become increasingly common and accepted in human interfaces and for machine control. In the field of home appliances, it is now quite common to find capacitive touch controls operable through glass or plastic panels. These sensors are increasingly typified by U.S. Patent No. 6,452,514 which describes a matrix sensor approach employing charge-transfer principles. Electrical appliances, such as TVs, washing machines, and cooking ovens increasingly have capacitive sensor controls for adjusting various parameters, for example volume, time and temperature.

[6] Due to increasing market demand for capacitive touch controls, there is an increased need for lower cost-per-function as well as greater flexibility in usage and configuration. There exists a substantial demand for new human interface technologies which can, at the right price, overcome the technical deficits of electromechanical controls on the one hand, and the cost of touch screens or other exotica on the other.

[7] EP1273851A2 discloses a device for adjusting temperature settings, power settings or other parameters of a cooking apparatus. The device comprises a strip sensor which may be linear, curved or circular and may be a capacitive touch sensor or some other form of touch sensor. A linear display is arranged in parallel to the sensor. The capacitive touch sensor is sensitive to the touch of a finger and the display strip is made up of multiple display segments which illuminate to show the current touch setting as defined by a finger touch on the capacitive touch sensor. A predetermined calibration curve relating to a parameter to be adjusted is mapped onto the strip, the range extending from a minimum value to a maximum value. The minimum value may correspond to an off condition of the domestic appliance. Additional operational modes may be associated with the adjustment strip to ascribe new functions to the sensor strip.

These can be selected by touching the display for a certain time. For example, a first additional mode can be entered by touching for 5 seconds, and a second additional mode by touching for 10 seconds. One of the additional operational modes is a zoom mode which provides for fine adjustment of the parameter value. The zoom operational mode can be activated by a contact time of, for example, 10 seconds. In the zoom mode an additional digital display is activated to show the current numerical value of the parameter being adjusted. In the zoom mode, only a fraction (e.g. 10%) of the original adjustment range is mapped onto the adjustment strip so that moving a finger across the full length of the sensor strip from left to right (or right to left) will only increase (decrease) the current setting of the parameter value, thereby providing a finer adjustment. During this fine adjustment, the display strip keeps its original function as a relative indicator of the full range between the minimum and maximum values.

[8] More generally, linear, curved and circular sensor strips for adjusting cooker settings have been known for many years, for example see U.S. Patent No. 4,121,204 (resistive or capacitive sensor), DE19645907A1 (capacitive sensor), DE19903300A1 (resistive sensor), and EP1602882A1 (optical sensor).

[9] WO2006/133976A1, WO2007/006624A1 and WO2007/023067A1 are more recent examples of work on touch-sensitive control strips for domestic appliances using capacitive sensors. These three patent applications were filed before the priority date of the present application, but first published after the priority date of the present application. In particular, WO2006/133976A1 and WO2007/023067A1 disclose sensors with a zoom function similar to the abovedescribed EP1273851A2 which is used for setting a timer.

[10] WO2006/133976A1 provides an adjustment strip with two operational modes. In the first mode the full parameter value range is mapped across the sensor strip. For example 0 to 99 minutes in a timer function. If a user wishes to set the timer to 30 minutes, he touches the strip approximately one third way along. A parameter value of say 34 minutes is sensed by the capacitive sensor, and displayed to the user on a numeric display. Once the initial value has been set, the effect of touching the sensor field is automatically changed to a second mode in which the parameter value is decreased (or increased) finely from the initially selected value by an amount that depends on the distance moved by the finger along the sensor strip. In the example,

the user can then slide his finger from right to left to reduce the time from 34 minutes to the desired 30 minutes, using the display for visual feedback. In this way, the user can initially make a rough selection of the desired parameter value with a point and touch action, and then refine it to the exact value desired by a finger sliding action.

[11] WO2007/023067A1 provides an adjustment strip with two operational modes that switch between mapping the full parameter value range across the sensor strip and a partial range selected to show the sub-range of parameter values between which the parameter is most often set by a user. The example of setting the timer on a cooker is given.

[12] While a zoom function is useful, prior art implementations of the zoom function have limitations regarding the manner in which the transition is effected from the full range mode to the zoom mode. In EP1273851A2, the user is made to wait for a certain time, 10 seconds in the specific example, until the transition occurs. On the other hand, in WO2006/133976Al the transition automatically occurs as soon as a value from the full range is selected.

SUMMARY

[13] Particular embodiments provide an improved capacitive position sensor for an electrical appliance in which a desired parameter value can be more efficiently and accurately selected.

[14] Particular embodiments provide a capacitive position sensor for detecting a position of an object comprising: a sensing element comprising a sensing path; at least one terminal connected to the sensing element; at least one sensing channel connected to the at least one terminal in which the sensing channel is operable to generate a signal indicative of capacitance between the terminal and a system ground; means to determine a position of an object on the sensing element; and means to further refine the position of the object corresponding to a value in a parameter range of values.

[15] Particular embodiments provide a capacitive position sensor for setting a parameter or function to a desired value in a range of parameter or function values by determining the position of an object on a capacitive position sensor, the capacitive position sensor comprising: a sensing element comprising a sensing path; at least one terminal connected to the sensing element; at least one sensing channel connected to the at least one terminal in which the sensing channel is operable to generate a signal indicative of capacitance between the terminal and a system ground; means to determine a position of an object on the sensing element; means to further refine the position of the object corresponding to a value in the range of parameter or function values; and a processor operable to interpret and process the signal to determine the approximate position of an object on the sensing path, the processor being configured to provide a first mode of the capacitive position sensor in which the range of parameter or function values is mapped onto the sensing path and in which the parameter or function can be set to approximately the desired value by a touch of the sensing path at a first point, and a second mode in which displacement of an object on the sensing element adjusts the parameter or function from the value initially set in the first mode, wherein the processor is configured to switch from the first mode to the second mode responsive to capacitive coupling caused by moving displacement of an object along the sensing path in relation to the first point of touch.

[16] Particular embodiments provide a method for determining the position of an object on a capacitive position sensor as hereinbefore defined, the method comprising bringing an object into proximity with the sensing element so as to determine a position of the object, initiating a change in mode of the sensor to respond to capacitive coupling caused by moving displacement of an object on the sensor element, displacing an object on the sensing element to select a value in a parameter range of values, and processing the signal to determine the selected parameter value.

[17] Particular embodiments provide a method for setting a parameter or function to a desired value in a range of parameter or function values by determining the position of an object on a capacitive position sensor, the capacitive position sensor comprising: a sensing element comprising a sensing path; at least one terminal connected to the sensing element; at least one sensing channel connected to the at least one terminal in which the sensing channel is operable to generate a signal indicative of capacitance between the terminal and a system ground; means to determine a position of an object on the sensing element; and means to further refine the position of the object corresponding to a value in the range of parameter or function values, the method comprising: in a first mode of the capacitive position sensor in which the range of parameter or function values is mapped onto the sensing path bringing an object into proximity with the sensing element at a first point so as to determine a position of the object and thereby initially set the parameter or function to approximately the desired value; initiating a change in mode of the sensor from the first mode to a second mode responsive to capacitive coupling caused by moving displacement of the object along the sensing path in relation to the first point of touch of the object on the sensing element; in the second mode displacing the object on the sensing element to adjust the parameter or function from the value initially set to the desired value; and processing the signal to determine the selected parameter or function value.

[18] In particular embodiments, the capacitive sensor may work in a first mode and a second mode. In a first mode, a signal may be generated which is indicative of capacitive coupling of an object, for example a user's finger, with the sensing element. The signal generated in the first mode may provide an approximate position of an object in relation to a desired parameter value the user wishes to select. A processor may be provided to interpret and

process the signal to determine the approximate position of an object on the sensing element. In the first mode of operation, the capacitive sensor may generate a signal indicative of capacitive coupling caused by bringing an object into proximity with a desired location on the sensor or by moving displacement of the object in proximity with the sensing element.

[19] In particular embodiments, the capacitive sensor may enter a second mode of operation if moving displacement of the object in proximity with the sensing element during a first mode of operation exceeds a minimum threshold value. For example, for a sensing element in the form of a rotary capacitive sensor, if a user displaces an object in proximity with the sensing element during a first mode of operation by a minimum threshold angle in relation to a first point of touch of the object on the sensing element, the capacitive sensor may switch into a second mode of operation. The minimum threshold angle may be determined by an algorithm programmed into a microcontroller and the threshold angle may be set at different values depending on the sensitivity required and the parameter which is being adjusted. In one embodiment, the threshold angle may be set at 20 degrees before the capacitive sensor switches from the first mode to the second mode of operation. An approximate parameter value may be obtained in the first mode and in the second mode a desired parameter value may be selected.

[20] In the second mode of operation, an object may be displaced in proximity with the sensing element by a pre-determined threshold value, for example 20 degrees, to effect an incremental change in the parameter value thereby allowing a desired specific parameter value to be selected. Advantageously, a capacitive sensor of particular embodiments operating in a first mode may allow a parameter value to be selected (which may be the desired value, or near to the desired value, the user wishes to select) and in a second mode the sensor may effect an incremental increase or decrease of the parameter value selected in the first mode. In the second mode, a parameter value may be increased or decreased by a pre-determined amount, for example ± 1 unit, ±5 units, or ± 10 units, based on the number of times an object is displaced on the sensing element exceeding a pre-determined threshold value. Therefore, the threshold value may correspond to an increase or decrease of the parameter value by, say, ± 1 unit, and each time the threshold value is reached (n times) the parameter value will increase or decrease by ± 1 (n times ± 1).

[21] In particular embodiments, the capacitive sensor may enter a second mode of operation by effectively "zooming-in" on a narrower range of parameter values, compared to the parameter range displayed in the first mode, so that a user may accurately select a desired parameter value. The narrower range of parameter values shown during the second mode will be determined by the parameter value selected in the first mode, for example plus and minus 10 units from the value selected in the first mode. In the second mode of operation, an object may be displaced along the sensing element so as to select the desired parameter value.

[22] The processor for determining the position of an object in proximity with the sensing element in a first mode of operation may be operable for also determining the position of an object in proximity with the sensing element in a second mode of operation.

[23] In particular embodiments, the capacitive sensor may function in a first mode of operation in which an approximate parameter value may be selected followed by a second mode of operation in which a specific parameter value may be selected. The range of parameter values associated with the capacitive sensor (i.e. the resolution) may determine whether a desired parameter value can be selected in the first mode of operation. The second mode of operation will allow a desired parameter value to be accurately selected, for example, either by zooming-in on a narrower range of parameter values around the parameter value selected in the first mode and displacing an object in proximity with the sensing element to select the desired value, or, by displacing an object in proximity with the sensing element to exceed a predetermined threshold value in order to change the parameter value selected from the first mode by one or more increments. The number of times the threshold value is exceeded may determine the number of times the parameter value is increased or decreased.

[24] A capacitive sensor of particular embodiments may be incorporated into a control panel of an electronic appliance or gadget, for example a cooking oven, microwave oven, television, washing machine, MP3 player, mobile phone, or other multimedia device. A wide range of parameters or functions may be controlled by the capacitive sensor of particular embodiments, dependent on the type of electronic appliance in which the capacitive sensor is incorporated, for example, temperature, volume, contrast, brightness, or frequency. The parameter or function to be controlled may be selected prior to use of the capacitive sensor.

[25] Advantageously, the sensor has a higher degree of resolution in the second mode allowing a user to move their finger in proximity with the sensing element to select a specific parameter value. If the sensing element is in the form of a closed loop, a user may be able to scroll clockwise or anticlockwise around the sensing element to select the desired value. In the second mode for example, a 20 degree rotation may be equivalent to changing a parameter value by 1 unit. The amount of rotation required by an object on the sensing element to cause an incremental change in a parameter value may be varied dependent on the parameter or function being controlled. Control circuitry or a program-controlled microprocessor may be used to control the degree of rotation required to cause a change in a parameter value.

[26] In particular embodiments, the sensing element is arcuate in shape. In particular embodiments, the sensing element is in the form of a closed loop for use in a rotary capacitive position sensor. In a rotary capacitive position sensor embodiment, an object may be moved along the sensing element of the sensor for a plurality of revolutions and the distance moved by the object may determine the output signal which is generated by the sensing channel(s).

[27] In the first mode of operation of the capacitive sensor, capacitive coupling of an object in proximity with a sensing element may be detected to give an approximate position in relation to a range of values for a given parameter. If a user wishes to obtain different position data, the object may be removed from proximity with the sensing element and then brought into proximity with the said sensing element again. In other words, a user may initiate the first mode of the sensor again simply by retouching the sensing element. When the second mode of operation is initiated, a user may scroll the sensing element to select a specific value of a certain parameter. An output signal may be generated indicative of a specific parameter value when an object ceases displacement at a certain position on the sensing element. In an embodiment, if a user releases touch from the sensing element in a second mode and retouches the sensing element then the first mode of operation may be activated again.

[28] In particular embodiments, the capacitive position sensor may further comprise one or more discrete sensing areas in the centre region of a rotary sensing element. If the sensing areas in the centre region of the sensing element sense capacitive coupling to an object, any signal produced from the sensing element is reduced or "locked out" using the Adjacent Key

Suppression™ technology described in the applicant's earlier U.S. Patent No. 6,993,607 and U.S. Patent Application Publication No. 2006/0192690, both incorporated herein by reference. Any output signal from the rotary sensing element caused by capacitive coupling with an object may also lock out a signal from the central sensing areas. The sensing element may be embodied by a single resistor, for example it may comprise a resistive material deposited on a substrate to form a continuous pattern. This provides for an easy-to-fabricate resistive sensing element which can be deposited on the substrate in any one of a range of patterns. Alternatively, the sensing element may be made from a plurality of discrete resistors. The discrete resistors may be alternately connected in series with a plurality of conducting sense plates, the sense plates providing for increased capacitive coupling between the object and the resistive sensing element. This provides for a resistive sensing element which can be fabricated from widely available off-the-shelf items. The disclosure of WO2005/019766 is incorporated herein by reference as an example of the capacitance measurement circuitry which may be used. Alternatively, a resistor-less sensing element similar to that described in U.S. Patent No. 4,264,903 may be used to form the capacitive sensor of particular embodiments.

[29] The resistive sensing element may have a substantially constant resistance per unit length. This provides for a capacitive position sensor having a simple uniform response. Where greater positional resolution is required or when employing a relatively long resistive sensing element, the resistive sensing element may include a plurality of terminals.

[30] The object to be detected may be a pointer, for example a finger or a stylus, which can be freely positioned by a user. Alternatively, the object may be a wiper held in proximity to the resistive sensing element, the position of the wiper along the resistive sensing element being detected by the capacitive position sensor. The position of the wiper may be adjusted by a user, for example by turning a rotary knob, or may be coupled to a shaft driven by connected equipment such that the capacitive position sensor can act as an encoder.

[31] Particular embodiments provide a sensor having high reliability, a sealed surface, low power consumption, simple design, ease of fabrication, and the ability to operate using off-the-shelf logic or microcontrollers.

[32] In U.S. Patent No. 6,466,036, the applicant teaches a capacitive field sensor employing a single coupling plate to detect change in capacitance to ground. This apparatus comprises a circuit employing repetitive charge-then-transfer or charge-plus-transfer cycles using common integrated CMOS push-pull driver circuitry. This technology forms the basis of particular embodiments and is incorporated by reference herein.

[33] Some definitions are now made. "Element" refers to the physical electrical sensing element made of conductive substances. "Electrode" refers to one of the galvanic connection points made to the element to connect it to suitable driver/sensor electronics. The terms "object" and "finger" are used synonymously in reference to either an inanimate object such as a wiper or pointer or stylus, or alternatively a human finger or other appendage, any of whose presence adjacent the element will create a localized capacitive coupling from a region of the element back to a circuit reference via any circuitous path, whether galvanically or non-galvanically. The term "touch" includes either physical contact between an object and the element, or, proximity in free space between object and element, or physical contact between object and a dielectric (such as glass) existing between object and element, or, proximity in free space including an intervening layer of dielectric existing between object and element. Hereinafter the terms "circle" or "circular" refer to any ellipsoid, trapezoid, or other closed loop of arbitrary size and outline shape having an open middle section.

BRIEF DESCRIPTION OF THE DRAWINGS

[34] FIGURE 1 shows a control panel of an apparatus embodying a rotary capacitive sensor, the sensor being used in a first mode of operation.

[35] FIGURE 2A shows the capacitive sensor of FIGURE 1 being used in a second mode of operation, with the user scrolling around the sensor in an anticlockwise direction.

[36] FIGURE 2B shows the capacitive sensor of FIGURE 1 being used in a second mode of operation, with the user scrolling around the sensor in a clockwise direction.

[37] FIGURE 3 shows a control panel of an apparatus according to another embodiment, in which a rotary capacitive sensor is being used in a first mode of operation.

[38] FIGURE 4 shows the capacitive sensor of FIGURE 3 being used in a second mode of operation.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[39] FIGURE 1 illustrates part of a control panel 50 having a capacitive sensor 60 and a digital readout display 70. The control panel 50 may be incorporated into an electronic appliance such as a cooking oven, microwave oven, washing machine, fridge freezer, television, MP3 player, mobile telephone or the like. The parameter or function to be controlled by the capacitive sensor will depend on the type of electrical appliance in which the capacitive sensor is incorporated. Parameters like volume, temperature, operating program, brightness, contrast are some examples of functions that may be controlled by the capacitive sensor of particular embodiments. In particular embodiments, the parameter to be controlled may be chosen from a predetermined list of parameters so that a user may advantageously adjust different parameters on an electrical appliance or apparatus. The capacitive sensor 60 shown in FIGURE 1 is set to control cooking temperature of a microwave or cooking oven.

[40] The capacitive sensor 60 comprises a rotary sensing element 100 for detecting capacitive coupling with an object, typically an operator's finger. A Liquid Crystal Display 75 (or other known display) is formed in the control panel 50 to illuminate the temperature scale around the sensing element. The temperature scale ranges from 0 to 300 degrees Centigrade. The capacitive sensor 60 is shown in a first mode of operation in which a user's finger is used to select a cooking temperature. A user's finger 80 is shown in proximity with a portion of the sensing element 100 corresponding to a temperature of 175 degrees Centigrade (°C) which is displayed on the digital readout display 70. The selected temperature of 175°C may be the desired temperature required by the user, but in most cases the temperature selected in the first mode of operation will indicate a temperature near to the actual temperature required by the user. A user may re-touch the sensing element 100 of the sensor to reactivate the first mode of operation and select a different temperature. The resolution of the sensor may determine how close the temperature selected in the first mode is to the desired temperature sought by the user.

[41] Turning now to FIGURES 2A and 2B, the capacitive sensor 60 is shown in a second mode of operation. The capacitive sensor automatically enters the second mode of operation after a temperature has been selected in the first mode of operation. In the second mode, a user is able to increase or decrease the temperature selected in the first mode by a pre-

determined increment. Changing the temperature by a given increment depends on a user displacing their finger in proximity with the sensing element 100 by a pre-determined threshold angle. The embodiment shown in FIGURES 2A and 2B requires a 20° rotation (i.e. threshold angle is 20°) to effect a temperature change of ± 1°C.

[42] As shown in FIGURE 2A, a user has displaced their finger in proximity with the sensing element 100 in an anti-clockwise direction to decrease the temperature of 175°C selected in the first mode. The user has moved his finger by 40° (i.e. 2x the threshold angle) from the first point of touch in the first mode of operation, to cause a temperature decrease by 2°C to 173°C (shown by arrow C). As shown in FIGURE 2B, the user has moved his finger by 40° in a clockwise direction from the first point of touch in the first mode of operation, to cause a temperature increase by 2°C to 177°C (arrow D). Advantageously, the capacitive sensor in the second mode of operation allows a user to accurately select a desired temperature. The resolution of the capacitive sensor in the second mode of operation is typically finer than that in the first mode of operation. The threshold angle may be re-settable and is typically determined by a program stored in a microcontroller.

[43] In the second mode of operation as illustrated in FIGURES 2A and 2B, a + and - indicator display 92 is present above the capacitive sensor 60 to indicate to the user that the temperature can be increased or decreased by 1 unit(s). The digital display 70 shows the temperature as it is changed by the user. The LCD 75 showing the temperature scale in the first mode is no longer highlighted during the second mode of operation.

[44] FIGURE 3 illustrates a rotary sensing element 20 of a capacitive position sensor 10 embodying particular embodiments. The capacitive sensor 10 is incorporated into a control panel of a cooking oven. The capacitive sensor 10 shown in FIGURE 1 is used to select a desired cooking temperature, although the sensor could be used for selecting any particular parameter value based on the electrical appliance in use. The sensor of FIGURE 1 is shown in a first mode of operation. A user's finger 30 approaches the rotary sensing element 20 and is capacitively coupled to the sensing element in the region between 150 to 200°C. A temperature of 175°(is shown in the digital display 70. The first mode of operation of the sensor allows the user to select an approximate cooking temperature. The rotary sensing element 20 may have a

diameter of about 2 inches which, previously, would have made it difficult for a user to accurately select a certain temperature.

[45] The capacitive sensor 10 automatically enters a second mode of operation after a temperature has been selected in the first mode, as illustrated in FIGURE 4. As shown in FIGURE 4, the temperature scale around the sensing element 20 has been modified or reset to expand the temperature range in the capacitively coupled region determined from the first mode of operation. The user may now select a desired temperature for cooking by scrolling his finger clockwise or anticlockwise around the sensing element until the desired temperature is reached, in this case 180°C as shown on the digital display 70. The temperature scale illustrated in FIGURE 4 is only an example of how the capacitive sensor may be programmed to zoom in on a pre-determined temperature range. In the second mode of operation, the number of degrees of rotation required to effect a temperature change by a certain increment may be adjusted. The temperature selected may be displayed on an analogue or digital readout display formed within the control panel, such as on digital display 70.

[46] Herein, "or" is inclusive and not exclusive, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A or B" means "A, B, or both," unless expressly indicated otherwise or indicated otherwise by context. Moreover, "and" is both joint and several, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A and B" means "A and B, jointly or severally," unless expressly indicated otherwise or indicated otherwise by context.

[47] This disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Similarly, where appropriate, the appended claims encompass all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Moreover, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, component, whether or not it or that

particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative

WHAT IS CLAIMED IS:

1. A method comprising:

receiving one or more first signals indicating one or more first capacitive couplings of an object with a sensing element that comprises a sensing path that comprises a length, the first capacitive couplings corresponding to the object coming into proximity with the sensing element at a first position along the sensing path of the sensing element

determining based on one or more of the first signals the first position of the object along the sensing path;

setting a parameter to an initial value based on the first position of the object along the sensing path, the initial value comprising a particular parameter value and being associated with a range of paratemeter values, the range of parameter values being associated with the length of the sensing path;

receiving one or more second signals indicating one or more second capacitive couplings of the object with the sensing element, the second capacitive couplings corresponding to a displacement of the object along the sensing path from the first position; and

determining based on one or more of the second signals the displacement of the object along the sensing path; and

adjusting the parameter within the range of paratemeter values based on the displacement of the object along the sensing path.

2. The method of Claim 1, wherein the sensing path comprises a closed loop.

3. The method of Claim 1, further comprising switching from a first mode of operation to a second mode of operation in response to one or more of the second signals if the displacement corresponding to the second capacitive couplings indicated by the second signals exceeds a pre-determined threshold, the second mode of operation being for adjusting the parameter within the range of parameter values based on the displacement of the object along the sensing path, the first mode of operation being for setting the parameter to the initial value.

4. The method of Claim 3, wherein the pre-determined threshold value is determined at least in part by the initial value and a sensitivity setting, the pre-determined threshold value being different for different initial values or different sensitivity settings.

5. The method of Claim 1, wherein adjusting the parameter comprises effecting an incremental change in the parameter from the initial value based on an amount of the displacement exceeding a pre-determined displacement threshold.

6. The method of Claim 1, wherein adjusting the parameter comprises changing the parameter from the initial value by a number of units based on a number of times an amount of the displacement exceeds a pre-determined displacement threshold.

7. The method of Claim 1, further comprising mapping all or a portion of the range of parameter values onto the sensing path around the initial value.

8. The method of Claim 1, wherein the parameter is selected from the group consisting of temperature, volume, contrast, brightness, and frequency.

9. The method of Claim 1, wherein the sensing element is part of an electronic appliance selected from the group consisting of a cooking oven, microwave oven, television, washing machine, MP3 player, mobile phone, and multimedia device.

10. One or more computer-readable non-transitory storage media embodying logic that is operable when executed to:

receive one or more first signals indicating one or more first capacitive couplings of an object with a sensing element that comprises a sensing path that comprises a length, the first capacitive couplings corresponding to the object coming into proximity with the sensing element at a first position along the sensing path of the sensing element

determine based on one or more of the first signals the first position of the object along the sensing path;

set a parameter to an initial value based on the first position of the object along the sensing path, the initial value comprising a particular parameter value and being associated with a range of parameter values, the range of parameter values being associated with the length of the sensing path;

receive one or more second signals indicating one or more second capacitive couplings of the object with the sensing element, the second capacitive couplings corresponding to a displacement of the object along the sensing path from the first position; and

determine based on one or more of the second signals the displacement of the object along the sensing path; and

adjust the parameter within range of parameter values based on the displacement of the object along the sensing path.

11. The media of Claim 10, wherein the sensing path comprises a closed loop.

12. The media of Claim 10, wherein the logic is further operable to switch from a first mode of operation to a second mode of operation in response to one or more of the second signals if the displacement corresponding to the second capacitive couplings indicated by the second signals exceeds a pre-determined threshold, the second mode of operation being for adjusting the parameter within the range of parameter values based on the displacement of the object along the sensing path, the first mode of operation being for setting the parameter to the initial value.

13. The media of Claim 12, wherein the pre-determined threshold value is determined at least in part by the initial value and a sensitivity setting, the pre-determined threshold value being different for different initial values or different sensitivity settings.

14. The media of Claim 10, wherein adjusting the parameter comprises effecting an incremental change in the parameter from the initial value based on an amount of the displacement exceeding a pre-determined displacement threshold.

15. The media of Claim 10, wherein adjusting the parameter comprises changing the parameter from the initial value by a number of units based on a number of times an amount of the displacement exceeds a pre-determined displacement threshold.

16. The media of Claim 10, wherein the logic is further operable to map all or a portion of the range of parameter values onto the sensing path around the initial value.

17. The media of Claim 10, wherein the parameter is selected from the group consisting of temperature, volume, contrast, brightness, and frequency.

18. The media of Claim 10, wherein the media and the sensing element are part of an electronic appliance selected from the group consisting of a cooking oven, microwave oven, television, washing machine, MP3 player, mobile phone, and multimedia device.

19. An apparatus comprising:

a sensing element that comprises a sensing path that comprises a length; and

one or more computer-readable non-transitory storage media embodying logic that is operable when executed to:

receive one or more first signals indicating one or more first capacitive couplings of an object with the sensing element, the first capacitive couplings corresponding to the object coming into proximity with the sensing element at a first position along the sensing path of the sensing element

determine based on one or more of the first signals the first position of the object along the sensing path;

set a parameter to an initial value based on the first position of the object along the sensing path, the initial value comprising a particular parameter value and being associated with a range of parameter values, the range of parameter values being associated with the length of the sensing path;

receive one or more second signals indicating one or more second capacitive couplings of the object with the sensing element, the second capacitive couplings corresponding to a displacement of the object along the sensing path from the first position; and

determine based on one or more of the second signals the displacement of the object along the sensing path; and

adjust the parameter within range of parameter values based on the displacement of the object along the sensing path.

CAPACITIVE POSITION SENSOR

ABSTRACT

In one embodiment, a method includes receiving one or more first signals indicating one or more first capacitive couplings of an object with a sensing element that comprises a sensing path that comprises a length. The first capacitive couplings correspond to the object coming into proximity with the sensing element at a first position along the sensing path of the sensing element. The method includes determining based on one or more of the first signals the first position of the object along the sensing path and setting a parameter to an initial value based on the first position of the object along the sensing path. The initial value includes a particular parameter value and is associated with a range of paratemeter values. The range of parameter values is associated with the length of the sensing path.

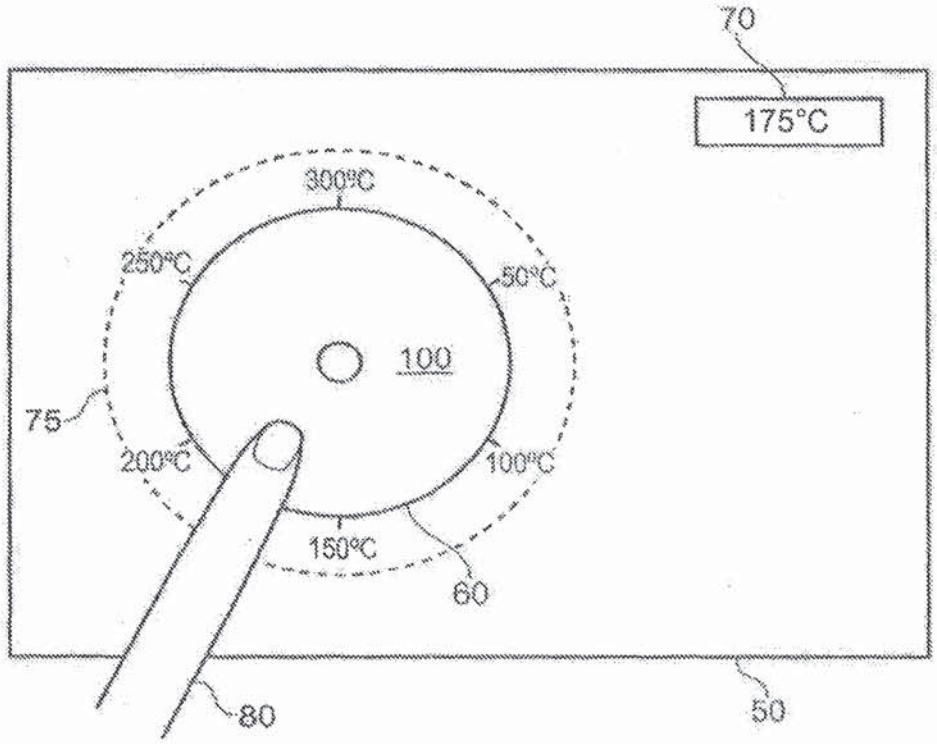

FIG. 1

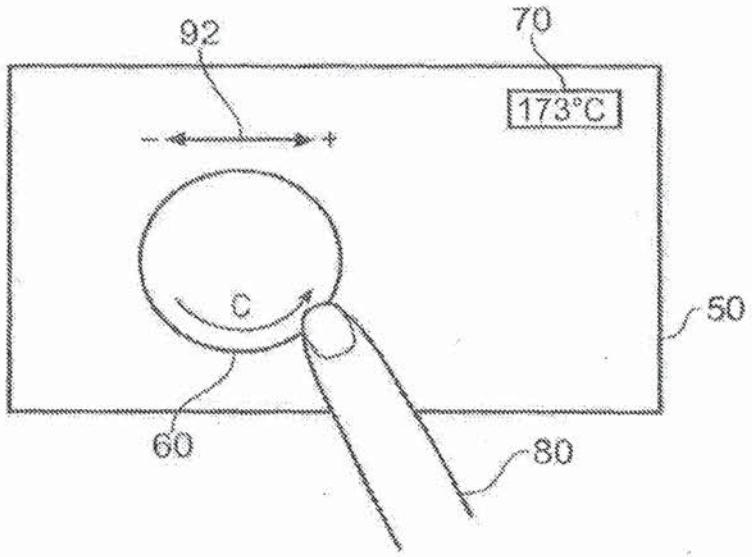

FIG. 2A

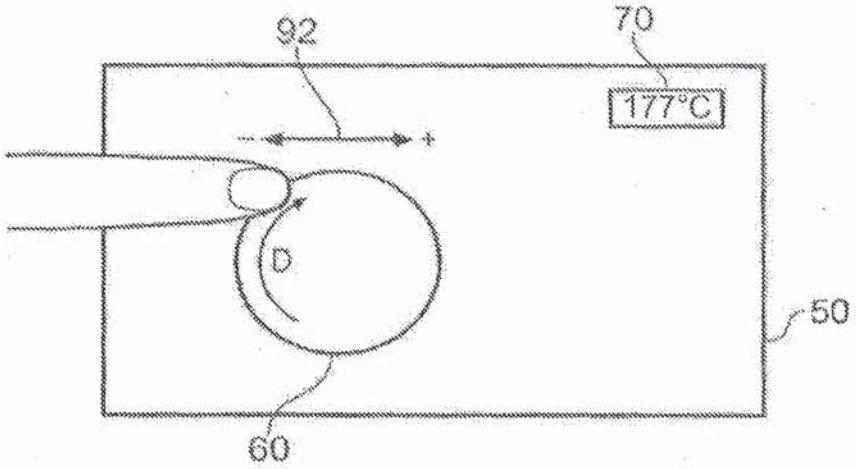

FIG. 2B

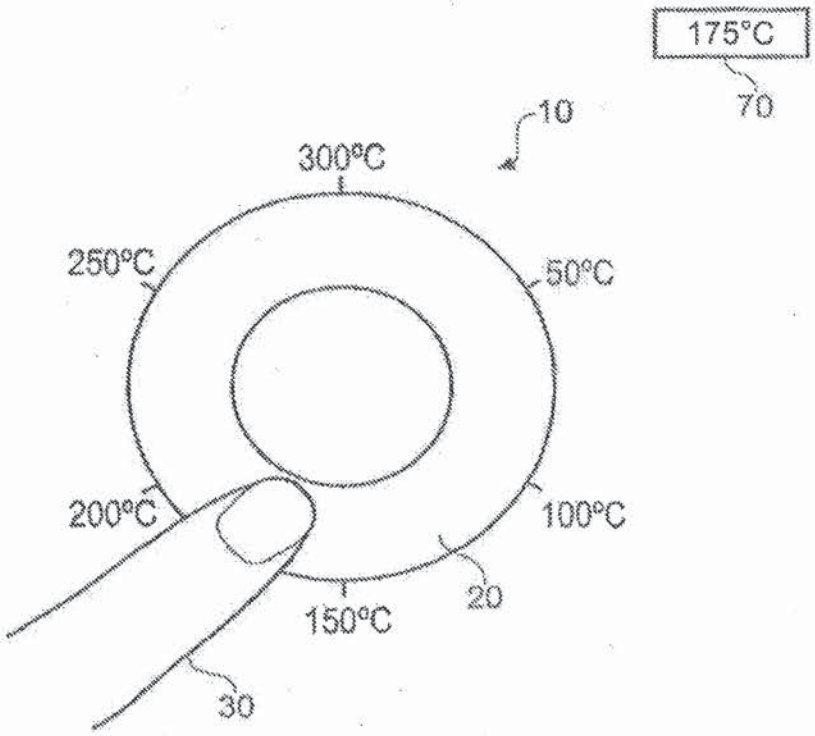

FIG. 3

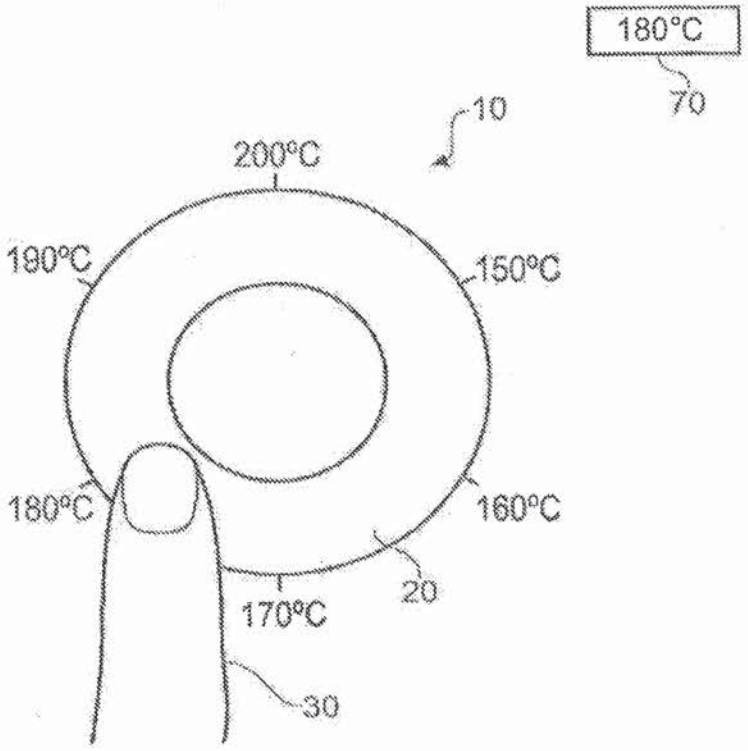

FIG. 4

Electronic Patent Application Fee Transmittal	
Application Number:	
Filing Date:	
Title of Invention:	Capacitive Position Sensor
First Named Inventor/Applicant Name:	Harald Philipp
Filer:	Travis W. Thomas/Paula Hurley
Attorney Docket Number:	080900.1118
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	330	330
Utility Search Fee	1111	1	540	540
Utility Examination Fee	1311	1	220	220
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1090**

