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(54) **Title:** A STYLUS WITH A DEFORMABLE STYLUS TIP

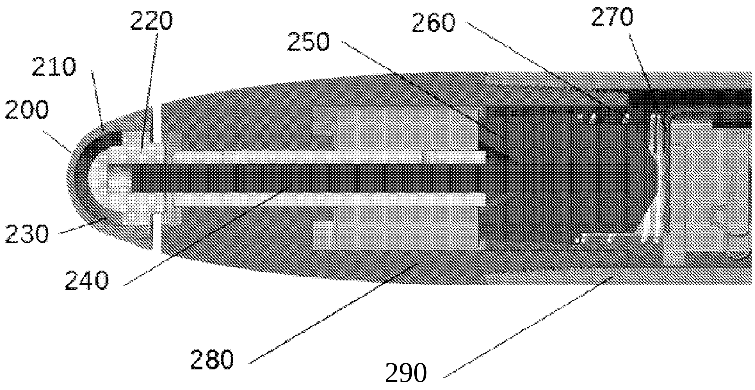

Figure 3

(57) **Abstract:** An embodiment of the invention provides a stylus comprising: a deformable stylus tip, a backstop, an air gap formed between an inner surface of deformable tip and an outer surface of backstop. The inner surface of deformable tip has a hemispherical shape with a first spherical centre, the outer surface of backstop has a hemispherical shape with a second spherical centre, and the first and second spherical centres are co- located.

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A STYLUS WITH A DEFORMABLE STYLUS TIP

Technical field

[0001] The present invention generally relates to improved styli suitable for touch surfaces of optical touch-sensing systems, and in particular in relation to FTIR-based (frustrated total internal reflection) touch systems.

Background art

[0002] A category of touch-sensitive panels known as 'Iη-glass optical systems' is now described and is also known from e.g. US8581884.

[0003] Figure 1 illustrates an example of a touch-sensitive apparatus 100 that is based on the concept of FTIR (frustrated total internal reflection), also denoted "FTIR system". The apparatus operates by transmitting light inside a transmissive panel 10, from light emitters 30a to light sensors or detectors 30b, so as to illuminate a touch surface 20 from within the transmissive panel 10. The transmissive panel 10 is made of solid material in one or more layers and may have any shape. The transmissive panel 10 defines an internal radiation propagation channel, in which light propagates by internal reflections.

[0004] In the example of figure 1, the propagation channel is defined between the touch surface 20 and bottom surface 25 of the transmissive panel 10, where the touch surface 20 allows the propagating light to interact with touching object 60 and thereby defines the touch surface 20. This is achieved by injecting the light into the transmissive panel 10 via coupling element 40 such that the light is reflected by total internal reflection (TIR) in the touch surface 20 as it propagates through the transmissive panel 10. The light may be reflected by TIR on the bottom surface 25 or against a reflective coating thereon. Upon reaching coupling element 40 on a far side of the panel, the light is coupled out of transmissive panel 10 and onto detectors 30b. The touch-sensitive apparatus 100 may be designed to be overlaid on or integrated into a display device or monitor.

[0005] In order to register a touch, a user may place a finger onto the surface of a touch panel. Alternatively, a stylus may be used. A stylus is typically a pen shaped object with one end configured to be pressed against the surface of the touch panel. An example of a stylus according to the prior art is shown in figure 2. Use of a stylus 150 may provide improved selection accuracy and pointer precision over a simple finger touch. This can be due to the engineered stylus tip 160 providing a smaller and/or more regular contact surface with the touch panel that is possible than with a human finger. Also, muscular control of an entire hand in a pen holding position can be more precise than a single finger for the purposes of pointer control due to lifelong training in the use of pens and pencils.

[0006] A stylus with a hard tip may be unsuitable for certain applications in which the contact surface between the stylus tip and the touch panel is measured when determining the presence of a touch. A hard stylus tip will present a very small contact surface to a similarly hard touch panel surface, resulting in a weak touch signal.

[0007] US patent application 20150029163 describes a stylus with a deformable tip portion made from a flexible material. The engagement surface between the stylus tip and the touch panel varies in dependence on the manner in which the stylus is used. Application of the stylus to the touch panel in a particular configuration may result in a particular engagement surface area and shape.

Summary of invention

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

[0009] One or more of these objectives, as well as further objectives that may appear from the description below, are at least partly achieved by means of a method for data processing, a computer readable medium, devices for data processing, and a touch-sensing apparatus according to the independent claims, embodiments thereof being defined by the dependent claims.

[0010] An embodiment of the invention provides a stylus comprising: a deformable stylus tip, a backstop, an air gap formed between an inner surface of deformable tip and an outer surface of backstop. The inner surface of deformable tip has a hemispherical shape with a first spherical centre, the outer surface of backstop has a hemispherical shape with a second spherical centre, and the first and second spherical centres are co-located.

[0011] A second embodiment of the invention comprises a stylus with a deformabie stylus tip, a backstop, an air gap formed between an inner surface of deformabie tip and an outer surface of backstop, a barometric sensor, an air channel configured to convey air from air gap to barometric sensor.

Brief description of drawings

[0012] Embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings.

[0013] Shows a cross section of an FTIR-based touch-sensitive apparatus according to the prior art.

[0014] Figure 2 shows a stylus according to the prior art.

[0015] Figure 3 shows a stylus with a mechanically actuated pressure sensor according to the present invention.

[0016] Figure 4 shows the stylus of figure 3 including the power source and radio.

[0017] Figure 5 shows a system according to the present invention including stylus and touch sensitive system receiver electronics.

[0018] Figure 6a shows a larger cross-section of tip 200 from figure 3.

