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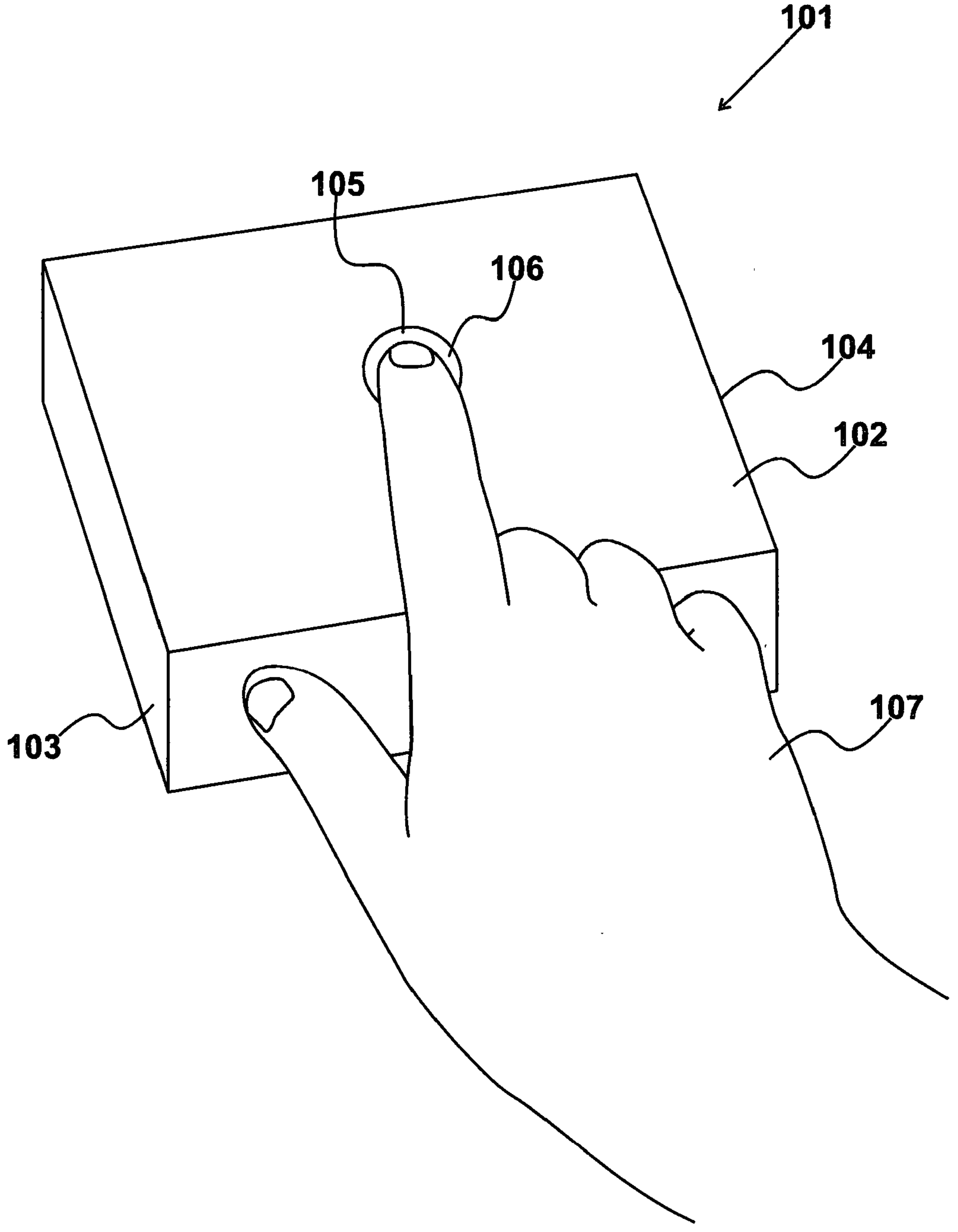