Electronic Acknowledgement Receipt	
EFS ID:	10189352
Application Number:	13118280
International Application Number:	
Confirmation Number:	9244
Title of Invention:	Capacitive Position Sensor
First Named Inventor/Applicant Name:	Harald Philipp
Customer Number:	12323
Filer:	Travis W. Thomas/Paula Hurley
Filer Authorized By:	Travis W. Thomas
Attorney Docket Number:	080900.1118
Receipt Date:	27-MAY-2011
Filing Date:	
Time Stamp:	19:36:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1090
RAM confirmation Number	5103
Deposit Account	020384
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees) Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees) Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_080900_1118.pdf	1031565 d56e5dfe76b3359a89ab9f28c98b6833f463 1fdc	no	4
Warnings:					
Information:					
2	Oath or Declaration filed	declaration_080900_1118.pdf	187065 dacde2f8155157e1cd3fbecd584c7658e61c 28bf	no	1
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Information:					
3	Power of Attorney	POA_080900_1118.pdf	140787 d97e1a121ad4e3379dfa3c1a9778c267436 649e6	no	2
Warnings:					
Information:					
4	Assignee showing of ownership per 37 CFR 3.73(b).	373b_080900_1118.pdf	441852 a9405cfab12cc5a3c7784793cb4e977b9f42 c4da	no	2
Warnings:					
Information:					
5	Transmittal Letter	IDS_080900_1118.pdf	94870 540a932e6b0560333138449afc0f6ca2e15a 2fe1	no	1
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6	Information Disclosure Statement (IDS) Filed (SB/08)	SB08_080900_1118.pdf	83222 b5791af595d33976b460fcca62cb8617edc2 2136	no	2
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Information:					
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	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**

	Specification		1	16	
	Claims		17	21	
	Abstract		22	22	
Warnings:					
Information:					
8	Drawings-only black and white line drawings	Figures_080900_1118.pdf	93576 74e2e3591af68eb4cd4f0536c34307de009e719d	no	4
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
9	Fee Worksheet (PTO-875)	fee-info.pdf	32367 ad94e3bf0cf0e34de8dca96bdd4c930b67b2467f	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2229773		

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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.

PTO/SB/14 (11-08)
Approved for use through 09/30/2010. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	080900.1118
	Application Number	
Title of Invention	Capacitive Position Sensor	

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.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Harald		Philipp	

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

City	Zug	Country Of Residence[i]	CH
Citizenship under 37 CFR 1.41(b)[i]	DE		

Mailing Address of Applicant:

Address 1	Baer & Karrer AG		
Address 2	Baarerstrasse 8		
City	Zug	State/Province	
Postal Code	CH-6301	Country[i]	CH

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	12323		
Email Address	ptomail1@bakerbotts.com	Add Email	Remove Email

Application Information:

Title of the Invention	Capacitive Position Sensor		
Attorney Docket Number	080900.1118	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)	2858		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	3

PTO/SB/14 (11-08)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	080900.1118
	Application Number	
Title of Invention	Capacitive Position Sensor	

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).
Enter either 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	12323		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this 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(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/703614	2010-02-10
Prior Application Status	Abandoned		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12/703614	Continuation of	11/868566	2007-10-08
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
11/868566	non provisional of	60/862358	2006-10-20

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

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. 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(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

PTO/SB/14 (11-08)
Approved for use through 09/30/2010. OMB 0651-0032
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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	080900.1118
	Application Number	
Title of Invention	Capacitive Position Sensor	

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

Assignee Information:

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

Assignee 1 Remove

If the Assignee is an Organization check here. ☒

Organization Name	Atmel Corporation		
Mailing Address Information:			
Address 1	2325 Orchard Parkway		
Address 2			
City	San Jose	**State/Province**	CA
Country [i]	US	Postal Code	95131
Phone Number		Fax Number	
Email Address			

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

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Travis Thomas/			Date (YYYY-MM-DD)	2011-05-27
First Name	Travis	Last Name	Thomas	Registration Number	48667

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.**

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 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 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 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.

PTO/SB/01A (07-07)
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U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Capacitive Position Sensor

As the below named inventor(s), I/we declare that:

This declaration is directed to:

☑ The attached application, or

☐ Application No. _____ filed on _____

☐ As amended on _____ (if applicable).

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

All statements made herein of my/our own knowledge are true, all statements made herein 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 are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one: Harald Philipp Date: _____

Signature: _____ Citizen of: US

Inventor two: _____ Date: _____

Signature: _____ Citizen of: _____

☐ Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. 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 1 minute 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.

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/118,280	05/27/2011	2858	1090	080900.1118	19	3

CONFIRMATION NO. 9244

12323
Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

FILING RECEIPT

Date Mailed: 06/16/2011

Receipt is acknowledged of this non-provisional 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 APPLICANT, 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 Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections 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**

Applicant(s)

Harald Philipp, Zug, SWITZERLAND;

Assignment For Published Patent Application

ATMEL CORPORATION, San Jose, CA

Power of Attorney: The patent practitioners associated with Customer Number 12323

Domestic Priority data as claimed by applicant

This application is a CON of 12/703,614 02/10/2010 PAT 7,952,367 *
which is a CON of 11/868,566 10/08/2007 ABN
which claims benefit of 60/862,358 10/20/2006
(*)Data provided by applicant is not consistent with PTO records.

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.)

If Required, Foreign Filing License Granted: 06/10/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/118,280**

Projected Publication Date: 09/22/2011

Non-Publication Request: No

Early Publication Request: No

Title

Capacitive Position Sensor

Preliminary Class

324

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 (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

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).

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/118,280

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	330
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	540
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	220
TOTAL CLAIMS (37 CFR 1.16(i))	19 minus 20 =	*			OR	x 52 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 220 =	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 $270 ($135 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).						0.00
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	1090

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	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
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	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/118,280	05/27/2011	Harald Philipp	080900.1118

CONFIRMATION NO. 9244

12323
Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

POA ACCEPTANCE LETTER

OC000000048150448

Date Mailed: 06/16/2011

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 05/27/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/dpham/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/118,280	05/27/2011	Harald Philipp	080900.1118

CONFIRMATION NO. 9244

12323
Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

PUBLICATION NOTICE

OC000000049973661

Title: Capacitive Position Sensor

Publication No.US-2011-0227589-A1
Publication Date:09/22/2011

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/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08	Application Number: 13/118280		First Named Inventor: Harald Philipp
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	**Attorney Docket No:** 080900.1118	**Art Unit:** Unassigned	**Filing Date:** 27 May 2011

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**FIRST NAMED INVENTOR**
	A	7,663,607	02-16-2010	Hotelling
	B	7,920,129	04-05-2011	Hotelling
	C	8,031,094	10-04-2011	Hotelling
	D	8,031,174	10-04-2011	Hamblin
	E	8,049,732	11-01-2011	Hotelling

UNPUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**FILING DATE**	**FIRST NAMED INVENTOR**
	F			
	G			
	H			
	I			

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**COUNTRY**	**TRANSLATION (YES OR NO)**
	J				
	K				

NON-PATENT LITERATURE (NPL)			
		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	**DATE**
	L		
	M		
	N		
	O		
	P		
	Q		
	R		

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation 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 the applicant.

U.S. PATENT AND TRADEMARK OFFICE

Electronic Acknowledgement Receipt	
EFS ID:	11617254
Application Number:	13118280
International Application Number:	
Confirmation Number:	9244
Title of Invention:	Capacitive Position Sensor
First Named Inventor/Applicant Name:	Harald Philipp
Customer Number:	12323
Filer:	Jeffery D Baxter/Darla Rupert
Filer Authorized By:	Jeffery D Baxter
Attorney Docket Number:	080900.1118
Receipt Date:	14-DEC-2011
Filing Date:	27-MAY-2011
Time Stamp:	15:16:47
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		1118ids.pdf	96614 90a744f73385e2544d29e6b29d44f13360e74a2b	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
	Information Disclosure Statement (IDS) Form (SB08)	2	2
Warnings:			
Information:			
	Total Files Size (in bytes):	96614	

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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:	Harald Philipp
Application No.:	13/118280
Filing Date:	27 May 2011
Confirmation No.:	9244
Group Art Unit:	Unknown
Title:	*Capacitive Position Sensor*

Information Disclosure Statement

Applicant submits this Information Disclosure Statement (IDS) under 37 C.F.R. § 1.97(b)(3). Applicant respectfully requests the Examiner to consider and cite in the examination of this Application the documents listed in the attached Form PTO/SB/08. Under 37 C.F.R. § 1.98(a)(2)(ii), Applicant has not provided copies of U.S. patents or U.S. patent application publications.

Under 37 C.F.R. § 1.97(g), the filing of this IDS shall not be construed as a representation that a search has been made. Moreover, under 37 C.F.R. § 1.97(h), the filing of this IDS shall not be construed to be an admission that the information cited in this IDS is or is considered to be material to patentability as defined by 37 C.F.R. §1.56(b). Furthermore, the filing of this IDS shall not be construed to be an admission that any information cited in this IDS is or is considered to be prior art under 35 U.S.C. §§ 102-103.

The Commissioner may charge any fee due and credit any overpayment in this Patent Application to Deposit Account No. 02-0384 of Baker Botts L.L.P.

Respectfully submitted,

BAKER BOTTS L.L.P.
Attorneys for Applicant

Travis W. Thomas
Reg. No. 48,667

Date: 14 December 2011

DAL01:1187330

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

12323 7590 06/19/2012

Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

EXAMINER	
NGUYEN, VINCENT Q	
ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 06/19/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/118,280	05/27/2011	Harald Philipp	080900.1118	9244

TITLE OF INVENTION: CAPACITIVE POSITION SENSOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	09/19/2012

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 SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

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: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

12323 7590 06/19/2012
Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/118,280	05/27/2011	Harald Philipp	080900.1118	9244

TITLE OF INVENTION: CAPACITIVE POSITION SENSOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	09/19/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, VINCENT Q	2858	324-686000

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 03-02 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 has been filed for recordation as set forth in 37 CFR 3.11. 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. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): (**Please first reapply any previously paid issue fee shown above**)
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information 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 12 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.

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 NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/118,280	05/27/2011	Harald Philipp	080900.1118	9244

12323 7590 06/19/2012

Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

EXAMINER	
NGUYEN, VINCENT Q	
ART UNIT	PAPER NUMBER
2858	

DATE MAILED: 06/19/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

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 Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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.	Applicant(s)	
	13/118,280	PHILIPP, HARALD	
	Examiner	Art Unit	
	Vincent Q. Nguyen	2858	

-- 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 _____.
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 *1-19*.
4. ☐ 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 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. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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).
7. ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 12/14/11, 5/27/11
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Vincent Q Nguyen/
Primary Examiner, Art Unit 2858

DETAILED ACTION

Allowable Subject Matter

1. Claims 1-19 are allowed.

2. The following is an examiner's statement of reasons for allowance:

The prior art of record does not teach or fairly suggest, in combination with the rest of the limitation of the claims,

a method having the steps of setting a parameter to an initial value based on the first position of the object along the sensing path, the initial value comprising a particular parameter value and being associated with a range of parameter values, the range of parameter values being associated with the length of the sensing path; determining based on one or more of the second signals the displacement of the object along the sensing path; and adjusting the parameter within the range of parameter values based on the displacement of the object along the sensing path, as recited in the independent claim 1;

an apparatus, one or more computer-readable non-transitory storage media operable when execute to set a parameter to an initial value based on the first position of the object along the sensing path, the initial value comprising a particular parameter value and being associated with a range of parameter values, the range of parameter values being associated with the length of the sensing path; determine based on one or more of the second signals the displacement of the object along the sensing path; and adjust the parameter within range of parameter values based on the displacement of the object along the sensing path; as recited in the independent claims 10 and 19.

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."

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Vincent Q. Nguyen whose telephone number is (571)272-2234. The examiner can normally be reached on 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Melissa J. Koval can be reached on (571) 272-2121. 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 http://pair-direct.uspto.gov. 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.

/Vincent Q Nguyen/
Primary Examiner, Art Unit 2858

Vincent Q Nguyen
Primary Examiner
Art Unit 2858

June 13, 2012

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13118280	PHILIPP, HARALD
	Examiner	Art Unit
	VINCENT Q NGUYEN	2858

ORIGINAL		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
324	686	G 0 1 R 27 / 26 (2006.01.01)	

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
324	667				

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		17												
	2		18												
	3		19												
	4														
	5														
	6														
	7														
	8														
	9														
	10														
	11														
	12														
	13														
	14														
	15														
	16														

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	19	
/VINCENT Q NGUYEN/ Primary Examiner.Art Unit 2858	06/13/2012	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	3

U.S. Patent and Trademark Office

Part of Paper No. 20120613

Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination	
13/118,280	PHILIPP, HARALD	
Examiner	**Art Unit**	
Vincent Q. Nguyen	2858	

SEARCHED			
Class	Subclass	Date	Examiner
324	667 676-690	6/13/2012	V.N.

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
324	**686**	6/13/2012	**V.N.**
324	667	6/13/2012	V.N.

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST Search (See search history printout)	6/13/2012	V.N.
Update the search for parent application 12/703,614 Double patenting checked vs. 7,952,367, 7,830,160	6/13/2012	V.N.
Same as above	6/13/2012	**V.N.**

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	11	("20030043174" | "20040027395" | "20040196267" | "20040207605" | "20050052429" | "20050078027" | "20060016800" | "20080094077" | "20100141277" | "4121204" | "4264903").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/13 13:27
L2	1126	setting near4 parameter near3 initial	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/06/13 13:29
L3	12158	capacit$4 with position$4 near (sens$4 detect$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 13:29
L4	6	2 and 3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 13:29
L5	3883	324/676-690.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 13:45
L6	3	2 and 5	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 13:45
L7	219	324/667.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 13:46
L9	3	12/703614	US-PGPUB; USPAT;	OR	OFF	2012/06/13 13:52

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S1	5055	capacit$4 near10 position near (sens$4 determin$4 detect$4 measur$4).ti,ab,clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 10:48
S2	673	setting near3 parameter near5 initial near value	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 10:50
S3	4	S1 and S2	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 10:50
S4	4	US-7663607-$.DID. OR US-7920129-$.DID. OR US-8031094-$.DID. OR US-8031174-$.DID.	US-PGPUB; USPAT	OR	OFF	2012/06/13 11:33
S5	15	US-4121204-$.DID. OR US-4264903-$.DID. OR US-20030043174-$.DID. OR US-20040027395-$.DID. OR US-20040196267-$.DID. OR US-20040207605-$.DID. OR US-20050052429-$.DID. OR US-20050078027-$.DID. OR US-20060016800-$.DID. OR US-20080094077-$.DID. OR US-20090051660-$.DID. OR US-20090115431-$.DID. OR US-1273851-$.DID. OR US-1602882-$.DID. OR US-2443296-$.DID.	US-PGPUB; USPAT	OR	OFF	2012/06/13 11:37
S6	12	("20030043174" | "20040027395" | "20040196267" | "20040207605" | "20050052429" | "20050078027" | "20060016800" | "20080094077" | "20090051660" | "20090115431" | "4121204" | "4264903").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/06/13 12:18
S7	79	("4264903").URPN.	USPAT	OR	OFF	2012/06/13 12:20
S9	234	"6452514"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:50
S10	2662	setting near3 parameter near5 initial	US-PGPUB; USPAT; USOCR; FPRS;	OR	ON	2012/06/13 12:51

			EPO; JPO; DERWENT; IBM_TDB			
S11	3	S9 and S10	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:51
S12	3586	capacit$4 with position$4 near (sens$4 detect$4).ti,ab,clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:52
S13	5	S10 and S12	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:52
S14	2	S13 not S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:52
S15	6	11/868566	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/06/13 12:53

6/ 13/ 2012 2:09:28 PM
C:\ Users\ vnguyen4\ Documents\ EAST\ Workspaces\ capacitive-position-sensor.wsp

Paper received 5/27/2011 13/118,280

PTO/SB/08	Application Number: Unassigned		First Named Inventor: Harald Philipp
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Attorney Docket No: 080900.1118	Art Unit: 2858 Unassigned	Filing Date: Herewith 5/27/2011

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS

		DOCUMENT NUMBER	PUBLICATION OR ISSUE DATE	FIRST NAMED INVENTOR
	A	4,121,204	10-17-1978	Welch et al.
	B	4,264,903	04-28-1981	Bigelow
	C	2003/0043174	03-06-2003	Hinckley et al.
	D	2004/0027395	02-12-2004	Lection et al.
	E	2004/0196267	10-07-2004	Kawai et al.
	F	2004/0207605	10-21-2004	Mackey
	G	2005/0052429	03-10-2005	Philipp
	H	2005/0078027	04-14-2005	Philipp
	I	2006/0016800	01-26-2006	Paradiso et al.
	J	2008/0094077	04-24-2008	Philipp
	K	2009/0051660	02-26-2009	Feland et al.
	L	2009/0115431	05-07-2009	Philipp

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	PUBLICATION OR ISSUE DATE	COUNTRY	TRANSLATION (YES OR NO)
	M	19645907 A1	05-20-1998	DE	
	N	19903300 A1	08-05-1999	DE	
	O	10133135 A1	01-30-2003	DE	
	P	10313401 A1	10-07-2004	DE	
	Q	212004000044 U1	06/07/2006	DE	
	R	102005002952 A1	07-27-2006	DE	
	S	102005018298 A1	10-19-2006	DE	
	T	1273851 A2	01-08-2003	EP	
	U	1602882 A1	12/07/2005	EP	
	V	2443296 A	04-30-2008	GB	
	W	2003088176 A1	10-23-2003	WO	
	X	2006133976 A1	12-21-2006	WO	
	Y	2007006624 A1	01-18-2007	WO	
	Z	2007023067 A1	03-01-2007	WO	
	AA	2007072294 A1	06-28-2007	WO	
	BB	2010075463 A4	09-02-2010	WO	

EXAMINER	DATE CONSIDERED
/Vincent Q. Nguyen/	06/13/2012

EXAMINER: Initial if citation 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 the applicant.

U.S. PATENT AND TRADEMARK OFFICE

Paper received 5/27/2011 13/118,280

PTO/SB/08	Application Number: Unassigned		First Named Inventor: Harald Philipp
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	**Attorney Docket No:** 080900.1118	**Art Unit:** Unassigned	**Filing Date:** 5/27/2011 Herewith

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**FIRST NAMED INVENTOR**
	A			
	B			
	C			
	D			

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**COUNTRY**	**TRANSLATION (YES OR NO)**
	E				
	F				
	G				
	H				

NON-PATENT LITERATURE (NPL)			
		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	**DATE**
	I	UK Intellectual Property Office, Combined Search and Examination Report in Corresponding UK application.	February 22, 2008
	J	Application Serial No. 11/868566, Non-Final Office Action mailed 10-01-09, 19 pages.	October 1, 2009
	K	Application Serial No. 12/317305, Non-Final Office Action mailed 10-01-09, 15 pages.	October 1, 2009
	L	Application Serial No. 12/317305, Interview Summary and Supplemental Office Action mailed 02-09-10, 12 pages.	February 9, 2010
	M	Application Serial No. 12/317305, Response filed 03-01-10 to Non-Final Office Action mailed 10-01-09 and the Supplemental Office Action mailed 02-09-10, 14 pages.	March 1, 2010
	N	Application Serial No. 12/317305, Notice of Allowance mailed 04-12-10, 7 pages.	April 4, 2010
	O	International Application Serial No. PCT/US2009/069322, International Search Report mailed 05-07-10, 3 pages.	May 7, 2010
	P	International Application Serial No. PCT/US2009/069322, Written Opinion mailed 05/07/10, 5 pages.	May 7, 2010
	Q	German Application Serial No. 102007049559.7, Office Action mailed 01-04-11, 10 pages.	January 4, 2011

EXAMINER	DATE CONSIDERED
/Vincent Q. Nguyen/	06/13/2012

EXAMINER: Initial if citation 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 the applicant.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N./

Paper received 12/14/2011

PTO/SB/08	Application Number: 13/118280		First Named Inventor: Harald Philipp
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Attorney Docket No: 080900.1118	Art Unit: 2858 Unassigned	Filing Date: 27 May 2011

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	PUBLICATION OR ISSUE DATE	FIRST NAMED INVENTOR
	A	7,663,607	02-16-2010	Hotelling
	B	7,920,129	04-05-2011	Hotelling
	C	8,031,094	10-04-2011	Hotelling
	D	8,031,174	10-04-2011	Hamblin
	E	8,049,732	11-01-2011	Hotelling

UNPUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	FILING DATE	FIRST NAMED INVENTOR
	F			
	G			
	H			
	I			

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	PUBLICATION OR ISSUE DATE	COUNTRY	TRANSLATION (YES OR NO)
	J				
	K				

NON-PATENT LITERATURE (NPL)			
		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	DATE
	L		
	M		
	N		
	O		
	P		
	Q		
	R		

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N./

EXAMINER	DATE CONSIDERED
/Vincent Q. Nguyen/	06/13/2012

EXAMINER: Initial if citation 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 the applicant.

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Alexandria, Virginia 22313-1450
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BIB DATA SHEET

CONFIRMATION NO. 9244

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/118,280	05/27/2011 RULE	324	2858	080900.1118

APPLICANTS
Harald Philipp, Zug, SWITZERLAND;

**** CONTINUING DATA ***************************
This application is a CON of 12/703,614 02/10/2010 PAT 7,952,367 *
which is a CON of 11/868,566 10/08/2007 ABN
which claims benefit of 60/862,358 10/20/2006
(*)Data provided by applicant is not consistent with PTO records.

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
06/10/2011

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	☐ Yes ☑ No	/VINCENT Q NGUYEN/ Examiner's Signature	☐ Initials	SWITZERLAND	4	19	3

ADDRESS
Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201
UNITED STATES

TITLE
Capacitive Position Sensor

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
1090	No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13118280	PHILIPP, HARALD
	Examiner	Art Unit
	VINCENT Q NGUYEN	2858

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/13/2012								
	1	=								
	2	=								
	3	=								
	4	=								
	5	=								
	6	=								
	7	=								
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	18	=								
	19	=								

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/118,280	05/27/2011	Harald Philipp	080900.1118	9244

12323 7590 08/24/2012

Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

EXAMINER	
NGUYEN, VINCENT Q	
ART UNIT	PAPER NUMBER
2858	

NOTIFICATION DATE	DELIVERY MODE
08/24/2012	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):

ptomail1@bakerbotts.com
ptomail2@bakerbotts.com

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P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
13/118,280	27 May, 2011	PHILIPP, HARALD	080900.1118

Baker Botts L.L.P.
2001 Ross Avenue, 6th Floor
Dallas, TX 75201

EXAMINER	
Vincent Q. Nguyen	
ART UNIT	PAPER
2858	20120814

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Specification page 16 of 22 ends incomplete (No period). Appropriate correction and/or explantion is required..

/Vincent Q Nguyen/
Primary Examiner, Art Unit 2858

PTO-90C (Rev.04-03)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

12323 7590 06/19/2012
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Dallas, TX 75201

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/118,280	05/27/2011	Harald Philipp	080900.1118	9244

TITLE OF INVENTION: CAPACITIVE POSITION SENSOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	09/19/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, VINCENT Q	2858	324-686000

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 03-02 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 Baker Botts L.L.P.
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 has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Atmel Corporation
(B) RESIDENCE: (CITY and STATE OR COUNTRY): San Jose, California

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
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☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 02-0384 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date 09/18/2012
Typed or printed name Chad D. Terrell Registration No. 52,279

This collection of information 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 12 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.

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Electronic Patent Application Fee Transmittal	
Application Number:	13118280
Filing Date:	27-May-2011
Title of Invention:	CAPACITIVE POSITION SENSOR
First Named Inventor/Applicant Name:	Harald Philipp
Filer:	Chad Christian Walters/Karen Langford
Attorney Docket Number:	080900.1118
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

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	1740	1740
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2040**

Electronic Acknowledgement Receipt	
EFS ID:	13772504
Application Number:	13118280
International Application Number:	
Confirmation Number:	9244
Title of Invention:	CAPACITIVE POSITION SENSOR
First Named Inventor/Applicant Name:	Harald Philipp
Customer Number:	12323
Filer:	Chad Christian Walters/Karen Langford
Filer Authorized By:	Chad Christian Walters
Attorney Docket Number:	080900.1118
Receipt Date:	18-SEP-2012
Filing Date:	27-MAY-2011
Time Stamp:	12:04:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$2040
RAM confirmation Number	9240
Deposit Account	020384
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance 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)	1118if.pdf	123077 ca9dc33eb80249f8f8418cd0352bd9801567d8b1	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	31753 49b95074207b80b3e99de763664ea4ac0465a74c	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	154830		

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.

PTO/SB/30 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Request for Continued Examination (RCE) Transmittal

Address to:
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P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	13/118,280
Filing Date	May 27, 2011
First Named Inventor	Harald Philipp
Art Unit	#2858 confirmation #9244
Examiner Name	Vincent Q. Nguyen
Attorney Docket Number	080900.1118

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      Ii. ☐ Other _____

   b. ☑ Enclosed

      I. ☐ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☑ Information Disclosure Statement (IDS)

      iv. ☑ Other Petition to Withdraw from Issue

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 02-0384 .

      i. ☑ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☑ Other $130.00 Petition to Withdraw from Issue fee (37 C.F.R. § 1.313(c)(2))

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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature		Date	November 5, 2012
Name (Print/Type)	Chad D. Terrell	Registration No.	52,279

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:	Harald Philipp
Application No:	13/118,280
Filed:	May 27, 2011
Art Unit:	2858
Confirmation No.:	9244
Examiner:	Vincent Q. Nguyen
Title:	*Capacitive Position Sensor*

MAIL STOP: RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Information Disclosure Statement (IDS)

Applicant respectfully requests, pursuant to 37 C.F.R. §§ 1.56, 1.97 and 1.98, that the documents listed on the attached PTO-1449 form be considered and cited in the examination of the above-identified patent application. No representation is made that a search has been made, that these documents are material to patentability, or that these documents qualify as prior art.

Copies of U.S. patents and U.S. patent application publications have not been provided. To the extent applicable, documents other than the U.S. patents and U.S. patent application publications are enclosed.

This IDS is being submitted with a Petition to Withdraw from Issue Pursuant to 37 C.F.R. § 1.313(c)(2) and a Request for Continued Examination (RCE), for which applicable fees are being submitted. Thus, no other fees are believed to be due for this IDS. Although Applicant believes no other fees are due, the Commissioner is hereby authorized to charge any necessary additional fees and credit any overpayments to Deposit Account No. 02-0384 of Baker Botts L.L.P.

Respectfully submitted,

BAKER BOTTS L.L.P.
Attorneys for Applicant

Chad D. Terrell
Reg. No. 52,279

Date: November 5, 2012

Correspondence Address:
Customer No. 12323

PTO/SB/08 **INFORMATION DISCLOSURE STATEMENT BY APPLICANT**	**Application Number:** 13/118,280		**First Named Inventor:** Harald Philipp
	Attorney Docket No: 080900.1118	**Art Unit:** 2858 confirm #9244	**Filing Date:** May 27, 2011

ISSUED U.S. PATENTS AND PUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**FIRST NAMED INVENTOR**
	A	7,875,814	25 January 2011	Chen
	B	8,040,326	18 October 2011	Hotelling
	C	8,179,381	15 May 2012	Frey
	D	2009/0315854	24 December 2009	Matsuo
	E	2012/0242588	27 September 2012	Myers
	F	2012/0242592	27 September 2012	Rothkopf
	G	2012/0243151	27 September 2012	Lynch
	H	2012/0243719	27 September 2012	Franklin
	I			
	J			
	K			

UNPUBLISHED U.S. APPLICATIONS				
		DOCUMENT NUMBER	**FILING DATE**	**FIRST NAMED INVENTOR**
	L	61/454936	21 March 2011	Myers
	M	61/454950	21 March 2011	Lynch
	N	61/454894	21 March 2011	Rothkopf
	O			

FOREIGN PATENT DOCUMENTS					
		DOCUMENT NUMBER	**PUBLICATION OR ISSUE DATE**	**COUNTRY**	**TRANSLATION (YES OR NO)**
	P	WO 2012/129247	27 September 2012	PCT	
	Q				
	R				

NON-PATENT LITERATURE (NPL)			
		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	**DATE**
	S		
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U.S. PATENT AND TRADEMARK OFFICE

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 September 2012 (27.09.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/129247 A2

(51) International Patent Classification:
H04M 1/02 (2006.01) *G06F 1/16* (2006.01)

(21) International Application Number:
PCT/US2012/029844

(22) International Filing Date:
20 March 2012 (20.03.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

61/454,950	21 March 2011 (21.03.2011)	US
61/454,894	21 March 2011 (21.03.2011)	US
61/454,936	21 March 2011 (21.03.2011)	US
13/108,256	16 May 2011 (16.05.2011)	US
13/171,295	28 June 2011 (28.06.2011)	US
13/184,303	15 July 2011 (15.07.2011)	US
13/422,724	16 March 2012 (16.03.2012)	US

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(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, 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,

[Continued on next page]

(54) Title: ELECTRONIC DEVICES WITH FLEXIBLE DISPLAYS

(57) Abstract: Electronic devices may be provided that contain flexible displays and internal components. An internal component may be positioned under the flexible display. The internal component may be an output device such as a speaker that transmits sound through the flexible display or an actuator that deforms the display in a way that is sensed by a user. The internal component may also be a microphone or pressure sensor that receives sound or pressure information through the flexible display. Structural components may be used to permanently or temporarily deform the flexible display to provide tactile feedback to a user of the device. Electronic devices may be provided with concave displays or convex displays formed from one or more flexible layers including a flexible display layer. Portions of the flexible display may be used as speaker membranes for display-based speaker structures.