[0019] Figure 6b shows an embodiment in which the material of deformabie head 210 is thinnest at the crown of deformabie head 210.

[0020] Figure 7 shows the tip 200 for figure 6a as applied to the touch sensitive surface.

[0021] Figure 8 shows a stylus with a barometric sensor according to the present invention.

[0022] Figure 9 shows a larger cross-section of the stylus tip from figure 8.

[0023] Figure 10 shows an embodiment of the invention comprising a finger-print sensor.

[0024] Figure 11 shows an embodiment of the invention featuring a mode selection button.

[0025] Figure 12 shows an embodiment of figure 8 with an iow friction coating 610.

Description **of embodiments**

[0026] Before describing embodiments of the invention, a few definitions will be given.

[0027] A "touch object" or "touching object" is a physical object that touches, or is brought in sufficient proximity to, a touch surface so as to be detected by one or more sensors in the touch system. The physical object may be animate or inanimate.

[0028] An "interaction" occurs when the touch object affects a parameter measured by the sensor.

[0029] A "touch" denotes a point of interaction as seen in the interaction pattern.

[0030] Throughout the following description, the same reference numerals are used to identify corresponding elements.

Main embodiment

[0031] Figure 3 illustrates an example of a stylus according to an embodiment of the present invention, tip 200 forms the component which will come into contact with a touch sensitive surface. In the present embodiment, tip 200 comprises deformable head 210, backstop 220, air gap 230, and is connected to main body of the stylus by rod 240. The main body of the stylus is formed by structure 297 (shown in figure 4), which is enclosed within fore casing 280 and stylus casing 290, and where fore casing 280 may be screwed into stylus casing 290. rod 240 passes through fore casing 280 and is enclosed at the end furthest from the tip by cap 250. cap 250 is spring loaded by spring 260 against structure 297 (shown in figure 4). cap 250 contacts pressure sensor 270.

[0032] Figure 4 shows the functional components of the stylus. pressure sensor 270 (not shown) is electrically connected to radio circuitry 294. radio circuitry 294 is provided with power from battery 292 and is electrically connected to antenna coil 296 for transmitting data to a receiver in a touch sensing system 298 shown in figure 5. structure 297 provides a single component upon which pressure sensor 270, radio circuitry 294, battery

292, antenna coil 296, fore casing 280, and stylus casing 290 are mounted.

[0033] When the stylus of this embodiment is applied to a touch sensitive surface, the tip 200 connected to rod 240 is actuated along the axis of the stylus toward pressure sensor 270. rod 240, via cap 250, applies a pressure to pressure sensor 270, which outputs an electrical signal corresponding to the applied force. The electrical output signal of pressure sensor 270 may then be processed by radio circuitry 294 to, for example, remove noise, apply a calibration, convert from an analogue signal to digital signal, etc. The processed signal is then transmitted by radio circuitry 294 to touch sensing system 298 via antenna coil 296.

[0034] For touch sensitive systems capable of determining the contact area of the touch (i.e. FTIR based touch systems), a deformable tip provides a significant advantage over a hard, un-yielding tip, as the contact surface area between the tip and the touch sensitive surface increases as the tip deforms. Consequently, for touch sensitive systems which require a minimum amount of surface contact area, a deformable tip may provide sufficient contact area to register a touch whereas a hard plastic tip may not. Furthermore, for touch systems capable of determining pressure applied to the surface from, at least partly, the contact surface area, a deformable tip will provide a greater contact surface area the harder it is pressed against the touch sensitive surface. If the dimensions of the deformable stylus tip are known, it is possible to determine how hard the stylus is being pressed against the touch sensitive surface by determining the contact surface area.

[0035] However, several significant disadvantages are presented by a fully deformable stylus tip. Firstly, a fully deformable stylus tip is not an intuitive user experience for a user and no notable pens work in the same way or provide a similar feel in a typical usage pattern. Therefore, a stylus with a significantly deforming tip may provide an uncomfortable and unfamiliar writing experience for a user.

[0036] Secondly, as the contact surface increases, the friction between the stylus tip and the touch sensitive surface will increase. In some use cases, when pressed hard, the stylus tip will deform more than enough to register a touch signal, whilst introducing sufficient friction against the touch sensitive surface that a comfortable and flowing writing style becomes impossible for the user. The drag on the stylus causes the movement of the stylus to become jerky and to tire the hand of the user.

[0037] Thirdly, whilst the stylus is being held at an angle away from the normal of the touch sensitive surface, a hard press on the deformable tip may result in the tip deforming significantly sideways from the axis of the stylus, providing an unpredictable contact surface area with the touch sensitive surface and an even less comfortable and less familiar user experience.

[0038] Figure 6a shows an enlarged cross-section of tip 200. When a user holding the stylus presses the stylus tip against a touch sensitive surface, deformable head 210 deforms into air gap 230, providing a flat contact surface with the touch sensitive surface.

[0039] In figure 7, backstop 220 is shown limiting the deformation of deformable head 210. This advantageously allows the amount of deformation in deformable head 210 to be controlled. In a preferred embodiment, backstop 220 is formed from a hard material, such as a hard plastic, wherein it does not significantly deform from a force typically applied by a user to a stylus. In an alternative embodiment, backstop 220 may be formed from a deformable material with a greater hardness than deformable head 210. In this embodiment, backstop 220 may also deform during application of the stylus tip to a touch sensitive surface but less so than deformable head 210.

