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

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— *with international search report (Art. 21(3))*

(54) **Title**: A BACKLIT TOUCHSCREEN CONTROL PANEL.

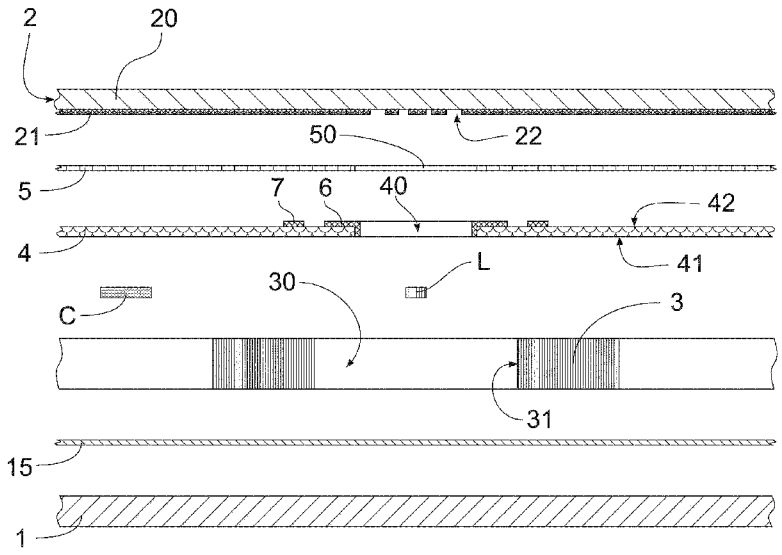

FIG. 2

(57) **Abstract**: A backlit touchscreen control panel (100) is disclosed, comprising a reflecting lower support plate (1), an upper plate (2) with transparent upper layer (20) and opaque lower layer (2) provided with a plurality of silk-screen printed wordings (22), a printed circuit board (4) with a plurality of openings (40) in register with said silk-screen printed wordings (22) of the upper plate, a plurality of pairs of electrodes (6, 7) obtained on the upper surface (42) of the printed circuit board and connected to a control circuit (C), a plurality of LEDs (L) mounted on the printed circuit board, a template (3) with a plurality of openings (30) in register with corresponding openings (40) of the printed circuit board, in such manner that each LED (L) is contained inside the openings (30) of the template.

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Description

A backlit touchscreen control panel.

The present patent application for industrial invention relates to a backlit touchscreen control panel.

US2010/0259497 discloses a backlit touchscreen panel comprising a transparent printed circuit whereon electrodes with symbols to be represented are mounted. The system also provides for masks and a lighting substrate that carries light sources and light guides coupled with light sources.

US2009/0115645 discloses a touch capacitative switch comprising a printed circuit board whereon transparent capacitative electrodes are mounted. By means of light guides LEDs direct the light towards a cover.

US2007/0068789 discloses a backlit display that comprises a printed circuit board whereon LEDs and light guides are mounted. Transparent electrodes are provided to let light pass onto a board separated from the one with LEDs.

US 2003/0122794 discloses a touch sensor with an integrated decorative panel that uses light pipes to transport the light of a LED. Transparent electrodes are provided to let the light pass.

EP 1 542 362 discloses a backlit touchscreen keyboard comprising a printed circuit with openings to let the light pass and transparent electrodes. The light source is separated from the printed circuit.

The backlit touchscreen panels disclosed in the prior documents are impaired by drawbacks, mainly due to the provision of light guides and pipes to transport the light from a light source that is separated from the printed circuit that carries the electrodes. The device disclosed in EP 1 542 362 that is not provided with light guides has low efficiency and uses a bulky light source.

Another complication of the prior documents is represented by the fact that transparent electrodes must be provided. The device of

US2010/0259497, which does not provide for transparent electrodes, must be provided with a transparent printed circuit and complicated etching on the electrodes to represent the symbol to be displayed.

The purpose of the present invention is to eliminate the drawbacks of the prior art, by disclosing a backlit touchscreen control panel that is effective, efficient, not bulky, thin and simple to make.

These purposes are achieved according to the invention, with characteristics claimed in independent claim 1.

Advantageous embodiments appear from the dependent claims.

The backlit touchscreen control panel according to the present invention comprises:

- a lower support plate with reflecting upper surface,
- an upper plate with transparent upper layer and opaque lower layer provided with a plurality of silk-screen printed wordings,
- a printed circuit board disposed under said upper plate, said printed circuit board comprising an upper surface, a reflecting lower surface and a plurality of openings in register with said silk-screen printed wordings of the upper plate,
- a plurality of pairs of electrodes obtained on the upper surface of the printed circuit board in such manner to generate a plurality of capacitors sensitive to the user's touch on the upper plate, wherein each pair of electrodes comprises a first electrode shaped as a closed loop, disposed around said opening of the printed circuit board and a second electrode shaped as a closed loop disposed around said first electrode and spaced from said first electrode,
- a control circuit mounted on said printed circuit board and connected to said pairs of electrodes,
- a plurality of LEDs mounted on said lower reflecting surface of the printed circuit board, wherein each LED is disposed in the proximity of an opening of the printed circuit board, and
- a template disposed between said lower support plate and said printed circuit board; said template comprising a plurality of openings defined

by a reflecting perimeter border wherein each opening of the template is disposed in register with a corresponding opening of the printed circuit board, said openings of the template having a higher surface than the openings of the printed circuit board, in such manner that each of said LEDs is contained inside said openings of the template and the light of each LED suffers multiple reflections inside a reflection chamber generated by the upper reflecting surface of the lower support structure, by the perimeter borders of the opening of the template and by the lower surface of said printed circuit board.

The advantages of the control panel according to the invention are obvious, using the multiple reflection of the light obtained in a reflection chamber, instead of using light guides as traditional panels.

Further characteristics of the invention will appear more evident from the detailed description below, which refers to a merely illustrative, not limiting, embodiment, as shown in the attached drawings, wherein:

Fig. 1 is an exploded perspective view of the various layers of the control panel according to the invention;

Fig. 2 is an exploded sectional view of the control panel according to the invention;

Fig. 3 is a sectional view of the control panel of Fig. 2 in assembled condition;

Fig. 4 is a top view of a portion of the printed circuit board of the control panel of Fig. 2;

Fig. 5 is a bottom view of a portion of a template disposed under the printed circuit board of the control panel of Fig. 2;

Fig. 6 is a top perspective view of the printed circuit board disposed on the template;

Fig. 7 is the same view as Fig. 6, wherein a plate with silk-screen printed wording is disposed onto the printed circuit board;

Fig. 8 is a diagrammatic view showing a distribution of the flux lines of the electrical field in case of electrode without internal border that surrounds an opening of the printed circuit board;

Fig. 9 is a diagrammatic view showing a distribution of the flux lines of the electrical field in case of electrode with internal border that surrounds an opening of the printed circuit board;

Referring to the aforementioned figures, a backlit touchscreen control panel according to the present invention is disclosed, generally indicated with numeral (100).