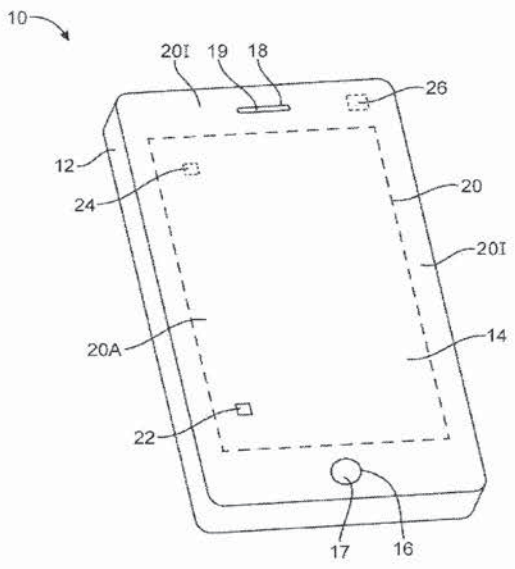


FIG. 1

WO 2012/129247 A2

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) **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, MD, 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, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Electronic Devices With Flexible Displays

This application claims priority to United States patent application No. 13/171,295, filed June 28, 2011, United States patent application No. 13/108,256, filed May 16, 2011, United States patent application No. 13/184,303, filed July 15, 2011, United States patent application No. 13/422,724, filed March 16, 2012, provisional patent application No. 61/454,894, filed March 21, 2011, provisional patent application No. 61/454,936, filed, March 21, 2011, and provisional patent application No. 61/454,950, filed March 21, 2011 which are hereby incorporated by reference herein in their entirety.

Background

This relates generally to flexible displays, and more particularly, to electronic devices with flexible displays.

Electronic devices such as portable computers and cellular telephones are often provided with rigid displays made from rigid display structures. For example, a liquid crystal display (LCD) may be formed from a stack of rigid display structures such as a thin-film transistor layer with display pixels for providing visual feedback to a user, a color filter layer for providing the display

pixels with color, a touch screen panel for gathering touch input from a user, and a cover glass layer for protecting the display and internal components.

Conventional devices may also have input-output components such as buttons, microphones, speakers, and other components. Openings are commonly formed in the housing of a conventional device to accommodate operation of these input-output components. For example, openings may be formed in a device housing to accommodate speaker and microphone ports and openings may be formed in a display cover glass layer to accommodate a speaker port and menu button.

The inclusion of these openings to accommodate input-output components may not be desirable. For example, the presence of openings may be aesthetically unappealing, may raise the risk of damage from environmental exposure, and may reduce the amount of active display area that is available to display images for a user.

There is often very little real estate available for mounting these input-output components. For example, input-output components are often mounted under an inactive portion of a display or within the sidewalls of an electronic device housing.

The size and number of input-output components such as speakers may be limited by the amount of space available in these locations. For example, a conventional device may have a single speaker mounted under an inactive portion of a display. The size and quality of such a speaker may be limited by a lack of space in the inactive portion of the display. Additionally, mounting a speaker in the inactive portion of a display may add undesirable width to the inactive portion of the display.

Devices with planar cover glass layers may be prone

to scratches and damage when dropped on a surface. Users can minimize scratches and damage from drop events using a protective case. Protective cases may not, however, be convenient or aesthetically appealing for many users.

It is often desirable to produce portable devices of minimal size. Users of portable electronic devices may find a thinner device more desirable than a thicker device. Compact portable devices are sometimes provided with convex housing shapes. A convex housing shape may increase the internal volume of a device while preserving a sleek, thin look that is aesthetically pleasing to a user.

A portable compact device with a convex housing may have a display. In conventional arrangements, the display is flat, so only the portions of the device other than the display have a convex shape. This may limit the internal volume of the device and may detract from its appearance.

It would therefore be desirable to be able to provide improved electronic devices.

Summary

Electronic devices may be provided with flexible displays. The flexible displays may be composed of one or more flexible layers and may be mounted on top of or under a cover layer. For example, a flexible display may be mounted on top of a rigid support member or may be mounted on the underside of a rigid cover layer.

Electronic devices may also be provided with user interface components (input-output components) such as buttons, microphones, speakers, piezoelectric actuators (for receiving electrical input from a user or tactile feedback to users), or other actuators such as vibrators, pressure sensors, and other components. These components

may be mounted under portions of a flexible display.

During operation of the electronic device, the flexibility of the display may allow a user to interact with the component through the display. For example, sound waves from a speaker or localized vibrations from an actuator in an electronic device may pass through the flexible display. The flexible display may also allow an internal microphone, pressure sensor, or force sensor (or other internal components) to receive external input. For example, a user may deflect a flexible display using a finger or other external object, barometric pressure may be monitored through the flexible display, or sound waves may be received through the flexible display.

Components may receive input or may supply output through a physically deformed portion of the flexible display (e.g., a deformation that occurs when a user presses on the display to compress the component). In some configurations, a portion of the flexible display may serve as a membrane that forms part of a microphone, speaker, pressure sensor, or other electronic component.

The ability of a user to compress a component such as a button switch by deforming the flexible display may allow the area of a device available for visual display to be enlarged. For example, the active area of a flexible display may overlap a component such as a button or speaker.

If desired, a flexible display may be deformed by an internal component to provide audio or tactile feedback to a user. For example, structures inside an electronic device may be pressed against portions of a flexible display to temporarily create an outline for a virtual on-screen button or to temporarily create a grid of ridges that serve to delineate the locations of keys in a keyboard (keypad).

Electronic devices may be provided with concave displays. Peripheral edge portions of a concave display may be raised relative to depressed central portions of the concave display. This helps reduce scratches and other damage due to contact with the central portion of the display.

Concave displays may include one or more flexible display layers and may be mounted on top of or under a cover layer. For example, a flexible display layer may be mounted on top of a rigid support member or may be mounted on the underside of a rigid cover layer

Concave displays may also include touch-sensitive capabilities by stacking a touch sensor array layer on top of or under flexible display layers. Rigid concave displays may be formed from a flexible display layer, a touch-sensitive layer, and a rigid cover layer or rigid support structure.

Devices having concave displays formed from curved flexible display layers may help maximize the use of the internal volume of an electronic device.

Electronic devices may be provided with convex displays. The convex displays may include one or more flexible display layers and may be mounted on top of or under a cover layer with a curved shape. For example, a flexible display layer may be mounted on top of a rigid support member having a convex surface or may be mounted on the concave underside of a rigid convex display cover layer.

Convex displays may be provided with touch-sensitive capabilities by stacking a touch sensor array on top of or under flexible display layers. Rigid convex displays may be formed from a flexible display layer, a touch-sensitive layer, and a rigid cover layer or support structure.

5

Devices having convex displays formed from curved flexible display layers may help maximize the use of the internal volume of an electronic device.

A display cover such as a cover glass layer may be mounted over a flexible display. The flexible display may be an organic light-emitting diode display having a flexible substrate formed from one or more sheets of polymer. The flexible display may include a touch sensor layer having an array of capacitive touch sensor electrodes.

There may be one or more display-based speaker structures in the electronic device. The display-based speaker structures may be mounted under the flexible display. Portions of the flexible display may be used as speaker membranes for the display-based speaker structures.

The flexible display may have an active area that is configured to display images to a user. Speaker membranes may be formed from the active portion of the flexible display. The display-based speaker structures may be driven by transducers that receive an electrical audio signal input from circuitry in the electronic device. Piezoelectric transducers or transducers formed from coils and magnets may be used to drive the display-based speaker structures.

A stiffening structure may be used to stiffen a portion of a flexible display that is used as a speaker membrane. The stiffening structure may be formed from a layer of foam interposed between sheets of stiffening material. The stiffening structure may form a stiff and lightweight support structure that allows the speaker membrane to respond accurately to the transducer.

A suspension structure may be used to attach a display-based speaker structure to surrounding housing

structures. The suspension structure may form a pliant interface between the speaker structure and the surrounding housing structures. The suspension structure may allow the speaker structure to vibrate during speaker operation while inhibiting lateral motion of the speaker structure.

Speaker structures may be configured to achieve a desired frequency response. The electronic device housing in which a speaker structure is mounted may be provided with an acoustic port to tune speaker frequency response. The type of transducer that is used in a speaker may be selected to tune speaker frequency response. The size and placement of internal device components that affect speaker volume and speaker mass may also be selected to tune speaker frequency response.

An electronic device may be provided with an array of display-based speaker structures. The speaker membrane for each speaker structure may be stiffened with an associated stiffening structure. Each stiffened speaker membrane may be surrounded by a ring of flexible display that is configured to absorb lateral vibrations and thus prevent interference between neighboring speakers.

Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of the preferred embodiments.

Brief Description of the Drawings

FIG. 1 is a perspective view of an illustrative electronic device with a flexible display and internal components in accordance with an embodiment of the present invention.

FIG. 2 is a diagram of an illustrative set of

display layers that may be used to form a flexible display in accordance with an embodiment of the present invention.

FIG. 3 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of an internal user interface component in accordance with an embodiment of the present invention.

FIG. 4 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of a button in accordance with an embodiment of the present invention.

FIG. 5 is a cross-sectional side view of another embodiment of a portion of an illustrative electronic device in the vicinity of a button in accordance with an embodiment of the present invention.

FIG. 6 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of an audio component in accordance with an embodiment of the present invention.

FIG. 7 is a cross-sectional side view of another embodiment of a portion of an illustrative electronic device in the vicinity of an audio component in accordance with an embodiment of the present invention.

FIG. 8 is a cross-sectional side view of yet another embodiment of a portion of an illustrative electronic device in the vicinity of an audio component in accordance with an embodiment of the present invention.

FIG. 9 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of an actuator such as a piezoelectric actuator in accordance with an embodiment of the present invention.

FIG. 10 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of an internal structural component in accordance with an embodiment of the present invention.

FIG. 11 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of a combined internal interface component in accordance with an embodiment of the present invention.

FIG. 12 is a perspective view of a portion of an illustrative electronic device with a flexible display and a combined internal interface component in accordance with an embodiment of the present invention.

FIG. 13 is a perspective view of a portion of an illustrative electronic device with a flexible display and a combined internal interface component mounted to actuator stage in accordance with an embodiment of the present invention.

FIG. 14 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of an internal structural component mounted to an actuator stage in accordance with an embodiment of the present invention.

FIG. 15 is a cross-sectional side view of a portion of an illustrative electronic device with a cover and an internal structural component mounted to an actuator in accordance with an embodiment of the present invention.

FIG. 16 is a cross-sectional side view of a portion of an illustrative electronic device in the vicinity of a pressure sensor in accordance with an embodiment of the present invention.

FIG. 17 is a perspective view of an illustrative electronic device with a concave display and a bezel in accordance with an embodiment of the present invention.

FIG. 18 is a cross-sectional side view of an illustrative electronic device having a concave display with a flexible display layer that conforms to the concave shape of a support structure in accordance with an

embodiment of the present invention.

FIG. 19 is a cross-sectional side view of a portion of an illustrative electronic device having a cover layer and a flexible display layer joined by an adhesive layer in accordance with an embodiment of the present invention.

FIG. 20 is a cross-sectional side view of a portion of an illustrative electronic device having a flexible display layer, a flexible touch-sensitive layer, and a cover layer joined by adhesive layers in accordance with an embodiment of the present invention.

FIG. 21 is a cross-sectional side view of an illustrative electronic device having a concave display with a radius of curvature chosen to protect the device from a drop surface in accordance with an embodiment of the present invention.

FIG. 22 is a perspective view of an illustrative electronic device with a convex display and a bezel formed from a housing structure in accordance with an embodiment of the present invention.

FIG. 23 is a cross-sectional side view of an illustrative electronic device with a convex display and internal components in accordance with an embodiment of the present invention.

FIG. 24 is a cross-sectional side view of a portion of an illustrative electronic device having a convex display with a flexible display layer that conforms to a support structure in accordance with an embodiment of the present invention.

FIG. 25 is a cross-sectional side view of a portion of an illustrative electronic device having a convex cover layer and a flexible display layer joined by an adhesive layer in accordance with an embodiment of the present invention.

10

FIG. 26 is a cross-sectional side view of a portion of an illustrative electronic device having a flexible display layer, a touch-sensitive layer and a convex cover layer joined by adhesive layers in accordance with an embodiment of the present invention.

FIG. 27 is a cross-sectional perspective view of an illustrative electronic device having a convex display and a connector port arranged to use the internal volume of the device in accordance with an embodiment of the present invention.

FIG. 28 is a cross-sectional perspective view of an illustrative electronic device having a convex display and internal components in accordance with an embodiment of the present invention.

FIG. 29 is a cross-sectional side view of an illustrative electronic device substantially surrounded by a convex display in accordance with an embodiment of the present invention.

FIG. 30 is a diagram of an illustrative electronic device such as a portable computer having a display and one or more speaker structures in accordance with an embodiment of the present invention.

FIG. 31 is a diagram of an illustrative electronic device such as a cellular telephone or other handheld device having a display and one or more speaker structures in accordance with an embodiment of the present invention.

FIG. 32 is a diagram of an illustrative electronic device such as a tablet computer having a display and one or more speaker structures in accordance with an embodiment of the present invention.

FIG. 33 is a diagram of an illustrative electronic device such as a computer monitor with a built-in computer having a display and one or more speaker

structures in accordance with an embodiment of the present invention.

FIG. 34 is a diagram of an illustrative set of display layers that may be used to form a flexible display in accordance with an embodiment of the present invention.

FIG. 35 is a diagram of an illustrative set of layers that may be used to form an organic light-emitting diode display in accordance with an embodiment of the present invention.

FIG. 36 is a cross-sectional side view of a portion of an illustrative electronic device in which a flexible display forms part of a speaker structure in accordance with an embodiment of the present invention.

FIG. 37 is a cross-sectional side view of a portion of an illustrative electronic device in which a flexible display forms part of a speaker structure in accordance with an embodiment of the present invention.

FIG. 38 is a cross-sectional side view of a portion of an illustrative electronic device in which a flexible display forms part of a speaker structure in accordance with an embodiment of the present invention.

FIG. 39 is a perspective view of an illustrative electronic device of the type shown in FIG. 38 having a cover layer with speaker openings in accordance with an embodiment of the present invention.

FIG. 40 is a cross-sectional side view of a portion of an illustrative electronic device in which a flexible display is stiffened with a support structure in accordance with an embodiment of the present invention.

FIG. 41 is a cross-sectional side view of a portion of an illustrative electronic device having a curved flexible display with a curved support structure in accordance with an embodiment of the present invention.

FIG. 42 is a cross-sectional side view of a

portion of an illustrative electronic device in which a flexible display forms part of a single speaker structure in accordance with an embodiment of the present invention.

FIG. 43 is a cross-sectional side view of a portion of an illustrative electronic device in which a flexible display forms part of an array of speaker structures in accordance with an embodiment of the present invention.

FIG. 44 is a bottom view of an illustrative electronic device of the type shown in FIG. 43 having a flexible display that forms part of an array of speaker structures in accordance with an embodiment of the present invention.

Detailed Description

Electronic devices may be provided with flexible displays. A flexible display may include one or more flexible layers. If desired, the flexible display may include a display cover layer such as a flexible or rigid display cover layer.

In some configurations, an electronic device may be provided with a flexible display and user interface components that are positioned behind, abutted against or integrated into the flexible display. FIGS. 1-16 show examples of configurations in which user interface components may be positioned behind, abutted against or integrated into the flexible display.

In some configurations, an electronic device may be provided with a concave display having one or more flexible display layers. FIGS. 1, 2, and 17-21 show examples of configurations in which an electronic device may be provided with a concave display having one or more flexible display layers.

In some configurations, an electronic device may

be provided with a convex display having one or more flexible display layers. FIGS. 1, 2, and 22-29 show examples of configurations in which an electronic device may be provided with a convex display having one or more flexible display layers.

In some configurations, a portion of the flexible display may form a membrane structure of an electronic component such as a speaker, a microphone, a laser microphone or a pressure sensor. FIGS. 30-44 show examples of configurations in which a portion of the flexible display may form a membrane structure of an electronic component.

As shown in the examples of FIGS. 1-16, an electronic device may be provided with a flexible display and user interface components. User interface components may include buttons, switches, microphones, actuators such as solenoids, motors, and piezoelectric actuators, connector ports, touch screens, proximity sensors and other components for accepting input from, or transmitting information to, a user or the surrounding environment.

Flexible displays may be formed from flexible layers such as a flexible display layer (e.g., a flexible organic light-emitting diode array), a flexible touch-sensitive layer (e.g., a sheet of polymer with an array of transparent capacitor electrodes for a capacitive touch sensor), a flexible substrate layer, etc. These flexible layers may, if desired, be covered by a flexible or rigid cover layer (sometimes referred to as a cover glass) or may be supported by a support structure (e.g., a rigid support structure on the underside of the flexible layers). In electronic devices with flexible displays that are covered by rigid cover layers, the cover layers may be provided with openings that provide access to the flexible layers of the display in the vicinity of a user

interface device. For example, a cover glass layer may have an opening that allows a button member to move relative to the cover glass layer. As the button member moves within the opening, underlying portions of the flexible display may be deformed (e.g., to allow actuation of an associated switch).

To maximize the area of the portion of the flexible display that is available for displaying visual information to the user, user interface components may be positioned behind, abutted against or integrated into the flexible display. The deformable nature of the flexible display may allow a user to interact with the user interface components (input-output components) by moving the display into contact with the user interface components or by otherwise allowing the display to locally flex (e.g., to allow sound to pass through the flexible display or to allow a barometric pressure measurements of the exterior environment to be made by an internal pressure sensor). If desired, a portion of the flexible display may form a membrane portion of an electrical component. Components that may be provided with a membrane that is formed from a portion of a flexible display include microphones, laser microphones, pressure sensors, speakers, etc.

An illustrative electronic device of the type that may be provided with a flexible display is shown in FIG. 1.

Electronic device 10 may be a portable electronic device or other suitable electronic device. For example, electronic device 10 may be a laptop computer, a tablet computer, a somewhat smaller device such as a wrist-watch device, pendant device, or other wearable or miniature device, a cellular telephone, a media player, etc.

Device 10 may include a housing such as housing

12. Housing 12, which may sometimes be referred to as a case, may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of these materials. In some situations, parts of housing 12 may be formed from dielectric or other low-conductivity material. In other situations, housing 12 or at least some of the structures that make up housing 12 may be formed from metal elements.

Device 10 may have a flexible display such as flexible display 14. Flexible display 14 may be formed from multiple layers of material. These layers may include a touch sensor layer such as a layer on which a pattern of indium tin oxide (ITO) electrodes or other suitable transparent electrodes have been deposited to form a capacitive touch sensor array. These layers may also include a layer that contains an array of display pixels. The touch sensor layer and the display layer may be formed using flexible sheets of polymer or other substrates having thicknesses of 10 microns to 0.5 mm or other suitable thicknesses (as an example).

The display pixel array may be, for example, an organic light-emitting diode (OLED) array. Other types of flexible display pixel arrays may also be formed (e.g., electronic ink displays, etc.). The use of OLED technology to form flexible display 14 is sometimes described herein as an example. This is, however, merely illustrative. Flexible display 14 may be formed using any suitable flexible display technology. The use of flexible displays that are based on OLED technology is merely illustrative.

In addition to these functional display layers (i.e., the OLED array and the optional touch sensor array), display 14 may include one or more structural

layers. For example, display 14 may be covered with a flexible or rigid cover layer and/or may be mounted on a support structure (e.g., a rigid support). Layers of adhesive may be used in attaching flexible display layers to each other and may be used in mounting flexible display layers to rigid and flexible structural layers.

In configurations for display 14 in which the cover layer for display 14 is flexible, input-output components that rely on the presence of flexible layers may be mounted at any suitable location under the display (e.g., along peripheral portions of the display, in a central portion of the display, etc.). In configurations for display 14 in which the flexible layers are covered by a rigid cover glass layer or other rigid cover layer, the rigid layer may be provided with one or more openings and the electronic components may be mounted under the openings. For example, a rigid cover layer may have openings such as a circular opening 16 for button 17 and a speaker port opening such as speaker port opening 18 (e.g., for an ear speaker for a user). Device 10 may also have other openings (e.g., openings in display 14 and/or housing 12 for accommodating volume buttons, ringer buttons, sleep buttons, and other buttons, openings for an audio jack, data port connectors, removable media slots, etc.).

In some embodiments, portions of flexible display 14 such as peripheral regions 20I may be inactive and portions of display 14 such as rectangular central portion 20A (bounded by dashed line 20) may correspond to the active part of display 14. In active display region 20A, an array of image pixels may be used to present text and images to a user of device 10. In active region 20A, display 14 may include touch sensitive components for input and interaction with a user of device 10. If

desired, regions such as regions 20I and 20A in FIG. 1 may both be provided with display pixels (i.e., all or substantially all of the entire front planar surface of a device such as device 10 may be covered with display pixels).

Device 10 may, if desired, have internal user interface components such as buttons 17 or speaker component 19 that occupy openings such as openings 16 and 18 respectively in an optional rigid cover layer of flexible display 14. Buttons 17 may be based on dome switches or other switch circuitry. Buttons 17 may include button members that form push buttons (e.g., momentary buttons), slider switches, rocker switches, etc. Device 10 may include internal structural components such as structural component 22 that add a raised structure to a portion of flexible display 14. Device 10 may include components such as interface components 24 and 26 that may be fully internal to device 10, but that receive input from the user or from the surrounding environment through physical interaction with flexible display 14. Interface components 22, 24, and 26 may be positioned in active region 20A or inactive region 20I of flexible display 14. Interface components 22, 24, and 26 may be positioned separately from one another or may be commonly located to form a combined component with structural and internal features. Interface components 24 and 26 may be positioned underneath flexible display 14 so that flexible display 14 must be deformed in order to contact components 24 or 26 or, if desired may be positioned to remain in constant contact with flexible display 14.

An exploded perspective view of an illustrative display is shown in FIG. 2. As shown in FIG. 2, flexible display 14 may be formed by stacking multiple layers including flexible display layer 14A, touch-sensitive

layer 14B, and cover layer 14C. Flexible display 14 may also include other layers of material such as adhesive layers, optical films, or other suitable layers. Flexible display layer 14 may include image pixels formed form light-emitting diodes (LEDs), organic LEDs (OLEDs), plasma cells, electronic ink elements, liquid crystal display (LCD) components, or other suitable image pixel structures compatible with flexible displays.

Touch-sensitive layer 14B may incorporate capacitive touch electrodes such as horizontal transparent electrodes 32 and vertical transparent electrodes 34. Touch-sensitive layer 14B may, in general, be configured to detect the location of one or more touches or near touches on touch-sensitive layer 14B based on capacitive, resistive, optical, acoustic, inductive, or mechanical measurements, or any phenomena that can be measured with respect to the occurrences of the one or more touches or near touches in proximity to touch sensitive layer 14B.

Software and/or hardware may be used to process the measurements of the detected touches to identify and track one or more gestures. A gesture may correspond to stationary or non-stationary, single or multiple, touches or near touches on touch-sensitive layer 14B. A gesture may be performed by moving one or more fingers or other objects in a particular manner on touch-sensitive layer 14B such as tapping, pressing, rocking, scrubbing, twisting, changing orientation, pressing with varying pressure and the like at essentially the same time, contiguously, or consecutively. A gesture may be characterized by, but is not limited to a pinching, sliding, swiping, rotating, flexing, dragging, or tapping motion between or with any other finger or fingers. A single gesture may be performed with one or more hands, by one or more users, or any combination thereof.

Cover layer 14C may be formed from plastic or glass (sometimes referred to as display cover glass) and may be flexible or rigid. If desired, the interior surface of peripheral inactive portions 20I of cover layer 14C may be provided with an opaque masking layer on such as black ink.

Touch-sensitive flexible display section 14AB may be formed from display pixel array layer 14A and optional touch sensor layer 14B.

FIG. 3 is a cross-sectional side view of a portion of flexible display 14 in the vicinity of internal user interface component 24. Flexible display 14 may be deformed away from its natural shape under pressure. For example, flexible display 14 may be deflected by pressure exerted by a user or by other external forces in direction 40. As shown in FIG. 3, pressure in direction 40 may cause flexible display 40 to deform as indicated by dashed lines 44. Internal component 24 may be configured to receive input due to deformation of flexible display 14. Internal component 24 may also provide a temporary return (restoring) pressure in direction 42.

Pressure in direction 42 may cause flexible display 14 to temporarily deform outward of device 10 as indicated by dashed lines 46. Pressure in direction 42 may, if desired, be formed by an internal actuator that deforms display 14 to provide a desired tactile sensation on the surface of display 14 to a user of device 10. Flexible display 14 may have a natural resiliency that, following deformation as indicated by dashed lines 44, causes flexible display to temporarily deform outward of device 10 as indicated by dashed lines 46 before returning to its natural shape. Internal component 24 may be a button, an actuator such as a motor, solenoid, vibrator, or piezoelectric actuator, a pressure sensor, an audio

component such as a microphone or speaker, or other component. Because display 14 is flexible, these components may operate effectively, even when covered by display 14. For example, audio components such as microphones and speakers may receive and transmit sound through flexible display 14. A barometric pressure sensor or a force sensor may also receive input through flexible display 14. Components such as actuators may be used to temporarily create raised ridges or other external features on the surface of the flexible display (e.g., to indicate to a user where an on-screen button or group of buttons is located). The portion of display 14 under which components 24 are mounted may be active (i.e., a portion of the display that contains OLED pixels or other display pixels) or inactive (i.e., a peripheral portion of the display outside of the active region).

FIG. 4 is a cross-sectional side view of a portion of device 10 in the vicinity of button 17 of device 10. As shown in FIG. 4, button 17 may have a button member such as button member 52 that reciprocates within opening 16 of cover layer 14C. When a user presses the exterior of button member 52 in direction 58, button member 52 may press against touch-sensitive flexible display section (layer) 14AB. Touch-sensitive flexible display section 14AB may be deformed to depress a dome switch such as dome switch 56 or other switch mechanism, thereby activating the switch (e.g., shorting internal switch terminals together to close the switch). Dome switches such as dome switch 56 may, if desired, be mounted to printed circuits such as printed circuit 54. Dome switch 56 may have a dome-shaped biasing member that pushes touch-sensitive flexible display section 14AB outward in direction 60 when the user releases pressure from button member 52. Dome switch 54 and printed circuit

54 may be recessed in a support structure such as support structure 50 behind flexible display 14. Other types of switches may used if desired, such as switches with spring-based biasing members or other biasing structures that bias button members such as button member 52. The use of a dome switch with a dome-shaped biasing structure is merely illustrative.

FIG. 5 is a cross-sectional side view of a portion of device 10 in the vicinity of button 17 of device 10. The illustrative embodiment of FIG. 5 differs from the illustrative embodiment of FIG. 4 in that cover layer 14C of flexible display 14 is not a rigid cover layer, but a flexible cover layer. In an embodiment in which flexible display 14 contains a flexible cover layer 14C, button 17 includes dome switch 56 and printed circuit 54. In the embodiment of FIG. 5, a user may press the exterior of flexible display 14 in direction 58. Flexible display 14 may be deformed to depress dome switch 56 or other switch mechanism, thereby activating the switch. As in FIG. 4, dome switches such as dome switch 56 may, if desired, be mounted to printed circuits such as printed circuit 54. Dome switch 56 may have a dome-shaped biasing member that pushes flexible display 14 outward in direction 60 when the user releases pressure from button member 52. Dome switch 54 and printed circuit 54 may be mounted in support structures 50 behind flexible display 14. Other types of switches may use spring-based biasing members or other biasing structures to bias button members such as button member 52. The use of a dome switch with a dome-shaped biasing structure is merely illustrative.

Providing device 10 with flexible display 14 without the need for an opening in flexible display 14 to access button 17 allows flexible display 14 to extend over button 17 without disruption. In both the FIG. 4 and FIG.

configurations, the portion of the flexible display that overlaps the button may be an active display portion or an inactive display portion. When an active display portion is configured so as to overlap buttons and other components, there is generally more area available for the active display portion. The presence of flexible display 14 over button 17 (or other components) may also reduce the risk of moisture or dirt entering into the interior of device 10.

FIG. 6 is a cross-sectional side view of a portion of device 10 in the vicinity of audio component 19. Audio component 19 may be recessed in a chassis 50 behind flexible display 14. Audio component 19 may be a speaker for providing sound to a user of device 10 or a microphone for receiving input from a user or the external environment. In the embodiment shown in FIG. 6, sound may be transmitted through flexible display 14 to a microphone or from a speaker. The portion of flexible display 14 that overlaps audio component 19 may be active or inactive. Arrangements in which component 19 is covered with part of the active area of display 14 may allow the size of active region 20A of flexible display 14 to be increased. The presence of flexible display 14 over audio component 19 may also reduce the risk of moisture or dirt entering into the interior of device 10.

FIG. 7 is a cross-sectional side view of a portion of device 10 in the vicinity of another embodiment of audio component 19. In the illustrative embodiment of FIG. 7, audio component 19 may be a speaker or microphone that contains a diaphragm such as diaphragm 70. Diaphragm 70 may be formed from a separate structure that is attached to the underside of flexible display 14 or may be formed from a part of flexible display 14. As in the embodiment shown in FIG. 6, audio component 19 may be

mounted within support structures 50. Audio component 19 may include a magnet such as magnet 74 and a coil such as coil 72 in which current may flow. If audio component 19 is a speaker, current may be driven through coil 72 to induce motion in diaphragm 70 and thereby emit sound through flexible display 14. If audio component 19 is a microphone, sound waves originating from the exterior of device 10 may induce vibrations in flexible display 14 which are transmitted to diaphragm 70 and ultimately to coil 72 in which current may be induced. The current produced in coil 72 may be used to transmit sound information to device 10. Diaphragm 70 may be a separate member in contact with flexible display 14 or may be an integral part of flexible display 14.

FIG. 8 is a cross-sectional side view of a portion of device 10 in the vicinity of another possible embodiment of audio component 19. As shown in FIG. 8, audio component 19 may be a laser microphone which uses vibrations in flexible display 14 induced by sound originating external to device 10 to produce an signal to be transmitted to device 10. As shown in FIG. 8, audio component 19 may be recessed in support structures 50. Audio component 19 may include a light emitting component such as laser component 80. Laser component 80 may emit a laser beam such as laser beam 84 in the direction of flexible display 14. Laser beam 84 may reflect off of flexible display 14 and a reflected laser beam such as reflected laser beam 86 may be absorbed by a laser absorbing component 82.

Laser beam 84 and reflected laser beam 86 may be used in combination with laser 80 and photosensitive element 82 to monitor variations in distance 88 from flexible display 14 to component 80 and component 82. Sound waves originating external to device 10 may induce

vibrations in flexible display 14 causing distance 88 to oscillate. The oscillations in distance 88 may be converted into sound-related information by device 10.

FIG. 9 is a cross-sectional side view of a portion of device 10 in the vicinity of a component such as component 22 of FIG. 1. In the embodiment shown in FIG. 9, component 22 may contain an actuator such as a piezoelectric (actuator 90). Piezoelectric actuators such as piezoelectric actuator 90 may vary in shape (e.g., thickness) in response to applied control voltages and may produce an output voltage when compressed (i.e., the piezoelectric element in actuator 90 may serve as a force sensor in addition to serving as a controllable actuator). A user of device 10 may exert force on flexible display 14 in direction 92. Flexible display 14 may be deformed to exert a mechanical pressure on piezoelectric element 90 or other force sensor, inducing a voltage which may be transmitted to device 10. Conversely, piezoelectric actuator 90 may be used to provide tactile feedback to a user of device 10. A voltage difference applied to the surfaces of piezoelectric actuator 90 may induce an expansion of piezoelectric actuator 90. Piezoelectric actuator 90 may then deform flexible display 90 in direction 94 providing tactile feedback to a user of device 10.

FIG. 10 is a cross-sectional side view of a portion of device 10 in the vicinity of structural component 22 of device 10. Structural component 22 may cause a permanent deformation such as deformation 102 in flexible display 14 to indicate the location of portion 101 of touch-sensitive layer 14B in display 14 to the user of device 10. Portion 101 may be, for example, a letter key or other button in a virtual keypad (keyboard) displayed on flexible display 14. A touch sensor array

associated with display 14 may be used to gather user input (i.e., the touch sensor array may be used to determine when a user has pressed the virtual key associated with portion 101). The location of portion 101 may also be indicated visually using associated display pixels in flexible display 14. At times, a user may desire to be able to locate portion 101 without having to look at flexible display 14. Deforming flexible display 14 in the vicinity of portion 101 using structural component 22 may allow a user to locate portion 101 without visual aid. Structural component 22 may be an isolated component indicating the location of a single portion 101 of touch-sensitive layer 14B or may be one of an array of components 22 indicating the locations of an array of portions 101 (e.g., the array of letter, number, and symbol keys in a virtual keypad displayed on display 14). Structural component 10 may be a separate component mounted to support structures 50 or may be an integral part of support structures 50.