[0040] In the embodiment shown in figures 6a and 7, air gap 230 has a particular shape and function. As shown in the figures, the width of the gap between any point on the inner surface 215 of deformable head 210 and the nearest point on the backstop surface 225 of backstop 220 is fixed for the majority of the inner surface 215. This is achieved by providing a hemispherical inner surface 215, the hemisphere shape having a spherical centre point and radius, with a matching hemispherical backstop surface 225, having a significantly co-located spherical centre point and reduced radius. This feature has the important advantage of providing a consistent contact area between the stylus tip and the touch sensitive surface when the stylus is applied to the touch sensitive surface at substantial angles to the normal of the touch sensitive surface. In a preferred embodiment, the radius of the hemispherical inner surface 215 is 3mm and the radius of hemispherical backstop surface 225 is 2mm. In this embodiment, the stylus tip provides a consistent contact area between the stylus tip and the touch sensitive surface when the stylus is applied at up to 70 degrees from the normal of the touch sensitive surface.

[0041] As shown in figure 6a, outer surface 216 of deformable head 210 is also hemispherical when deformable head 210 is in an un-deformed configuration. In the preferred embodiment shown in figure 6a, hemispherical outer surface 216 has a spherical centre point co-located with the spherical centre point of inner surface 215 and a radius of 3.5mm. The difference in radius between hemispherical outer surface 216 and hemispherical inner surface 215 defines the thickness of the material of deformable head 210.

[0042] In one embodiment shown in figure 6b, hemispherical outer surface 216 has a spherical centre point slightly offset from the spherical centre point of inner surface 215 (e.g. By between 0.01 mm and 0.3mm) such that the thickness of deformable head 210 is less at the crown of deformable head 210 (i.e. at the top of hemispherical outer surface 216) than at the sides. In a preferred embodiment, thickness of material forming deformable head 210 at the crown of deformable head 210 is between 100% and 60% of the thickness of the material of the deformable head 210 at the point deformable head 210 contacts backstop 220.

[0043] Figure 8 illustrates an example of a stylus according to another embodiment of the invention. tip 300 forms the component configured to come into contact with a touch sensitive surface. In the present embodiment, tip 300 comprises deformable head 310, backstop 320, backstop air channel 315, air gap 330. In this embodiment, air from air gap 330 may travel through backstop air channel 315 and into air channel 340. air channel 340 may be a channel travelling along the axis of the stylus and providing passage for air from air gap 330 to barometric sensor 350.

barometric sensor 350 is provided within internal space 360 of tip casing 380 and may be air sealed to backstop air channel 315 and from internal space 360 via seal 345. stylus casing 390 may be removably attached to tip casing 380 via a screw thread.

[0044] Different types of barometric sensor may be employed, including piezoresistive strain gauges, capacitive pressure sensors, piezoelectric sensors etc.

[0045] As with the embodiment shown in figure 4, the main body of the stylus is formed by structure 297 (not shown), which is enclosed within tip casing 380 and stylus casing 390, and where tip casing 380 may be screwed into stylus casing 390. structure 297 provides a single component upon which barometric sensor 350, tip casing 380 and stylus casing 390 are mounted.

[0046] Figure 9 shows an enlarged cross-section of tip 300. As with the embodiment shown in figure 6a, when a user holding the stylus presses the stylus tip against a touch sensitive surface, deformable head 310 deforms into air gap 330, providing a flat contact surface with the touch sensitive surface. The present embodiment provides a further advantage over the embodiment shown in figures 3 and 6 however. In the embodiment shown in figure 3, the amount of force applied to pressure sensor 270 may also be dependent on the angle at which the stylus is applied to the touch sensitive surface. When the stylus is applied with force to the touch sensitive surface and held at an angle from the normal of the touch sensitive surface, the amount of force communicated to pressure sensor 270 from tip 200 is less than the amount of force communicated if the axis of the stylus matches the normal of the touch sensitive surface.

i.e. Force applied to pressure sensor 270 ≈ downwards force applied to the stylus * cos (angle of the axis of the stylus from the normal of the touch sensitive surface).

[0047] The present embodiment addresses this problem by using the movement of air to convey the force on the tip to the force sensor. When the stylus is applied to the touch sensitive surface, deformable head 310 deforms into air gap 330, pushing the air in air gap 330 through air channel 340 to barometric sensor 350, wherein the output signal from barometric sensor 350 is used to determine the amount of pressure applied to the stylus tip. As this embodiment effectively measures the degree to which deformable head 310 is deformed rather than directly measuring the force applied to the tip, the embodiment provides an improved method of measuring force applied to the stylus when the stylus is applied to the touch sensitive surface at angles from the normal of the touch sensitive screen. In this embodiment, accurate force measurements may be made when the stylus is be applied to the touch sensitive surface at angles of up to 70 degrees from the normal of the touch sensitive surface.

[0048] In a preferred embodiment, channel mouth edge 322 is rounded to prevent damage of deformable head 310 when deformable head 310 is pressed against the mouth of backstop air channel 315 upon application of the stylus.

[0049] In an embodiment shown in figure 10, stylus 400 comprises fingerprint sensor 410. fingerprint sensor 410 is configured to recognise the finger print patterns of users of the stylus and therefore identify the stylus user when the stylus is picked up and held with a finger over the fingerprint sensor. This user identification information may then be sent via radio to touch sensing system 298 so that the input data provided by the user's interaction with the touch sensing system 298 may be matched with the user's id.

[0050] In an embodiment shown in figure 11, stylus 500 comprises mode button 510 positioned at an end of stylus 500. In this embodiment, activations of mode button 510 are transmitted to touch sensing system 298 and may be used to control modes of the user's interaction with the touch sensing system 298, including modifying settings for colour, brush style, brush size, erase mode, brush type, etc.