Hereinafter, the terms "lower and upper" refer to the disposition of Figs. 1, 2 and 3, it being understood that the control panel (100) can be disposed in any direction.

Referring now to Figs. 1, 2 and 3, the control panel (100) comprises a lower support plate (1) and an upper plate (2) between which a template (3) and a printed circuit board (4) are positioned. The template (3) is disposed on the support plate (1), the printed circuit board (4) is disposed on the template (3) and the plate (2) is disposed on the printed circuit board (4).

The support plate (1) is provided with two longitudinal parallel ribs (10) in such manner to define a longitudinal housing that contains the template (3), the printed circuit board (4) and the upper plate (2).

The upper surface of the support plate (1) must be a reflecting surface. The support plate (1) can be made of reflecting material, preferably a reflecting metallic material, such as aluminum, in addition or as an alternative, an adhesive layer (15) painted with reflecting white paint is applied onto the support plate (1) in such manner to obtain a perfectly reflecting upper surface.

Both the template (3) and the printed circuit (4) are made of reflecting material, or can be painted with reflecting paint, preferably a white paint.

The plate (2) comprises an upper layer (20) made of transparent material, preferably glass, and a lower layer (21) made of non-transparent opaque material, preferably the lower layer (21) is a black paint applied onto the glass. The lower layer (21) of the plate is silk-screened to obtain silk-screen printed wordings (22), such as symbols and words, which are visible from the transparent layer (20). The transparent layer (20) is the external

layer of the display and is the user interface, which is the surface adapted to be seen and touched by the user.

A biadhesive band (5) is interposed between the printed circuit board (4) and the plate (2). The biadhesive band (5) is provided with a plurality of openings (50) disposed in register with the silk-screen printed wordings (22) of the upper plate (2).

The printed circuit board (4) is provided with a plurality of openings (40) disposed in register with the openings (50) of the biadhesive band and the silk-screen printed wordings (22) of the upper plate.

Referring to Fig. 2, the printed circuit board (4) has a lower surface (41) and upper surface (42). The lower surface (41) is white. Also referring to Fig. 4, a first electrode (6) and a second electrode (7) are obtained on the upper surface (42) of the printed circuit board. The first electrode (6) is disposed around the opening (40) of the printed circuit board. Therefore the first electrode (6) is centrally open and shaped as a closed loop.

The second electrode (7) is disposed around the first electrode (6) in such manner that an annular empty space is left between the two electrodes. Therefore, also the second electrode (7) has an annular shape.

The electrodes (6, 7) are made of electroconductive material, such as copper, and are the two armors of a capacitor disposed on the printed circuit board (4). The printed circuit board (4) is made of dielectric material that generates an insulation layer between the two armors of the capacitor.

Each pair of electrodes (6, 7) is electrically connected to a control circuit (C) mounted on the lower surface (41) of the printed circuit board. In view of the above, when the user touches the plate (2) in correspondence of the silk-screen printed wording (22), the control circuit (C) detects a variation in the capacity of the capacitor formed by the two electrodes (6, 7). Such a capacity variation is indicative of the user's touch.

Advantageously, the first electrode (6) of the capacitor is made as metallization of the opening (40) of the printed circuit board. The electrode (6) has an internal perimeter border (60) that surrounds the perimeter border of the opening (40) and extends from the upper surface (42) to the lower

surface (41) of the printed circuit board. The opening (40) of the printed circuit board is surrounded by the internal border (60) of the electrode that has depth of approximately 1-2 mm.

A LED (L) is mounted on the lower surface (41) of the printed circuit board, in the proximity of each opening (40) of the printed circuit board. The LED (L) protrudes in lower position from the lower surface (41) of the printed circuit board.

The template (3) has thickness at least four times higher than the thickness of a traditional printed circuit board. Preferably the template (3) has thickness of approximately 4-8 mm. For example, the template (3) can be made of rubber and has a plurality of openings (30) disposed in register with the openings (40) of the printed circuit board.

Each opening (30) of the template is defined by a perimeter border (31). It is important that the perimeter border (31) of each opening of the template is reflecting. Therefore, either the template (3) is made of reflecting material or it is painted with a reflecting white paint in such manner to paint also the perimeter border (31) of the openings (30).

Referring to Fig. 5, the openings (30) of the template must have a higher surface than the openings (40) of the printed circuit board, in such manner that the LED (L) mounted on the lower surface (41) of the printed circuit board is contained inside the opening (30) of the template. For example, the openings (30) of the template are shaped as a semicircle and the LED (L) is situated in the peripheral part of the semicircle, on a straight line orthogonal to the diameter of the semicircle passing through the semicircle center.

The openings (30) can be also shaped as a parabola or semi-ellipse; in such a case, the LED (L) is situated in correspondence of the focus of the parabola or semi-ellipse, in such manner to generate uniform light reflection by the opening (30) of the template.

Referring to Fig. 3, each LED (L) is situated inside a reflecting chamber (8) formed by the upper surface (15) of the support plate (1), the perimeter border (31) of the opening (30) of the template and the lower

surface (41) of the printed circuit board. So, the light emitted by the LED (L) reaches the upper surface (15) of the support plate (1) and suffers multiple reflections inside the reflecting chamber (8). The thickness of the template (4) has been specifically studied to maximize the multiple reflections inside the reflecting chamber (8) and amplify and make light diffusion uniform.

Therefore the reflected light comes out of the reflecting chamber (8) through the opening (40) of the printed circuit board, which is surrounded by the metallization (60) of the electrode that additionally favors reflection. The reflected light crosses the opening (50) of the biadhesive band (5) and reaches the silk-screen printed wordings (22) lighting them up and making them perfectly legible for the user observing them from above the upper plate (20).

Said reflection system in the reflecting chamber (8) generates a high uniformity of the light that illuminates the silk-screen printed wording (22).