FIG. 11 is a cross-sectional side view of a portion of device 10 in the vicinity of a hybrid component such as component 100. Component 100 may include both an internal interface component such as internal component 24 and a structural component such as structural component 22. Structural component 22 may cause a permanent deformation such as deformation 102 in flexible display 14 in the vicinity of internal component 24 to indicate the location of internal component 22 to the user of device 10. The presence of flexible display 14 between the user of device 10 and internal component 24 may obscure the location of internal interface component 24. The location of interface component 24 may be indicated visually using display pixels in flexible display 14. The deformation of flexible display 14 in the vicinity of interface component

24 using structural component 22 may also allow the user to locate interface component 24 without visual aid. Component 100 may be an isolated component indicating the location of a single interface component 24 of touch-sensitive layer 14B or may be one of an array of components 100 indicating the locations of an array of interface components 24.

FIG. 12 is a perspective view of an embodiment of device 10 in which internal component 24 is a button such as button 17. In the embodiment of FIG. 12, as in FIG. 11, component 100 includes internal component 24 and structural component 22 (shown in FIG. 11). As shown in FIG. 12, a ridge or other deformation such as deformation 102 in flexible display 14 may be used to indicate the location of button 17.

FIG. 13 is a cross-sectional side view of a portion of device 10 in the vicinity of another illustrative embodiment of a hybrid component such as component 100 which includes an internal interface component such as internal component 24 and a structural component such as structural component 22 mounted to an actuator such as actuator stage 110. Component 100 may be recessed in chassis 50. Actuator stage 110 may be electrically or mechanically raised in direction 112 to temporarily produce deformations such as deformations 102 in flexible display 14. Deformations 102 in flexible display 14 may indicate the location of internal interface device 24 to a user of device 10. Actuator stage 110 may be electrically or mechanically lowered in direction 114 to remove deformations 102 in flexible display 14 returning flexible display 14 to its original shape. Component 100 may be an isolated component indicating the location of a single interface component 24 of touch-sensitive layer 14B or may be one of an array of

components 100 indicating the locations of an array of respective interface components 24.

FIG. 14 is a cross-sectional side view of a portion of device 10 in the vicinity of another illustrative embodiment of a component such as structural component 22. In the arrangement of FIG. 14, structural component 22 is mounted an actuator such as actuator stage 110. Some modes of operating device 10 may require visual interaction with a user of device 10 (e.g., a mode involving the display of images or video). In these visual modes, the location of portion 101 of touch-sensitive layer 14B of flexible display 14 may be indicated visually using display pixels in flexible display 14.

In other modes of operation of device 10, a user of device 10 may wish to determine the location of portion 101 without visual aid. In the embodiment shown in FIG. 14, component 22 may be recessed in support structures 50. Actuator stage 110 may be electrically or mechanically raised in direction 112 to move structural component 22 into contact with flexible display 14 to temporarily produce deformations such as deformations 102 in flexible display 14. Deformations 102 may indicate the location of portion 101 to a user of device 10. When no longer needed for tactile interaction (e.g., upon switching to a video display mode), actuator 110 may be electrically or mechanically moved in direction 114 to lower structural component 22 and remove deformations 102 in flexible display 14.

FIG. 15 is a cross-sectional side view of an embodiment of device 10 in which device 10 includes housing 12 and cover member 122. Cover member 122 may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other

suitable materials, or a combination of these materials. Cover member 122 may be a single structure or may include multiple cover structures. In order to facilitate lifting of cover 122 by a user of device 10, structural component 22 may be coupled to an actuator 130 which may be used to lift structural component 122 in direction 134. When lifted, structural component 134 may cause a deformation such as deformation 102 in flexible display 14. Flexible display 14 may exert a pressure on cover member 122, lifting cover member 122 in direction 134 allowing the user to grip cover member 122 in order to lift cover member 122 to an open position such as open position 140. Actuator 130 may then be used to lower structural component 22 in direction 132 in order to allow flexible display 14 to return to its original shape. Actuator 130 may be activated in response to a control signal produced by the user using actuator switch 124 or by a control signal from other suitable control circuitry.

FIG. 16 is a cross-sectional side view of a portion of device 10 in the vicinity of another illustrative embodiment of internal interface component 24. In the embodiment shown in FIG. 16, interface component 24 may be a pressure sensor that includes a pressure sensing module 140. Pressure sensing module 140 may be coupled between a contact member such as contact member 142 (which is in contact with flexible display 14) and electrical contacts 144. Pressure may be exerted on flexible display 14 (e.g., by a user of device 10 or due to atmospheric pressure changes in the surrounding environment of device 10). Pressure exerted on flexible display 14 may be transmitted to pressure sensing module 140 by contact member 142. Pressure information may be transmitted to device 10 through electrical contacts 144. Pressure sensing module 140 may sense pressure changes

using piezoelectric, capacitive, inductive, resistive, optical or other mechanisms. Providing device 10 with flexible display 14 allows flexible display 14 to extend over interface component 24, increasing the area of active region 20A of flexible display 14. The presence of flexible display 14 over interface component 24 may also reduce the risk of moisture or dirt entering into the interior of device 10.

In accordance with an embodiment, an electronic device is provided that includes a flexible display and an internal component, where the flexible display may be deformed by an action external to the device and deformation of the flexible display creates a response from the internal component.

In accordance with another embodiment, the flexible display includes a flexible display layer and a touch-sensitive layer.

In accordance with another embodiment, the flexible display layer of the flexible display includes an active display region and the internal component is covered with a portion of the active display region of the flexible display.

In accordance with another embodiment, the internal component includes a button and deformation of the flexible display compresses the button.

In accordance with another embodiment, the flexible display further includes a rigid cover layer having at least one opening.

In accordance with another embodiment, the opening includes a hole in the rigid cover layer, the button further includes a button member in the opening, the button member moves within the hole in the rigid cover layer, and the movement of the button member in the opening causes deformation of the flexible display.

30

In accordance with another embodiment, the internal component includes a pressure sensor and deformation of the flexible display exerts a mechanical pressure on the pressure sensor.

In accordance with another embodiment, the pressure sensor includes a piezoelectric actuator and the mechanical pressure induces a voltage on the piezoelectric actuator.

In accordance with another embodiment, the internal component includes a laser microphone for detecting a sound originating external to the electronic device and detecting the sound includes, with a laser, detecting deformation of the flexible display.

In accordance with an embodiment, an electronic device is provided that includes a flexible display and an audio component that transmits or receives sound through the flexible display.

In accordance with another embodiment, the flexible display includes an active display region and the audio component is mounted behind the active display region of the flexible display.

In accordance with another embodiment, the flexible display includes a flexible display layer and a touch-sensitive layer.

In accordance with another embodiment, the audio component includes a diaphragm and the diaphragm is mounted in contact with the flexible display.

In accordance with another embodiment, an electronic device is provides that includes a housing, a flexible display mounted on the housing, and a first internal component mounted under a portion of the flexible display, where the first internal component is configured to deform the portion of the flexible display.

In accordance with another embodiment, the first

internal component includes a piezoelectric actuator, where a voltage applied to the piezoelectric actuator causes an expansion of the piezoelectric actuator and the portion of the flexible display deforms in response to the expansion of the piezoelectric actuator.

In accordance with another embodiment, the first internal component includes a structural component, where the portion of the flexible display deforms in response to physical contact with the structural component and deformation of the portion of the flexible display causes the portion of the flexible display to conform to a surface of the structural component.

In accordance with another embodiment, the electronic device further includes a second internal component mounted under the portion of the flexible display, where the portion of the flexible display that conforms to the surface of the structural component indicates the location of the second internal component.

In accordance with another embodiment, the second internal component includes a button, where the portion of the flexible display is configured to be further deformed by an action external to the electronic device and further deformation of the portion of the flexible display compresses the button.

In accordance with another embodiment, the first internal component further includes an actuator, where the structural component is mounted on the actuator, where raising the actuator moves the structural component into contact with the portion of the flexible display, and where lowering the actuator moves the structural component out of contact with the flexible display.

In accordance with another embodiment, the flexible display includes a touch-sensitive layer, where deformation of the portion of the flexible display

conforming to the surface of the structural component indicates the location of a portion of the touch-sensitive layer of the flexible display.

In accordance with another embodiment, the electronic device further includes a second internal component mounted on the actuator and deformation of the portion of the flexible display conforming to the surface of the structural component indicates the location of the second internal component.

In accordance with another embodiment, the electronic device further includes a cover member and an actuator switch coupled to the actuator, where deformation of the flexible display exerts a pressure on the cover member and the pressure on the cover member lifts the cover member.

The foregoing is merely illustrative of the principles of this invention and various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

As shown in the examples of FIGS. 1, 2 and 17-21, an electronic device may be provided with a concave display. The concave display may include a flexible display layer that has been bent to curve the display.

Concave displays may be formed from flexible layers such as a flexible display layer (e.g., a flexible organic light-emitting diode array), a flexible touch-sensitive layer (e.g., a sheet of polymer with an array of transparent capacitor electrodes for a capacitive touch sensor), a flexible substrate layer, etc. These flexible layers may, if desired, be covered by a flexible or rigid cover layer (sometimes referred to as a cover glass) or may be supported by a support structure (e.g., a rigid support structure on the underside of the flexible layers). In electronic devices with concave displays that

are covered by rigid cover layers, the cover layers may be provided with openings that provide access to the flexible layers of the display. For example, a cover glass layer may have an opening that allows a button member to move relative to the cover glass layer. As the button member moves within the opening, underlying portions of the flexible display may be deformed (e.g., to allow actuation of an associated switch).

Electronic devices may also be provided with user interface components (input-output components) such as buttons, microphones, speakers, piezoelectric actuators or (for receiving electrical input from a user or tactile feedback to users), other actuators such as vibrators, pressure sensors, and other components. These components may be mounted under portions of a flexible display.

User interface components may be mounted under the flexible display or may be integrated into the flexible display. The deformable nature of the flexible display may allow a user to interact with the user interface components (input-output components) by moving the display into contact with the user interface components or by otherwise allowing the display to locally flex (e.g., to allow sound to pass through the flexible display or to allow barometric pressure measurements of the exterior environment to be made by an internal pressure sensor). If desired, a portion of the flexible display may form a membrane portion of an electrical component. Components that may be provided with a membrane that is formed from a portion of a flexible display include microphones, laser microphones, pressure sensors, speakers, etc.

Concave displays formed from flexible and rigid layers that all have concave shapes (i.e., displays formed from a collection of layers in which no layer of the

display is planar) may provide reduced vulnerability to damage during a drop event in which an electronic device strikes the ground or other external objects while maximizing the internal volume of the device that is available to hold electrical and mechanical device components.

An illustrative electronic device of the type that may be provided with a concave display is shown in FIG. 1. Electronic device 10 may be a portable electronic device or other suitable electronic device. For example, electronic device 10 may be a laptop computer, a tablet computer, a somewhat smaller device such as a wrist-watch device, pendant device, or other wearable or miniature device, a cellular telephone, a media player, etc.

Device 10 may include a housing such as housing 12. Housing 12, which may sometimes be referred to as a case, may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of these materials. In some situations, parts of housing 12 may be formed from dielectric or other low-conductivity material. In other situations, housing 12 or at least some of the structures that make up housing 12 may be formed from metal elements.

Device 10 may have a concave display such as concave display 14. Concave display 14 may be formed from multiple layers of material. These layers may include a touch sensor layer such as a layer on which a pattern of indium tin oxide (ITO) electrodes or other suitable transparent electrodes have been deposited to form a capacitive touch sensor array or a touch sensor layer formed using other touch technologies (e.g., resistive touch, acoustic touch, optical touch, etc.). These layers may also include a layer that contains an array of display

35

pixels. The touch sensor layer and the display layer may be formed using flexible sheets of polymer or other substrates having thicknesses of 10 microns to 0.5 mm or other suitable thicknesses (as an example).

The display pixel array may be, for example, an organic light-emitting diode (OLED) array containing rows and columns of OLED display pixels. Other types of flexible display pixel arrays may also be formed (e.g., electronic ink displays, etc.). The use of OLED technology to form flexible display 14 is sometimes described herein as an example. This is, however, merely illustrative. Flexible display 14 may be formed using any suitable flexible display technology. The use of flexible displays that are based on OLED technology is merely illustrative.

In addition to these functional display layers (i.e., the OLED array and the optional touch sensor array), display 14 may include one or more structural layers. For example, display 14 may be covered with a flexible or rigid cover layer and/or may be mounted on a support structure (e.g., a rigid support). Layers of adhesive may be used in attaching flexible display layers to each other and may be used in mounting flexible display layers to rigid and flexible structural layers.

In configurations for display 14 in which the cover layer for display 14 is flexible, input-output components that rely on the presence of flexible layers may be mounted at any suitable location under the display (e.g., along peripheral portions of the display, in a central portion of the display, etc.). In configurations for display 14 in which the flexible layers are covered by a rigid cover glass layer or other rigid cover layer, the rigid layer may be provided with one or more openings and the electronic components may be mounted under the

openings. For example, a rigid cover layer may have openings such as a circular opening 16 for button 17 and a speaker port opening such as speaker port opening 18 (e.g., for an ear speaker for a user). Device 10 may also have other openings (e.g., openings in display 14 and/or housing 12 for accommodating volume buttons, ringer buttons, sleep buttons, and other buttons, openings for an audio jack, data port connectors, removable media slots, etc.).

In some embodiments, portions of concave display 14 such as peripheral regions 20I may be inactive and portions of display 14 such as rectangular central portion 20A (bounded by dashed line 20) may correspond to the active part of display 14. In active display region 20A, an array of image pixels may be used to present text and images to a user of device 10. In active region 20A, display 14 may include touch sensitive components for input and interaction with a user of device 10. If desired, regions such as regions 20I and 20A in FIG. 1 may both be provided with display pixels (i.e., all or substantially all of the entire front planar surface of a device such as device 10 may be covered with display pixels).

Device 10 may, if desired, have internal user interface components such as buttons 17 or speaker component 19 that occupy openings such as openings 16 and 18 respectively in an optional rigid cover layer of concave display 14. Buttons 17 may be based on dome switches or other switch circuitry. Buttons 17 may include button members that form push buttons (e.g., momentary buttons), slider switches, rocker switches, etc. Device 10 may include internal structural components such as structural component 22 that add a raised structure to a portion of concave display 14. Device 10 may include

components such as interface components 24 and 26 that may be fully internal to device 10, but that receive input from the user or from the surrounding environment through physical interaction with concave display 14. Interface components 22, 24, and 26 may be positioned in active region 20A or inactive region 20I of concave display 14. Interface components 22, 24, and 26 may be positioned separately from one another or may be commonly located to form a combined component with structural and internal features. Interface components 24 and 26 may be positioned underneath concave display 14 so that concave display 14 must be deformed in order to contact components 24 or 26 or, if desired may be positioned to remain in constant contact with concave display 14.

An exploded perspective view of an illustrative display is shown in FIG. 2. As shown in FIG. 2, concave display 14 may be formed by stacking multiple layers including flexible display layer 14A, touch-sensitive layer 14B, and cover layer 14C. Display 14 may also include other layers of material such as adhesive layers, optical films, or other suitable layers. Flexible display layer 14 may include image pixels formed form light-emitting diodes (LEDs), organic LEDs (OLEDs), plasma cells, electronic ink elements, liquid crystal display (LCD) components, or other suitable image pixel structures compatible with flexible displays.

Touch-sensitive layer 14B may incorporate capacitive touch electrodes such as horizontal transparent electrodes 32 and vertical transparent electrodes 34. Touch-sensitive layer 14B may, in general, be configured to detect the location of one or more touches or near touches on touch-sensitive layer 14B based on capacitive sensors, resistive sensors, optical sensors, acoustic sensors, inductive sensors, or force sensors.

Software and/or hardware may be used to process the measurements of the detected touches to identify and track one or more gestures. A gesture may correspond to stationary or non-stationary, single or multiple, touches or near touches on touch-sensitive layer 14B. A gesture may be performed by moving one or more fingers or other objects in a particular manner on touch-sensitive layer 14B such as tapping, pressing, rocking, scrubbing, twisting, changing orientation, pressing with varying pressure and the like at essentially the same time, contiguously, or consecutively. A gesture may be characterized by, but is not limited to a pinching, sliding, swiping, rotating, flexing, dragging, or tapping motion between or with any other finger or fingers. A single gesture may be performed with one or more hands, by one or more users, or any combination thereof.

Cover layer 14C may be formed from plastic or glass (sometimes referred to as display cover glass) and may be flexible or rigid. If desired, the interior surface of peripheral inactive portions 20I of cover layer 14C may be provided with an opaque masking layer on such as black ink.

Touch-sensitive flexible display section 14AB may be formed from display pixel array layer 14A and optional touch sensor layer 14B.

FIG. 17 is perspective view of an illustrative embodiment of device 10 with concave display 14 in which device 10 is provided with a bezel such as bezel 200 surrounding the periphery of concave display 14. In the illustrative embodiment shown in FIG. 17, housing 12 of device 10 has an opening 204 that may provide access to a data port. The surface of bezel 200 may be formed in-plane with the surface of display 14 (i.e., so that bezel 200 and display 14 form a single smooth surface) or may be

formed at a right angle to the walls of housing 12 (as examples). Bezel 200 may be a separate bezel member or may be formed as a portion of housing 12. As shown in FIG. 17, top and bottom portions 202 of bezel 200 may have a concave (curved) shape that matches the cross-sectional curved shape of concave display 14.

FIG. 18 is a cross-sectional side view of an illustrative embodiment of device 10 in which concave display 14 is formed by mounting flexible display layer 14A to a concave support structure such as support structure 210 (e.g., a rigid support structure having at least a concave external surface such as a metal, glass, or plastic support structure) using a layer of adhesive material such as adhesive layer 212. As shown in FIG. 18, the internal volume of device 10, defined by housing 12, bezel 202 and concave display 14 may include volume 216 above a plane (indicated by dashed line 214) defined by the deepest point in the curvature of display 14. This is because the inner surface of support structure 210 is convex (in the FIG. 18 example). Volume 216 provides space in addition to rectangular volume 218 in which internal components such as component 220 (e.g., printed circuit boards, antennas or other components) may be positioned. The ability to bend flexible display 14 into the concave shape of FIG. 18 may therefore help maximize the interior space that is available within device 10 to mount device components.

FIG. 19 is a cross-sectional side view of a portion of device 10. In the illustrative embodiment of FIG. 19, concave display 14 is formed from flexible display layer 14A, adhesive layer 212, and rigid cover layer 14C (e.g., a layer of rigid plastic or a layer of rigid cover glass having a concave external surface and a convex inner surface to which flexible display layer 14A

conforms). Concave display 14 may be formed adjacent to bezel portion 200 of housing 12 or may be joined to housing 12 by an additional mounting member. The concave shape of cover layer 14C of display 14 may provide reduced susceptibility to damage if device 10 is dropped. Forming flexible display layer 14A in a shape that matches the concave shape of cover layer 14C (i.e., so that layer 14A conforms to the convex inner surface of layer 14C) may provide additional internal volume 216 to device 10.

FIG. 20 is a cross-sectional side view of a portion of another embodiment of device 10. In the illustrative embodiment of FIG. 20, concave display 14 is formed from flexible display layer 14A attached to optional touch-sensitive layer 14B by adhesive layer 212. Touch-sensitive layer 14B may further be attached to rigid cover layer 14C (e.g., a glass or plastic layer) using adhesive layer 230 such that all layers (212, 14B, 230, and 14C) of display 14 conform to the concave shape of cover layer 14C. Concave display 14 may be directly adjacent to bezel portion 200 of housing 12 or may be joined to housing 212 by an additional mounting member. The concave shape of all layers (14A, 212, 14B, 230, and 14C) of display 14 may provide reduced susceptibility to damage in the event that device 10 is dropped and may provide additional internal volume 216.

FIG. 21 is a cross-sectional side view of device 10 and a common drop surface such as drop surface 240 (e.g., sidewalk concrete, asphalt, tile, or any other surface) on which device 10 may be dropped. Drop surface 240 may have a surface roughness due to surface features such as surface features 242. Surface features 242 may have a characteristic height such as height 244 (e.g., 1-2 mm for a concrete surface). As shown in FIG. 21, device 10 may be provided with concave display 14. Concave

display 14 may be provided with a curvature defined by maximum depth 248 defined by the distance from the outermost surface of device 10, indicated by dashed line 246 and the deepest point in the curvature of display 14 (indicated by dashed line 214). The outermost surface of device 10 may be defined by bezel 200, or, in the absence of bezel 200, may be defined by juncture point 250 at which the peripheral edges of display 14 meet housing 12.

Maximum depth 248 may be chosen to be larger than characteristic size 244 of surface features 242 of common drop surface 240. Providing device 10 with a concave display having curvature chosen to provide a maximum depth (depth 248) that is larger than characteristic height 244 may significantly reduce the risk of damage (e.g., scratches or other damage) to device 10 during a drop event.

Providing concave display 14 with flexible display layer 14A capable of conforming to the shape of cover layer 14C allows all layers of display 14 to be conformed to same concave shape. Providing device 10 with concave display 14 in which all layers of concave display 14 conform to the same concave shape may reduce the susceptibility of device 10 to damage when dropped on common drop surface 240 while providing additional internal volume 216 in which internal components may be positioned.

Electronic devices may be provided with concave displays that reduce the risk of damage in the event of a drop while maximizing the internal volume of the device. Concave displays may be formed from one or more flexible layers including a flexible display layer. The flexible display layer may be mounted to a rigid support structure or a rigid cover layer. Flexible display layers that conform to the curved shape of a rigid cover structure

provide additional internal volume in which internal components of the device may be positioned.

In accordance with an embodiment, an electronic device is provided that includes a housing and a concave display mounted in the housing, where the concave display has a rigid internal support structure having a concave surface and a flexible display layer attached to the rigid internal support structure that conforms to the concave surface of the rigid support structure.

In accordance with another embodiment, the concave display further includes a first adhesive layer and the first adhesive layer attaches the flexible display layer to the concave surface of the rigid internal support structure.

In accordance with another embodiment, the concave display further includes a touch-sensitive layer.

In accordance with another embodiment, the concave display further includes first and second adhesive layers, where the first adhesive layer attaches the flexible display layer to the touch-sensitive layer and where the second adhesive layer attaches the flexible display layer to the rigid internal support structure.

In accordance with another embodiment, the housing includes a bezel and the bezel surrounds a periphery of the concave display.

In accordance with another embodiment, the rigid internal support structure has a convex inner surface and the electronic device further includes at least one internal component mounted adjacent to the convex inner surface.

In accordance with another embodiment, the rigid internal support structure has at least one opening.

In accordance with another embodiment, the at least one opening includes a hole in the rigid internal

support structure and the at least one internal component is mounted in the hole in the rigid internal support structure.

In accordance with another embodiment, an electronic device is provided that includes a housing and a concave display mounted in the housing, where the concave display includes a rigid cover layer having at least one concave outer surface and at least one corresponding convex inner surface and includes a flexible display layer, where the flexible display layer conforms to the convex inner surface of the rigid cover layer.

In accordance with another embodiment, the flexible display layer includes image pixels formed from organic light-emitting diodes.

In accordance with another embodiment, the concave display further includes a first adhesive layer, where the first adhesive layer attaches the flexible display layer to the convex inner surface of the rigid cover layer.

In accordance with another embodiment, the rigid cover layer has at least one opening, where the electronic device further includes an internal component and where the internal component is mounted adjacent to the flexible display layer under the at least one opening in the rigid cover layer.

In accordance with another embodiment, the internal component includes a speaker and the speaker transmits sound through the flexible display layer.

In accordance with another embodiment, the internal component includes a button, where the electronic device further includes a button member in the at least one opening in the rigid cover layer, where the button member moves within the at least one opening in the rigid cover layer, and where the movement of the button member

compresses the button.

In accordance with another embodiment, an electronic device is provided that includes an electronic device housing and a concave display mounted in the electronic device housing, where the concave display includes a rigid cover layer having a concave outer surface and a convex inner surface, a flexible display layer, and a touch-sensitive layer, where the flexible display layer and the touch-sensitive layer each conform to the convex inner surface of the rigid cover layer.

In accordance with another embodiment, the concave display further includes first and second adhesive layers, where the flexible display layer is attached to the touch-sensitive layer with the first adhesive layer and where the touch-sensitive layer is attached to the convex inner surface of the rigid cover layer with the second adhesive layer.

In accordance with another embodiment, the electronic device further includes at least one internal component mounted adjacent to the flexible display layer of the concave display.

In accordance with another embodiment, the rigid cover layer of the convex display has at least one opening, where the at least one internal component is an audio component, and where the audio component is mounted under the at least one opening in the rigid cover layer.

In accordance with another embodiment, the concave outer surface of the concave display has a curvature and peripheral edges, where the curvature has a deepest point, where the deepest point and at least some of the peripheral edges define a maximum depth associated with the curvature of the concave display and where the maximum depth of the concave display is between 0.5 millimeter and 20 millimeters.

45

In accordance with another embodiment, the electronic device further includes an internal component, where the internal component is mounted at a distance from the peripheral edges of the concave outer surface, and where the distance is smaller than the maximum depth.

The foregoing is merely illustrative of the principles of this invention and various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

As shown in the examples of FIGS. 1, 2 and 22-29, an electronic device may be provided with a convex display. The convex display may include a flexible display layer that has been bent to form a curved surface.

Convex displays may be formed from flexible layers such as a flexible display layer (e.g., a flexible organic light-emitting diode array), a flexible touch-sensitive layer (e.g., a sheet of polymer with an array of transparent capacitor electrodes for a capacitive touch sensor), a flexible substrate layer, etc. These flexible layers may, if desired, be covered by a flexible or rigid cover layer (sometimes referred to as a cover glass) or may be supported by a support structure (e.g., a rigid support structure on the underside of the flexible layers). In electronic devices with convex displays partially covered by rigid cover layers, the cover layers may be provided with openings that provide access to the flexible layers of the display. For example, a cover glass layer may have an opening that allows a button member to move relative to the cover glass layer. As the button member moves within the opening, underlying portions of the flexible display may be deformed (e.g., to allow actuation of an associated switch).

Electronic devices may also be provided with user interface components (input-output components) such

as buttons, microphones, speakers, piezoelectric actuators or (for receiving electrical input from a user or tactile feedback to users), other actuators such as vibrators, pressure sensors, and other components. These components may be mounted under portions of a flexible display.

User interface components may be mounted under the flexible display or may be integrated into the flexible display. The deformable nature of the flexible display may allow a user to interact with the user interface components (input-output components) by moving the display into contact with the user interface components or by otherwise allowing the display to locally flex (e.g., to allow sound to pass through the flexible display or to allow a barometric pressure measurements of the exterior environment to be made by an internal pressure sensor). If desired, a portion of the flexible display may form a membrane portion of an electrical component. Components that may be provided with a membrane that is formed from a portion of a flexible display include microphones, laser microphones, pressure sensors, speakers, etc.

Convex displays formed from flexible and rigid layers that all have convex shapes i.e., displays formed from a collection of layers in which no layer of the display is planar) may provide an aesthetically desirable external appearance while maximizing the internal volume of the device that is available to hold electrical and mechanical device components.

An illustrative electronic device of the type that may be provided with a convex display is shown in FIG. 1.

Electronic device 10 may be a portable electronic device or other suitable electronic device. For example, electronic device 10 may be a laptop computer, a tablet

computer, a somewhat smaller device such as a wrist-watch device, pendant device, or other wearable or miniature device, a cellular telephone, a media player, etc.

Device 10 may include a housing such as housing 12. Housing 12, which may sometimes be referred to as a case, may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of these materials. In some situations, parts of housing 12 may be formed from dielectric or other low-conductivity material. In other situations, housing 12 or at least some of the structures that make up housing 12 may be formed from metal elements.

Device 10 may have a convex display such as convex display 14. Convex display 14 may be formed from multiple layers of material. These layers may include a touch sensor layer such as a layer on which a pattern of indium tin oxide (ITO) electrodes or other suitable transparent electrodes have been deposited to form a capacitive touch sensor array or a touch sensor layer formed using other touch technologies (e.g., resistive touch, acoustic touch, optical touch, etc.). These layers may also include layer that contains an array of display pixels. The touch sensor layer and the display layer may be formed using flexible sheets of polymer or other substrates having thicknesses of 10 microns to 0.5 mm or other suitable thicknesses (as an example).

The display pixel array may be, for example, an organic light-emitting diode (OLED) array containing rows and columns of OLED display pixels. Other types of flexible display pixel arrays may also be formed (e.g., electronic ink displays, etc.). The use of OLED technology to form flexible display 14 is sometimes described herein as an example. This is, however, merely

illustrative. Flexible display 14 may be formed using any suitable flexible display technology. The use of flexible displays that are based on OLED technology is merely illustrative.

In addition to these functional display layers (i.e., the OLED array and the optional touch sensor array), display 14 may include one or more structural layers. For example, display 14 may be covered with a flexible or rigid cover layer and/or may be mounted on a support structure (e.g., a rigid support). Layers of adhesive may be used in attaching flexible display layers to each other and may be used in mounting flexible display layers to rigid and flexible structural layers.

In configurations for display 14 in which the cover layer for display 14 is flexible, input-output components that rely on the presence of flexible layers may be mounted at any suitable location under the display (e.g., along peripheral portions of the display, in a central portion of the display, etc.). In configurations for display 14 in which the flexible layers are covered by a rigid cover glass layer or other rigid cover layer, the rigid layer may be provided with one or more openings and the electronic components may be mounted under the openings. For example, a rigid cover layer may have openings such as a circular opening 16 for button 17 and a speaker port opening such as speaker port opening 18 (e.g., for an ear speaker for a user). Device 10 may also have other openings (e.g., openings in display 14 and/or housing 12 for accommodating volume buttons, ringer buttons, sleep buttons, and other buttons, openings for an audio jack, data port connectors, removable media slots, etc.).

In some embodiments, portions of convex display 14 such as peripheral regions 20I may be inactive and

portions of display 14 such as rectangular central portion 20A (bounded by dashed line 20) may correspond to the active part of display 14. In active display region 20A, an array of image pixels may be used to present text and images to a user of device 10. In active region 20A, display 14 may include touch sensitive components for input and interaction with a user of device 10. If desired, regions such as regions 20I and 20A in FIG. 1 may both be provided with display pixels (i.e., all or substantially all of the entire front planar surface of a device such as device 10 may be covered with display pixels).

Device 10 may, if desired, have internal user interface components such as buttons 17 or speaker component 19 that occupy openings such as openings 16 and 18 respectively in an optional rigid cover layer of convex display 14. Buttons 17 may be based on dome switches or other switch circuitry. Buttons 17 may include button members that form push buttons (e.g., momentary buttons), slider switches, rocker switches, etc. Device 10 may include internal structural components such as structural component 22 that add a raised structure to a portion of convex display 14. Device 10 may include components such as interface components 24 and 26 that may be fully internal to device 10, but that receive input from the user or from the surrounding environment through physical interaction with convex display 14. Interface components 22, 24, and 26 may be positioned in active region 20A or inactive region 20I of convex display 14. Interface components 22, 24, and 26 may be positioned separately from one another or may be commonly located to form a combined component with structural and internal features. Interface components 24 and 26 may be positioned underneath convex display 14 so that convex display 14

50

must be deformed in order to contact components 24 or 26 or, if desired may be positioned to remain in constant contact with convex display 14.

An exploded perspective view of an illustrative display is shown in FIG. 2. As shown in FIG. 2, convex display 14 may be formed by stacking multiple layers including flexible display layer 14A, touch-sensitive layer 14B, and cover layer 14C. Display 14 may also include other layers of material such as adhesive layers, optical films, or other suitable layers. Flexible display layer 14 may include image pixels formed form light-emitting diodes (LEDs), organic LEDs (OLEDs), plasma cells, electronic ink elements, liquid crystal display (LCD) components, or other suitable image pixel structures compatible with flexible displays.

Touch-sensitive layer 14B may incorporate capacitive touch electrodes such as horizontal transparent electrodes 32 and vertical transparent electrodes 34. Touch-sensitive layer 14B may, in general, be configured to detect the location of one or more touches or near touches on touch-sensitive layer 14B based on capacitive sensors, resistive sensors, optical sensors, acoustic sensors, inductive sensors, or force sensors.

Software and/or hardware may be used to process the measurements of the detected touches to identify and track one or more gestures. A gesture may correspond to stationary or non-stationary, single or multiple, touches or near touches on touch-sensitive layer 14B. A gesture may be performed by moving one or more fingers or other objects in a particular manner on touch-sensitive layer 14B such as tapping, pressing, rocking, scrubbing, twisting, changing orientation, pressing with varying pressure and the like at essentially the same time, contiguously, or consecutively. A gesture may be

characterized by, but is not limited to a pinching, sliding, swiping, rotating, flexing, dragging, or tapping motion between or with any other finger or fingers. A single gesture may be performed with one or more hands, by one or more users, or any combination thereof.

Cover layer 14C may be formed from plastic or glass (sometimes referred to as display cover glass) and may be flexible or rigid. If desired, the interior surface of peripheral inactive portions 20I of cover layer 14C may be provided with an opaque masking layer on such as black ink.