[0051] In the embodiment shown in figure 12, deformable stylus tip 600 comprises low friction coating 610. Application of an low friction coating 610 to deformable stylus tip 600 allows a producer of the stylus to even more closely control the interaction experience for the user of the stylus. In a preferred embodiment, a low friction coating 610 with a friction co-efficient of less than 0.35 is used. This will provide a significantly smoother writing experience than a deformable stylus tip 600 made of raw silicone, which has a friction co-efficient of 0.65. A low friction co-efficient is particularly advantageous when combined with a deformable stylus tip 600 as it prevents the increased surface contact area resulting from the stylus being pressed against the touch sensitive surface from interfering with the user experience of the stylus due to significantly increased friction. A low friction coating 610 with a friction co-efficient of less than 0.35 will ensure a smooth writing experience for a user for a range of typical forces applied to the stylus. In a preferred embodiment, a friction co-efficient of approximately 0.30 provides an optimal writing experience.

[0052] In a preferred embodiment of the embodiment shown in figure 12, the low friction coating 610 is a thin film coating applied to deformable stylus tip 600. The preferred thin film coating may be Slick Sil® or parylene and other silicone based lubricants for reducing the friction coefficient of the material of deformable head 310.

Reference signs list

A. touch-sensitive apparatus 100
B. transmissive panel 10
C. touch surface 20
D. bottom surface 25
E. emitters 30a
F. detectors 30b
G. coupling element 40
H. in-coupling point 45
I. light beam 50
J. touching object 60
K. stylus 150
L. tip 160
M. tip 200

N. deformable head 210

O. inner surface 215

P. outer surface 216

Q. backstop 220

R. backstop surface 225

S. air gap 230

T. rod 240

U. cap 250

V. spring 260

W. pressure sensor 270

X. fore casing 280

Y. stylus casing 290

Z. battery 292

AA. radio circuitry 294

BB. antenna coil 296

CC. structure 297

DD. touch sensing system 298

EE. tip 300

FF. deformable head 310

GG. backstop air channel 315

HH. backstop 320

II. channel mouth edge 322

JJ. air gap 330

KK. air channel 340

LL. seal 345

MM. barometric sensor 350

NN. internal space 360

OO. tip casing 380

PP. stylus casing 390

QQ. stylus 400

RR. fingerprint sensor 410

SS. stylus 500

TT.mode button 510

UU. deformable stylus tip 600

W . low friction coating 610

Claims

1. A stylus comprising:

a deformable stylus tip (210),

a backstop (220),

an air gap (230) formed between an inner surface of deformable tip (210) and an outer surface of backstop (220),

wherein the inner surface of deformable tip (210) has a hemispherical shape with a first spherical centre, the outer surface of backstop (220) has a hemispherical shape with a second spherical centre, and wherein the first and second spherical centres are co-located.

2. The stylus of claim 1, further comprising pressure sensor (270) and rod (240), wherein rod (240) is configured to connect backstop (220) to pressure sensor (270) such that force applied to backstop (220) is detected by pressure sensor (270).

3. The stylus of any preceding claim, wherein rod (240) further comprises cap (250), interposed between rod (240) and pressure sensor (270), and wherein a spring (260) provides a spring force on cap (250).

4. The stylus of claim 1, wherein stylus further comprises barometric sensor (350) and air channel (340) configured to convey air from air gap (220) to barometric sensor (350).

5. The stylus of any preceding claim, wherein stylus is configured to communicate the output signal of pressure sensor (270 or 350) to a touch sensor system.

6. The stylus of any preceding claim, wherein stylus further comprises a finger print sensor configured to identify a user holding the stylus according to the user's finger prints.

7. The stylus of any preceding claim, wherein stylus further comprises a mode button (510), and wherein stylus is configured to transmit activations of mode button (510) by a user to a touch sensing system.

8. The stylus of any preceding claim, wherein an outer surface of deformable stylus tip (210) comprises an low friction coating (610) having a friction coefficient of less than 0.35.

9. The stylus of claim 8, wherein the low friction coating (610) is a parylene, Slick Sil, or silicone based lubricant.

10. A stylus comprising:

a deformable stylus tip (210),

a backstop (220),

an air gap (230) formed between an inner surface of deformable tip (210) and an outer surface of backstop (220),

a barometric sensor (350)

an air channel (340) configured to convey air from air gap (220) to barometric sensor (350).

11. The stylus of claim 10, wherein the inner surface of deformable tip (210) has a hemispherical shape with a first spherical centre, the outer surface of outer surface of backstop (220) has a hemispherical shape with a second spherical centre, and wherein the first and second spherical centres are co-located.