When the control panel (100) must display words, advantageously the openings (40) of the printed circuit board have a rectangular shape and a slightly higher surface than the surface occupied by the silk-screen printed working (22).

The extension of the internal border (60) of the first electrode along the lateral walls of the opening (40) of the printed circuit board provides advantages in terms of uniform lighting of the wordings. In fact, when the user looks at the working with eyes in perpendicular direction to the upper plate (2), he will perceive uniform lighting of the letters in view of the performance of the reflection chamber (8).

Nevertheless, referring now to Fig. 7, when the observer's eyes are in oblique position with respect to the upper plate (2), in absence of said metallization (60) of the electrode, part of the wording (22) (“TEXT” in the example) may appear darker. This phenomenon occurs because a portion of the wording projection towards the lower parts intercepts the vertical wall of the opening (40) obtained in the printed circuit board. Since the material used for the printed circuit is typically opaque, the part of the wording projected onto it will be less illuminated.

Vice versa, when a portion of the electrode (60) surrounds the opening (40) of the printed circuit board, the reflectance of the opening (40) of the board is comparable with the reflectance of the white surfaces of the reflection chamber (8). This preserves the lighting uniformity of the letters also when they are observed from an oblique position.

The extension of the internal border (60) of the first electrode (6) along the lateral walls of the opening (40) of the printed circuit board provides an additional advantage in terms of improved touch sensitivity of the control panel.

In fact, the presence of the opening (40) of the printed circuit board reduces the surface of the electrode (6) compared to a situation without opening, by an amount equal to the surface of the opening. Such a reduction is translated into a corresponding reduction of the electrical field in the central area of the button, which in turns results in lower touch sensitivity of the detection device.

Fig. 8 shows the distribution of the flux lines of the electrical field (70) when the electrode (6) is not provided with internal border (60) surrounding the opening (40) of the printed circuit board. The lower density of the flux lines of the electrical field in the central area of Fig. 8 represents a lower intensity of the electrical field in that area.

Fig. 9 shows the distribution of the flux lines of the electrical field (70) when the electrode (6) is provided with internal border (60) surrounding the opening (40) of the printed circuit board. The higher density of the flux lines of the electrical field in the central area of Fig. 9, which is due to the introduction of the internal border (60), represents a recovery of the electrical field intensity in that area, with improved touch sensitivity of the control panel.

Numerous variations and modifications can be made to the present embodiment of the invention, within the reach of experts of the field, while still falling within the scope of the invention as claimed in the attached claims.

Claims

1) A backlit touchscreen control panel (100) comprising:

- a lower support plate (1) with reflecting upper surface,
- an upper plate (2) with transparent upper layer (20) and opaque lower layer (2) provided with a plurality of silk-screen printed wordings (22),
- a printed circuit board (4) disposed under said upper plate (2), said printed circuit board (4) comprising an upper surface (42), a reflecting lower surface (41) and a plurality of openings (40) in register with said silk-screen printed wordings (22) of the upper plate,
- a plurality of pairs of electrodes (6, 7) obtained on the upper surface (42) of the printed circuit board in such manner to generate a plurality of capacitors sensitive to the user's touch on the upper plate (2), wherein each pair of electrodes comprises a first electrode (6) shaped as a closed loop, disposed around said opening (40) of the printed circuit board and a second electrode (7) shaped as a closed loop disposed around said first electrode (6) and spaced from said first electrode,
- a control circuit (C) mounted on said printed circuit board (4) and connected to said pairs of electrodes,
- a plurality of LEDs (L) mounted on said reflecting lower surface (41) of the printed circuit board, wherein each LED (L) is disposed in the proximity of an opening (40) of the printed circuit board,
- a template (3) disposed between said lower support plate and said printed circuit board (4); said template (3) comprising a plurality of openings (30) defined by a reflecting perimeter border (31) wherein each opening (30) of the template is disposed in register with a corresponding opening (40) of the printed circuit board, said openings (30) of the template having a higher surface than the openings (40) of the printed circuit board, in such manner that each of said LEDs (L) is contained inside said openings (30) of the template and the light of each LED suffers multiple reflections inside a reflection chamber (8) generated by the reflecting upper surface of the lower

support structure (1), the perimeter borders (31) of the opening (30) of the template and the lower surface (41) of said printed circuit board.

2) The backlit touchscreen control panel (100) of claim 1, characterized in that said first electrode (6) of each capacitor is obtained as metallization of said opening (40) of the printed circuit board and is provided with internal border (60) surrounding said opening (40) of the printed circuit board.

3) The backlit touchscreen control panel (100) of claim 1 or 2, characterized in that said template (3) has thickness from 4 to 8 mm.

4) The backlit touchscreen control panel (100) of any one of the preceding claims, characterized in that it comprises a biadhesive layer (5) disposed between said printed circuit board (4) and said upper plate (2), said biadhesive layer (5) comprising openings (50) in register with said openings (40) of the printed circuit board.

5) The backlit touchscreen control panel (100) of any one of the preceding claims, characterized in that it comprises a reflecting biadhesive layer (15) disposed between said lower support plate (1) and said template (3).

6) The backlit touchscreen control panel (100) of any one of the preceding claims, characterized in that said template (3) is made of reflecting material.

7) The backlit touchscreen control panel (100) of any one of the preceding claims, characterized in that said template (3) is painted with reflecting white paint.

8) The backlit touchscreen control panel (100) of any one of the preceding claims, characterized in that said silk-screen printed wording (22) is a word or a symbol and in that said opening (40) of the printed circuit board has a rectangular shape with surface containing the silk-screen printed word or symbol.

9) The backlit touch-screen control panel (100) of claim 8, characterized in that said opening (30) of the template (3) has a semi-circular shape and said LED (L) is disposed in peripheral position of said opening

(30) on a straight line orthogonal to the diameter of the semicircle passing through the center of the semicircle.

10) The backlit touch-screen control panel (100) of claim 8, characterized in that said opening (30) of the template (3) is shaped as a parabola or semi-ellipse and said LED (L) is disposed in correspondence of the focus of said parabola or semi-ellipse.

