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(54) Title: IMPROVED MODULAR-TYPE SOLAR ENERGY COLLECTOR ELEMENT FOR TILES

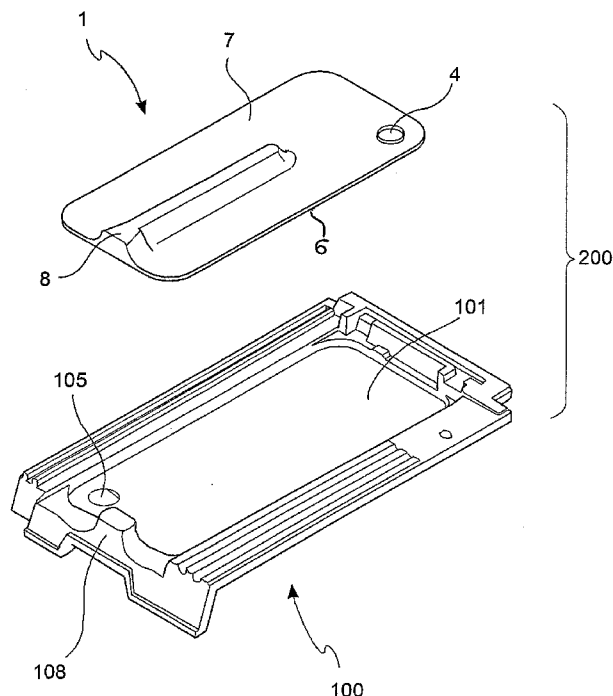


FIG. 24

(57) Abstract: A solar energy collector element (1), of a modular type, comprises a substantially plate-like body, having a first wall (6) and a second wall (7) facing one another and connected by a plurality of connecting portions so as to define an inner cavity, suitable to receive, hold and convey a thermal conductive fluid, cavity which mainly extends along a development plane substantially parallel to at least one of the two walls (6, 7); and at least one inlet duct (4) and an outlet duct for the inlet and the outlet, respectively, of the thermal conductive fluid to and from the cavity. Such solar energy collector element (1) has shape and dimensions suitable to make it housable in a single roofing tile (100) of a modular type, associable to other roofing tiles of a modular type for the covering of a roof; furthermore, the inner cavity of the solar energy collector element (1) is suitable to be put into communication with an inner cavity of at least one further solar energy collector element that is structurally analogous and arranged adjacent, by connection between the respective inlet (4) and outlet ducts, so as to define an enlarged volume for containing, conveying and heating the thermal conductive fluid.



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DESCRIPTION**IMPROVED MODULAR-TYPE SOLAR ENERGY COLLECTOR ELEMENT FOR
TILES**

The object of the present invention is a solar energy collector element. The object of the present invention is also a roofing tile of a modular type for roofs and a covering element for roofs.

Covering elements of such type aim to combine the functionalities of roof covering and solar collector.

Among the several types of known solar energy collector elements, there are some of a modular type and reduced dimensions, comparable or somewhat larger to those of a conventional roofing tile for roofs. For example, elements of this type are known, which are designed as "miniaturized" panels, comprising parallel tubes or serpentine tubes that are mounted on a base and covered by a transparent lid. These systems, although modular and with small dimensions, have some drawbacks: in fact, they result to be relatively complex to be manufactured and installed, leading to high costs in the case a whole roof is to be implemented on the basis of such elements. Furthermore, such solution is not satisfactory, and sometimes even unacceptable, from an aesthetical point of view, since such a roof considerably differs from a typical roof with roofing tiles.

On the other hand, a particular type of roofing tile is known, which is suitable to act as a solar energy collector per se. A hollow channel is provided within such roofing tile, which channel is located between the upper and the lower parts of the roofing tile itself. The hollow channel is, in turn, provided with an inlet opening and an outlet opening, respectively facing the

upper part and the lower part, so that the apertures of the covering elements that are mutually partially overlapped (i.e., of the roofing tiles forming the roof) can be connected, thus creating a continuous system of channels through which a thermal conductive liquid flows.

The already cited upper part and lower part of the covering element are made of two different materials as regards the thermal conductivity thereof: the material of the lower part is such as to have a low thermal conductivity, while the material of the upper part (for example, composed by sinterized minerals) is such as to have a high thermal conductivity. In this manner, the lower part acts as a thermal insulating layer, and prevents the heat irradiation downwardly, while the high thermal conductivity of the material of the upper part allows the transmission to the thermal conductive liquid of the heat that is produced by the solar irradiation.