Fig. 1

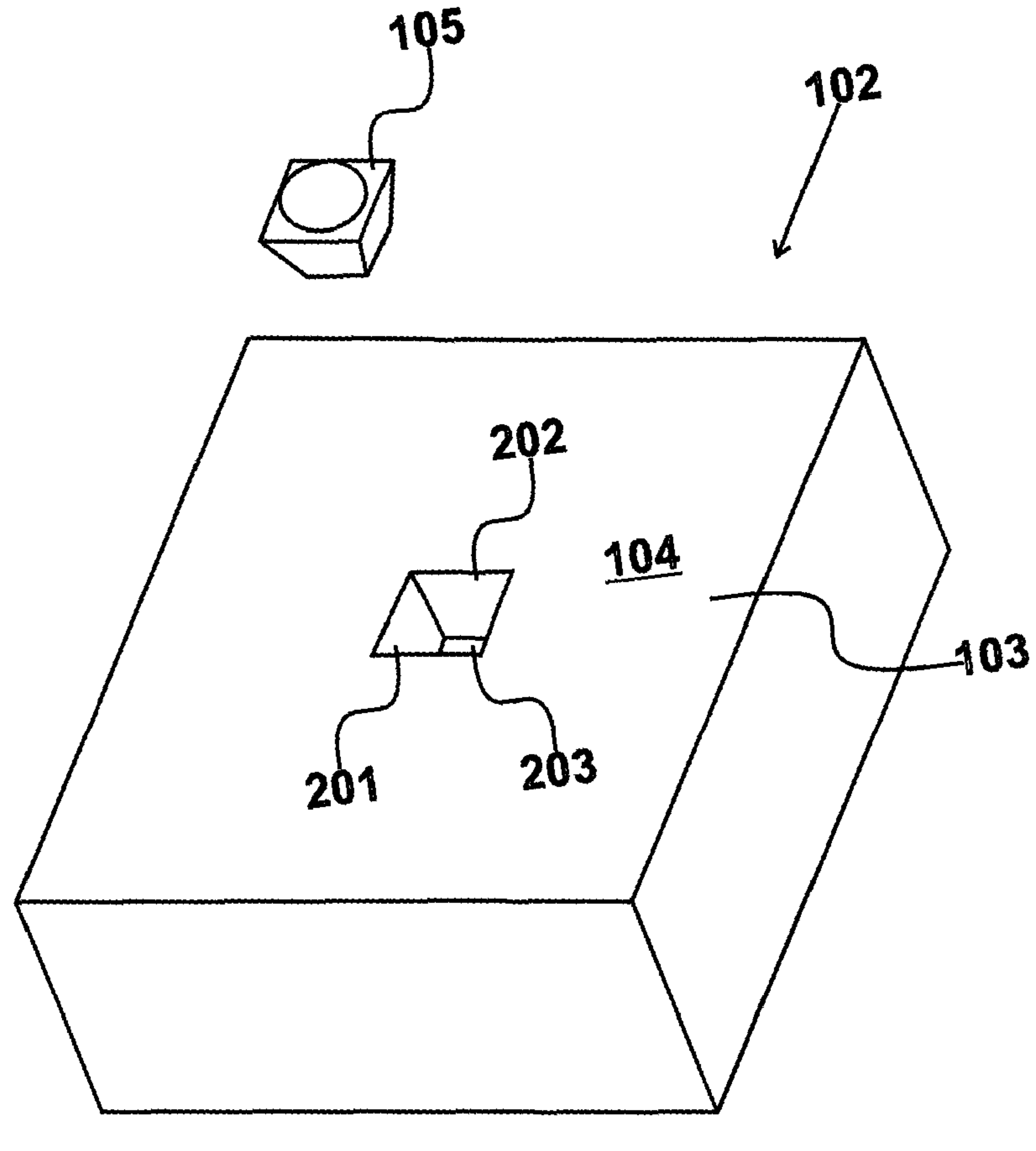

Fig. 2

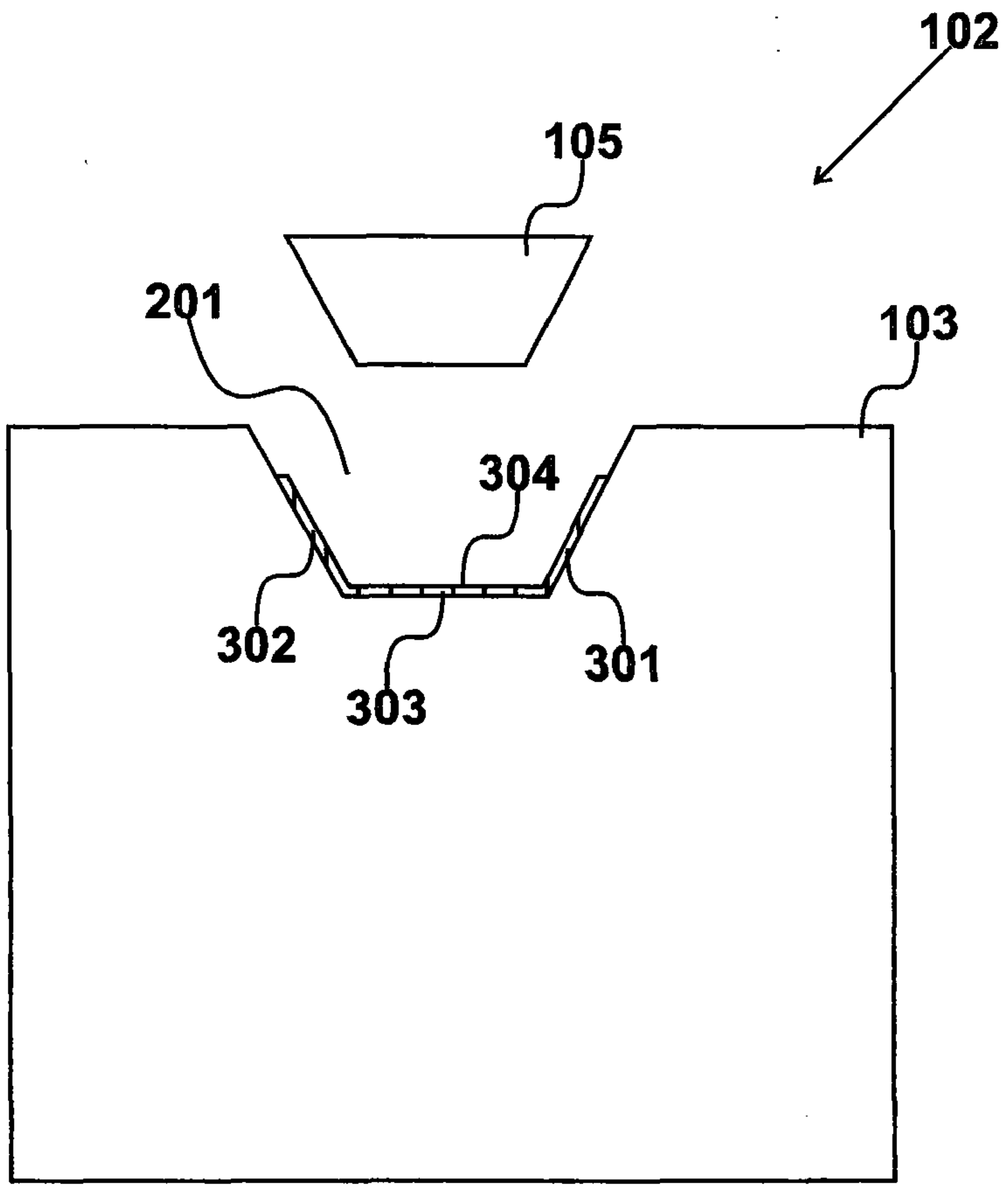

Fig. 3

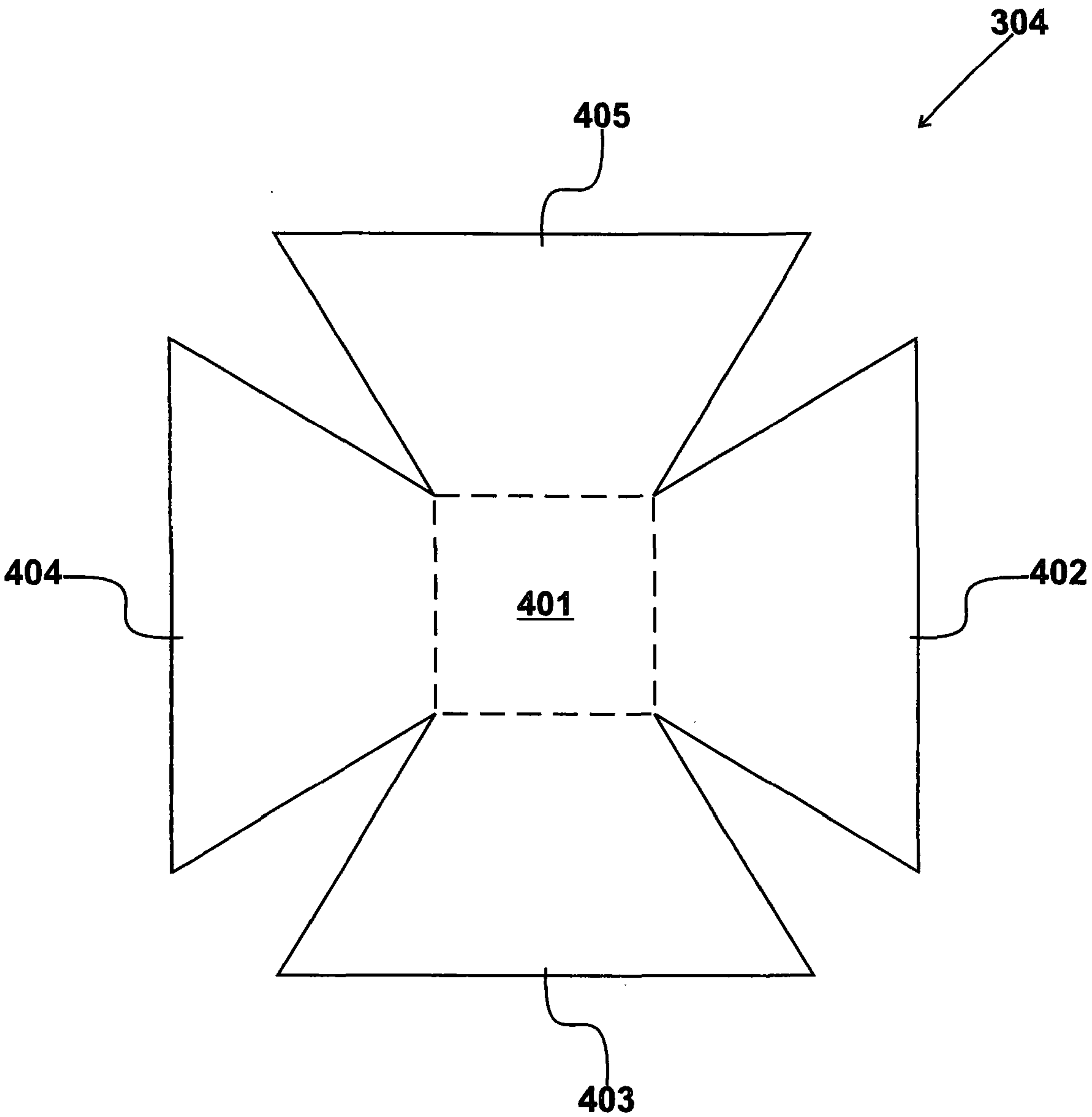

Fig. 4

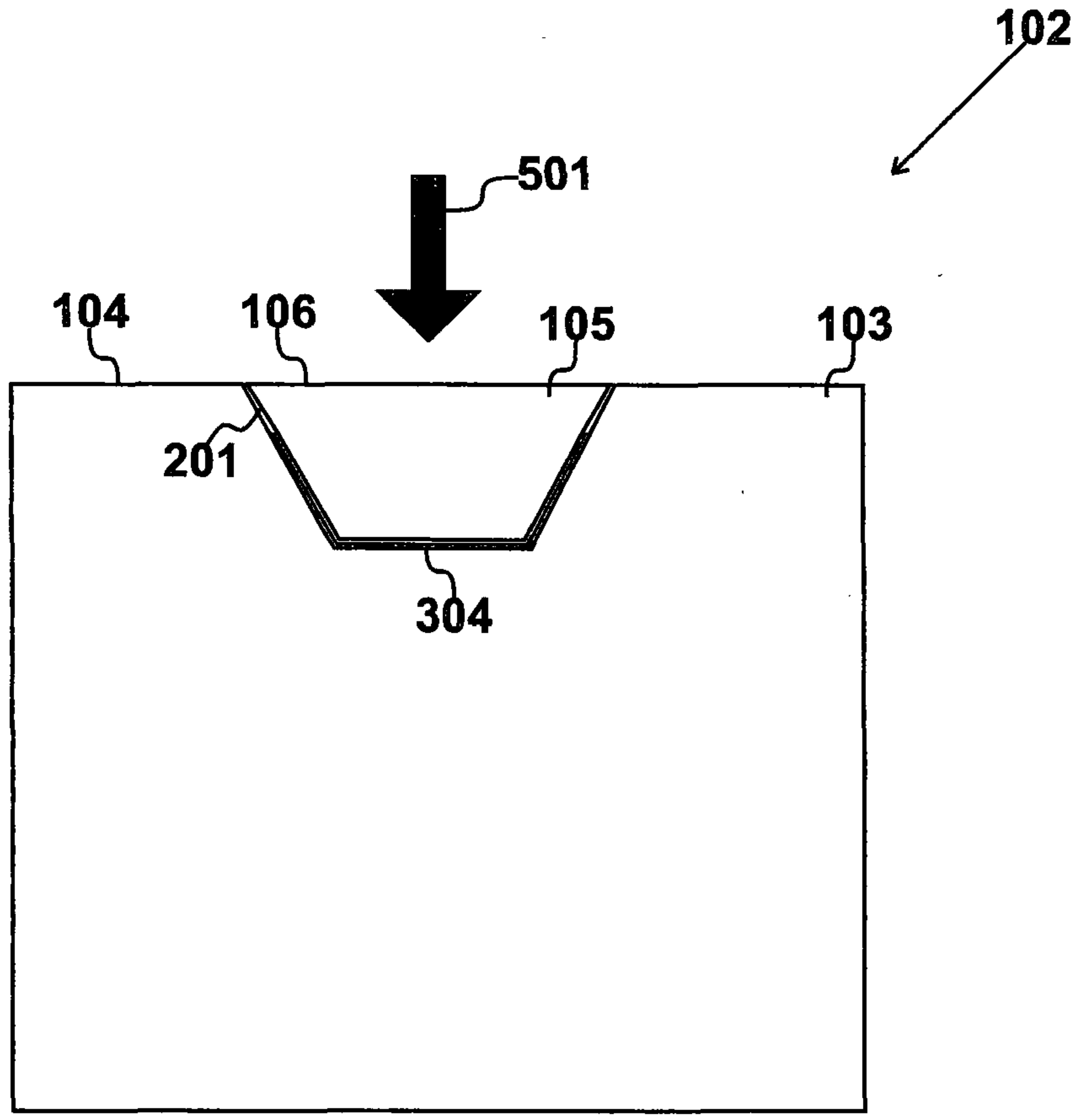

Fig. 5

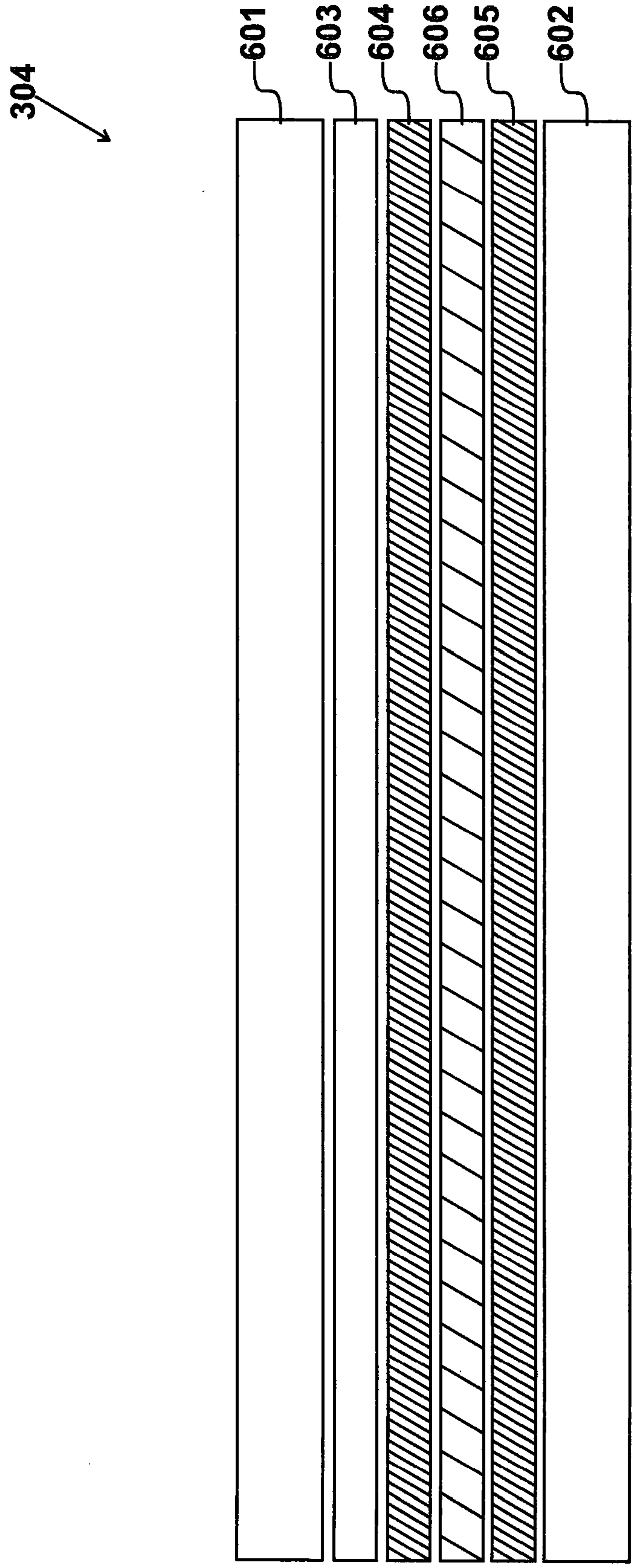

Fig. 6

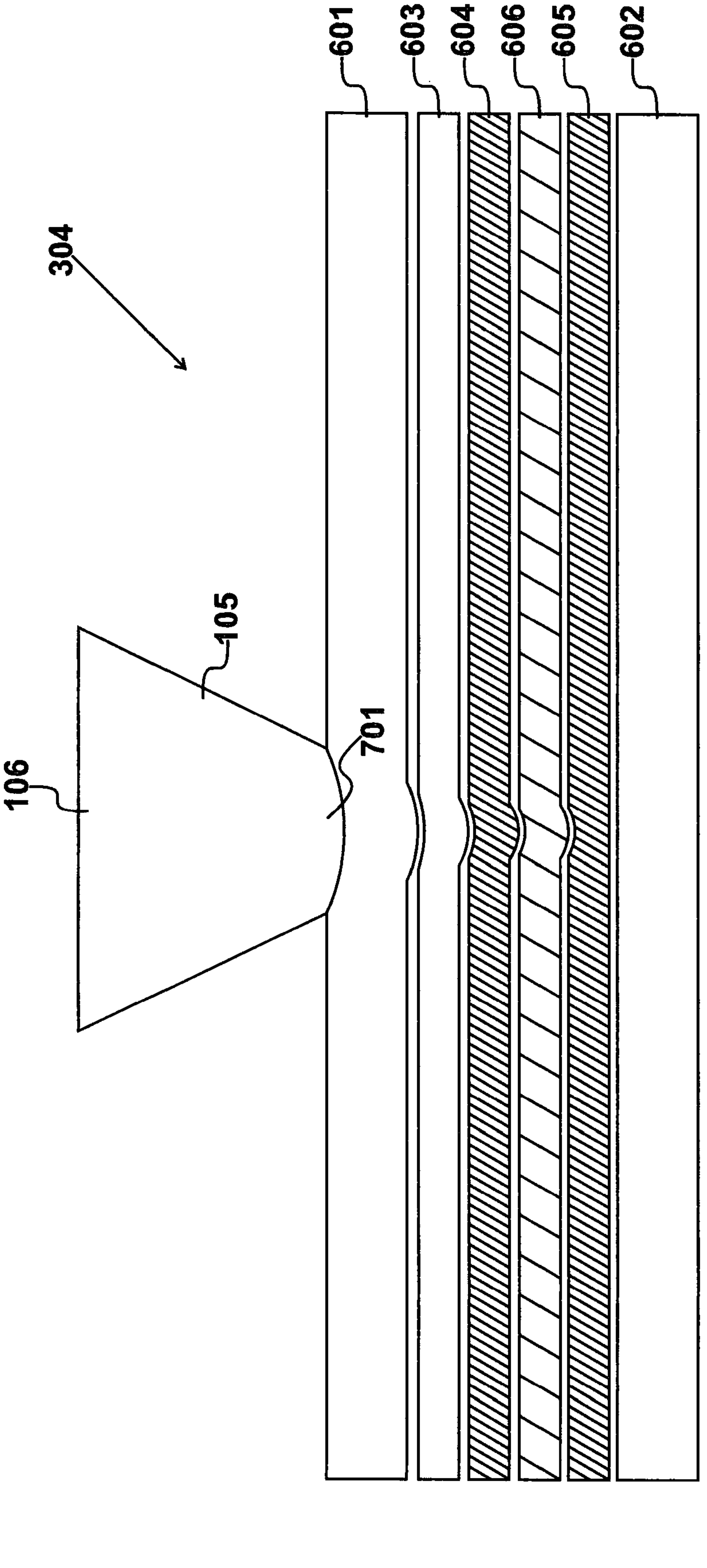

Fig. 7

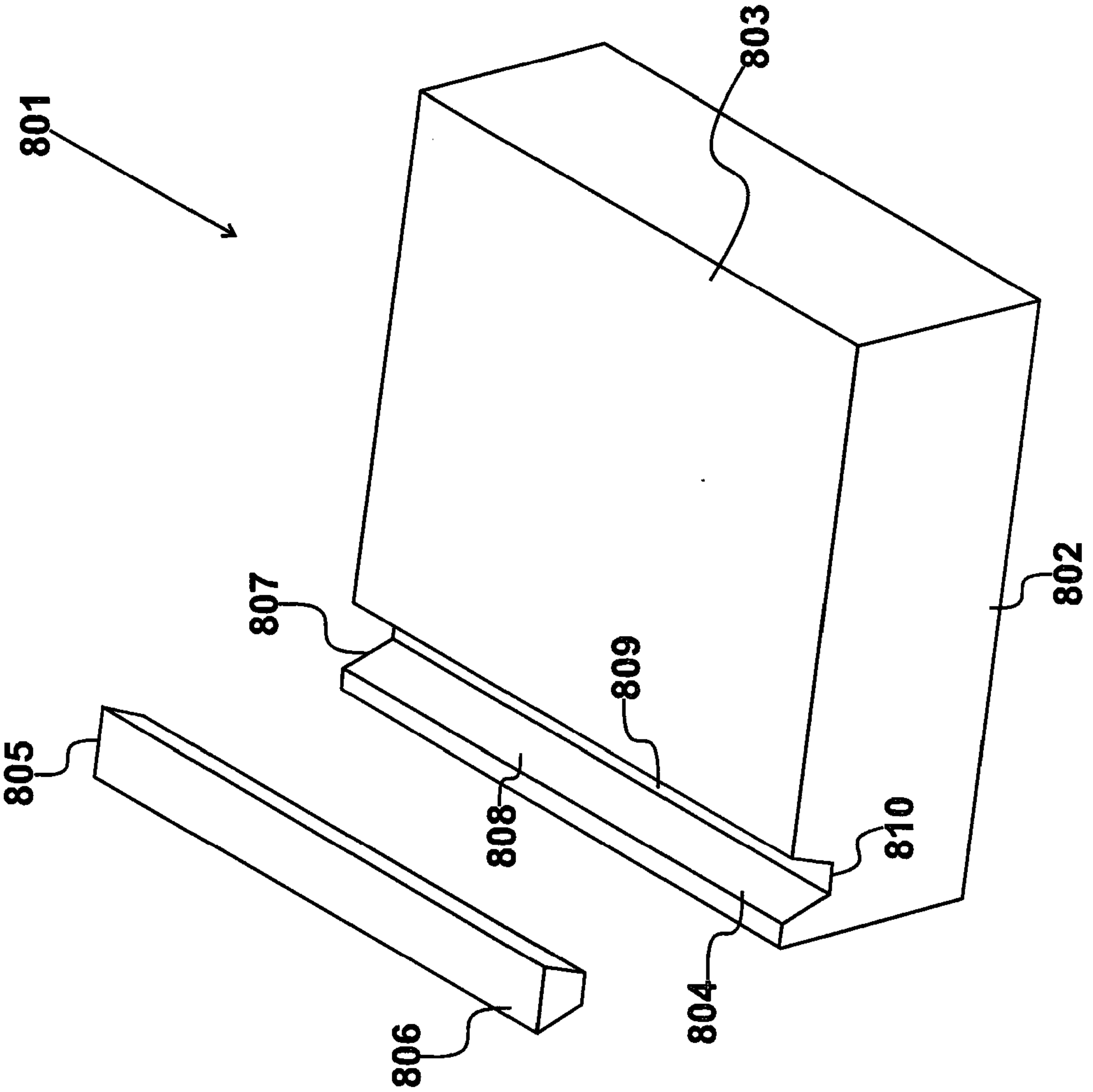

Fig. 8

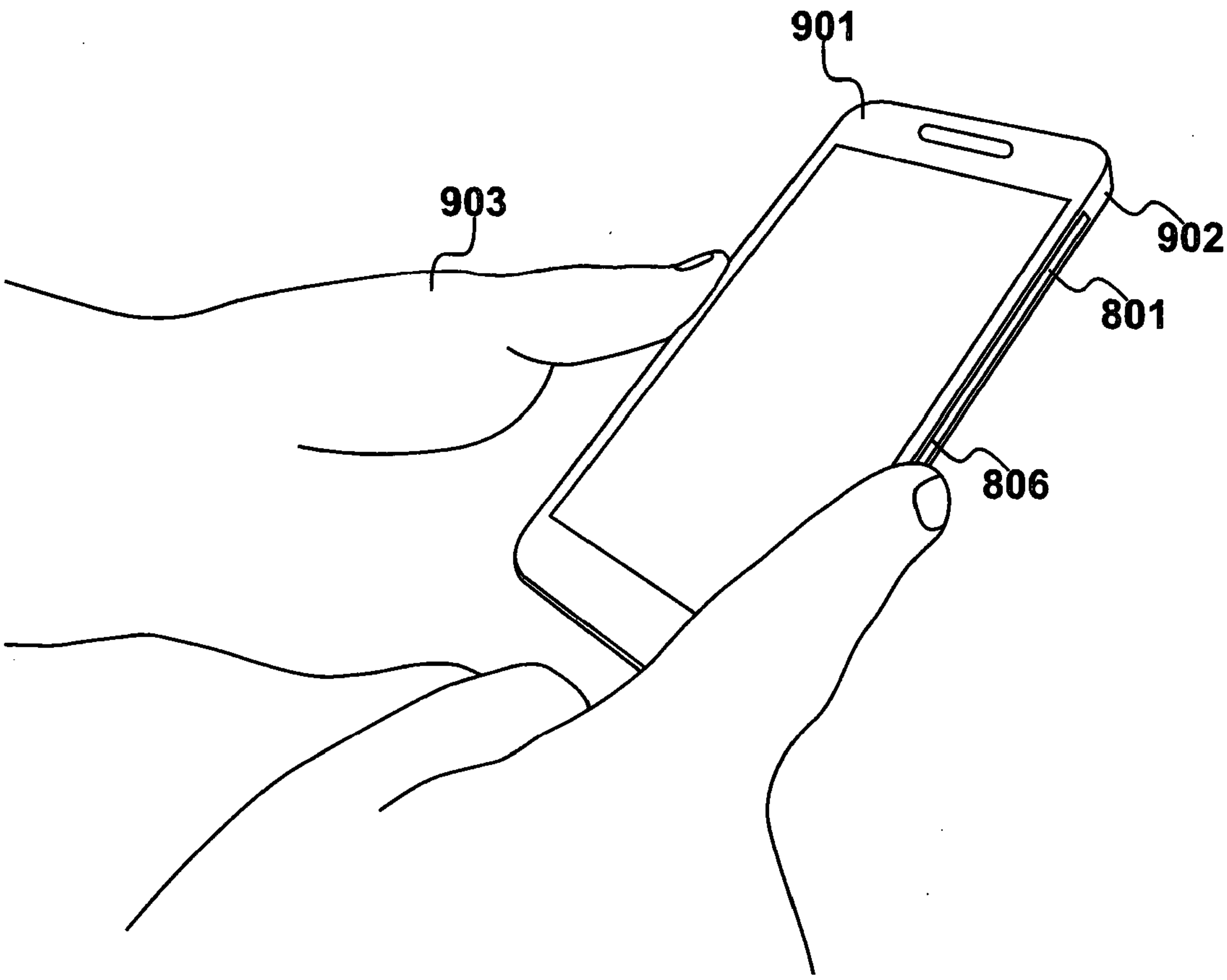

Fig. 9

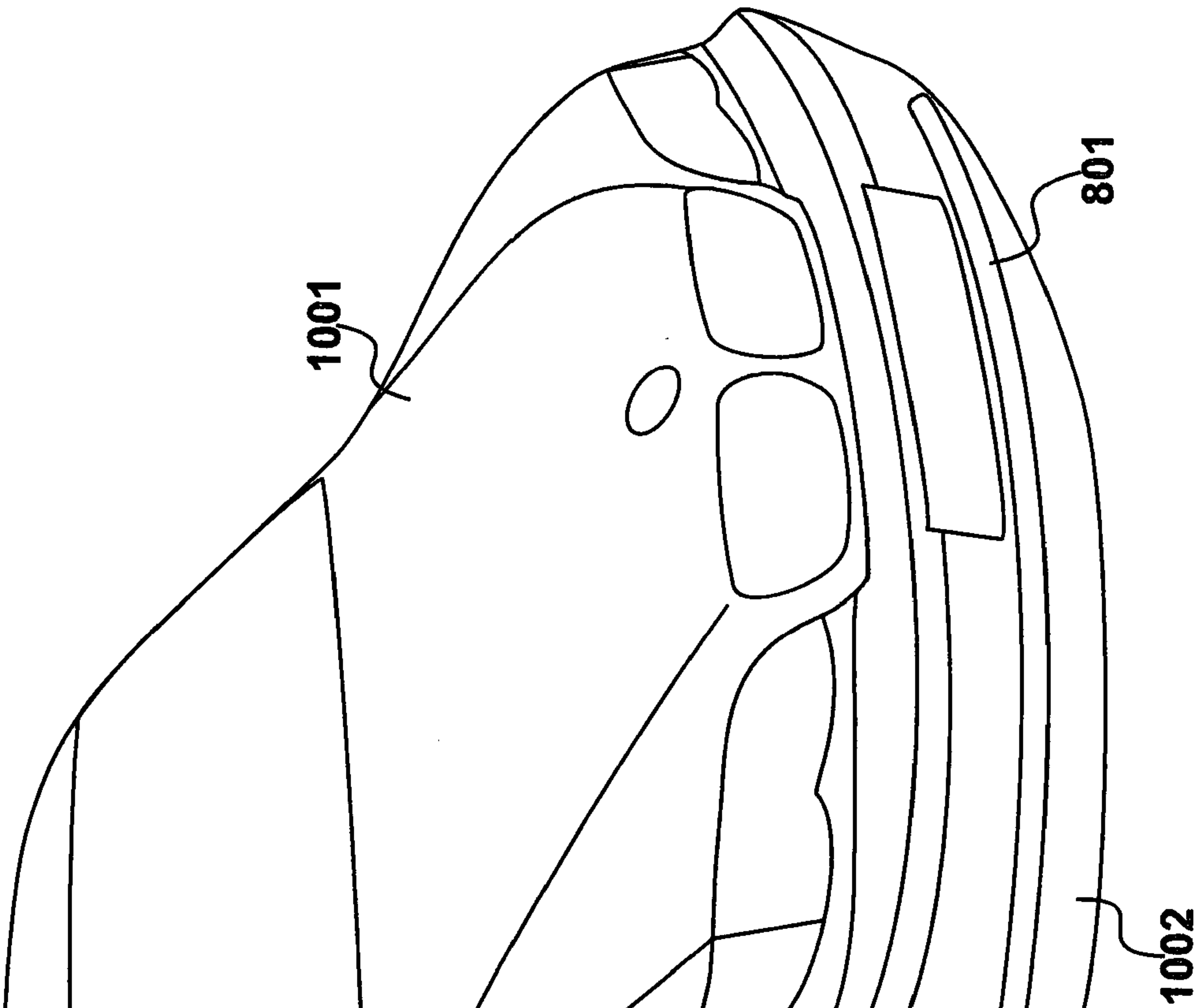

Fig. 10

Detecting Force

The present invention relates to a sensor for detecting input force and the manufacture of such a sensor and a method of detecting an input force.