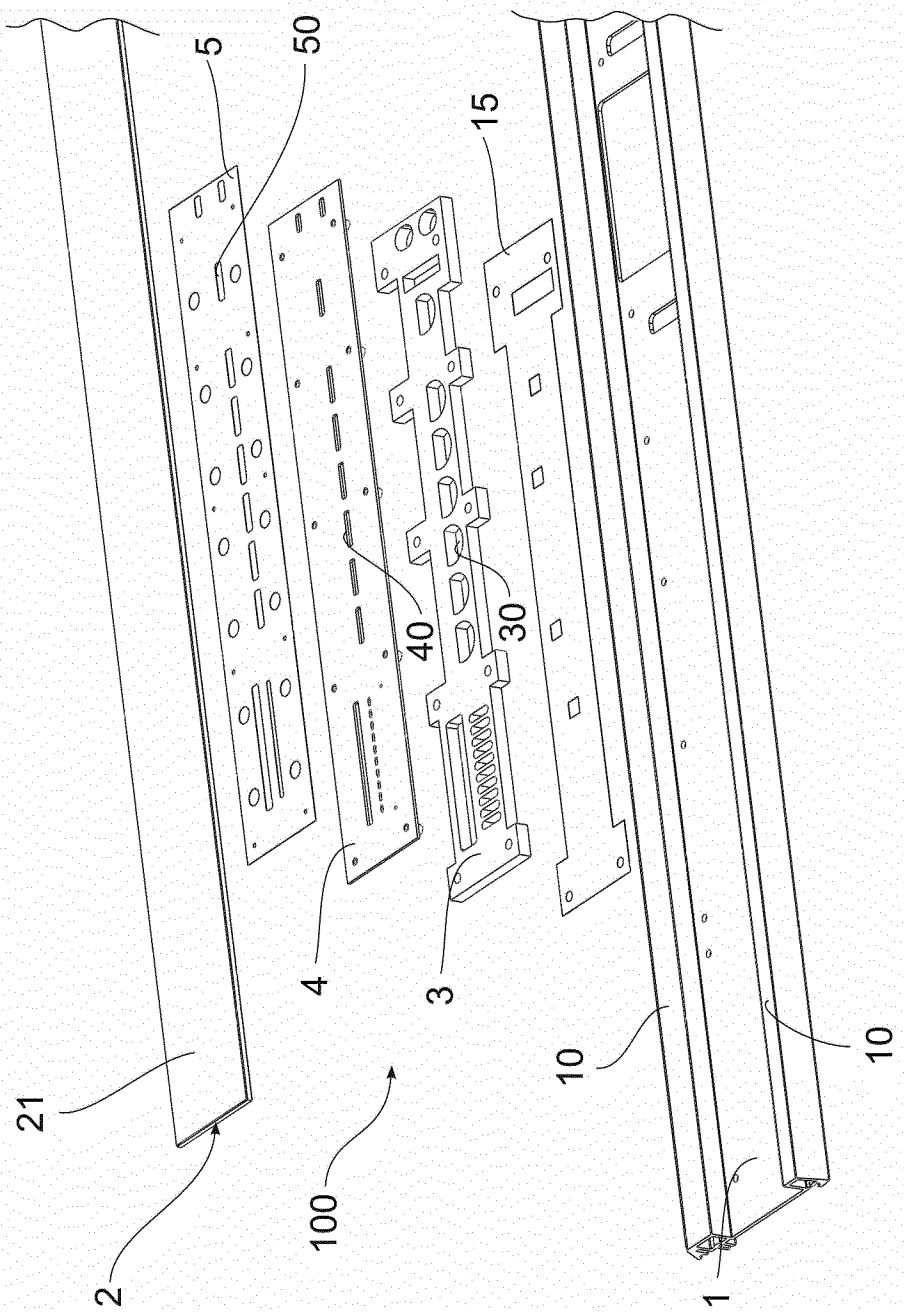

FIG. 1

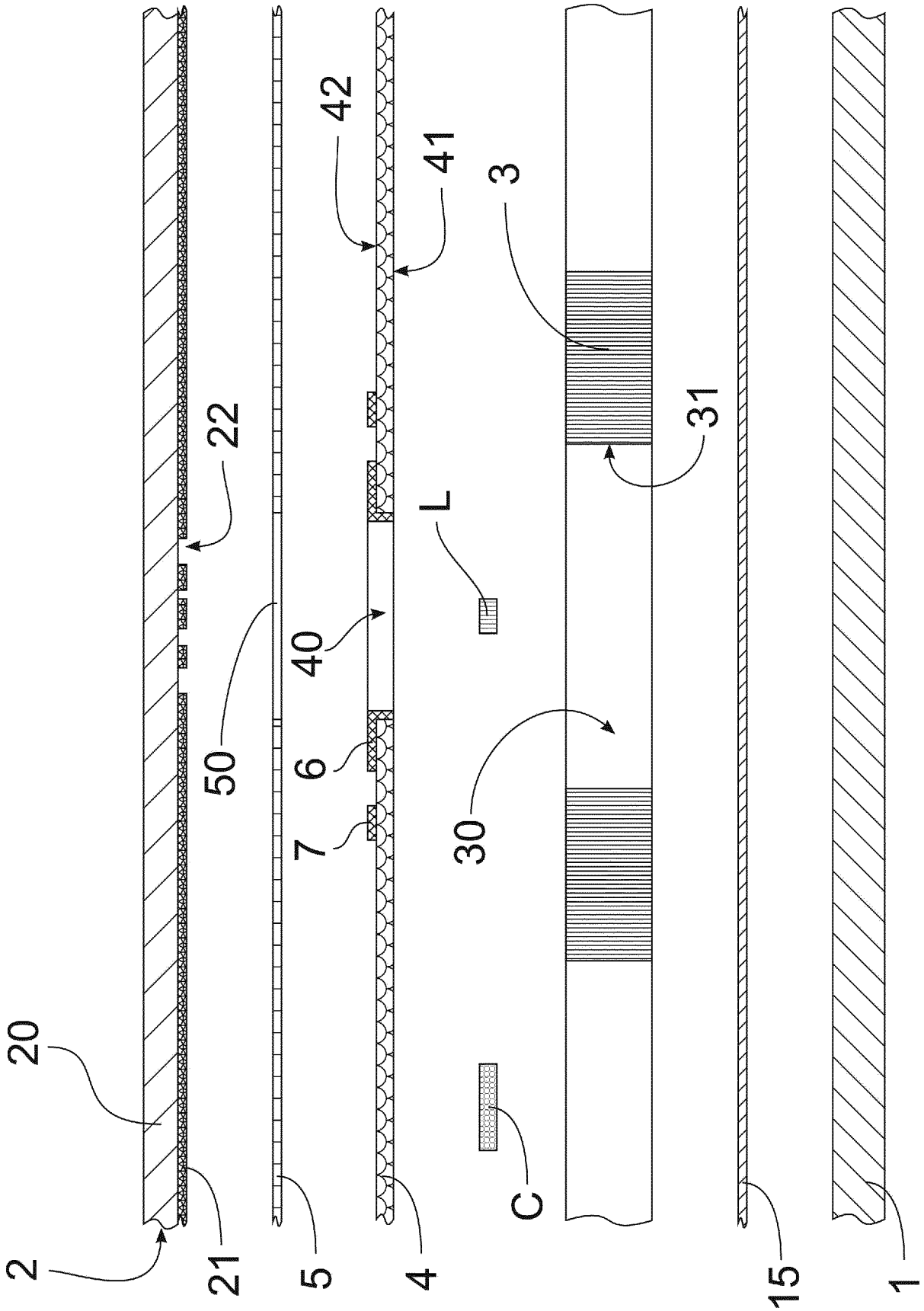

FIG. 2

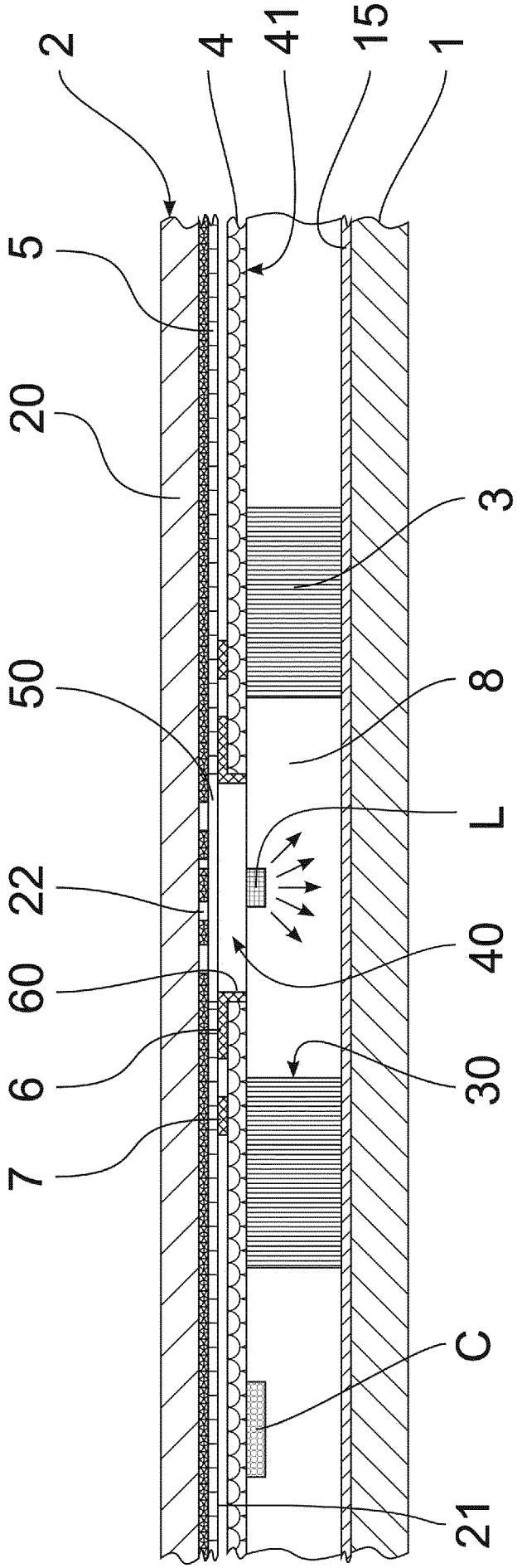

FIG. 3

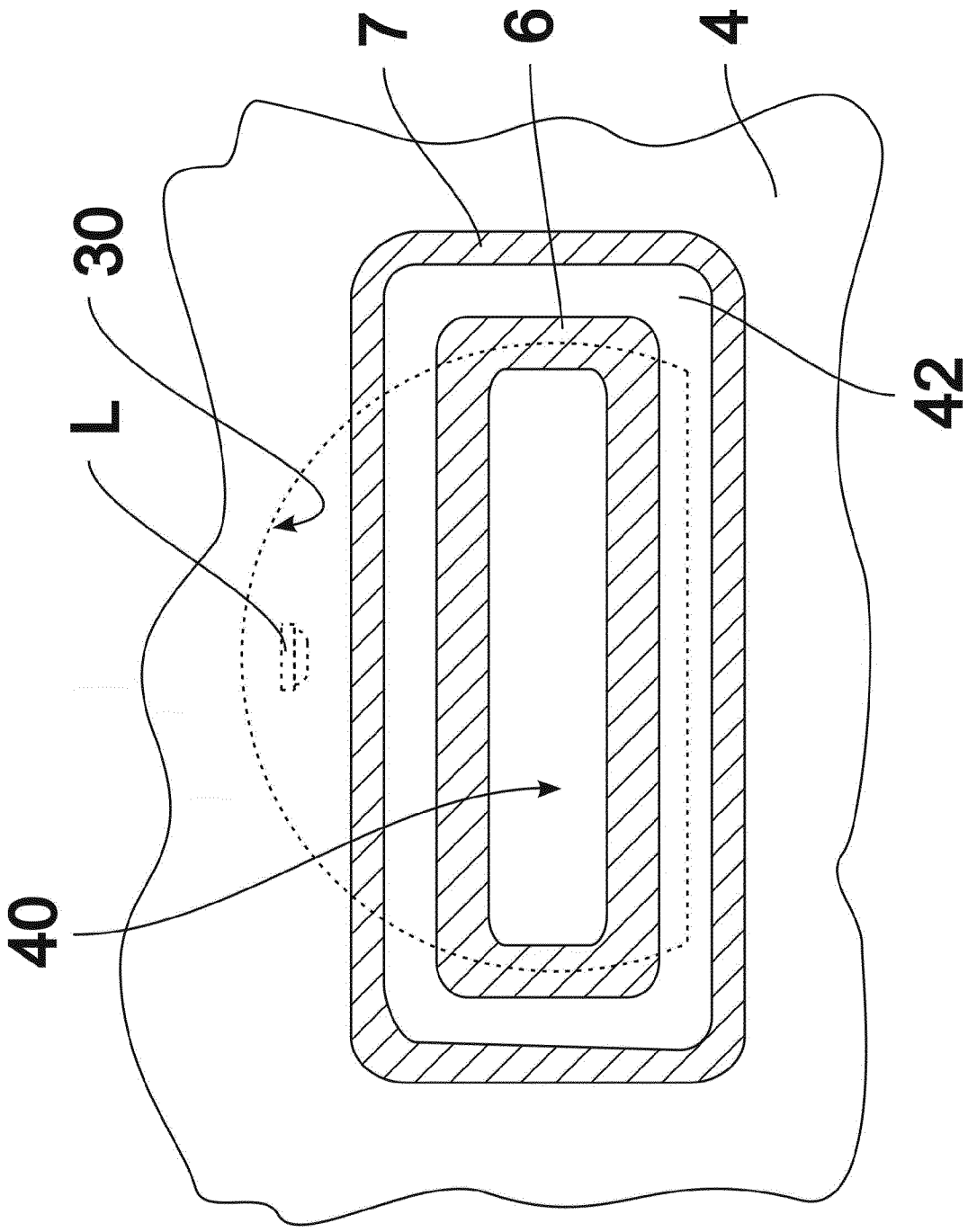

FIG.4

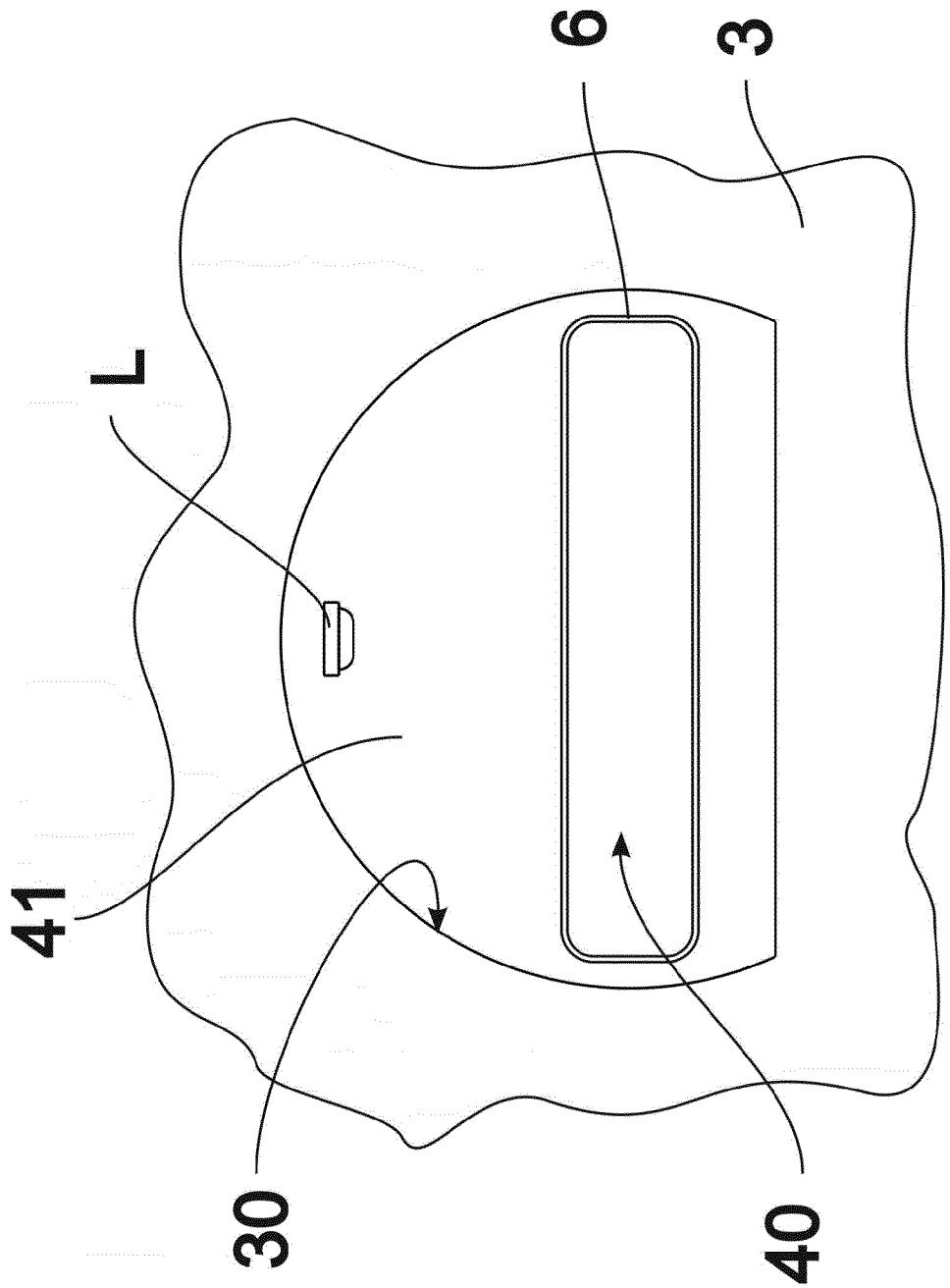

FIG.5

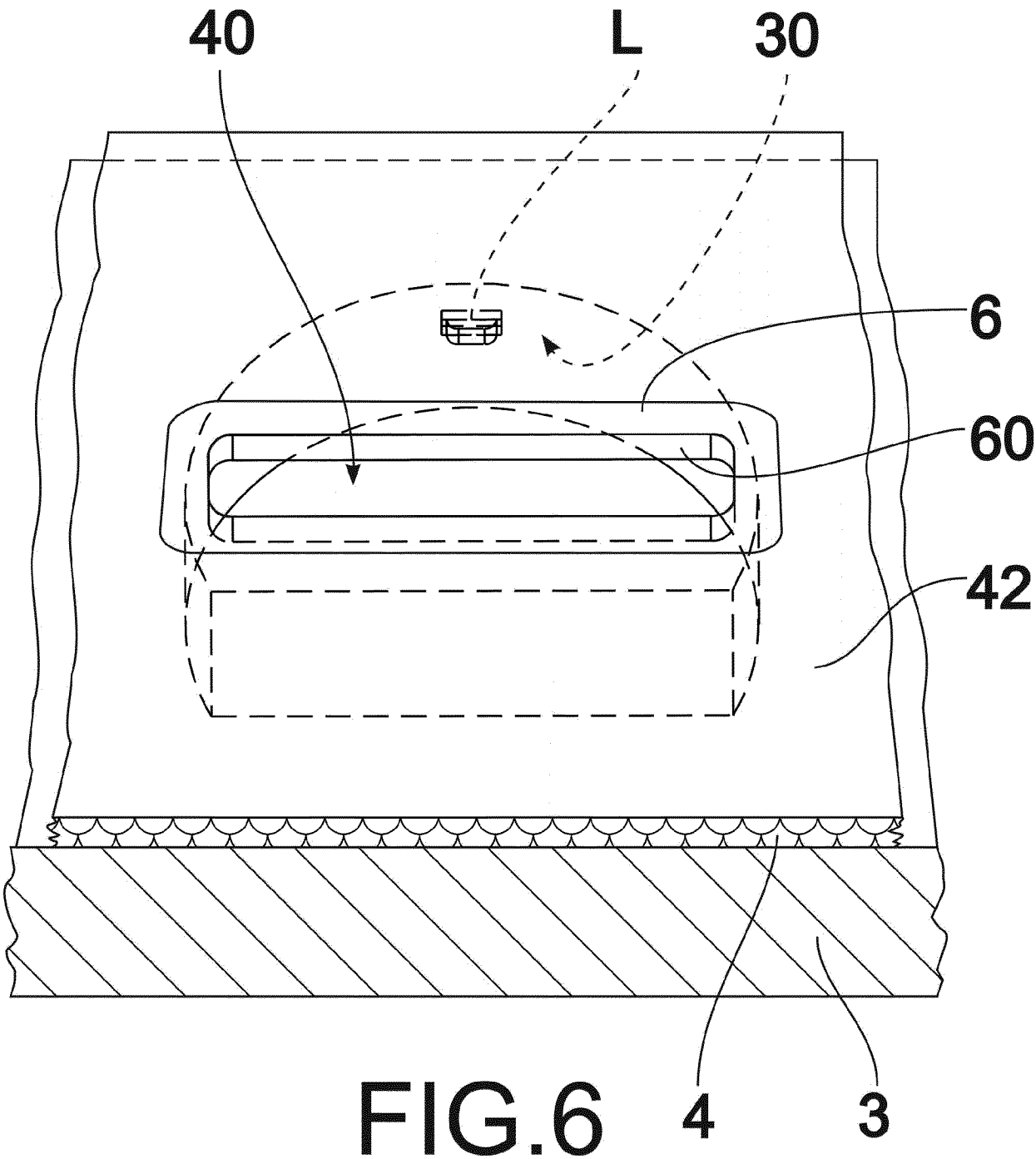