A roofing tile of this type results to be satisfactory from an aesthetical point of view, since it is very similar to an ordinary roofing tile. However, it has considerable drawbacks, too: the heat transfer efficiency is not optimal, and results to be lower, for example, than the efficiency of a solar panel mounted on the roof. Furthermore, a roofing tile of the mentioned type has a considerable manufacturing complexity, especially depending on the different materials to be used for the manufacturing of the two parts of the roofing tile itself; consequently, the cost of such type of roofing tile results to be so high, in relation to the considered context of roofs' covering, to preclude the actual use of such solution.

The object of the present invention is to devise

and to provide a solar energy collector element (or simply "collector element", or "thermal exchange device"), as well as a particular roofing tile suitable to receive it, which are improved relative to the above-described prior art, and such as to allow, at least partially, to remedy the above-cited drawbacks with reference to the prior art.

Such object is achieved by a solar energy collector element in accordance with claim 1.

Further embodiments of such solar energy collector element are defined by the dependant claims 2-11.

A roofing tile with particular characteristics suitable to specifically house such solar energy collector element is defined by claim 12.

A covering element for roofs comprising the above-mentioned solar energy collector element and corresponding roofing tile is defined by claim 13.

Further embodiments of such covering element are defined by claims 14 and 15.

A roof using such covering element is defined by claim 16.

Further characteristics and advantages of the device according to the invention will result from the description reported below of preferred exemplary embodiments, given by way of non-limiting, indicative example, with reference to the annexed Figures, in which:

- Fig. 1 illustrates a perspective view of a solar energy collector element according to an example of the invention;
- Fig. 2 illustrates an exploded view of the collector element of Fig. 1;
- Fig. 3 and Fig. 4 illustrate a top and a bottom

orthogonal view, respectively, of the collector element of Fig. 1;

- Figs. 5, 6 and 7 illustrate three different sectional views of the collector element of Fig. 1, along three different sectional planes, indicated respectively in Fig. 3 as V-V, in Fig. 4 as VI-VI, and again in Fig. 3 as VII-VII;

- Fig. 8 illustrates an orthogonal top view of the lower sheet of the collector element of Fig. 1;

- Fig. 9 illustrates a sectional view of a bulge of the sheet of Fig. 8, along the plane IX-IX;

- Fig. 10 and Fig. 11 illustrate a perspective view and an exploded view, respectively, of a collector element according to a further example of the invention;

- Fig. 12 illustrates an exploded view of a collector element according to a further example of the invention;

- Fig. 13 illustrates an exploded view of a collector element according to a further example of the invention;

- Figs. 14, 15, 16, 17 illustrate, in a perspective bottom view, further collector elements according to further examples of the invention;

- Figs. 18 and 19 illustrate examples of bending of the perimetrical portions of the sheets comprised in a collector element according to an example of the invention;

- Fig. 20 illustrates a connecting sleeve between an outlet duct and an inlet duct of the thermal conductive fluid, belonging to two collector elements, according to an example of the invention;

- Fig. 21 illustrates a perspective view of a collector element according to a further example of the invention;

- Fig. 22 illustrates an exploded view of a collector element according to a further example of the invention;
- Fig. 23 illustrates a perspective view of a roofing tile for collector element according to an example of the invention;
- Figs. 24, 25 and 26 illustrate, respectively, an exploded view, an assembled view, and a sectional view of a covering element according to an example of the invention;
- Figs. 27 and 28 illustrate an exploded view and an assembled view, respectively, of a covering element according to a further example of the invention;
- Fig. 29 illustrates a sectional view of a covering element according to a further example of the invention;
- Fig. 30 illustrates a sectional view of a covering element according to a further example of the invention;
- Fig. 31 illustrates a sectional view of a covering element according to a further example of the invention;
- Fig. 32 illustrates a perspective view of a plurality of covering elements according to an example of the invention;
- Fig. 33 illustrates a side view of a plurality of adjacent covering elements installed on a roof, according to an example of the invention.

With reference to Figs. 1 to 9, an example of solar energy collector element (or also simply "collector element") 1 according to an example of the invention is now described.

Such collector element 1 is suitable to heat a thermal conductive fluid, for example, water, directly intended to the use or to the heat exchange with a further fluid.

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The collector element 1 comprises a substantially plate-like body 2 (indicated in Fig. 1), having an inner cavity 3 (or inner volume), visible in particular in Figs. 5, 6, 7, suitable to receive, to contain and to convey a thermal conductive fluid.

The collector element 1 also comprises an inlet duct 4 and an outlet duct 5, arranged to allow the inlet and outlet, respectively, of the thermal conductive fluid to and from the cavity.