Touch-sensitive flexible display section 14AB may be formed from display pixel array layer 14A and optional touch sensor layer 14B.

FIG. 22 is perspective view of an exemplary embodiment of device 10 with convex display 14 and convex housing 12 in which housing 12 has an opening 300 that may provide access to, e.g., an audio port. A portion of housing 12 may form a bezel such as bezel 304. Bezel 304 may be formed so that bezel 304 and display 14 form a common smooth surface or may be formed raised above or depressed below the outer surface of display 14. Bezel 304 may be a separate bezel member or may be formed as a portion of housing 12. As shown in FIG. 22, top and bottom portions 306 of bezel 200 may have a convex (curved) shape that matches the cross-sectional curved shape of convex display 14.

FIG. 23 is a cross-sectional side view of an illustrative embodiment of device 10 taken along line 302 of FIG. 22 and viewed in direction 303. As shown in FIG. 23, device 10 has a convex shape formed by convex housing 12 and convex display 14. Device 10 may also include internal components such as battery 310 and components 312. The convex shape of housing 12 and display 14 of

device 10 may provide device 10 with a thin appearance while providing an interior space that is able to accommodate internal components such as battery 310.

FIG. 24 is a cross-sectional side view of an illustrative embodiment of device 10 in which convex display 14 is formed by mounting flexible display layer 14A to a convex support structure such as support structure 320 (e.g., a rigid support structure having at least a convex external surface such as a metal, glass, or plastic support structure) using a layer of adhesive material such as adhesive layer 322. As shown in FIG. 24, the internal volume of device 10, defined by housing 12 and convex display 14 may include volume 326 above plane 324 (defined by inner edges 328 of display 14) and below inner surface 330 of display 14. This is because inner surface 330 of support structure 320 is concave (in the FIG. 24 example). Volume 326 provides space which may be used for placement of internal components such as component 332 (e.g., printed circuit boards, antennas or other components). The ability to bend flexible display layer 14A into the convex shape of FIG. 24 that matches the convex outer surface of support structure 320 may therefore help maximize the interior space that is available within device 10 to mount device components.

FIG. 25 is a cross-sectional side view of a portion of device 10. In the illustrative embodiment of FIG. 25, convex display 14 is formed from flexible display layer 14A, adhesive layer 322, and rigid cover layer 14C (e.g., a layer of rigid plastic or a layer of rigid cover glass having a convex external surface and a concave inner surface to which flexible display layer 14A conforms). Convex display 14 may be formed adjacent to bezel portion housing 12 or may be joined to housing 12 by an additional mounting member. Providing device 10 with a layer such as

flexible display layer 14A that conforms to the convex shape of cover layer 14C (i.e., so that layer 14A conforms to the concave inner surface of layer 14C) may provide additional internal volume 326 between plane 324 (defined by inner edges 328 of display 14) and inner surface 330 of display 14.

FIG. 26 is a cross-sectional side view of a portion of another embodiment of device 10. In the illustrative embodiment of FIG. 26, convex display 14 is formed from flexible display layer 14A attached to optional touch-sensitive layer 14B by adhesive layer 322. Touch-sensitive layer 14B may further be attached to rigid cover layer 14C (e.g., a glass or plastic layer) using adhesive layer 340 such that all layers (322, 14B, 340, and 14C) of display 14 conform to the convex shape of cover layer 14C (i.e., so that layers 14A and 14B conform to the concave inner surface of cover layer 14C). Convex display 14 may be formed adjacent to housing 12 or may be joined to housing 212 by an additional mounting member. The convex shape of all layers (14A, 322, 14B, 340, and 14C) may combine with convex housing 12 to provide a thin appearance for device 10 and may provide additional internal volume 326 between plane 324 (defined by inner edges 328 of display 14) and inner surface 330 of display 14.

FIG. 27 is a cross-sectional perspective view of an illustrative electronic device 10 in the vicinity of a connecting structure such as connecting structure 350 (e.g. an audio port or other female connector). As shown in FIG. 27, audio port 350 may have electrical contacts 352 for mating with contacts 356 of a connector such as mating connector 354 (e.g., a mating audio plug or other male connector). In the embodiment of FIG. 27, a portion of audio port 350 may occupy a portion of internal volume

326 above plane 324 (defined by inner edges 328 of display 14). The convex shape of display 14 of device 10 may provide a thin appearance and may provide additional internal volume 326 between plane 324 (defined by inner edges 328 of display 14) and inner surface 330 of display 14 in which a portion of mating connectors such as connector 350 may be mounted.

FIG. 28 is a cross-sectional side view of an illustrative electronic device 10 in the vicinity of a stack of components 360 such as printed circuit boards (PCBs), sensors, switches, connectors, battery structures, or other electronic components. In the embodiment shown in FIG. 28, some components 360 may be mounted partially or completely in a portion of internal volume 326 above plane 324 (defined by inner edges 328 of display 14). The convex shape of display 14 of device 10 may provide a thin appearance and may provide additional internal volume 326 between plane 324 (defined by inner edges 328 of display 14) and inner surface 330 of display 14 in which PCBs and other components 360 may be mounted. The example of FIG. 29 in which components 360 are mounted in volume 326 is merely illustrative. Other components or structures may occupy volume 326, if desired.

FIG. 29 is a cross-sectional side view of an illustrative electronic device in which display 14 of device 10 completely surrounds device 10. As shown in FIG. 29, device 10 may have convex front (upper) and rear (lower) surfaces that are joined along curved sidewalls. Display 14 may cover the front, rear, and sidewall surfaces of device 10 so as to completely surround electrical components 360 (e.g., printed circuit boards, integrated circuits, switches, sensors, etc.). Edges 372 may be joined by a joining member such as joining member 370. Member 370 may be a separate member formed of

plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of these materials, or may be formed from an adhesive material.

In the example of FIG. 29, display 14 may be formed by stacking multiple layers including flexible display layer 14A, touch-sensitive layer 14B, and cover layer 14C. Display 14 may also include other layers of material such as adhesive layers, optical films, or other suitable layers. As an example, display 14 may be formed by mounting flexible display layer 14A to a rigid convex support structure having one or more convex outer surfaces and one or more associated concave inner surfaces that completely surrounds device 10. In another configuration, display 14 may be formed from flexible display layer 14A, adhesive layer 322, and rigid cover layer 14C (e.g., a rigid cover layer with one or more convex outer surfaces and one or more associated concave inner surfaces). In another possible configuration, convex display 14 may be formed by attaching flexible display layer 14A to optional touch-sensitive layer 14B using adhesive layer 322. Touch-sensitive layer 14B may further be attached to rigid cover layer 14C (e.g., a glass or plastic layer) using adhesive layer 340 so that all layers (322, 14B, 340, and 14C) of display 14 conform to the convex shape of cover layer 14C. These examples are merely illustrative and other configurations of display 14 may be used.

The convex shape of display 14 of device 10 may provide a thin appearance for device 10 and may help to maximize the internal volume of the device in which components such as battery 310, PCBs 360 or other components such as component 312 may be mounted. Surrounding device 10 completely with convex display 14 may allow the area of a device available for visual

display to be enlarged.

The foregoing is merely illustrative of the principles of this invention and various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

Electronic devices may be provided with convex displays. A convex display may be used to maximize the internal volume of a device. Convex displays may be formed from one or more flexible layers. A flexible display layer may be mounted to a rigid support structure or a rigid cover layer. Flexible display layers that conform to the curved shape of a rigid structure may provide additional internal volume in which internal components of the device may be positioned.

In accordance with another embodiment, an electronic device is provided including a housing and a display mounted in the housing, where the display has a flexible display layer that conforms to a convex outer surface of a rigid support structure.

In accordance with another embodiment, the display further includes an adhesive layer and the adhesive layer attaches the flexible display layer to the convex outer surface of the rigid support structure.

In accordance with another embodiment, the display further includes a touch-sensitive layer.

In accordance with another embodiment, the display further includes first and second adhesive layers, where the first adhesive layer attaches the flexible display layer to the touch-sensitive layer and the second adhesive layer attaches the flexible display layer to the convex outer surface of the rigid support structure.

In accordance with another embodiment, the flexible display layer includes image pixels formed from organic light-emitting diodes.

57

In accordance with another embodiment, the housing has at least one opening, where the opening is associated with a connector port and the electronic device further includes a connector structure mounted in the connector port.

In accordance with another embodiment, an electronic device is provided that includes a housing and a display mounted in the housing, where the display includes a rigid cover layer having at least one convex outer surface and having at least one associated concave inner surface and includes a flexible display layer that conforms to the concave inner surface.

In accordance with another embodiment, the display further includes an adhesive layer and the adhesive layer bonds the flexible display layer to the concave inner surface of the rigid cover layer.

In accordance with another embodiment, the rigid cover layer includes glass.

In accordance with another embodiment, the flexible display layer includes image pixels formed from organic light-emitting diodes.

In accordance with another embodiment, the flexible display layer includes image pixels formed from organic light-emitting diodes.

In accordance with another embodiment, the display further includes a touch sensor layer that conforms to the concave inner surface.

In accordance with another embodiment, the concave display further includes first and second adhesive layers, where the first adhesive layer attaches the flexible display layer to the touch sensor layer and the second adhesive layer attaches the touch sensor layer to the concave inner surface of the display.

In accordance with another embodiment, the touch

sensor layer includes indium-tin-oxide electrodes.

In accordance with another embodiment, the electronic device further includes an internal component, where the concave inner surface of the display provides an additional internal volume for the electronic device and where the internal component is mounted at least partially in the additional internal volume.

In accordance with another embodiment, an electronic device is provided having at least a front surface and a rear surface and including electronic components interposed between the front and rear surfaces and a display that substantially covers at least the front and rear surfaces and that surrounds the electronic components, where the display includes a rigid cover layer having at least one inner surface and a flexible display layer that is bent to conform to the inner surface.

In accordance with another embodiment, the display further includes a touch-sensitive layer attached to at least a portion of the flexible display layer.

In accordance with another embodiment, the inner surface includes a concave inner surface and the electronic device further includes a connector structure and a housing having an opening, where the connector structure is mounted in the opening to form a connector port.

In accordance with another embodiment, the electronic device has at least two sidewall surfaces and the display substantially covers the two sidewall surfaces.

In accordance with another embodiment, the display has at least two edges and the edges of the display are joined by a joining member.

The foregoing is merely illustrative of the principles of this invention and various modifications can

be made by those skilled in the art without departing from the scope and spirit of the invention. The foregoing embodiments may be implemented individually or in any combination.

As shown in the examples of FIGS. 30-44, an electronic device may be provided with a flexible display and other user interface components. The user interface components may include buttons, switches, microphones, actuators such as solenoids, motors, and piezoelectric actuators, connector ports, touch screens, proximity sensors and other components for accepting input from, or transmitting information to, a user of the electronic device.

Flexible displays may be formed from flexible layers such as a flexible display layer (e.g., a flexible organic light-emitting diode array), a flexible touch-sensitive layer (e.g., a sheet of polymer with an array of transparent capacitor electrodes for a capacitive touch sensor), a flexible substrate layer, etc. These flexible layers may, if desired, be covered by a flexible or rigid cover layer (sometimes referred to as a cover glass) or may be supported by a support structure (e.g., a rigid support structure on the underside of the flexible layers). In electronic devices with flexible displays that are covered by rigid cover layers, the cover layers may be provided with openings that provide access to the flexible layers of the display in the vicinity of a user interface device. For example, a cover glass layer may have an opening that allows a button member to move relative to the cover glass layer. As another example, a cover glass layer may have one or more speaker openings through which sound may pass.

To maximize the area of the portion of the flexible display that is available for displaying visual

information to the user, user interface components may be positioned behind, abutted against, or integrated into the flexible display. The deformable nature of the flexible display may allow a user to interact with the user interface components (input-output components) by moving the display into contact with the user interface components or by otherwise allowing the display to locally flex (e.g., to allow sound to pass through the flexible display or to allow barometric pressure measurements of the exterior environment to be made by an internal pressure sensor).

If desired, a portion of the flexible display may form a membrane structure for an electrical component. For example, a portion of the flexible display may form a speaker membrane for a speaker component. Components that may be provided with a membrane structure formed from a portion of a flexible display include speakers, microphones, laser microphones, pressure sensors, etc.

An illustrative electronic device of the type that may be provided with a flexible display is shown in FIG. 30. Electronic device 10 may be a computer such as a computer that is integrated into a display. For example, electronic device 10 may be a computer monitor, a laptop computer, a tablet computer, a somewhat smaller portable device such as a wrist-watch device, pendant device, or other wearable or miniature device, a cellular telephone, a media player, a tablet computer, a gaming device, a speaker device, a navigation device, a computer monitor, a television, or other electronic equipment.

Device 10 may include a housing such as housing 412. Housing 412, which may sometimes be referred to as a case, may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of these

materials. In some situations, parts of housing 412 may be formed from dielectric or other low-conductivity material. In other situations, housing 412 or at least some of the structures that make up housing 412 may be formed from metal elements.

Housing 412 may be formed using a unibody configuration in which some or all of housing 412 is machined or molded as a single structure or may be formed using multiple structures (e.g., an internal frame structure, one or more structures that form exterior housing surfaces, etc.).

As shown in FIG. 30, housing 412 may have multiple parts. For example, housing 412 may have upper portion 412A and lower portion 412B. Upper portion 412A may be coupled to lower portion 412B using a hinge that allows portion 412A to rotate about rotational axis 416 relative to portion 412B. A keyboard such as keyboard 418 and a touch pad such as touch pad 420 may be mounted in housing portion 412B.

Device 10 may have a flexible display such as flexible display 414. Flexible display 414 may be formed from multiple layers of material. These layers may include a touch sensor layer such as a layer on which a pattern of indium tin oxide (ITO) electrodes or other suitable transparent electrodes have been deposited to form a capacitive touch sensor array. These layers may also include a display layer that contains an array of display pixels. The touch sensor layer and the display layer may be formed using flexible sheets of polymer (e.g., polyimide) or other substrates having thicknesses of 10 microns to 0.5 mm, having thicknesses of less than 0.2 mm, or having other suitable thicknesses (as examples).

The display pixel array may be an organic light-

emitting diode (OLED) array, for example. Other types of flexible display pixel arrays may also be formed (e.g., electrowetting displays, electrophoretic displays, flexible liquid crystal displays, flexible electrochromic displays, etc.). The use of OLED technology to form flexible display 414 is sometimes described herein as an example. This is, however, merely illustrative. In general, any suitable type of flexible display technology may be used in forming display 414.

In addition to these functional display layers (i.e., the OLED array and the optional touch sensor array), display 414 may include one or more structural layers. For example, display 414 may be covered with a flexible or rigid cover layer and/or may be mounted on a support structure (e.g., a rigid support). If desired, layers of adhesive may be used to attach flexible display layers to each other and/or to mount flexible display layers to rigid and flexible structural layers.

In some embodiments, display 414 may have an active area such as active area AA and an inactive area such as area IA. In active display region AA, an array of image pixels may be used to present text and images to a user of device 10. In active region AA, display 414 may include touch sensitive components for input and interaction with a user of device 10. If desired, both central portion AA and peripheral portion IA may be provided with display pixels (i.e., all or substantially all of the entire front planar surface of upper housing portion 412A may be provided with display pixels).

In the example of FIG. 31, device 10 has been implemented using a housing that is sufficiently small to fit within a user's hand (e.g., device 10 of FIG. 31 may be a handheld electronic device such as a cellular telephone). As show in FIG. 31, device 10 may include a

display such as display 414 mounted on the front of housing 412. Display 414 may be substantially filled with active display pixels or may have an inactive portion such as inactive portion IA that surrounds an active portion such as active portion AA. Display 414 may have openings (e.g., openings in inactive region IA or active region AA of display 414) such as an opening to accommodate button 422 and an opening to accommodate speaker port 424.

FIG. 32 is a perspective view of electronic device 10 in a configuration in which electronic device 10 has been implemented in the form of a tablet computer. As shown in FIG. 32, display 414 may be mounted on the upper (front) surface of housing 412. An opening may be formed in display 414 to accommodate button 422 (e.g., an opening may be formed in inactive region IA surrounding active region AA).

FIG. 33 is a perspective view of electronic device 10 in a configuration in which electronic device 10 has been implemented in the form of a television or in the form of a computer integrated into a computer monitor. As shown in FIG. 33, display 414 may be mounted on the front surface of housing 412. Stand 426 may be used to support housing 412. Display 414 may include an inactive region such as inactive region IA that surrounds active region AA.

An exploded perspective view of an illustrative display is shown in FIG. 34. As shown in FIG. 34, flexible display 414 may be formed by stacking multiple layers including flexible display layer 414A and touch-sensitive layer 414B. An optional cover layer such as cover layer 462 may be formed over flexible display 414. Cover layer 462 may be a layer of glass, plastic, or other protective display layer.

Flexible display 414 may also include other

layers of material such as adhesive layers, optical films, sealant layers, or other suitable layers. Flexible display layer 414A may include image pixels formed from light-emitting diodes (LEDs), organic LEDs (OLEDs), plasma cells, electrowetting display elements, electrophoretic display elements, liquid crystal display (LCD) components, or other suitable image pixel structures compatible with flexible displays.

Touch-sensitive layer 414B may incorporate capacitive touch electrodes such as horizontal transparent electrodes 432 and vertical transparent electrodes 434. Touch-sensitive layer 414B may, in general, be configured to detect the location of one or more touches or near touches on touch-sensitive layer 414B based on capacitive, resistive, optical, acoustic, inductive, or mechanical measurements, or any phenomena that can be measured with respect to the occurrences of the one or more touches or near touches in proximity to touch sensitive layer 414B.

Flexible display 414 may be formed from display pixel array layer 414A and optional touch sensor layer 414B. In the example of FIG. 34, touch-sensitive layer 414B is interposed between cover layer 462 and flexible display layer 414A. This arrangement is merely illustrative. If desired, flexible display layer 414A may be interposed between cover layer 462 and touch-sensitive layer 414B (e.g., flexible display layer 414A may be arranged on top of touch-sensitive layer 414B). If desired, touch-sensitive layer 414B and flexible display layer 414A may be integrated as a single layer. For example, capacitive touch electrodes such as electrodes 432 and 434 and display pixels such as display pixels 430 may be formed on a common substrate, if desired.

FIG. 35 is a cross-sectional side view of a

65

portion of flexible display layer 414A. As shown in FIG. 35, flexible display layer 414A may contain multiple sublayers. For example, display layer 414A may include a substrate layer such as substrate layer 415. Substrate layer 415 may be formed from a flexible or rigid dielectric such as glass, ceramic, or plastic. As an example, substrate layer 415 may be formed from one or more flexible sheets of polymer (e.g., polyimide). Substrate layer 415 may have a thickness of 10 microns to 0.5 mm, may have a thickness of less than 0.2 mm, or may have other suitable thickness (as examples).

A thin-film transistor (TFT) layer such as TFT layer 417 may include a layer of thin-film transistor structures (e.g., polysilicon transistors and/or amorphous silicon transistors) formed on substrate layer 415.

An organic emissive layer such as OLED layer 419 may be formed over TFT layer 417. OLED layer 419 may include a light-emitting material such as an array of organic light-emitting diode structures that are used to form display pixels such as display pixels 430 of FIG. 34.

A sealant layer such as sealant layer 421 may be formed over OLED layer 419 to protect the structures of OLED layer 419 and TFT layer 417. Sealant layer 421 may be formed from one or more layers of polymer (e.g., one or more layers of polymer that are deposited onto OLED layer 419), metal foil (e.g., a layer of metal foil that is laminated, sputtered, evaporated, or otherwise applied onto OLED layer 419), or other suitable coating or conformal covering.

Electronic device 10 may be provided with one or more speaker structures for providing sound to a user of electronic device 10. FIG. 36 is a cross-sectional side view of a portion of electronic device 10 in the vicinity of a speaker structure such as speaker structure 448.

66

Sound produced by speaker structure 448 may be transmitted through flexible display 414 to the exterior of device 10. Flexible display 414 may be used as a speaker membrane structure for speaker 448. Portions such as portion 414M that serve as a speaker membrane for speaker 448 may be located in an active or inactive portion of display 414. Arrangements in which speaker membrane 414M forms an active display area may allow the size of the active region of flexible display 414 to be increased relative to its inactive region.

As shown in FIG. 36, speaker structure 448 may be driven by a transducer such as transducer 450. Transducer 450 may be configured to receive electrical audio signal input from circuitry in device 10 and to convert the electrical signal into sound. In the example of FIG. 36, transducer 450 is formed from a magnet such as magnet 440 surrounded by coils such as coils 442. Magnet 440 may be a permanent magnet formed from ferrite material, ceramic material, iron alloy material, rare earth material, other suitable material, or a combination of these materials. Coils 442 may be formed from copper, aluminum, silver, other suitable materials, etc. If desired, there may be one or more sets of coils surrounding magnet 440.

When current passes through coils 442, a magnetic field is produced. This allows coils 442 to act as a variable electromagnet with a magnetic field that interacts with the constant magnetic field produced by permanent magnet 440. For example, the negative pole of the electromagnet may be repelled by the negative pole of permanent magnet 440. The magnetic force created by this repulsion will force magnet 440 away from coils 442. When the current flowing through coils 442 changes direction, the polarity of the variable electromagnet reverses.

Magnet 440 may be pushed back and forth rapidly (along the z-axis) as the current in coils 442 alternates directions.

Portions of flexible display 414 such as portion 414M may form a speaker membrane for speaker 448. As magnet 440 moves back and forth along the z-axis, attached speaker membrane 414M will in turn vibrate the air in front of speaker membrane 414M, creating sound waves.

In some arrangements, an optional support structure such as support structure 446 (sometimes referred to as a stiffening structure or stiffener) may be interposed between transducer 450 and speaker membrane 414M. Support structure 446 may be used to stiffen speaker membrane portion 414M of display 414. Support structure 446 may be formed from a metal plate, from specialized composite structures (e.g., a layer of foam interposed between layers of stiffener, etc.), from other support materials or stiffening structures, or from a combination of these materials. Using a support structure such as support structure 446 may allow speaker membrane 414M to respond more accurately to the movement of magnet 440. In arrangements where optional support structure 446 is not used, magnet 440 may be configured to stiffen portion 414M of display 414 that serves as a speaker membrane structure.

There may be one or more speaker structures 448 in device 10. Some or all of speaker structures 448 in device 10 may have speaker membranes that are formed from flexible display 414. If desired, some, all, or substantially all of flexible display 414 may be used as a speaker membrane for one speaker, for two speakers, for three speakers, or for more than three speakers.

A suspension structure such as suspension structure 454 may be used to attach portions of flexible display 414 to a rigid support structure such as housing

412. Suspension structure 454 may prevent speaker membrane 414M from moving laterally along the x-axis and/or the y-axis, but may allow free motion of speaker membrane 414M along the z-axis as speaker 448 produces sound. Suspension structure 454 may be formed from an elastomeric material, foam material, resin coated material, other suitable materials, or a combination of these materials. As shown in the example of FIG. 36, suspension structure 454 may form a pliant interface between speaker membrane 414M and housing sidewalls 412S. This is merely illustrative. If desired, suspension structure 454 may form a pliant interface between speaker membrane 414M and any suitable surrounding housing structure or any suitable rigid support structure.

If desired, other suspension structures may be incorporated into speaker structure 448. For example, there may be one or more suspension structures attached to magnet 440. This type of suspension structure may provide a restoring force that returns magnet 440 to an equilibrium position after being displaced by magnetic forces.

The desired range of frequencies produced by speaker 448 may depend on several factors. For example, the desired range of frequencies produced by speaker 448 may depend on the type of electronic device in which speaker 448 is implemented, may depend on the location of speaker 448 in device 10, may depend on the other speaker structures that are being used in combination with speaker structure 448, etc. Design choices may be made to obtain a desired frequency response from speaker 448. For example, materials used in forming speaker 448 may be selected based on the desired frequency response.

The type of enclosure that surrounds speaker 448 may also be selected based on the desired frequency

response. For example, the enclosure that surrounds the speaker may be ported. As shown in FIG. 36, housing 412 may optionally be provided with an opening or port such as acoustic port 452 (sometimes referred to as a funnel, horn, vent, hole, etc.). Port 452 may be used to equalize the pressure between the inside of housing 412 and the outside of housing 412. This may in turn augment the sound waves produced by speaker 448. A ported enclosure such as the ported enclosure shown in the example of FIG. 36 may increase the magnitude of low-frequency sound waves produced by speaker 448 (e.g., a speaker with a ported enclosure may have a higher bass output than a speaker with a sealed enclosure).

As shown in FIG. 36, port 452 may have a portion such as portion 452P that protrudes into the enclosure. The size and shape of protruding portion 452P may be customized to obtain a desired frequency response. For example, protruding portion 452P of port 452 may have a "horn" shape, in which the diameter of opening 452 varies along the length of portion 452P. Protruding portion 452P may have a curved shape, if desired. In general, protruding portion 452P may have any suitable shape, and opening 452 may have any suitable size. The characteristics of port 452 will depend on the desired frequency response of speaker 448, the structure of device 10, etc., and may be modified accordingly. The example shown in FIG. 36 is merely illustrative.

If desired, speaker 448 may be provided with a sealed enclosure that does not have a port. The example of FIG. 36 in which housing 412 is provided with port 452 is merely illustrative. The type of enclosure into which speaker 448 is implemented (e.g., a sealed enclosure, a ported enclosure, etc.) will depend on the desired frequency response of speaker 448, the structure of device

10, etc., and may be modified accordingly.

Electronic device 10 may have internal components or structures such as internal component 456. Internal components such as internal component 456 may optionally be used to tune the resonant frequency of speaker 448. Internal component 456 may be a battery or other internal structure. If desired, optional component 456 may be omitted or may otherwise not be used to tune the resonant frequency of speaker 448.

If desired, housing 412 may have one or more raised edges such as optional raised portion 412'. Raised portion 412' may have an upper surface that lies above the upper surface of display 414 (e.g., the upper surface of raised portion 412' may protrude above the upper surface of flexible display 414 in vertical dimension z). Optional raised housing 412' may allow a user to hold device 10 in hand without disrupting the speaker functionality of display 414. Raised portion 412' of housing 412 may surround the entire periphery of display 414, or may be located on one side of display 414, on two sides of display 414, on three sides of display 414, or on all four sides of display 414. Raised portion 412' may be formed as an integral part of housing 412 or may be formed as a separate structure in contact with housing 412.

FIG. 37 is a cross-sectional side view of a portion of electronic device 10 in the vicinity of another possible embodiment of speaker structure 448. As shown in FIG. 37, speaker structure 448 may be driven by a transducer such as transducer 450. In the example of FIG. 37, transducer 450 may be formed from one or more central sets of coils 442 surrounded by a magnet such as magnet 440. In some arrangements, inner portion 444 of coils 442 may also contain a magnet structure (e.g., coils 442 may surround a magnet structure). Magnet structures that are

formed within inner portion 444 of coils 442 may be formed as an integral part of outer magnet 440 (e.g., may be joined above and/or below coils 442) or may be a separate magnet structure. If desired, inner portion 444 of coils 442 may be free of magnet structures.

As with the transducer of FIG. 36, transducer 450 of FIG. 37 may be configured to receive electrical audio signal input from circuitry in device 10 and to convert the electrical signal into sound. As current passes through coils 442, a magnetic field is produced. The magnetic field produced by coils 442 interacts with the constant magnetic field produced by permanent magnet 440. The interaction of the electromagnet with the constant magnetic field will create a magnetic force between coils 442 and magnet 440 (e.g., an attractive or repulsive force). When the current flowing through coils 442 changes direction, the polarity of the variable electromagnet (and thus the direction of magnetic force) is reversed. Coils 442 may be pushed back and forth (along the z-axis) by the varying magnetic force as the current in coils 442 alternates directions.

As coils 442 move back and forth, attached speaker membrane 414M will in turn vibrate the air in front of speaker membrane 414M, creating sound waves. Support structure 446 may be used to stiffen speaker membrane 414M so that membrane portion 414M of flexible display 414 responds accurately to the movement of transducer 450.

In the example of FIG. 37, speaker 448 may be provided with a sealed enclosure that does not have a port. This is merely illustrative. Any suitable type of enclosure (e.g., a sealed enclosure, a ported enclosure, etc.) may be used. The type of enclosure into which speaker 448 is implemented will depend on the desired

frequency response of speaker 448, the structure of device 10, etc., and may be modified accordingly.

FIG. 38 is a cross-sectional side view of a portion of device 10 in the vicinity of another possible embodiment of speaker structure 448. In the example of FIG. 38, speaker 448 is supported by a rigid structure within device 10 such as rigid structure 466. Rigid structure 466 may be formed from housing structures or internal components, or may be a dedicated structure used to form a frame (sometimes referred to as a chassis or "basket") or other rigid support structure for speaker 448. Suspension structure 454 may be used to form a pliant interface between speaker 448 and rigid structure 466. As with the suspension structure of FIGS. 7 and 8 (in which suspension structure 454 is attached to housing sidewalls 412S), suspension structure 454 of FIG. 38 may prevent speaker membrane portions 414M of display 414 from moving laterally along the x-axis and/or the y-axis, but may allow free motion of speaker membrane 414M along the z-axis as speaker 448 produces sound. Suspension structure 454 may be attached to any suitable portion of speaker 448 (e.g., support structure 446, magnet 440, speaker membrane portion 414M, etc.)

The type of arrangement shown in FIG. 38 may be beneficial for configurations in which speaker 448 is not in the vicinity of housing sidewalls 412S or in other configurations in which speaker 448 is not attached to housing 412. For example, speaker 448 may be located in the central portion of a large display. In this type of configuration, a rigid structure such as rigid structure 466 of FIG. 38 may be used to support speaker 448, if desired.

There may be one or more speakers 448 in device 10. Multiple speakers 448 may be attached to a common

rigid structure 466 or each speaker 448 may be attached to a separate rigid structure 466.

If desired, a cover layer such as optional cover layer 462 may be formed over flexible display 414. Cover layer 462 may be formed from glass, plastic, or other suitable material. Cover layer 462 may allow a user to hold device 10 in hand without disrupting the speaker functionality of display 414. Cover layer 462 may also serve to protect display 414 and other parts of device 10 while still allowing speaker membrane 414M to move freely along the z-axis as speaker 448 produces sound. Cover layer 462 may be in contact with display 414 or there may be a gap 463 interposed between cover layer 462 and display 414. Gap 463 may be filled with air or may include a layer of material such as a layer of sealant (as an example).

One or more holes such as holes 464 (sometimes referred to as openings or speaker openings) may be formed in cover layer 462 so that sound may pass from speaker 448 to the exterior of device 10.

A perspective view of device 10 showing how holes 464 may be formed in cover layer 462 is shown in FIG. 39. As shown in FIG. 39, holes 464 may be formed in a "speaker grill" fashion in which an array of openings is formed in front of one or more speakers. Holes 464 may be formed in cover layer 462 in any suitable location. For example, holes 464 may be formed in localized areas of cover layer 462 that overlap a speaker structure, or holes 464 may be formed in a uniform array that covers some, all, or substantially all of the front surface of display 414. Holes 464 may have any suitable size. For example, holes 464 may have a diameter between .25 mm and .5 mm, between .5 mm and 1 mm, between 1 mm and 1.5 mm, more than 1.5 mm, less than 1.5 mm, etc. The size, shape, and

number of openings 464 formed in cover layer 462 may depend on the type and number of speakers 448 in device 10.

FIG. 40 is a cross-sectional side view of device 10 in the vicinity of support structure 446. Support structure 446 may be used to stiffen portions of flexible display 414. As discussed in connection with FIG. 36, stiffening structure 446 may be formed from a metal plate, from fiber-based composite materials, from laminated layers of one or more materials, or from other suitable materials. As shown in the example of FIG. 40, stiffening structure 446 may be formed from a layer of foam 474 interposed between first and second stiffening sheets 472. Sheets 472 may be formed from polymer, metal, glass, ceramic, fiber-based composites, or other suitable materials. This type of structure may provide a stiff and lightweight support structure for display 414. If desired, support structure 446 may be used to stiffen speaker membrane portions 414M of display 414, may be used to stiffen other portions of display 414, or may be used to stiffen all or substantially all of display 414.

Support structure 446 may be shaped in any desired fashion. For example, support structure 446 may be curved, may be planar, or may have a combination of curved and planar portions.

FIG. 41 is a cross-sectional side view of device 10 in the vicinity of curved support structure 446. As shown in FIG. 41, flexible display 414 may conform to the shape of stiffening structure 446. In the example of FIG. 41 stiffening structure 446 has a curved shape so that flexible display 414 is concave. This is, however, merely illustrative. In general, stiffening structure 446 and the attached portion of display 414 may have any suitable shape. For example, stiffening structure 446 may have a

curved shape so that flexible display 414 is convex. The example of FIG. 41 in which display 414 has a concave shape may be suitable for configurations in which display 414 forms a speaker membrane for speaker 448. A concave shaped speaker membrane may improve the quality of sound produced by speaker 448. Speakers with convex membranes may also be used.