It is known to provide sensors for use in a wide variety of applications and industries. Sensors which provide touch capabilities in response to mechanical interactions such as pressure are often used in applications such as in electronic devices as part of a touchscreen, buttons or similar, or in respect of input devices such as joysticks for use in gaming.

When sensors are provided in commercial applications, it is often important that they present a tactile interface which appeals to a user. It can be difficult to achieve ergonomic designs without compromising on functionality. Thus, more functional sensors, in particular those which provide measurements in three dimensions, are increasingly complex in order to enable the ergonomic requirements of commercial users to be met.

According to an aspect of the present invention, there is provided a sensor for detecting input force in accordance with claim 1.

According to a further aspect of the present invention, there is provided a method of detecting an input force in accordance with claim 12.

According to a still further aspect of the present invention, there is provided a method of manufacturing a sensor for detecting input force, in accordance with claim 16.

The invention will now be described by way of example only, with reference to the accompanying drawings, of which:

Figure 1 shows a sensor capable of detecting input force;

Figure 2 shows a diagrammatic view of the sensor of Figure 1;

Figure 3 shows a diagrammatic cross sectional view of the sensor of Figures 1 and 2;

Figure 4 shows an example sensing device for use in the sensor described previously;

Figure 5 shows a cross sectional side view of the sensor of Figure 1;

Figure 6 shows a diagrammatic cross-sectional view of a plurality of layers which make up a sensing device;

Figure 7 shows the plurality of layers of Figure 6 in response to a mechanical interaction;

Figure 8 shows an alternative embodiment of a sensor for detecting input force;

Figure 9 shows the sensor of Figure 8 being utilised in an electronic device; and

Figure 10 shows a vehicle incorporating a sensor in the vehicle's bumper.

Figure 1

A sensor capable of detecting input force is illustrated in Figure 1. Figure 1 shows an apparatus in the form of a joystick **101** which comprises a sensor for detecting input force.