Furthermore, the collector element 1 comprises a first wall 6 (for example, a first sheet indicated with the references 6, 16, 26, 36, 96 in Figs. 1 to 9, 10 to 13, and 22; or a first wall 86, in Fig. 21), and a second wall 7 (for example, a second sheet indicated with the references 7, 17, 27, 37, 97 in Figs. 1 to 9, 10 to 13, and 22; or a second wall 87, in Fig. 21), facing one another. Such first wall 6 and second wall 7, as will be illustrated below, are mutually connected by a plurality of connecting portions.

It shall be observed that in the embodiment illustrated in Figs. 1 to 9, and in the embodiments shown in Figs. 10 to 13, and 22, the body 2 is implemented by a first sheet and a second sheet, which are manufactured separately and subsequently connected. Instead, in the embodiment illustrated in Fig. 21, the first wall and the second wall (86, 87) are obtained from a body in a single piece.

Advantageously, the body 2 and the corresponding inner cavity 3 mainly extend along a development plane that is substantially parallel to at least one, or preferably to both (as illustrated, for example, in Fig. 1), the walls 6 and 7.

Advantageously, furthermore, the inlet 4 and outlet 5 ducts extend in a direction that is substantially perpendicular to that of the development plane of the cavity, as illustrated particularly in Figs. 1, 5 and 7. In fact, such geometry is suitable to make the collector element 1 to cooperate modularly in a proper manner with analogous collector elements 1', of an analogous modular type, as will be described below.

Suitably, the collector element 1, on a portion of the upper part thereof, has a rib 8 suitable to cooperate with a special supporting structure that, as illustrated below, will be the roofing tile according to the present invention.

Referring now in particular to Fig. 2, it shall be noticed that the collector element 1 comprises a first sheet 6, provided with the inlet duct 4, and a second sheet 7, provided with the outlet duct 5.

The first 6 and the second 7 sheets substantially extend along a plane.

In accordance with an embodiment, the first 6 and the second 7 sheets have a substantially rectangular shape.

According to an embodiment, the first 6 and the second 7 sheets have surfaces of the order of size of tens of dm^2 , preferably between 5 and 8 dm^2 , and perimeters of the order of size of dm, preferably between 10 and 15 dm.

Advantageously, the first 6 and second 7 sheets are of a metal material, even inexpensive, in particular of steel, or alternatively, aluminium or copper.

According to a further embodiment, the first 6 and second 7 sheets are in a synthetic material having a

properly high thermal conductivity.

The first 6 and the second 7 sheets result to be mutually connected by a plurality of connecting portions (indicated in Figs. 1 to 9 with the numeral references 9 and 10), so as to define the inner cavity 3 of the collector element 1 suitable to receive, to contain and to convey a thermal conductive fluid.

The inner cavity 3 is substantially determined by two surfaces facing one another, therefore definable as inner surfaces, of the first 6 and the second 7 sheets, respectively. In this manner, the inner cavity results to mainly extend along a development plane that is parallel to the development plane of the two sheets 6 and 7.

The sheet 6 is so arranged as to constitute the upper part of the body of the collector element 1; therefore, the outer surface of the sheet 6, i.e., the surface opposite the already cited inner surface of the same sheet 6, is suitable to be exposed to the solar irradiation and to collect the heat thereof.

The sheet 7 is arranged as to constitute the lower part of the body of the collector element 1; therefore, the outer surface of the sheet 7, i.e., the surface opposite the already cited inner surface of the same sheet 7, is suitable to be put in contact with the proper roofing tile, according to the present invention, which will be illustrated below.

It shall be noticed that in Figs. 2 and 3 the outer surface of the sheet 6 and the outer surface of the sheet 7, i.e., the upper outer surface and the lower outer surface, respectively, of the body 2 of the collector element 1 are visible.

Referring now to the plurality of connecting

portions between the first 6 and the second 7 sheets, it results to be comprising a first connecting portion 9 (indicated in Fig. 1 and further illustrated in Figs. 18 and 19) and second connecting portions 10 (indicated in Figs. 2, 4, 6, 8, 9).

The first connecting portion 9 extends along the perimetrical edge of the first sheet 6 and the second sheet 7.

It shall be noted that the first connecting portion 9 is suitable to ensure that the first 6 and the second 7 sheets, once they have been assembled one to the other, define the inner cavity 3, suitable to contain the thermal conductive fluid, of the body 2 of the collector element 1, so that such body 2 results to be fluid-tight.

Therefore, such first connecting portion 9 is so implemented as to ensure the above-mentioned property in the presence of different possible working conditions of the collector element 1, for example, while fluid pressure and temperature levels occurs, such as those expected under the standard operative condition of the collector element 1.

According to an embodiment, the first connecting portion 9 comprises a sealing profile along the whole perimetrical edge of the sheets 6 and 7.

In accordance with an embodiment, such sealing profile is implemented by means of a perimetrical outer welding seam between the first 6 and the second 7 sheets.