FIG. 42 is a cross-sectional side view of device 10 in the vicinity of a single speaker structure. As shown in FIG. 42, portion 414M of flexible display 414 may form a speaker membrane for speaker structure 448. Transducer 450 for speaker 448 may be any suitable type of transducer (e.g., one or more sets of coils surrounded by a magnet, one or more sets of coils surrounding a magnet, a piezoelectric transducer, a microphone transducer, a sensor, an actuator, etc.). Speaker 448 may be the only speaker in device 10 or may be one of a plurality of speakers in device 10. Display-based speaker structure 448 may be used in conjunction with speaker structures that are not display-based. For example, there may be other speakers in device 10 which do not use display 414 as a speaker membrane. Speaker structure 448 of FIG. 42 may use all or substantially all of display 414 as a speaker membrane (e.g., the entire front face of device 10 may be occupied by a speaker), or may use only a portion of display 414 as a speaker membrane.

In the example of FIG. 43, an array of transducers 450 may be used to form a plurality of display-based speakers 448. Display-based speaker structures 448 may be used in conjunction with speaker structures that are not display-based. Each display-based speaker 448 may have an associated transducer 450. Each associated transducer 450 may be any suitable type of transducer (e.g., one or more sets of coils surrounded by

a magnet, one or more sets of coils surrounding a magnet, a piezoelectric transducer, a microphone transducer, a sensor, an actuator, etc.). The type of transducer 450 used may be different for each speaker 448 (e.g., the array of speakers 448 in FIG. 43 may include different types of transducers, if desired). Providing speakers 448 with different types of transducers, different structures, and different characteristics may give device 10 the ability to produce sound with a wider range of frequencies.

FIG. 44 is a bottom view of a portion of device 10 showing how an array of display-based speakers such as the array shown in FIG. 43 may be implemented in device 10. In the example of FIG. 44, support structure 446 is formed on the underside of display 414. Support structure 446 may be used to stiffen speaker membrane portions 414M of display 414 (e.g., support structure 446 may be interposed between transducer 450 and display 414). Support structure 446 may also be used to stiffen portions of display 414 between adjacent speakers 448.

Each speaker 448 may be surrounded by a ring 414' of flexible display 414 that is not stiffened by support structure 446. Flexible ring-shaped portions 414' of flexible display 414 may provide a barrier structure around each speaker 448 that prevents interference between adjacent speakers 448. For example, as speaker membrane 414M vibrates, ring 414' (which is surrounded by support structure 446) may absorb vibrations moving laterally in display 414 (e.g., in directions along the x-axis and/or y-axis). This may allow adjacent speakers 448 to operate independently without being disrupted by the vibrations of a neighboring speaker.

If desired, speakers 448 may include a variety of speaker types. Examples of speaker types that may be

used for speakers 448 include subwoofers, woofers, mid-range speakers, tweeters, supertweeters, etc. If desired, different channels of audio input may be routed to each speaker. For example, speakers 448 may include a center channel speaker, a left channel speaker, a right channel speaker, a surround channel speaker, etc. Any suitable characteristic of speakers 448 (e.g., size, type, location, input channel, etc.) may be modified to achieve a desired frequency response and/or to accommodate the structure of device 10.

Electronic devices that contain flexible displays and one or more display-based speaker structures may be provided. The speaker structures may be positioned under the flexible display. Portions of the flexible display may be used as speaker membranes for the speaker structures. The speaker structures may be driven by transducers that convert electrical audio signal input into sound. Piezoelectric transducers or transducers formed from coils and magnets may be used to drive the speaker structures. Speaker membranes may be formed from active display areas of the flexible display. Some, all, or substantially all of the flexible display may be used as a speaker membrane for one or more display-based speaker structures. An optional cover layer may be provided with speaker openings so that sound may pass from the display-based speaker structures to the exterior of the device.

In accordance with another embodiment, an electronic device is provided including a flexible display and a speaker structure having a speaker membrane, where the speaker membrane is formed from a portion of the flexible display.

In accordance with another embodiment, the electronic device further includes a stiffening structure

configured to stiffen the portion of the flexible display that forms the speaker membrane.

In accordance with another embodiment, the stiffening structure includes a layer of foam.

In accordance with another embodiment, the stiffening structure includes first and second stiffening sheets that are attached to opposing first and second sides of the layer of foam.

In accordance with another embodiment, the flexible display includes an active portion configured to display images and the speaker membrane is formed from the active portion of the flexible display.

In accordance with another embodiment, the electronic device further includes a rigid structure and a suspension structure configured to attach portions of the speaker structure to the rigid structure.

In accordance with another embodiment, the electronic device further includes an electronic device housing in which the flexible display is mounted, where the rigid structure is formed at least partly from the electronic device housing.

In accordance with another embodiment, the electronic device further includes a cover layer formed over the flexible display, where the cover layer includes at least one opening formed over the speaker membrane.

In accordance with another embodiment, the electronic device further includes an electronic device housing in which the flexible display is mounted, where the electronic device housing has at least one acoustic port.

In accordance with another embodiment, the flexible display includes an organic light-emitting diode display having a substrate formed from a flexible sheet of polymer.

In accordance with another embodiment an electronic device is provided including a flexible display and a plurality of speaker structures, where portions of the flexible display form speaker membranes for the plurality of speaker structures.

In accordance with another embodiment, the electronic device further includes a plurality of stiffening structures configured to stiffen the portions of the flexible display that form the speaker membranes.

In accordance with another embodiment, the flexible display includes a set of stiffened regions, where each of the stiffened regions in the set of stiffened regions forms part of a respective one of the speaker structures, flexible regions, where each of the flexible regions surrounds a respective one of the stiffened regions in the set of stiffened regions, and a surrounding stiffened region, where each of the flexible regions is surrounded by portions of the surrounding stiffened region.

In accordance with another embodiment, the speaker structures include a left channel speaker and a right channel speaker.

In accordance with another embodiment, the electronic device further includes transducers configured to drive the speaker structures, where each transducer includes coils and a magnet.

In accordance with another embodiment, the electronic device further includes piezoelectric transducers configured to drive the speaker structures.

In accordance with another embodiment, the flexible display includes an organic light-emitting diode display having a substrate formed from a flexible sheet of polymer.

In accordance with another embodiment, a

portable electronic device is provided, including a housing, a flexible organic light-emitting diode display mounted in the housing, where the flexible organic light-emitting diode display has a substrate formed from a flexible sheet of polymer, and at least one speaker having a speaker membrane formed from a portion of the flexible sheet of polymer.

In accordance with another embodiment, the portable electronic device further includes a stiffening structure interposed between the at least one speaker and the speaker membrane, where the stiffening structure includes a composite material.

In accordance with another embodiment, the speaker membrane has a concave shape.

In accordance with another embodiment, the housing includes a rectangular housing with four peripheral edges and the flexible organic light-emitting diode display and the speaker membrane extend between the four peripheral edges.

The foregoing is merely illustrative of the principles of this invention and various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention. The foregoing embodiments may be implemented individually or in any combination.

What is Claimed is:

1. An electronic device, comprising:

a flexible display; and

an internal component, wherein the flexible display may be deformed by an action external to the device, and wherein deformation of the flexible display creates a response from the internal component.

2. The electronic device defined in claim 1 wherein the flexible display comprises:

a flexible display layer; and

a touch-sensitive layer.

3. The electronic device defined in claim 2 wherein the flexible display layer of the flexible display includes an active display region, and wherein the internal component is covered with a portion of the active display region of the flexible display.

4. The electronic device defined in claim 3 wherein the internal component comprises a button, and wherein deformation of the flexible display compresses the button.

5. The electronic device defined in claim 4 wherein the flexible display further comprises a rigid cover layer having at least one opening.

6. The electronic device defined in claim 5 wherein the opening comprises a hole in the rigid cover layer, wherein the button further comprises a button member in the opening, wherein the button member moves within the hole in the rigid cover layer, and wherein the

movement of the button member in the opening causes deformation of the flexible display.

7. The electronic device defined in claim 3 wherein the internal component comprises a pressure sensor, and wherein deformation of the flexible display exerts a mechanical pressure on the pressure sensor.

8. The electronic device defined in claim 7 wherein the pressure sensor comprises a piezoelectric actuator, and wherein the mechanical pressure induces a voltage on the piezoelectric actuator.

9. The electronic device defined in claim 3 wherein the internal component comprises a laser microphone for detecting a sound originating external to the electronic device, and wherein detecting the sound comprises with a laser, detecting deformation of the flexible display.

10. An electronic device, comprising:
a flexible display; and
an audio component that transmits or receives sound through the flexible display.

11. The electronic device defined in claim 10 wherein the flexible display includes an active display region, and wherein the audio component is mounted behind the active display region of the flexible display.

12. The electronic device defined in claim 11 wherein the flexible display comprises:
a flexible display layer; and
a touch-sensitive layer.

13. The electronic device defined in claim 11 wherein the audio component comprises a diaphragm, and wherein the diaphragm is mounted in contact with the flexible display.

14. An electronic device, comprising:

a housing;

a flexible display mounted on the housing; and

a first internal component mounted under a portion of the flexible display, wherein the first internal component is configured to deform the portion of the flexible display.

15. The electronic device defined in claim 14 wherein the first internal component comprises a piezoelectric actuator, wherein a voltage applied to the piezoelectric actuator causes an expansion of the piezoelectric actuator, and wherein the portion of the flexible display deforms in response to the expansion of the piezoelectric actuator.

16. The electronic device defined in claim 14 wherein the first internal component comprises a structural component, wherein the portion of the flexible display deforms in response to physical contact with the structural component, and wherein deformation of the portion of the flexible display causes the portion of the flexible display to conform to a surface of the structural component.

17. The electronic device defined in claim 16 further comprising a second internal component mounted

under the portion of the flexible display, wherein the portion of the flexible display that conforms to the surface of the structural component indicates the location of the second internal component.

18. The electronic device defined in claim 17 wherein the second internal component comprises a button, wherein the portion of the flexible display is configured to be further deformed by an action external to the electronic device, and wherein further deformation of the portion of the flexible display compresses the button.

19. The electronic device defined in claim 16 wherein the first internal component further comprises an actuator, wherein the structural component is mounted on the actuator, wherein raising the actuator moves the structural component into contact with the portion of the flexible display, and wherein lowering the actuator moves the structural component out of contact with the flexible display.

20. The electronic device defined in claim 19 wherein the flexible display comprises a touch-sensitive layer and wherein deformation of the portion of the flexible display conforming to the surface of the structural component indicates the location of a portion of the touch-sensitive layer of the flexible display.

21. The electronic device defined in claim 19 further comprising a second internal component mounted on the actuator, and wherein deformation of the portion of the flexible display conforming to the surface of the structural component indicates the location of the second internal component.

85

22. The electronic device defined in claim 19 further comprising:

a cover member; and

an actuator switch coupled to the actuator, wherein deformation of the flexible display exerts a pressure on the cover member, and wherein the pressure on the cover member lifts the cover member.

23. An electronic device, comprising:

a housing; and

a concave display mounted in the housing, wherein the concave display has a rigid internal support structure having a concave surface and a flexible display layer attached to the rigid internal support structure that conforms to the concave surface of the rigid support structure.

24. The electronic device defined in claim 23 wherein the concave display further comprises a first adhesive layer, and wherein the first adhesive layer attaches the flexible display layer to the concave surface of the rigid internal support structure.

25. The electronic device defined in claim 23 wherein the concave display further comprises a touch-sensitive layer.

26. The electronic device defined in claim 25 wherein the concave display further comprises first and second adhesive layers, wherein the first adhesive layer attaches the flexible display layer to the touch-sensitive layer, and wherein the second adhesive layer attaches the flexible display layer to the rigid internal support

structure.

27. The electronic device defined in claim 23 wherein the housing comprises a bezel, and wherein the bezel surrounds a periphery of the concave display.

28. The electronic device defined in claim 26 wherein the rigid internal support structure has a convex inner surface and wherein the electronic device further comprises at least one internal component mounted adjacent to the convex inner surface.

29. The electronic device defined in claim 28, wherein the rigid internal support structure has at least one opening.

30. The electronic device defined in claim 29 wherein the at least one opening comprises a hole in the rigid internal support structure, and wherein the at least one internal component is mounted in the hole in the rigid internal support structure.

31. An electronic device, comprising:

a housing; and

a concave display mounted in the housing, wherein the concave display includes a rigid cover layer having at least one concave outer surface and at least one corresponding convex inner surface and includes a flexible display layer, wherein the flexible display layer conforms to the convex inner surface of the rigid cover layer.

32. The electronic device defined in claim 31 wherein the flexible display layer comprises image pixels formed from organic light-emitting diodes.

33. The electronic device defined in claim 31 wherein the concave display further comprises a first adhesive layer, and wherein the first adhesive layer attaches the flexible display layer to the convex inner surface of the rigid cover layer.

34. The electronic device defined in claim 33 wherein the rigid cover layer has at least one opening, wherein the electronic device further comprises an internal component, and wherein the internal component is mounted adjacent to the flexible display layer under the at least one opening in the rigid cover layer.

35. The electronic device defined in claim 34 wherein the internal component comprises a speaker and wherein the speaker transmits sound through the flexible display layer.

36. The electronic device defined in claim 34 wherein the internal component comprises a button, wherein the electronic device further comprises a button member in the at least one opening in the rigid cover layer, wherein the button member moves within the at least one opening in the rigid cover layer, and wherein the movement of the button member compresses the button.

37. An electronic device, comprising:

an electronic device housing; and

a concave display mounted in the electronic device housing, wherein the concave display comprises a rigid cover layer having a concave outer surface and a convex inner surface, a flexible display layer, and a touch-sensitive layer, wherein the flexible display layer

and the touch-sensitive layer each conform to the convex inner surface of the rigid cover layer.

38. The electronic device defined in claim 37 wherein the concave display further comprises first and second adhesive layers, wherein the flexible display layer is attached to the touch-sensitive layer with the first adhesive layer, and wherein the touch-sensitive layer is attached to the convex inner surface of the rigid cover layer with the second adhesive layer.

39. The electronic device defined in claim 38 further comprising at least one internal component mounted adjacent to the flexible display layer of the concave display.

40. The electronic device defined in claim 39 wherein the rigid cover layer of the convex display has at least one opening, wherein the at least one internal component is an audio component, and wherein the audio component is mounted under the at least one opening in the rigid cover layer.

41. The electronic device defined in claim 38 wherein the concave outer surface of the concave display has a curvature and peripheral edges, wherein the curvature has a deepest point, wherein the deepest point and at least some of the peripheral edges define a maximum depth associated with the curvature of the concave display and wherein the maximum depth of the concave display is between 0.5 millimeter and 20 millimeters.

42. The electronic device defined in claim 41 further comprising an internal component, wherein the

internal component is mounted at a distance from the peripheral edges of the concave outer surface, and wherein the distance is smaller than the maximum depth.

43. An electronic device, comprising:

a housing; and

a display mounted in the housing, wherein the display has a flexible display layer that conforms to a convex outer surface of a rigid support structure.

44. The electronic device defined in claim 43 wherein the display further comprises an adhesive layer, and wherein the adhesive layer attaches the flexible display layer to the convex outer surface of the rigid support structure.

45. The electronic device defined in claim 43 wherein the display further comprises a touch-sensitive layer.

46. The electronic device defined in claim 45 wherein the display further comprises first and second adhesive layers, wherein the first adhesive layer attaches the flexible display layer to the touch-sensitive layer, and wherein the second adhesive layer attaches the flexible display layer to the convex outer surface of the rigid support structure.

47. The electronic device defined in claim 46 wherein the flexible display layer comprises image pixels formed from organic light-emitting diodes.

48. The electronic device defined in claim 46, wherein the housing has at least one opening, wherein the

opening is associated with a connector port, the electronic device further comprising a connector structure mounted in the connector port.

49. An electronic device, comprising:

a housing; and

a display mounted in the housing, wherein the display includes a rigid cover layer having at least one convex outer surface and having at least one associated concave inner surface and includes a flexible display layer that conforms to the concave inner surface.

50. The electronic device defined in claim 49 wherein the display further comprises an adhesive layer, and wherein the adhesive layer bonds the flexible display layer to the concave inner surface of the rigid cover layer.

51. The electronic device defined in claim 49 wherein the rigid cover layer comprises glass.

52. The electronic device defined in claim 51 wherein the flexible display layer comprises image pixels formed from organic light-emitting diodes.

53. The electronic device defined in claim 49 wherein the flexible display layer comprises image pixels formed from organic light-emitting diodes.

54. The electronic device defined in claim 49 wherein the display further comprises a touch sensor layer that conforms to the concave inner surface.

55. The electronic device defined in claim 54

wherein the concave display further comprises first and second adhesive layers, wherein the first adhesive layer attaches the flexible display layer to the touch sensor layer, and wherein the second adhesive layer attaches the touch sensor layer to the concave inner surface of the display.

56. The electronic device defined in claim 55 wherein touch sensor layer comprises indium-tin-oxide electrodes.

57. The electronic device defined in claim 49 further comprising an internal component, wherein the concave inner surface of the display provides an additional internal volume for the electronic device, and wherein the internal component is mounted at least partially in the additional internal volume.

58. An electronic device having at least a front surface and a rear surface, comprising:

electronic components interposed between the front and rear surfaces; and

a display that substantially covers at least the front and rear surfaces and that surrounds the electronic components, wherein the display comprises a rigid cover layer having at least one inner surface and a flexible display layer that is bent to conform to the inner surface.

59. The electronic device defined in claim 58 wherein the display further comprises a touch-sensitive layer attached to at least a portion of the flexible display layer.

60. The electronic device defined in claim 58 wherein the inner surface comprises a concave inner surface, the electronic device further comprising a connector structure and a housing having an opening, wherein the connector structure is mounted in the opening to form a connector port.

61. The electronic device defined in claim 58 wherein the electronic device has at least two sidewall surfaces, and wherein the display substantially covers the two sidewall surfaces.

62. The electronic device defined in claim 61 wherein the display has at least two edges, and wherein the edges of the display are joined by a joining member.

63. An electronic device, comprising:

a flexible display; and

a speaker structure having a speaker membrane, wherein the speaker membrane is formed from a portion of the flexible display.

64. The electronic device defined in claim 63, further comprising:

a stiffening structure configured to stiffen the portion of the flexible display that forms the speaker membrane.

65. The electronic device defined in claim 64 wherein the stiffening structure comprises a layer of foam.

66. The electronic device defined in claim 65 wherein the stiffening structure comprises first and

second stiffening sheets that are attached to opposing first and second sides of the layer of foam.

67. The electronic device defined in claim 63 wherein the flexible display comprises an active portion configured to display images and wherein the speaker membrane is formed from the active portion of the flexible display.

68. The electronic device defined in claim 63, further comprising:

a rigid structure; and

a suspension structure configured to attach portions of the speaker structure to the rigid structure.

69. The electronic device defined in claim 68, further comprising:

an electronic device housing in which the flexible display is mounted, wherein the rigid structure is formed at least partly from the electronic device housing.

70. The electronic device defined in claim 63, further comprising:

a cover layer formed over the flexible display, wherein the cover layer comprises at least one opening formed over the speaker membrane.

71. The electronic device defined in claim 63 further comprising an electronic device housing in which the flexible display is mounted, wherein the electronic device housing has at least one acoustic port.

72. The electronic device defined in claim 63

wherein the flexible display comprises an organic light-emitting diode display having a substrate formed from a flexible sheet of polymer.

73. An electronic device, comprising:

a flexible display; and

a plurality of speaker structures, wherein portions of the flexible display form speaker membranes for the plurality of speaker structures.

74. The electronic device defined in claim 73, further comprising:

a plurality of stiffening structures configured to stiffen the portions of the flexible display that form the speaker membranes.

75. The electronic device defined in claim 73 wherein the flexible display comprises:

a set of stiffened regions, wherein each of the stiffened regions in the set of stiffened regions forms part of a respective one of the speaker structures;

flexible regions, wherein each of the flexible regions surrounds a respective one of the stiffened regions in the set of stiffened regions; and

a surrounding stiffened region, wherein each of the flexible regions is surrounded by portions of the surrounding stiffened region.

76. The electronic device defined in claim 73 wherein the speaker structures comprise a left channel speaker and a right channel speaker.

77. The electronic device defined in claim 73, further comprising:

transducers configured to drive the speaker structures, wherein each transducer comprises coils and a magnet.

78. The electronic device defined in claim 73 further comprising piezoelectric transducers configured to drive the speaker structures.

79. The electronic device defined in claim 73 wherein the flexible display comprises an organic light-emitting diode display having a substrate formed from a flexible sheet of polymer.

80. A portable electronic device, comprising:

a housing;

a flexible organic light-emitting diode display mounted in the housing, wherein the flexible organic light-emitting diode display has a substrate formed from a flexible sheet of polymer; and

at least one speaker having a speaker membrane formed from a portion of the flexible sheet of polymer.

81. The portable electronic device defined in claim 80, further comprising:

a stiffening structure interposed between the at least one speaker and the speaker membrane, wherein the stiffening structure comprises a composite material.

82. The portable electronic device defined in claim 80 wherein the speaker membrane has a concave shape.

83. The portable electronic device defined in claim 80 wherein the housing comprises a rectangular

housing with four peripheral edges and wherein the flexible organic light-emitting diode display and the speaker membrane extend between the four peripheral edges.