Sensor **102** comprises a housing **103** which has a top surface **104** and a contact element **105** which is enclosed by a cavity in housing **103**. Contact element **105** comprises an external surface **106** which is configured to receive a mechanical interaction so as to operate sensor **102**. As illustrated, external surface **106** and top surface **104** provide a substantially flush profile extending from the external surface to the top surface, and will be further described with respect to Figure 5.

In the embodiment, external surface **106** comprises a moulded portion which comprises a finger-shaped profile which conforms to the finger of user **107**. In the embodiment, contact element **105** comprises an elastomeric material.

As shown, in use, sensor **102** is able to detect an input force when user **107** applies a mechanical interaction by means of an application of force to external surface **106** from the finger of user **107**. In the embodiment, sensor **102** is configured to detect a property of mechanical interaction, such as a force magnitude or position of force, in response to the finger press by user **107**. In this way, sensor **102** is used as a joystick and provides a low profile joystick which a user can control with minimal movements of their finger.

Figure 2

A diagrammatic view of sensor **102** is shown with respect to Figure 2. Housing **103** comprises cavity **201** disposed therein and top surface **104** as previously described. Contact element **105** is shown in exploded view so as to expose cavity **201**. However, in use, it is appreciated that contact element **105** is enclosed in cavity **201** as will be further described with respect to Figure 5.

In the embodiment, cavity **201** comprises four side walls, such as side wall **202** and bottom wall **203**. Contact element **105** comprises a mutually co-operating profile comprising corresponding side walls which therefore allows contact element **105** to be enclosed by cavity **201** in use.

Figure 3

A cross sectional diagrammatic side view of sensor **102** is illustrated with respect to Figure 3. Again, contact element **105** is shown in exploded view from housing **103** and cavity **201**.

In this embodiment, side walls **301** and **302** and bottom wall **303**, define a v-shaped or u-shaped cross sectional profile. Each of the walls **301**, **302** and **303** have a sensing device **304** attached thereto. In the embodiment, sensing device **304** is a single sensing device, although it is appreciated that, in alternative embodiments, a sensing device can be attached to each of the walls independently.

Thus, when contact element **105** is positioned within cavity **201**, a contact can be made between contact element **105** and sensing device (or devices) **304**.

Figure 4

An example embodiment of sensing device **304** will now be described with respect to Figure 4. Figure 4 illustrates a plan view of a sensing device prior to its application in cavity **201** described previously. Sensing device **304** comprises a central portion **401** and four extending portions **402**, **403**, **404** and **405**.

In the embodiment, central portion **401** is configured to be positioned in line with bottom wall **303** and extending portions **402**, **403**, **404** and **405** are configured to attach to side walls, such as side walls **301** and **302**. Each extending portion extends from central portion **401** and includes a foldable interface which allows sensing device **304** to be folded and bent in manufacture so as to fit in cavity **201**. For example, foldable interface **406** provides a foldable line between extending portion **402** and central portion **401** to enable extending portion **402** to align against side wall **301** in the manner shown in Figure 3. It is appreciated that the dashed lines of Figure 4 illustrate where foldable interfaces are present in sensing device **304**.

Figure 5

In manufacture of sensor **102**, contact element **105** is positioned in cavity **201** of housing **103** such that contact element **105** is enclosed in cavity **201**.

External surface **106** and top surface **104** of housing **103** provide a substantially flush profile which extends from external surface **106** to top surface **104**.

In use, contact element **105** is configured to provide a physical contact between contact element **105** and sensing device **304** on application of a mechanical interaction in the direction of arrow **501** onto external surface **106**. It is appreciated that while arrow **501** illustrates a force applied in a perpendicular direction to external surface **106**, a force applied to external surface **106** in a non-perpendicular direction is still able to provide the physical contact between contract element **105** and sensing device **304**. Thus, when inactive, sensing device **304** and contact element **105** are in a resting position whereby sensing device is not active (i.e. not providing a reading of force), and when the physical contact is made, sensing device **304** becomes active by means of the mechanical interaction applied. This will be described further in respect of Figures 6 and 7 which describe sensing device **304** in further detail.

Figure 6

Figure 6 shows a diagrammatic cross-sectional exploded view of a plurality of layers which make up sensing device **304** in an example embodiment.

In the example embodiment, sensing device **304** comprises a plurality of layers which combine to enable the detection of the magnitude and position of a mechanical interaction when applied to sensing device **304** by means of contact element **105**. In Figure 6, the plurality of layers are shown slightly apart in an exploded view, however, it is appreciated that these layers can be touching in the resting position but remain inactive until a mechanical interaction, such as a pressure is applied.

In the embodiment, sensing device **304** comprises substrates **601** and **602**. Substrates **601** and **602** may comprise a PET (Polyethylene terephthalate) substrate although it is appreciated that other substrates may be suitable. Sensing device **304** further includes a conductive layer **603** which comprises silver and two further conductive layers **604** and **605** which comprise a printed carbon material. A further central layer **606** comprising a pressure sensitive variably resistive material is sandwiched between the two carbon layers **604** and **605**. In the embodiment, the pressure sensitive variably resistive material comprises a quantum tunnelling composite material.

This particular arrangement provides a single point pressure sensor which, on application of force to one of the outer substrates, experiences a reduction in electrical resistance by means of the pressure sensitive variably resistive material thereby providing a means for detecting the position and magnitude of the applied mechanical interaction. Single point pressure sensors of this type are available from the applicant, Peratech Holdco Limited, Brompton-on-Swale, United Kingdom. In an embodiment, the sensing device is able to detect magnitude and position in three dimensional Cartesian axes, such that the force itself (in the z direction) can be determined, along with the x, y position of the applied force.

Figure 7

The diagrammatic view of Figure 6 is shown in Figure 7 and illustrates the response to a mechanical interaction by means of contact element **105**. When a mechanical interaction is applied to the external surface **106** of contact element **105**, physical contact is made along a bottom contact surface **701** of contact element **105**. It is appreciated that, in the example previously described with respect to Figure 5, such physical contact can be made with side contact surfaces of contact element **105** and the sensing device attached to the corresponding side walls of cavity **201**.

When this physical contact is made, each layer of sensing device **304** is compressed as shown to provide a conductive path through the layers of variable electrical resistance. Thus, a magnitude of force and position of force can be determined by utilising appropriate electrical circuitry in a manner known in the art.

Figure 8

An alternative embodiment of a sensor for detecting input force in accordance with the present invention will now be described with respect to Figure 8. Sensor **801** is shown in diagrammatic exploded form for illustrative purposes.