FIG.6

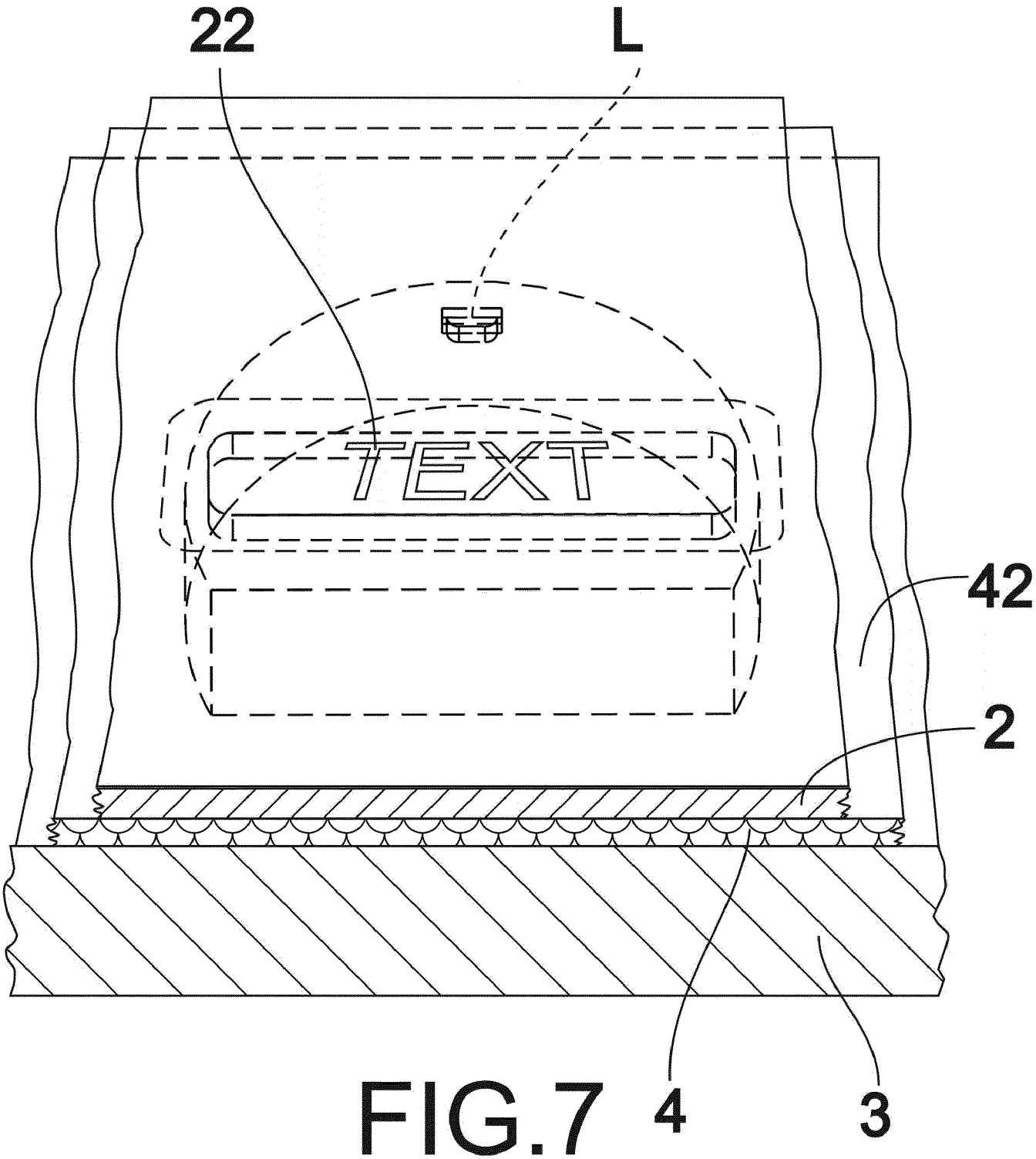

FIG.7

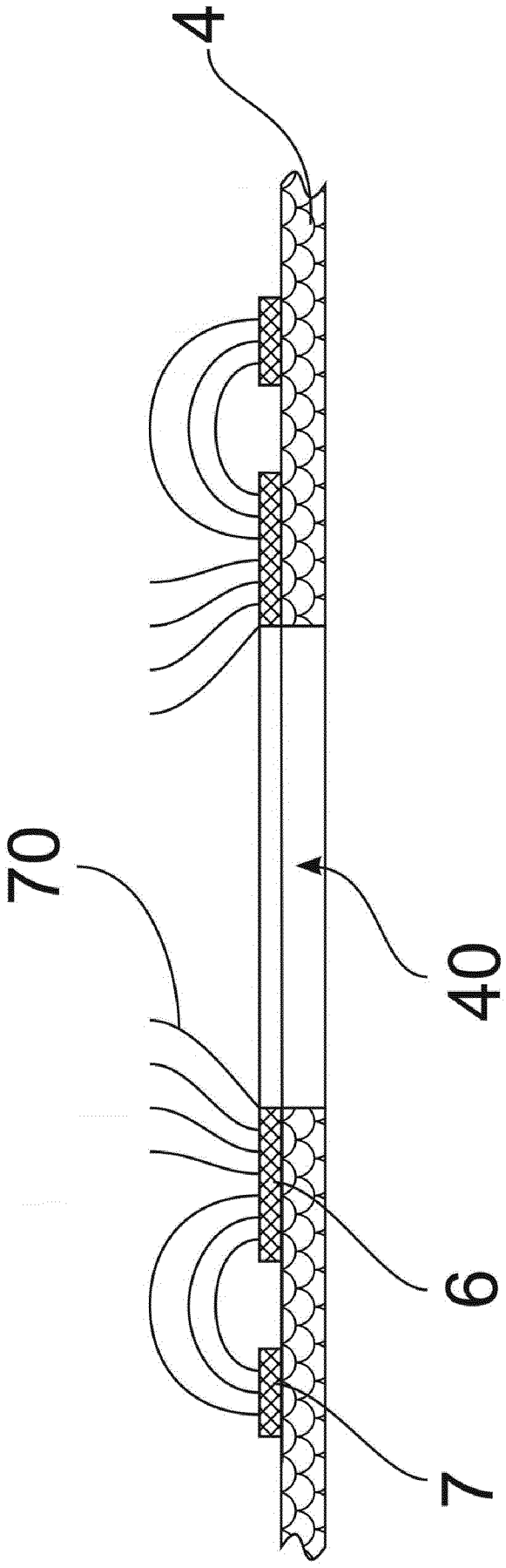

FIG. 8

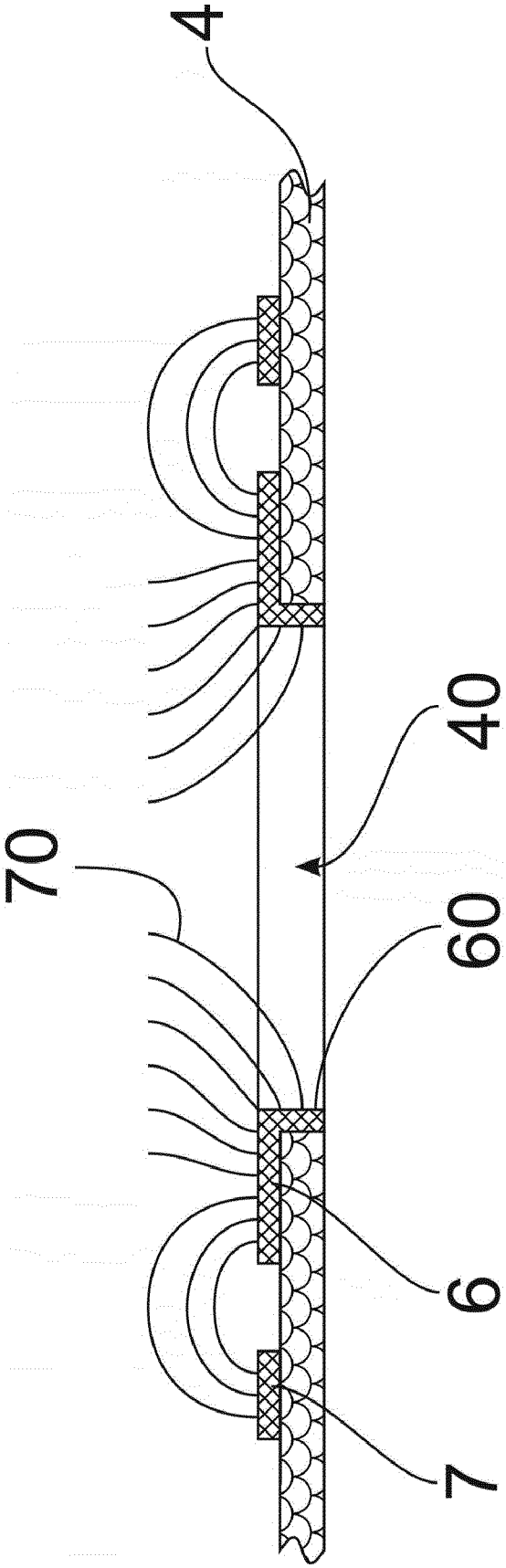

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/063351

A. CLASSIFICATION OF SUBJECT MATTER
INV. H03K17/96 G06F3/041
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H03K G06F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 239 152 A (CALDWELL DAVID W [US] ET AL) 24 August 1993 (1993-08-24) column 2, line 30 - column 4, line 43; figures 1a-2b	1-10
A	EP 2 141 808 A2 (SEOUL SEMICONDUCTOR CO LTD [KR]) 6 January 2010 (2010-01-06) paragraph [0015] - paragraph [0032]; figures 1,2	1-10
A	WO 2009/153161 A1 (PREH GMBH [DE]; OFENHITZER THOMAS [DE]; PESCHEL MARKUS [DE]; JEGER JOH) 23 December 2009 (2009-12-23) page 7, line 8 - page 10, line 13; figures 1-6	1-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 July 2013	06/08/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kassner, Holger

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/063351

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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