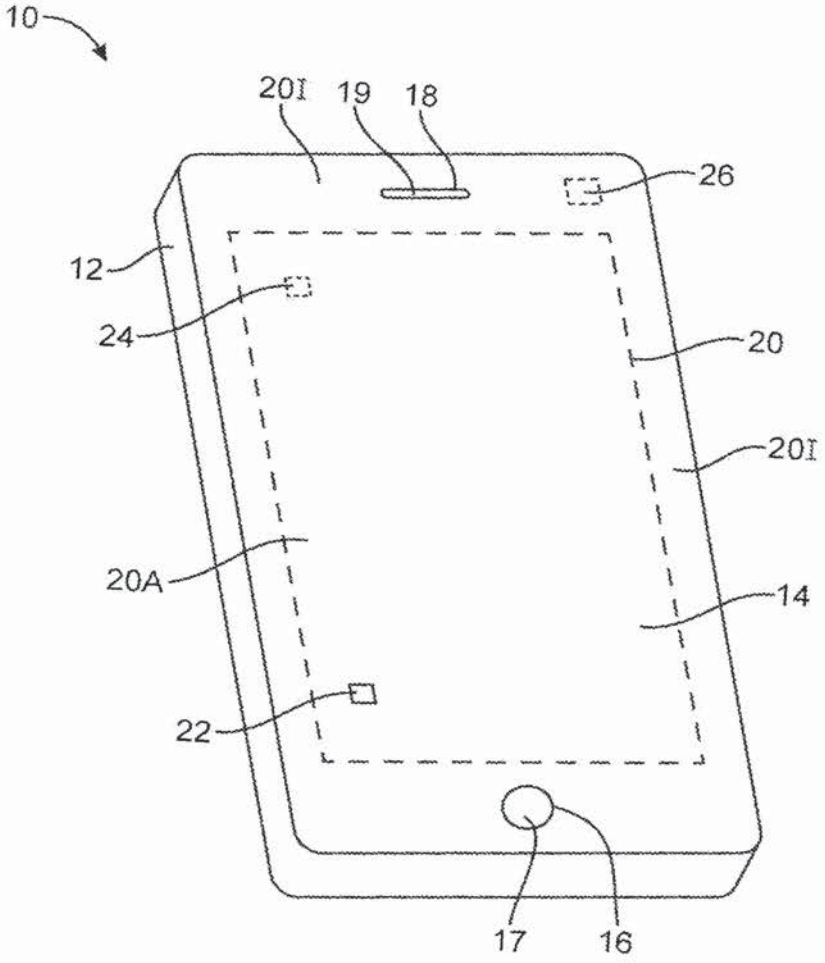


FIG. 1

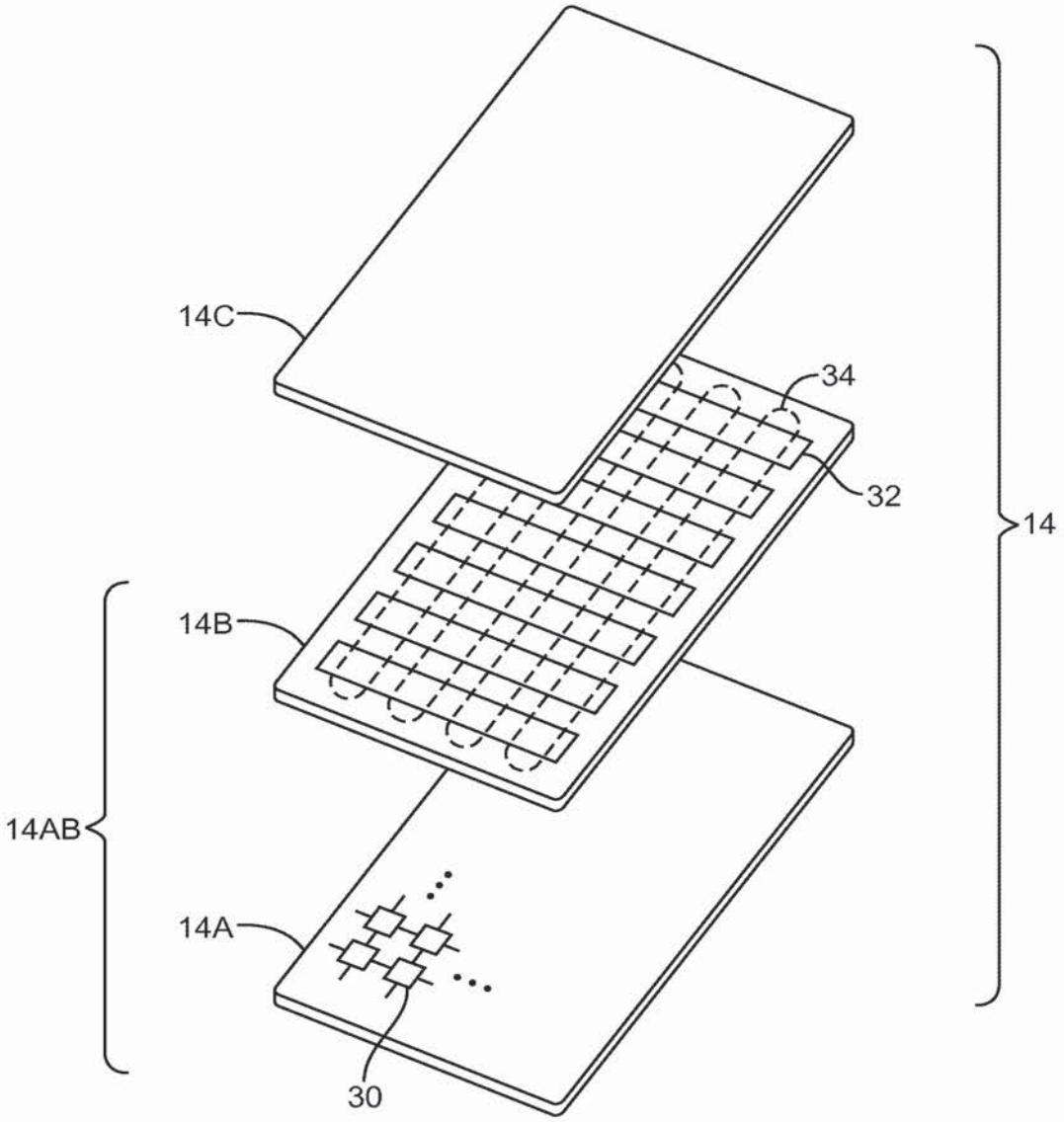


FIG. 2

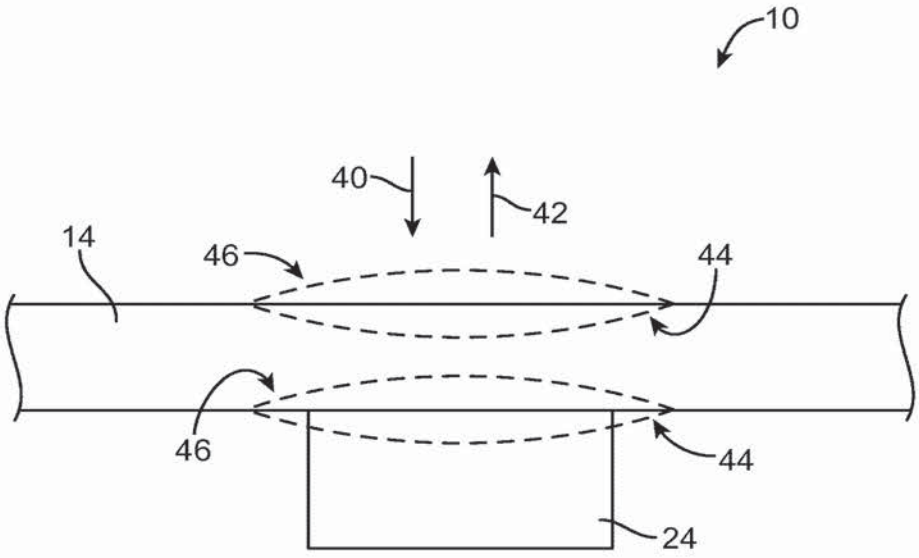


FIG. 3

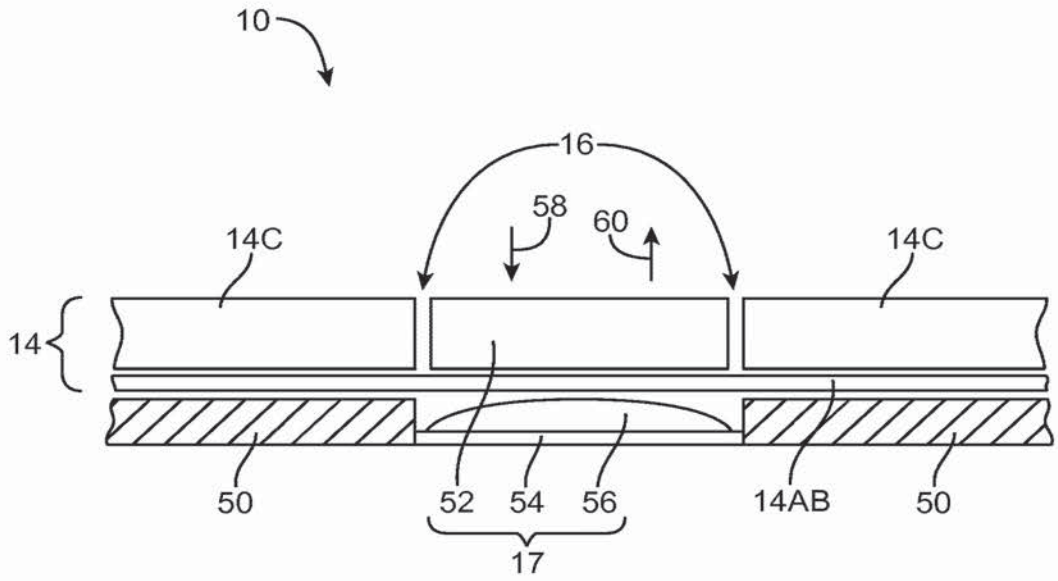


FIG. 4

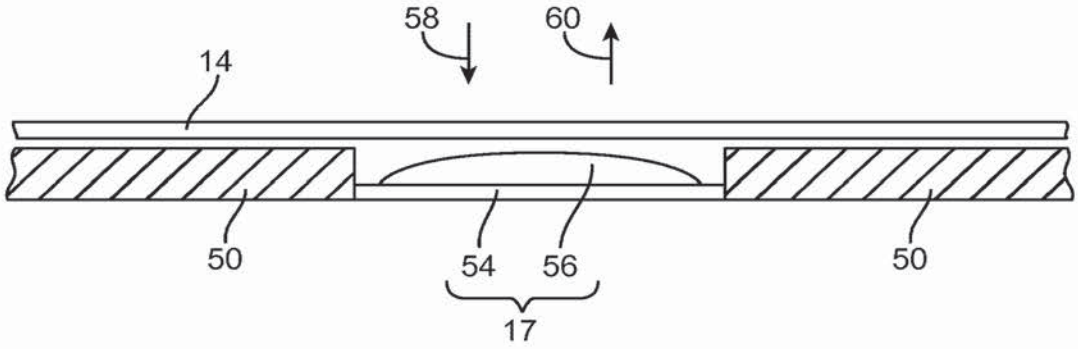


FIG. 5

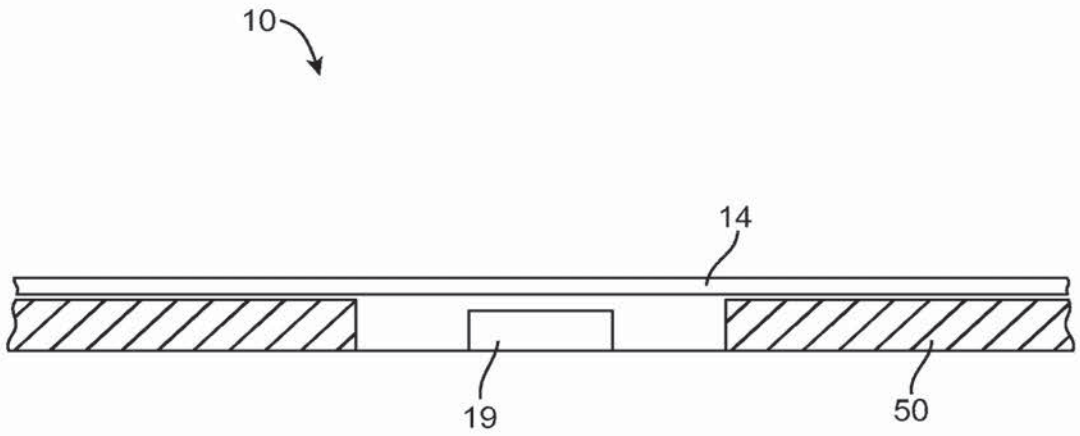


FIG. 6

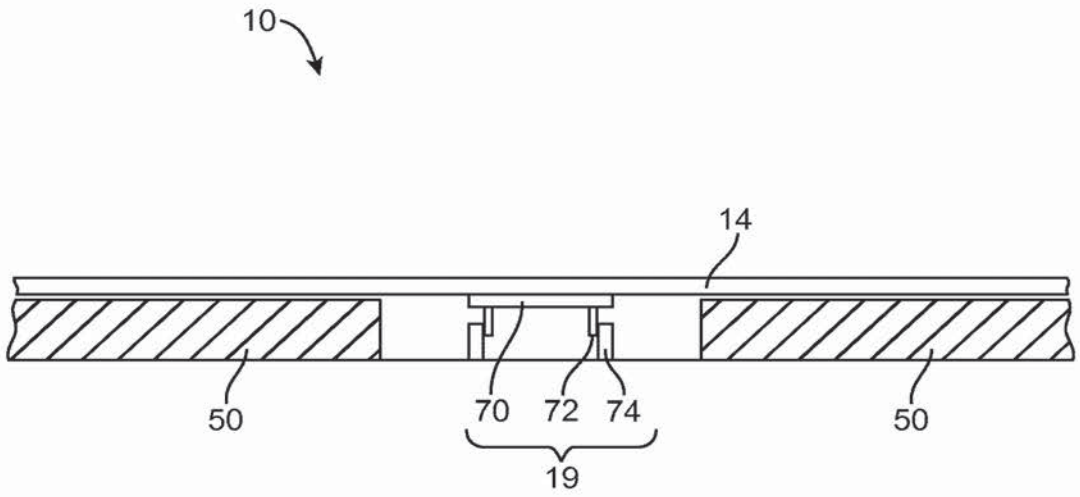


FIG. 7

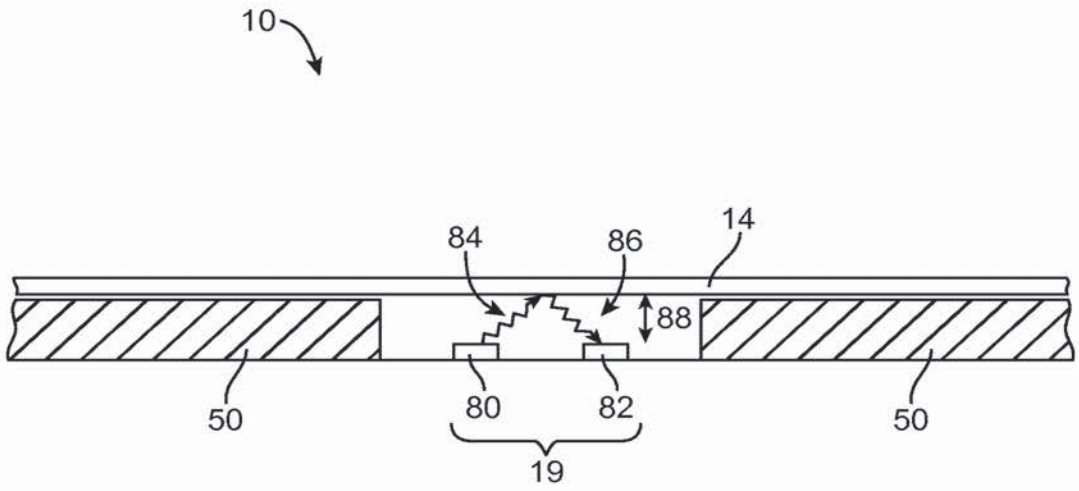


FIG. 8

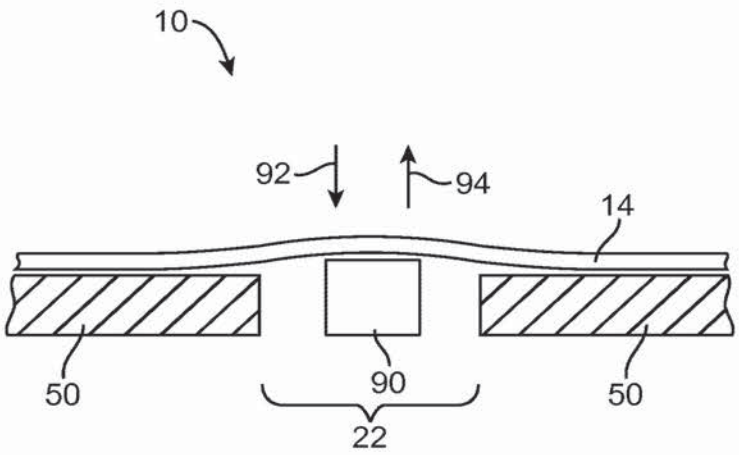


FIG. 9

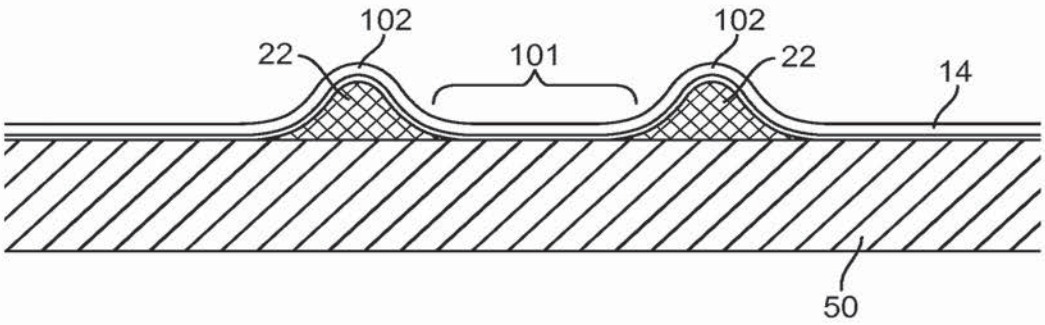


FIG. 10

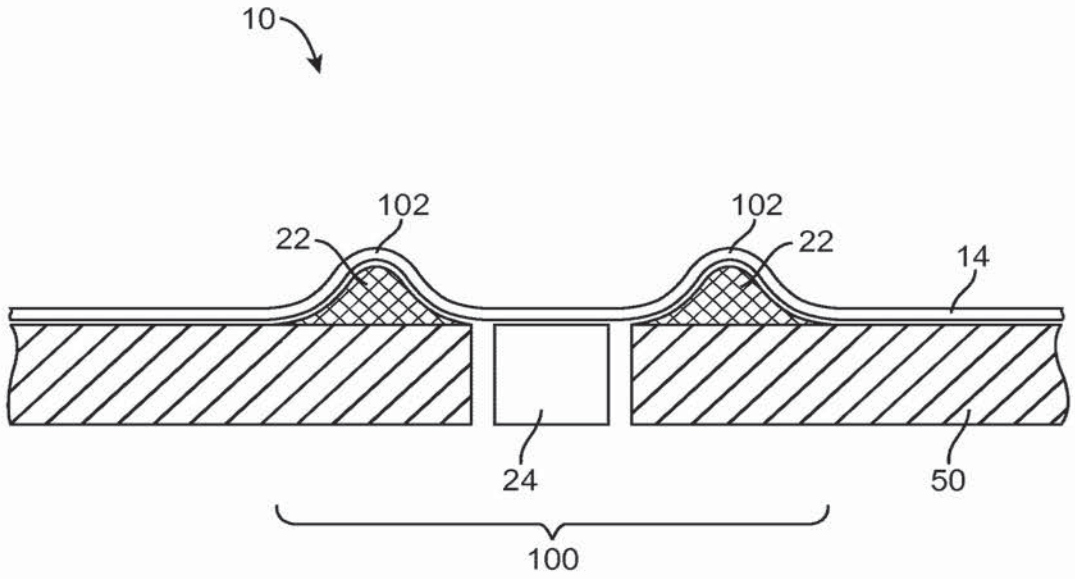


FIG. 11

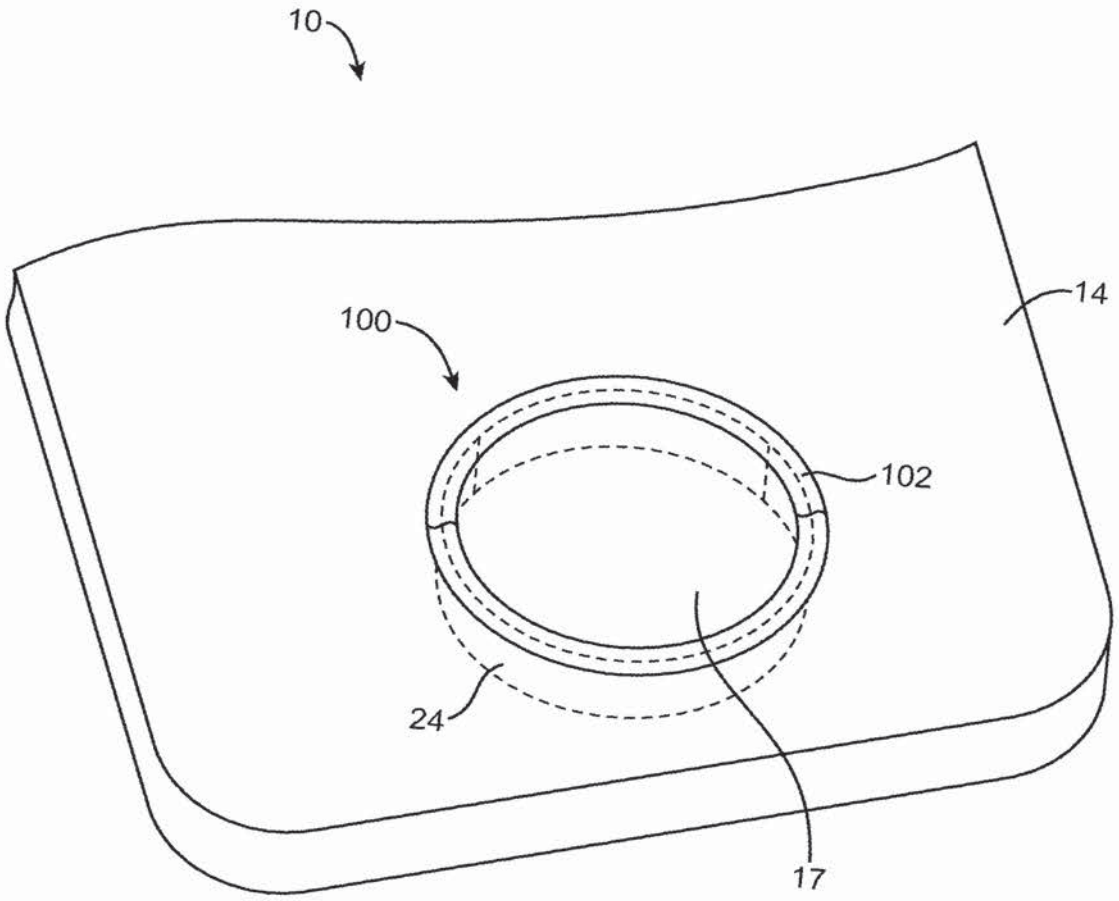


FIG. 12

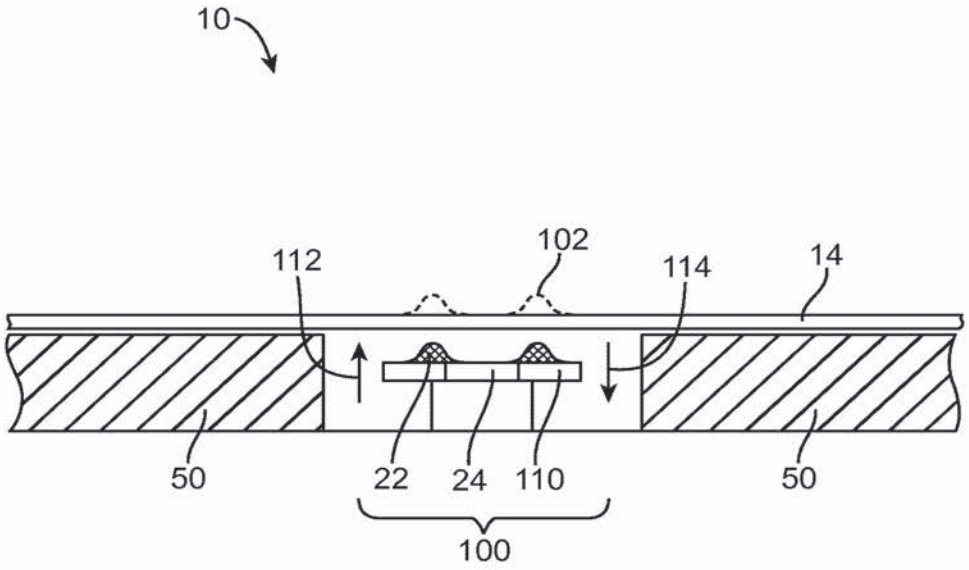


FIG. 13

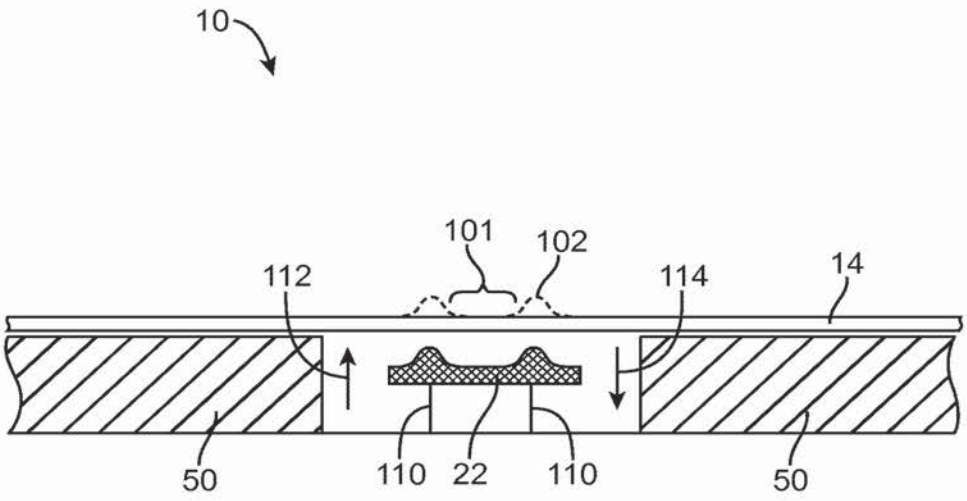


FIG. 14

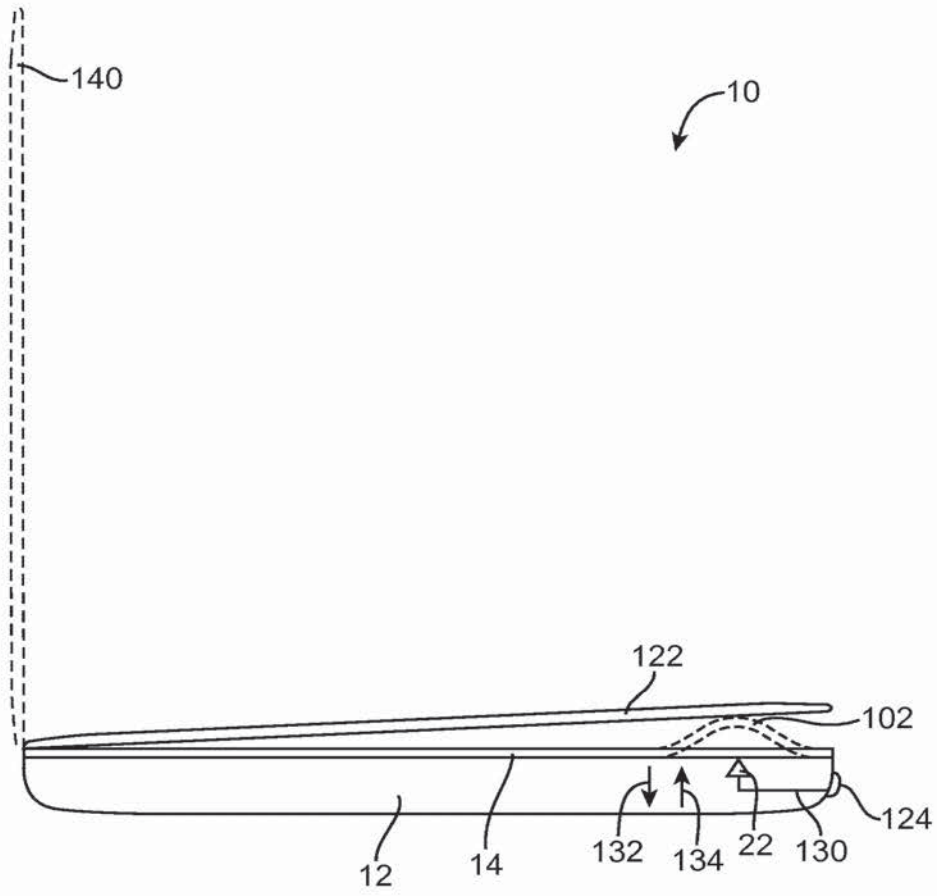


FIG. 15

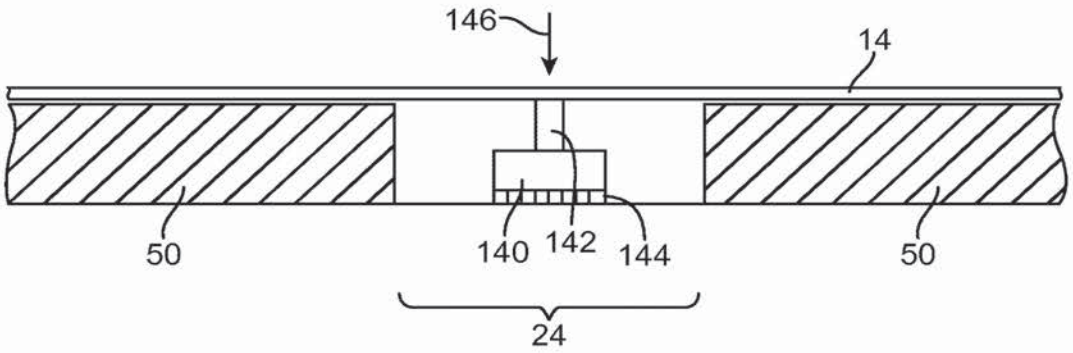


FIG. 16

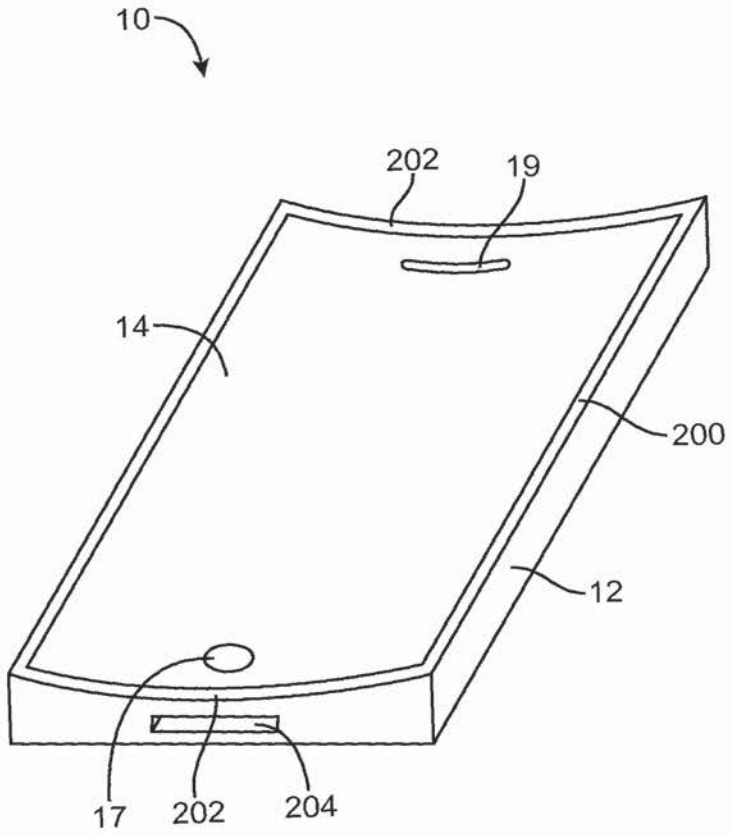


FIG. 17

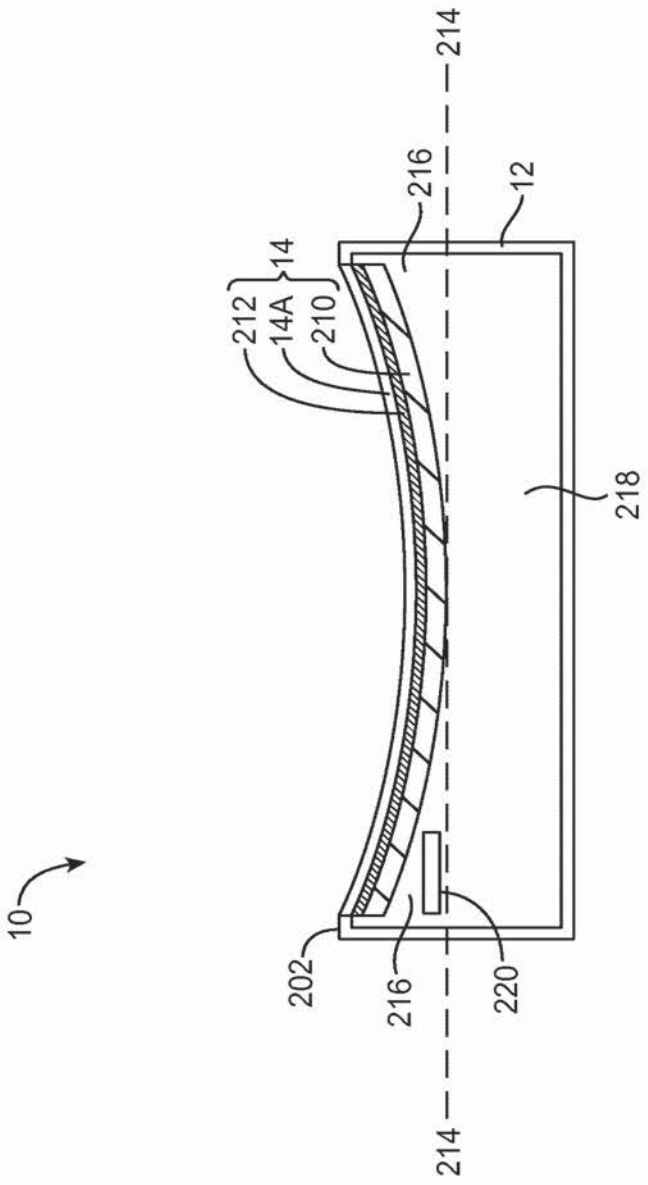


FIG. 18

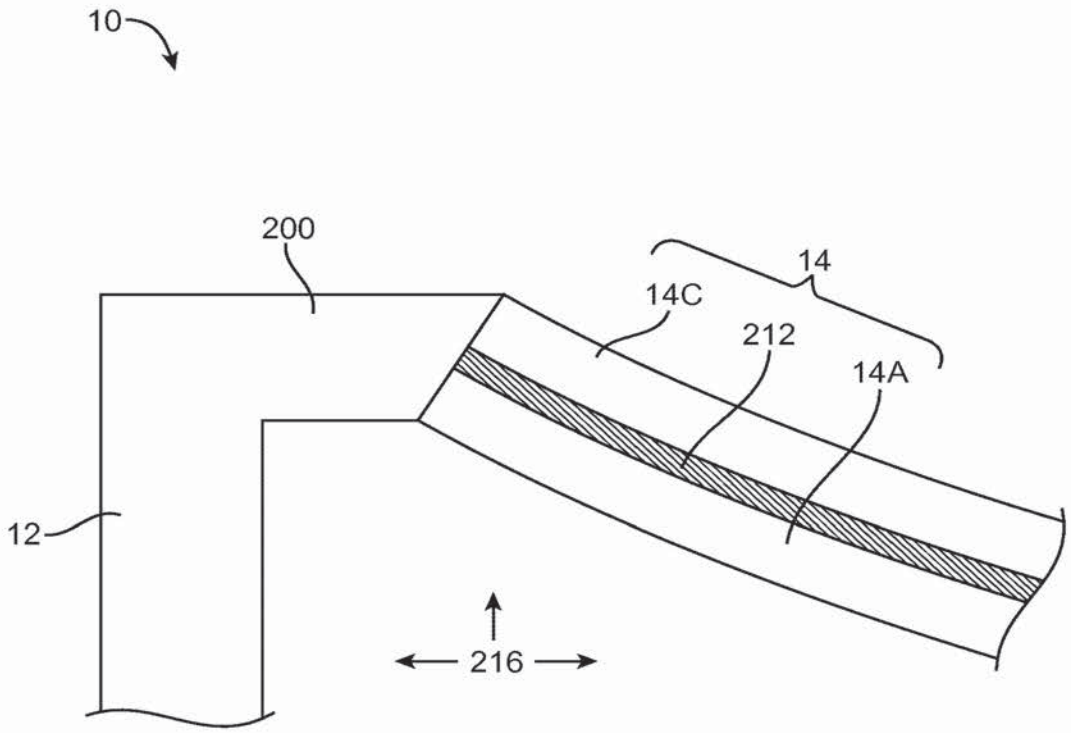


FIG. 19

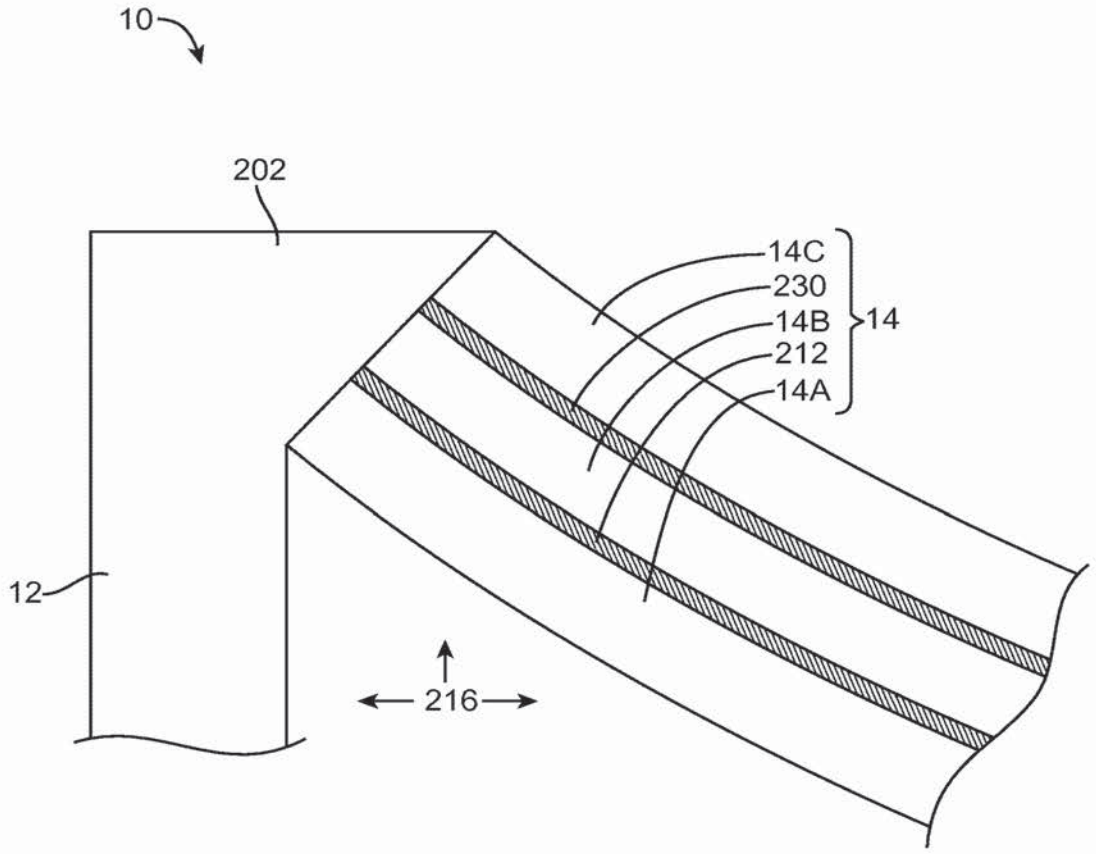


FIG. 20