Sensor **801** comprises a housing **802** having a top surface **803** and a cavity **804** disposed therein. In a similar manner to sensor **102** as previously described, sensor **801** further comprises a contact element **805** which comprises an external surface **806** and which, in use is enclosed by cavity **804**. When enclosed in cavity **804**, external surface **806** and top surface **803** provide a substantially flush profile which extends from the external surface **806** to the top surface **803**.

In this embodiment, cavity **804** comprises an elongate channel **807** which has two longitudinal side walls **808** and **809** and a bottom wall **810**, and each of these walls are provided with a sensing device, which may be substantially similar to that as previously described with respect to Figures 6 and 7. Contact element **805** comprises a mutually co-operating profile to cavity **804** and, in this embodiment, is therefore also elongated. In the embodiment, the cross sectional profile of the contact element comprises a v-shaped or u-shaped profile and cavity **804** therefore provides a corresponding inverted v-shaped or u-shaped cross sectional profile.

In use, contact element **805** again provides physical contact between contact element **805** and the sensing device on application of a mechanical interaction to the external surface **806**.

Thus, it is appreciated that sensor **801** functions in a substantially similar manner to sensor **102**, the difference being that the cavity is elongated and the sensing devices and contact element may also be elongated to correspond with this amendment.

Figure 9

Sensor **801** can be utilised in an electronic device in the manner of Figure 9. In the embodiment, sensor **801** forms part of an electronic device **901** which, in this illustrated example, is a mobile telephone.

Sensor **801** extends along an edge **902** of a telephone **901** and provides a user with an input device to control aspects of the mobile telephone **901**. As sensor **801** provides a substantially flush profile along edge **902**, it is capable of being incorporated into an electronic device without substantially affecting the design, and thus, in use, a user **903** can utilise sensor **801** as an ergonomic input device.

In this embodiment, the input force provided by user **903** is configured to be applied as a sliding force along external surface **806**. The sensing devices are therefore configured to detect this mechanical interaction and provide corresponding outputs to electronic device **901**. For example, a sliding force could be used to control volume output from the telephone, or, in the case of a video or other media playing on the device, advance the video by fast-forwarding or re-winding. In an alternative embodiment, sensor **801** is configured to provide a toggle function along the external surface, such that different functions can be selected or switched on or off by providing a force in an upwards or downwards manner.

It is appreciated that, while the current example describes the electronic device as a mobile telephone, any other suitable electronic device can utilise a sensor in accordance with the present invention. For example, other suitable electronic devices could be a hand held computer, laptop, tablet, music and/or video players or other non-portable electronic devices requiring a user interface.

Figure 10

A further example embodiment utilising sensor **801** of Figure 8 is shown in Figure 10. Figure 10 shows a vehicle **1001** in the form of a car incorporating sensor **801** in the vehicle's bumper **1002**.

In this embodiment, sensor **801** is able to detect any external objects which come into contact with sensor **801**. In this way, sensor **801** provides a protective bumper and reacts to any objects which may impact vehicle **1001**.

It is appreciated that sensor **801** may be used in alternative applications in which the detection of external objects to provide a protective bumper is also required. For example, robotic devices may include a plurality of sensors substantially similar to sensor **801** and/or sensor **102** on the exterior of the robotic device. This would then be used as a bump detector to avoid such a robotic device from receiving damage from any impact.

CLAIMS

1. A sensor for detecting input force, comprising:

a housing defining a cavity therein and a top surface; and

a contact element enclosed by said cavity, said contact element comprising an external surface;

said cavity comprising at least one wall having an inner surface, said at least one wall having a sensing device attached thereto and aligned against said inner surface of said at least one wall;

said contact element being configured to provide physical contact between said contact element and said sensing device on application of a mechanical interaction to said external surface; wherein

said external surface and said top surface provides a substantially flush profile extending from said external surface to said top surface; and

said sensing device is configured to detect magnitude and position of the mechanical interaction when applied.

2. A sensor according to claim 1, wherein said sensing device is configured to detect magnitude and position in three dimensional Cartesian axes.

3. A sensor according to claim 1 or claim 2, wherein said sensing device is a single point pressure sensor.

4. A sensor according to claim 3, wherein said single point pressure sensor comprises a quantum tunnelling composite material.

5. A sensor according to any one of claims 1 to 4, wherein said cavity comprises four side walls and a bottom wall, each said wall having one said sensing device attached thereto.

6. A sensor according to any one of claims 1 to 4, wherein said cavity comprises an elongate channel having two longitudinal side walls and a bottom wall, each said longitudinal side wall and said bottom wall comprising one said sensing device.

7. A sensor according to any preceding claim, wherein said contact element and said cavity each comprise mutually co-operating profiles.

8. A sensor according to any preceding claim, wherein said contact element comprises a v-shaped cross sectional profile.

9. A sensor according to any preceding claim, wherein said contact element comprises an elastomeric material.

10. A sensor according to any preceding claim, wherein said external surface comprises a moulded portion which comprises a finger-shaped profile.

11. A sensor according to any preceding claim, wherein said sensor is configured to detect an external object thereby providing a protective bumper.

12. A method of detecting an input force, comprising the steps of:

providing a sensor having a housing defining a cavity therein and a contact element enclosed by said cavity;

applying a mechanical interaction to an external surface of said contact element, said external surface and a top surface of said housing providing a substantially flush profile extending from said external surface to said top surface;

providing a physical contact between said contact element and a sensing device attached and aligned with an inner surface of a side wall of said cavity; and

detecting a force magnitude and a position of force along three axes of said mechanical interaction in response to said physical contact.

13. A method of detecting an input force according to claim 12, further comprising the step of: detecting an external object in contact with said sensor so as to provide a protective bumper.

14. A method of detecting an input force according to claim 12, wherein said step of applying a mechanical interaction involves providing a sliding force along said external surface.

15. A method of detecting an input force according to claim 12, wherein said step of applying a mechanical interaction involves providing a toggle function along said external surface.

16. A method of manufacturing a sensor for detecting input force, comprising the steps of:

producing a housing having a top surface;

providing said housing with a cavity comprising at least one wall;

aligning a sensing device against an inner surface of said at least one wall, said sensing device being configured to detect a magnitude of force and position of a mechanical interaction when the mechanical interaction is applied;

attaching said sensing device to said inner surface of said at least one wall; and

positioning a contact element into said cavity such that said contact element is enclosed by said cavity and such that an external surface of said contact element and said top surface provides a substantially flush profile extending from said external surface to said top surface;

said contact element being able to provide physical contact between said contact element and said sensing device on application of a mechanical interaction to said external surface.

17. A method of manufacturing according to claim 16, wherein in said step of positioning said contact element into cavity, said contact element is positioned so as to mutually co-operate with said cavity.

18. A method of manufacturing according to claim 17, wherein said contact element is produced to have a v-shaped cross sectional profile.