Drawings

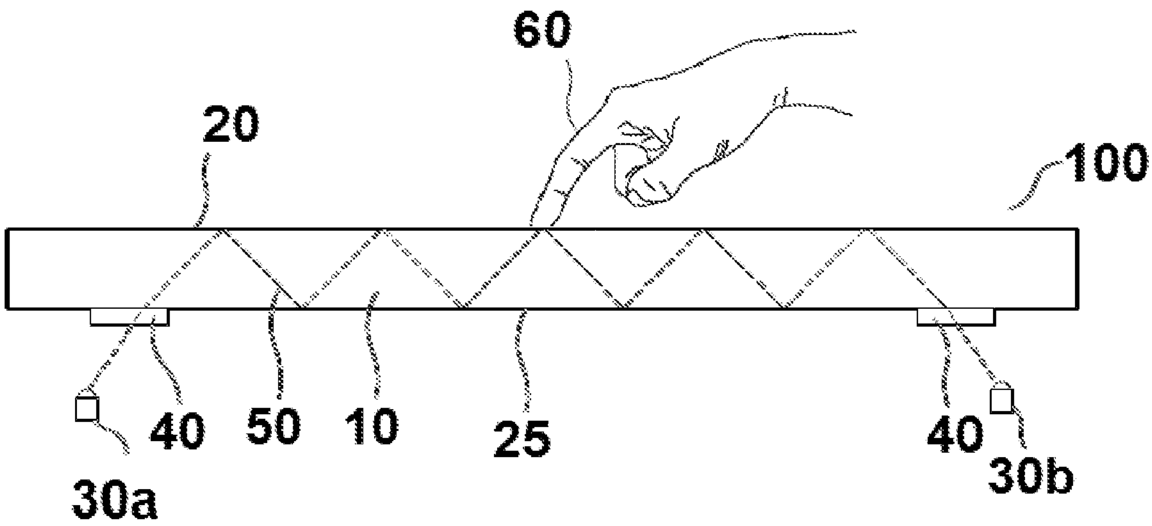

Figure 1

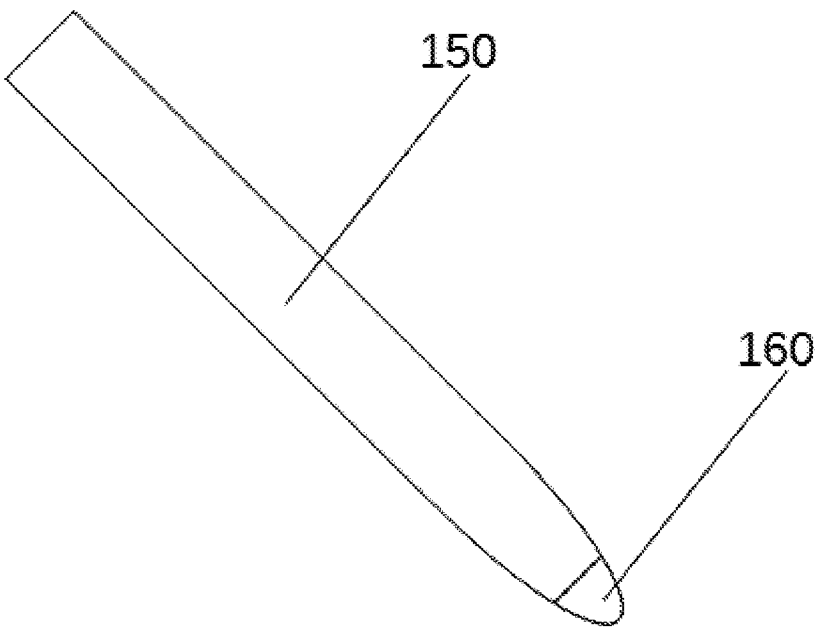

Figure 2

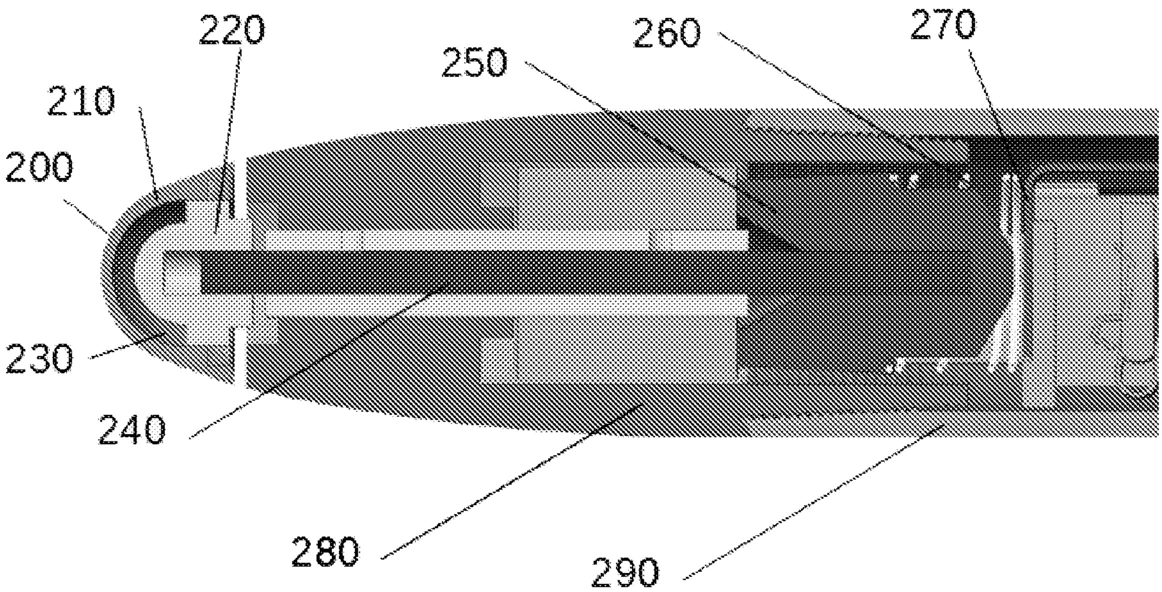

Figure 3

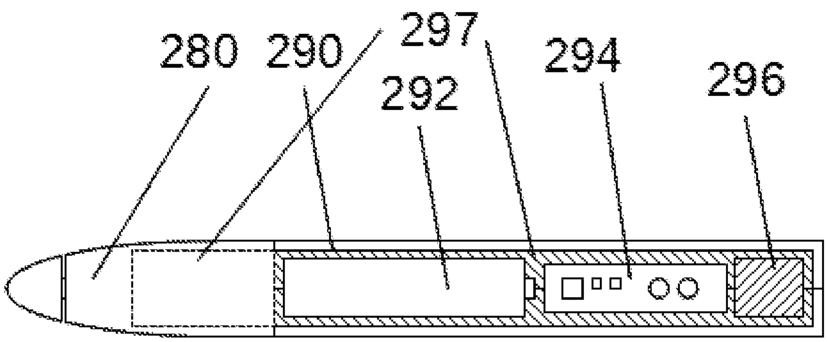

Figure 4

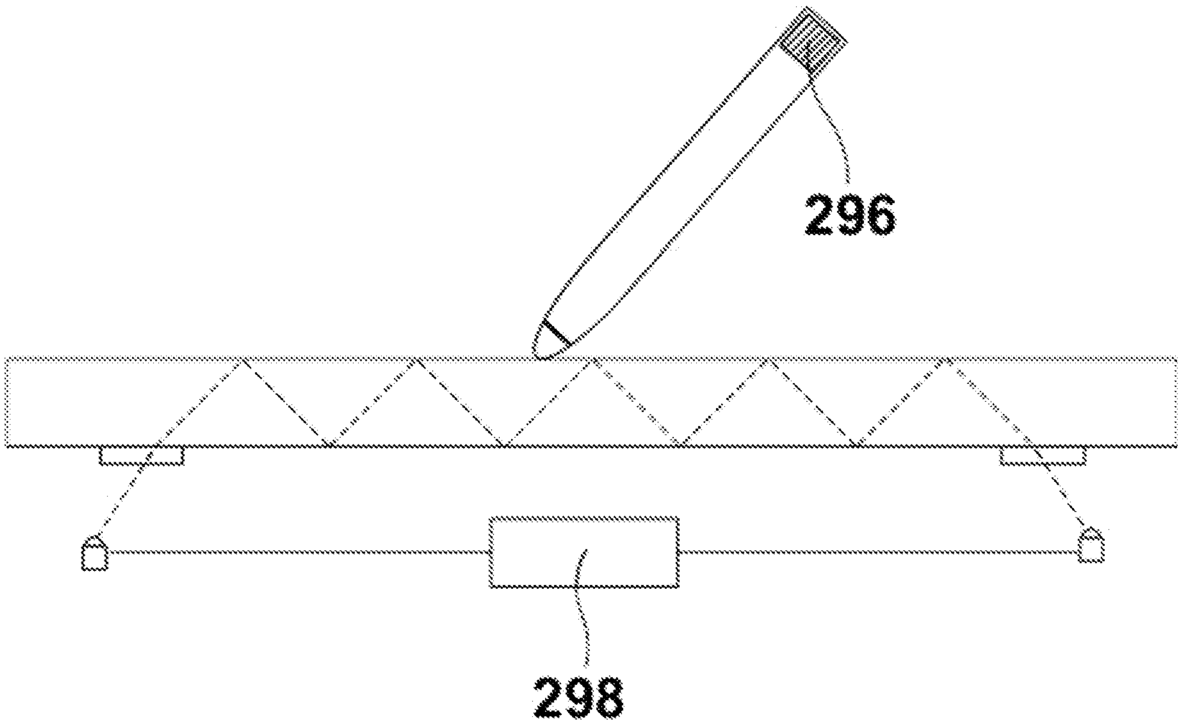

Figure 5

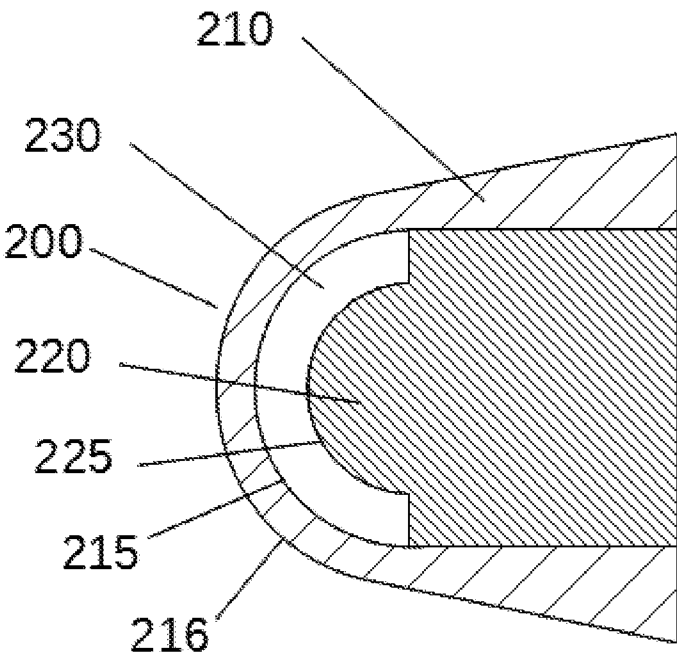

Figure 6A

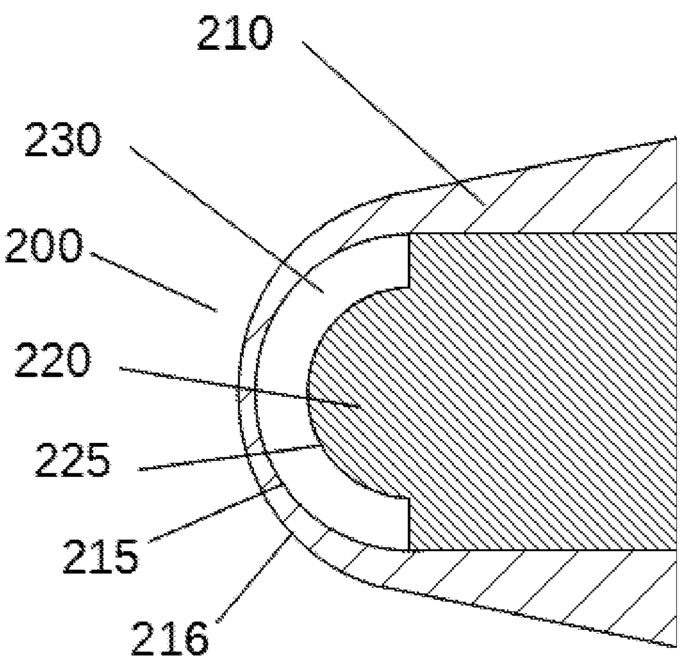