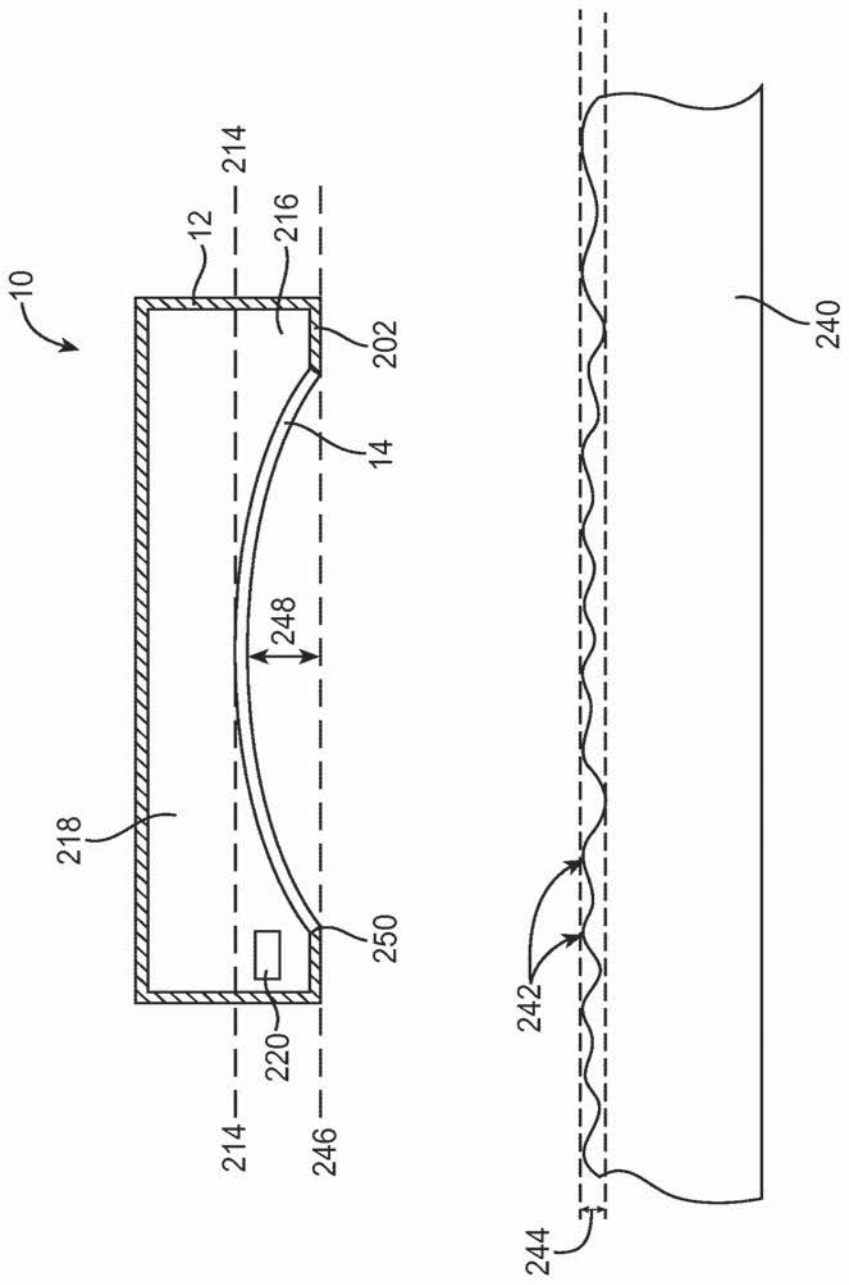


FIG. 21

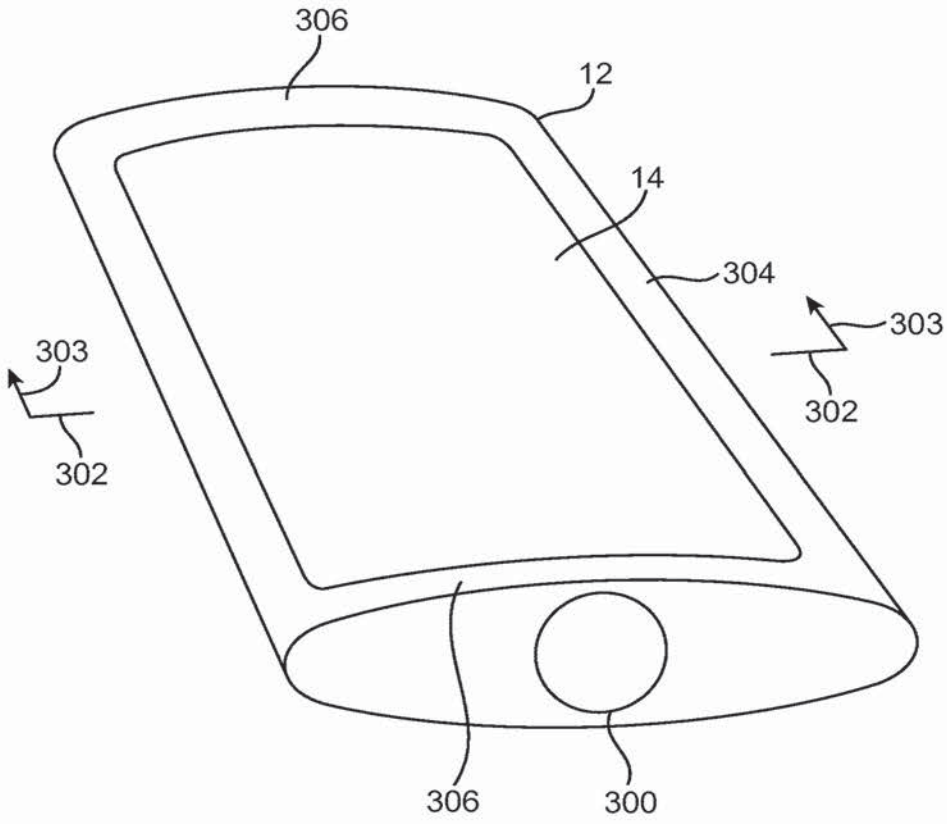


FIG. 22

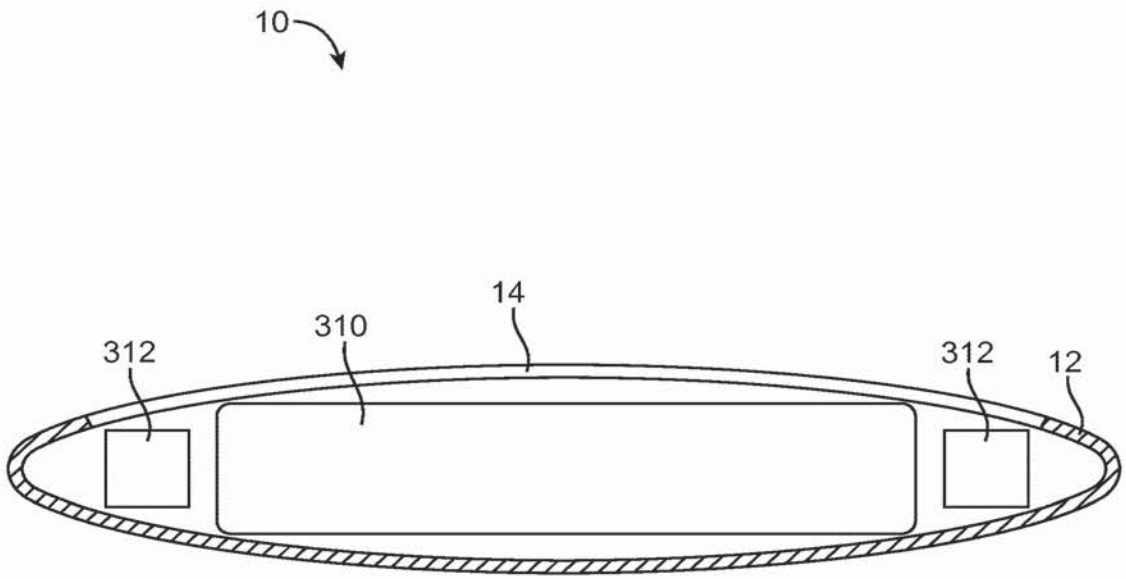


FIG. 23

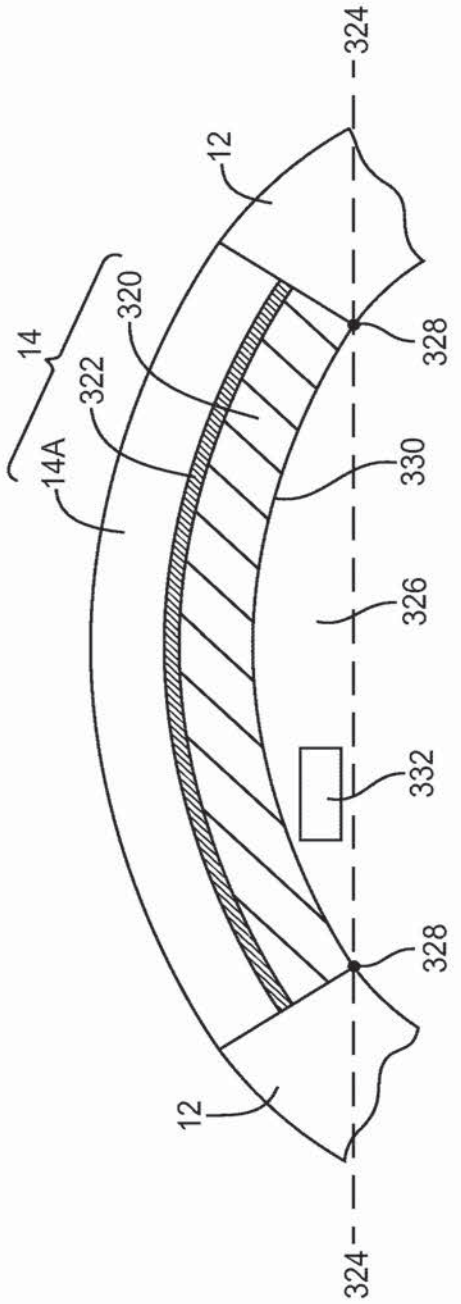


FIG. 24

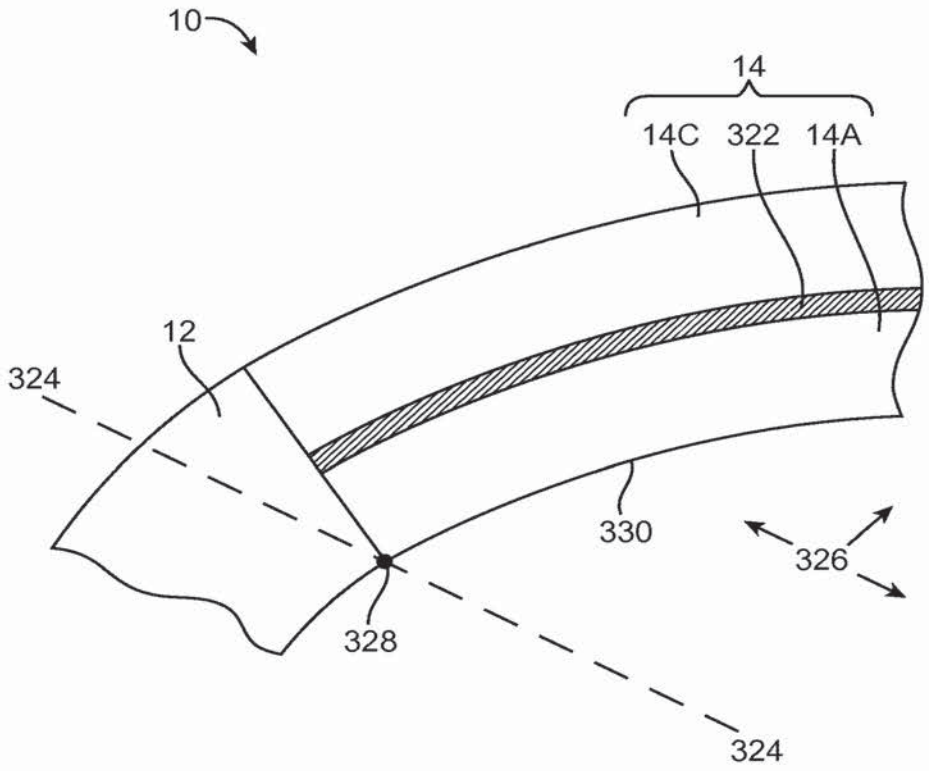


FIG. 25

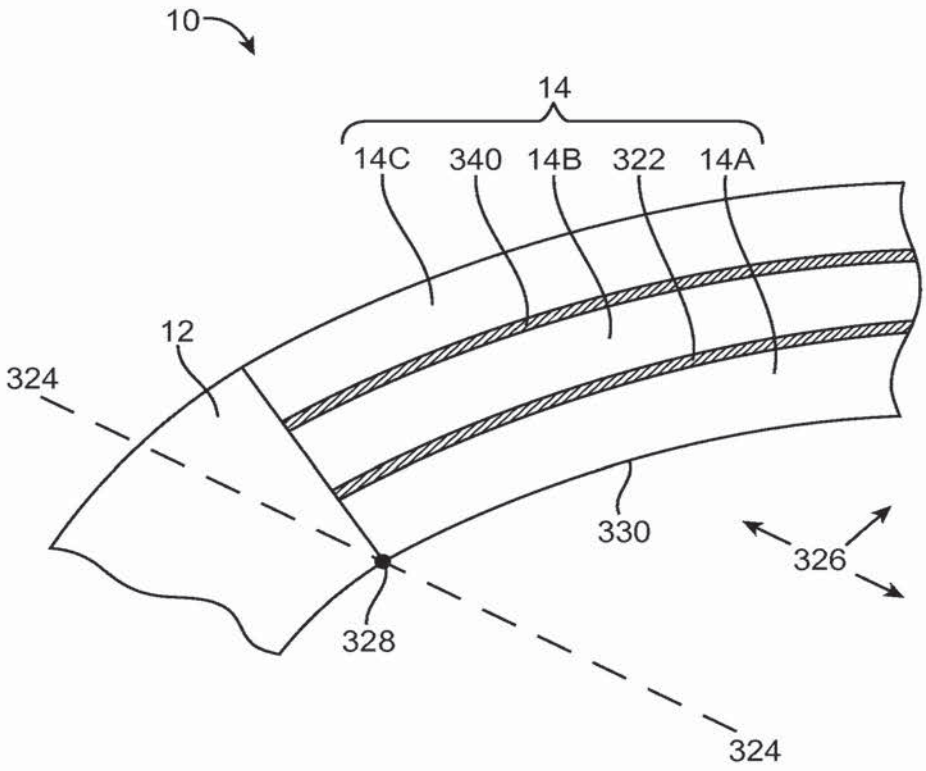


FIG. 26

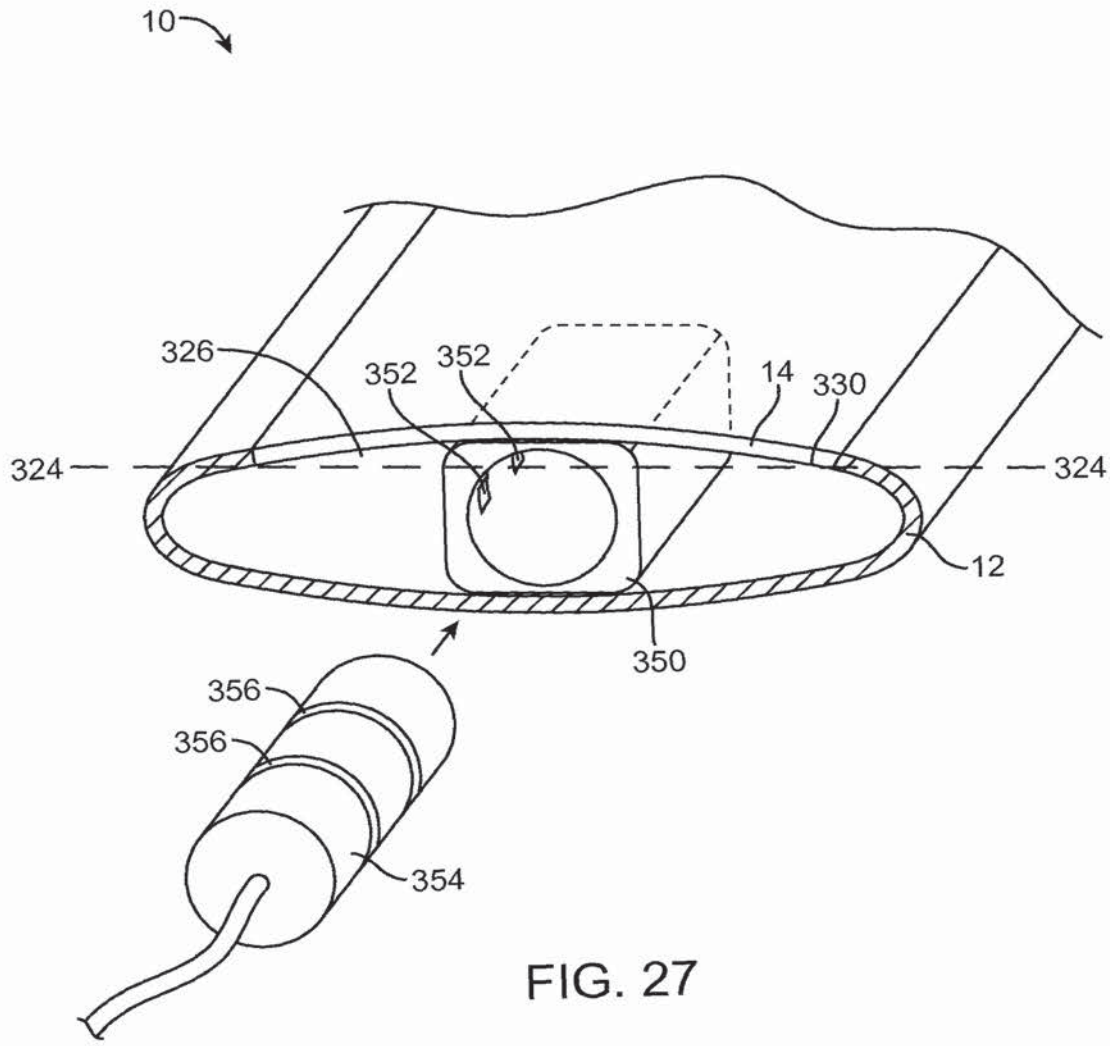


FIG. 27

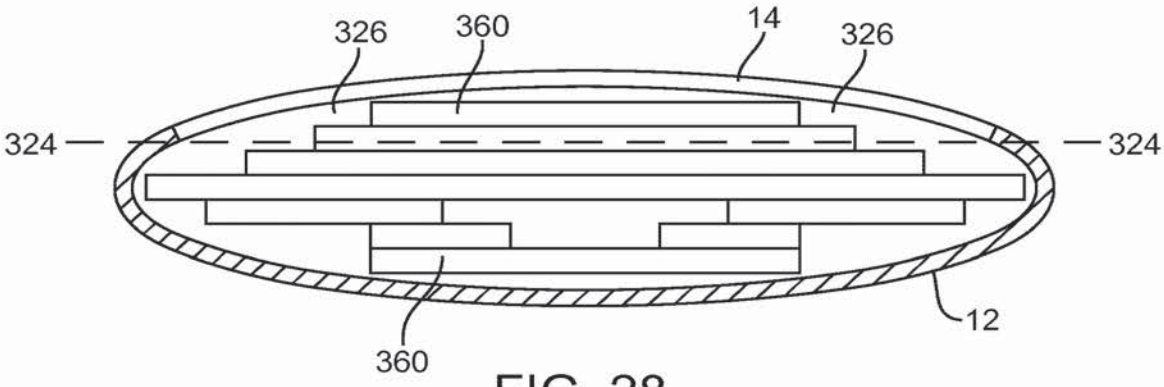


FIG. 28

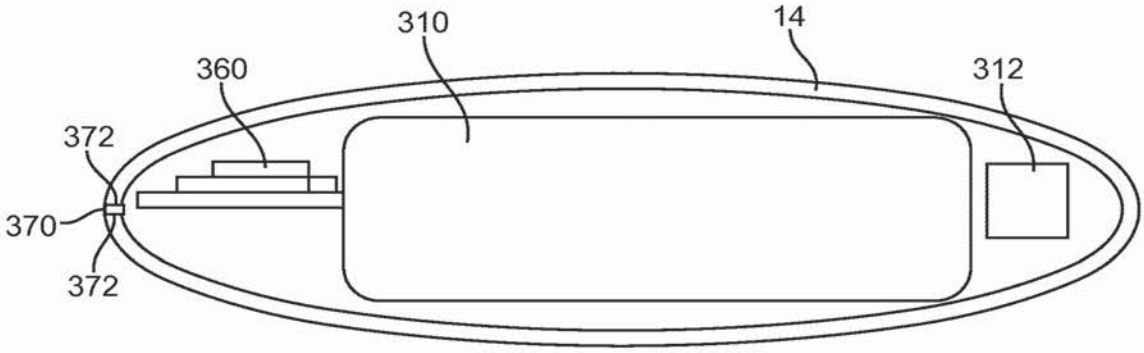


FIG. 29

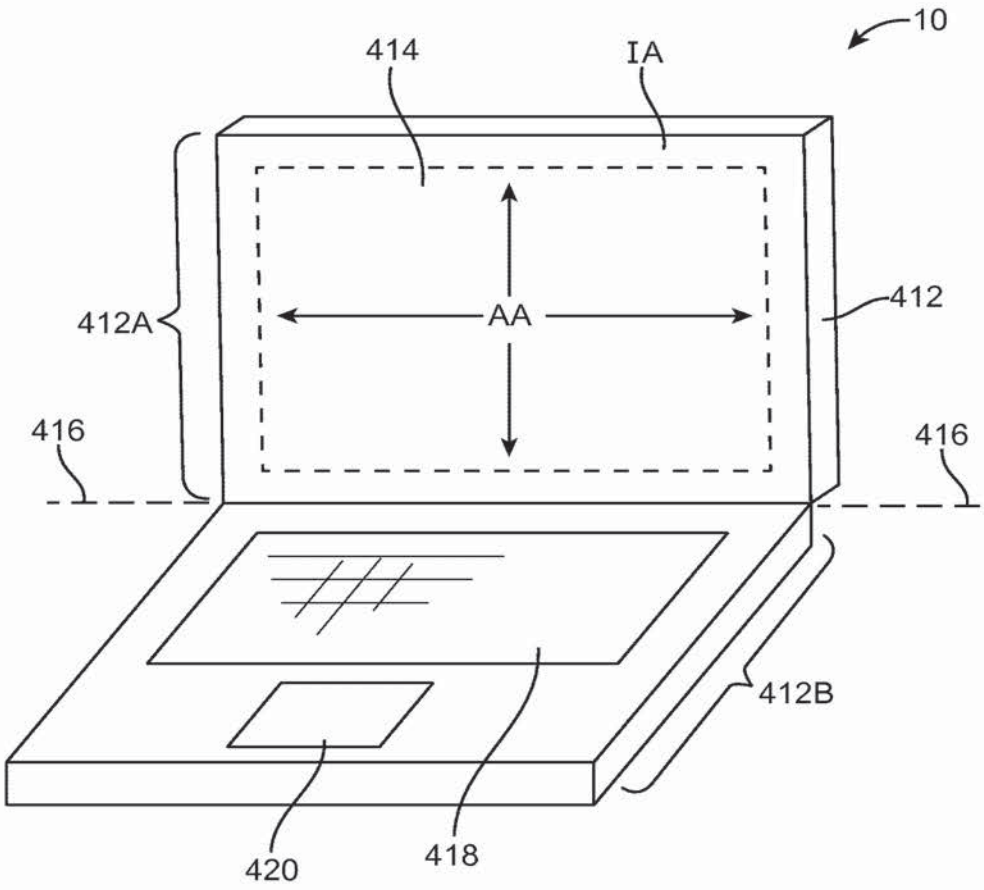


FIG. 30

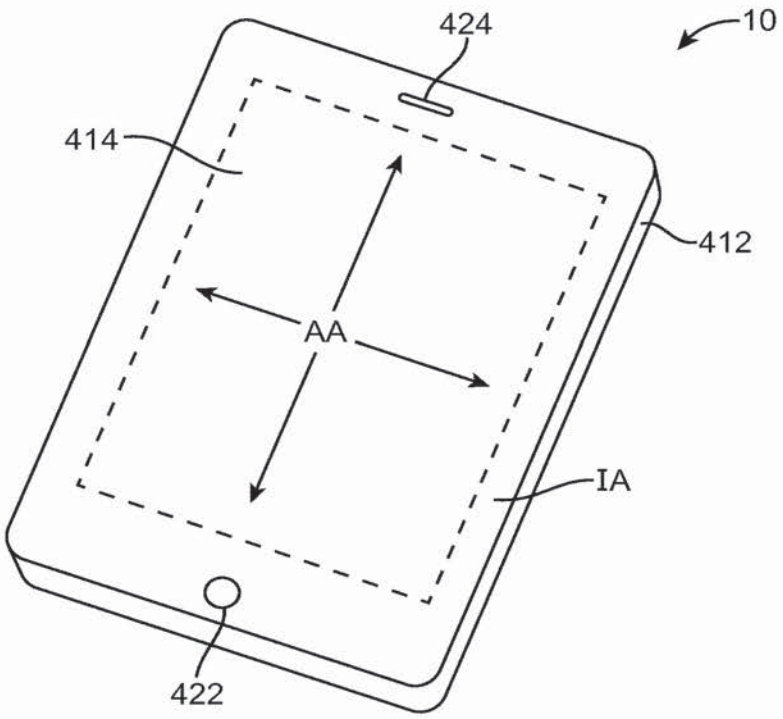


FIG. 31

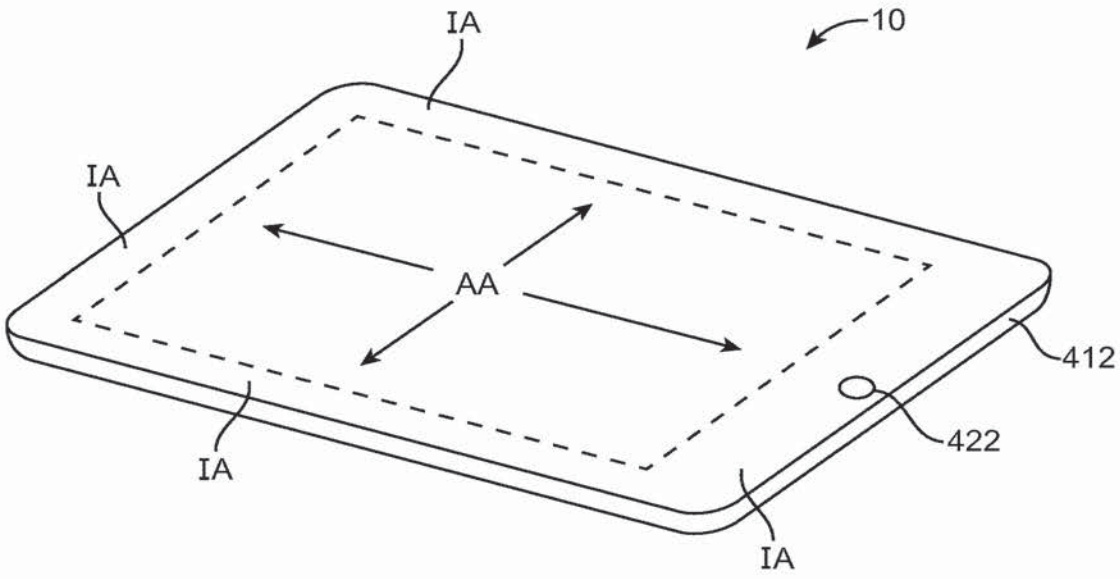


FIG. 32

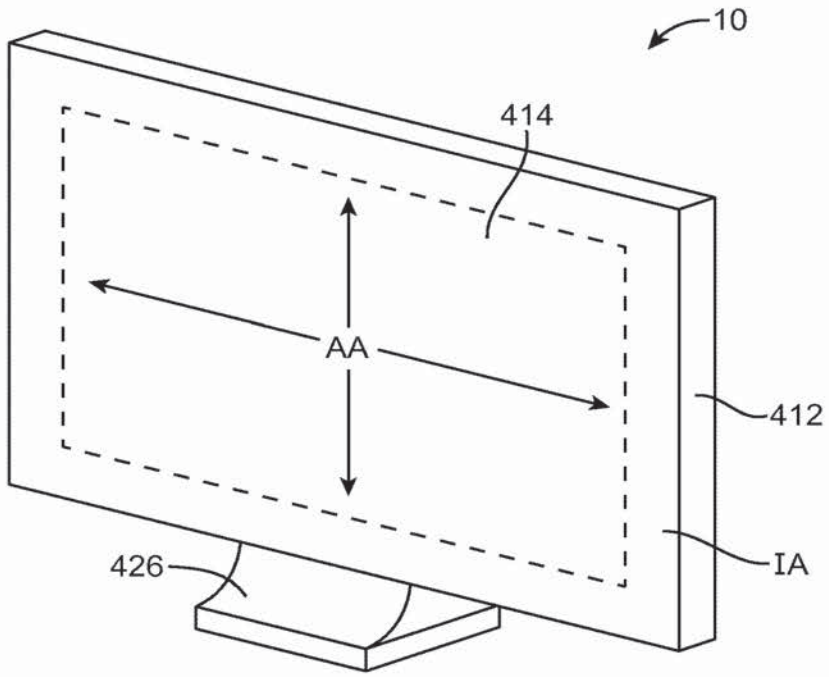


FIG. 33

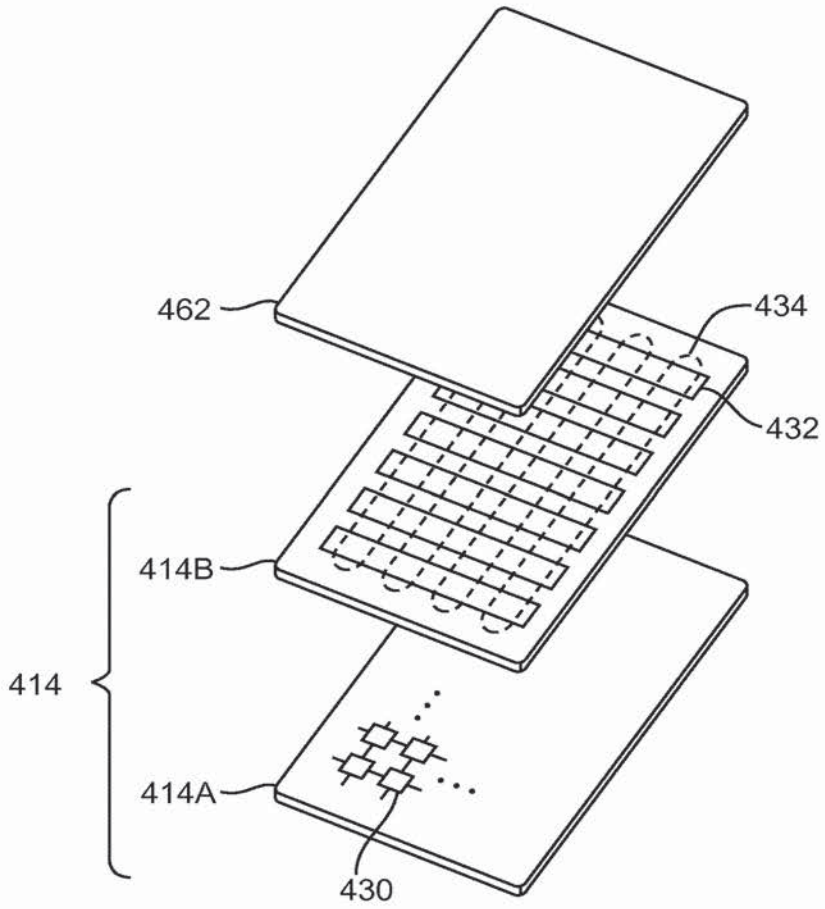


FIG. 34

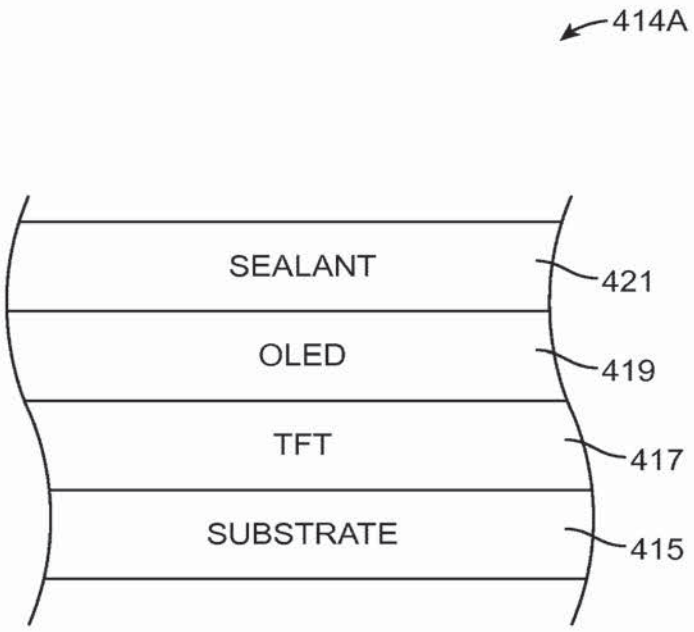
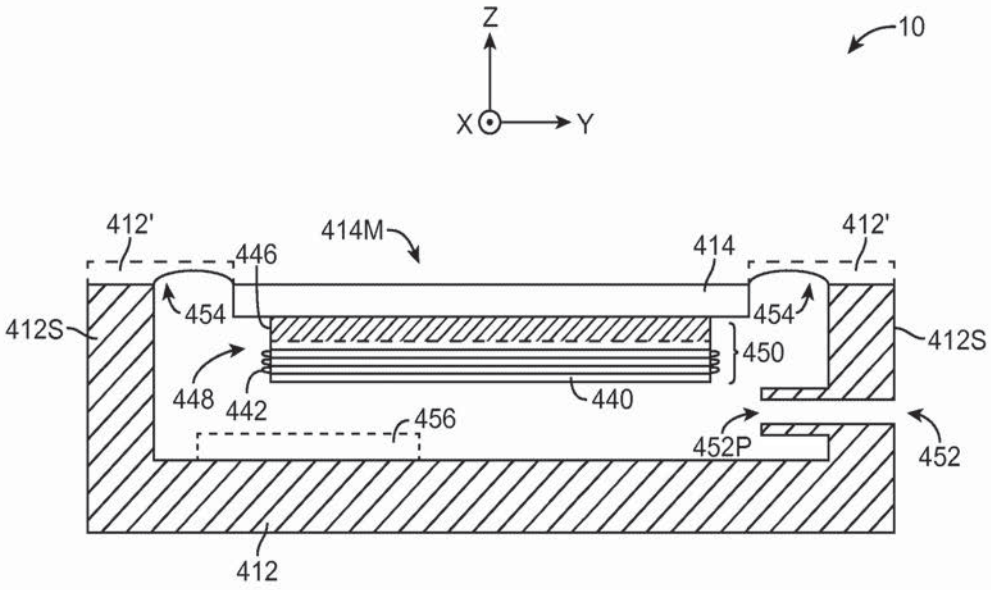


FIG. 35


Z
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412'
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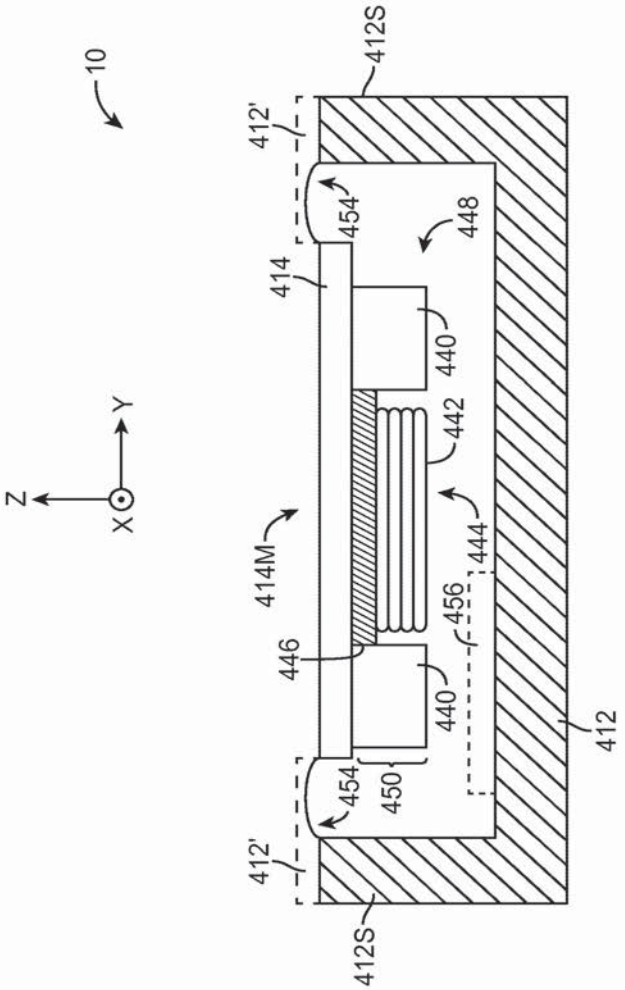
412

FIG. 36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454
412'
412
412S

FIG. 37