Figure 6B

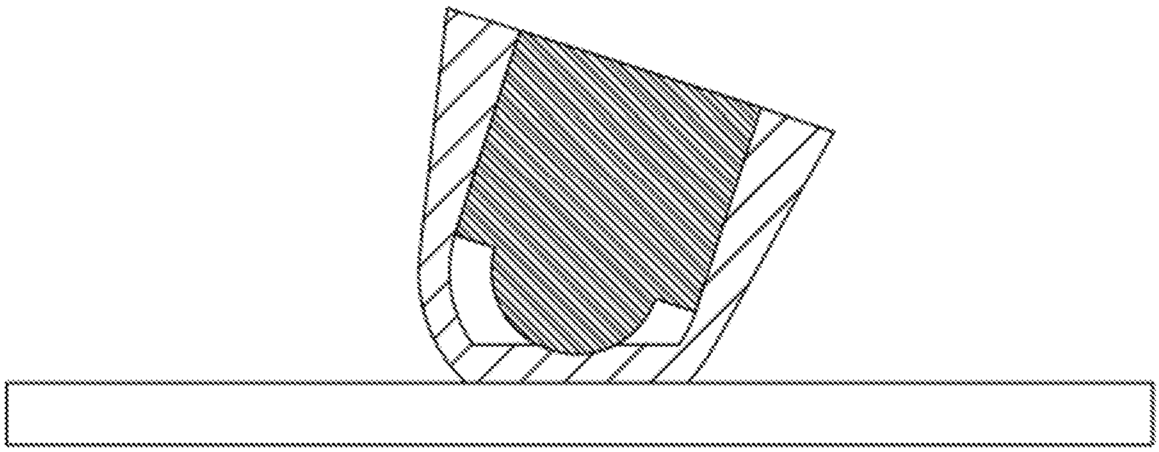

Figure 7

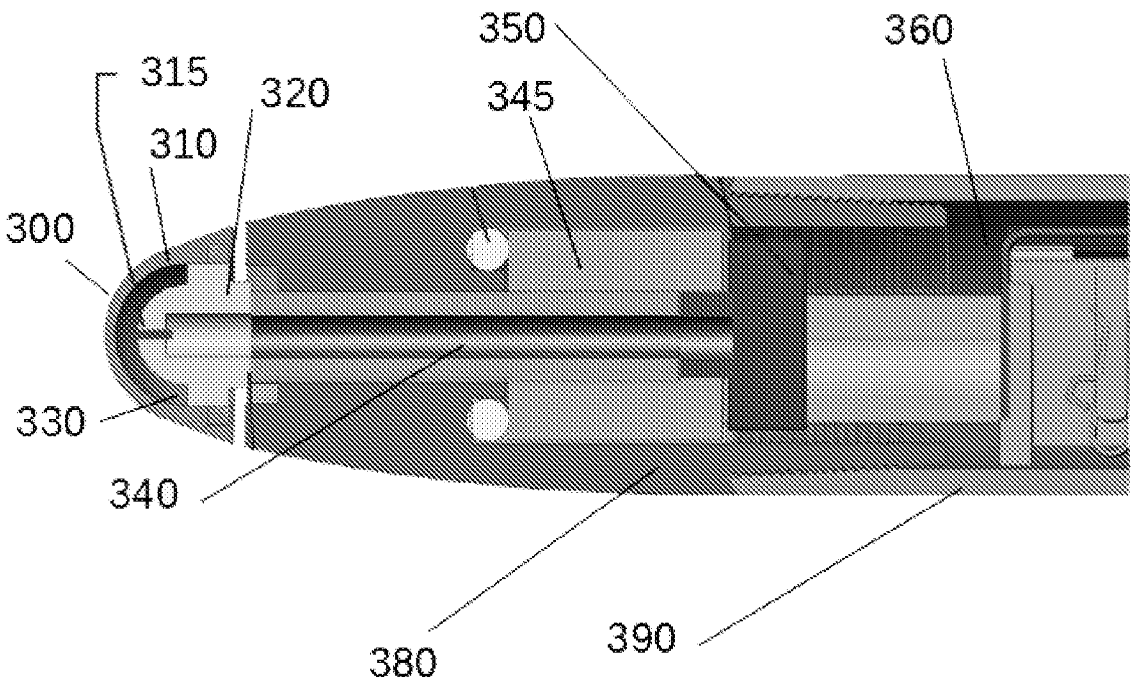

Figure 8

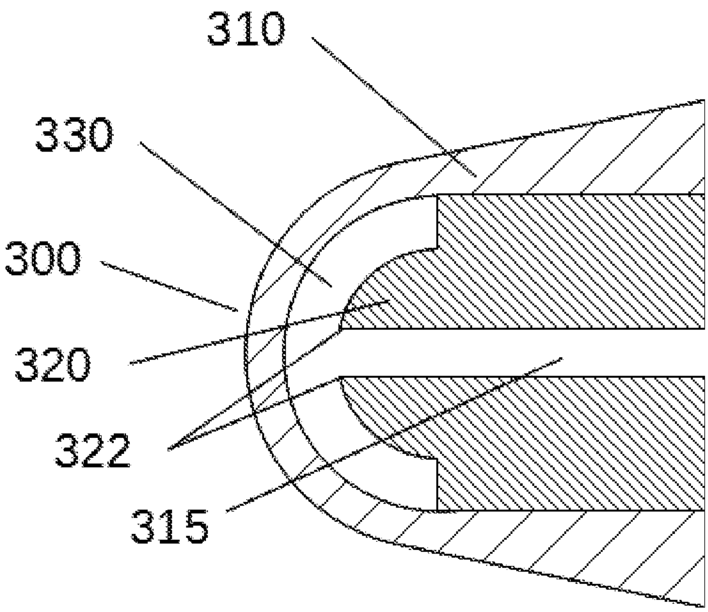

Figure 9

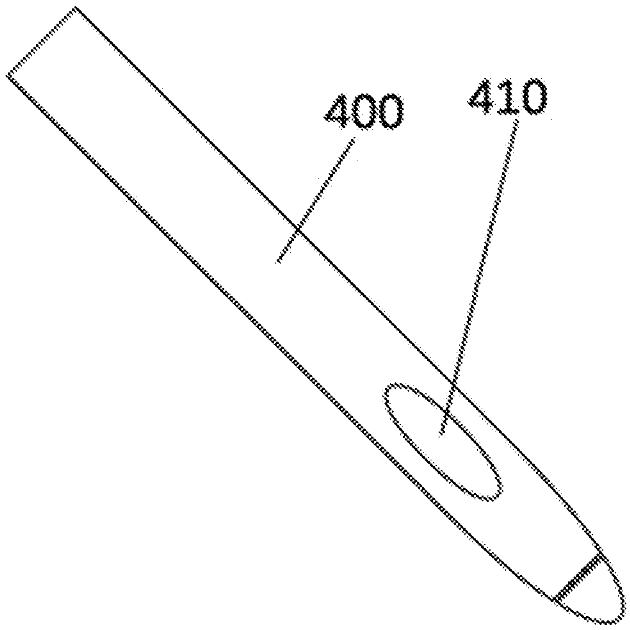

Figure 10

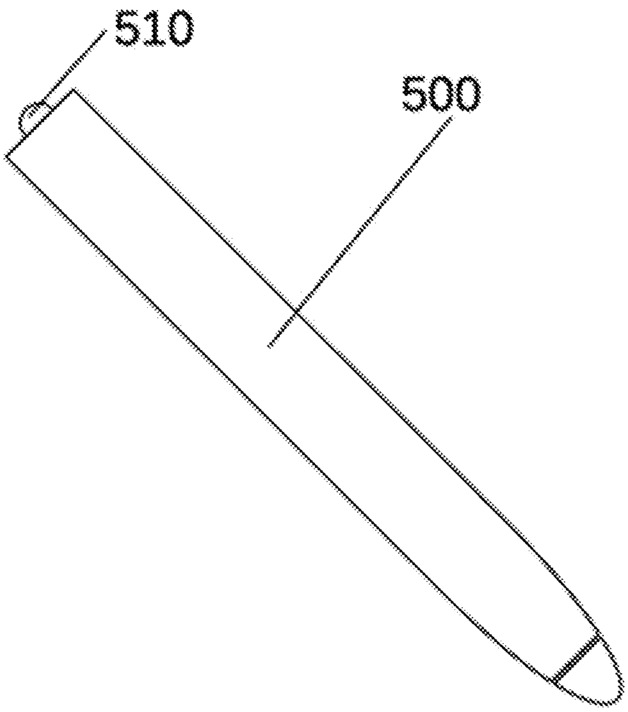

Figure 11

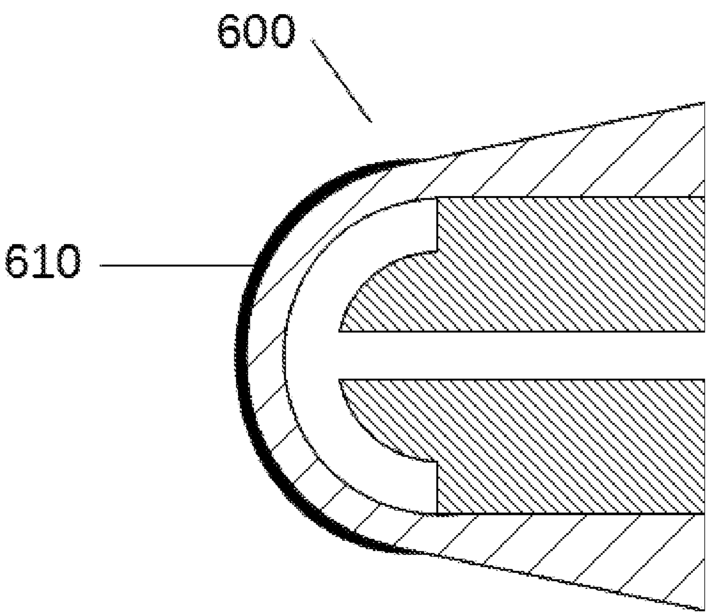

Figure 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050564

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G06F

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20150029161 A1 (KOO JAMES ET AL), 29 January 2015 (2015-01-29); abstract; paragraphs [0005], [0021]-[0024], [0036]-[0043], [0049]-[0051], [0070]-[0073]; figures 3-4	1, 5-9, 11
Y		2-4, 10
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Y	US 20130300720 A1 (HUNG GEORGE), 14 November 2013 (2013-11-14); abstract; paragraphs [0002], [0011], [0019], [0031]-[0035]; figures 1-4 --	4, 10
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International Patent Classification (IPC)

G06F 3/0354 (2013.01)
G06F 3/041 (2006.01)

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