According to an embodiment, illustrated in Fig. 18, the sealing profile is obtained by a shaping and a mutual welding of the first 6 and the second 7 sheets. In the illustrated example, the shaping of the upper sheet 6 consists in a downward 90° bend of a peripheral perimeter

portion of the sheet 6; while the shaping of the lower sheet 7 consists in an upward 90° bend of a peripheral perimeter portion of the sheet 7.

According to a further embodiment, described in Fig. 19, the sealing profile is obtained by a shaping and a mutual connection, for example by sealing with silicone, of the first 6 and the second 7 sheets. In this case, the kind of 90° bending of the sheets is such that the folded portions are mutually adjacent along the whole height of the perimeter sealing profile, and the folded portion of one of the two sheets is located towards the interior of the cavity 3, and internally with respect to the folded portion of the other sheet.

In accordance with different embodiments, further different folding geometries and further different connection methods of the two sheets can be used.

With particular reference to Figs. 2, 4, 6, 8, and 9, the second connecting portions 10 shall now be regarded, which result to be arranged within the inner cavity 3 of the collector element 1.

Particularly, the second connecting portions 10 result to be preferably distributed, in the illustrated examples, on the second sheet 7.

From a structural point of view, the plurality of second connecting portions which the second sheet 7 is provided with comprises bulges 10, i.e., portions projecting from a base plane, corresponding to the surface of the sheet itself, towards the inner cavity 3 of the body 2 of the collector element 1, such as illustrated, particularly, in the sectional view of Fig. 6.

In particular, the bulges 10 result to be

preferably raised with respect to the base plane of the second sheet 7 so that they extend upwards in the direction of the first sheet 6.

The section of one of the bulges 10, in one embodiment, is illustrated in Fig. 9, with reference to the section plane IX-IX indicated in Fig. 8.

The bulges 10 are indicated also in Figs. 2 and 8. In this regard, it shall be noticed that the bulges 10 are to be intended as "recessed" (or "concave") in the view of Fig. 2, which shows the sheet 7 outer surface; while they are to be intended as "projecting" (or "convex") in Fig. 8, which shows the sheet 7 inner surface.

The bulges 10 can be obtained by means of operations of a known type, such as moulding, lamination, drawing, or hydroforming.

From a morphological point of view, the bulges 10, sectioned by a plane parallel to the sheet 7, are preferably circular and occupy a surface ranging between 10% and 50%, more preferably between 20% and 25%, of the total surface of the sheet 7 itself. They are arranged according to a preferred geometry having a regular triangular basic element.

The bulges 10 preferably have a diameter of the order of size of the centimetres, and more preferably ranging between 0.5 cm and 3.5 cm, and height of the order of size of the millimetres, preferably ranging between 0.5 mm and 4.5 mm.

In another implementation example, not shown in the Figures, the second connecting portions 10 are distributed on the first sheet 6. In this case, they result to be preferably raised relative to a base plane

of the first sheet 6 so as to extend downwards and towards the second sheet 7.

In another implementation example, not shown in the Figures, the second connecting portions 10 are preferably distributed both on the first 6 and on the second 7 sheets. In this case, they result to be raised from both base planes of the first 6 and second 7 sheets, so that the bulges 10 of the first sheet 6 extend towards the second sheet 7 and the bulges of the second sheet 7 extend towards the first sheet 6. Furthermore, it shall be observed that, in this case, the bulges 10 of the first 6 and the second 7 sheets are preferably aligned in directions that are perpendicular to the respective base planes.

In accordance with an embodiment, the second connecting portions 10 are obtained at such bulges by, for example, punctual welding.

According to an embodiment, the second connecting portions 10 cooperate with the first connecting portion 9, in order to ensure the connection between the sheets 6 and 7.

By suitably arranging the bulges 10 on the inner surface of one or both the sheets 6 and 7, a suitable gap can be obtained between the same sheets, preferably of the order of size between 2 and 15 mm, and more preferably between 2 and 6 mm.

It shall be noticed that the second connecting portions 10 between the sheets 6 and 7 perform the further important function to have an influence on the kind of flow characterizing the flowing of the thermal conductive fluid. Particularly, the second connecting portions 10 are capable of deflecting continuously the

flow of the thermal conductive fluid, thus obtaining a double effect: a slowing down, on the whole, of the same flow, which is suitable to increase the energy transfer from the body of the collector element 1 to the thermal conductive fluid, and a homogenization of the fluid distribution within the cavity 3.

In fact, it shall be observed that, by selecting different sectional planes perpendicular to the sheets 6 and 7, the section of the cavity 3 results to be variable. For example, in the section along the plane V-V (in Fig. 5) and in the section along the plane VII-VII (in Fig. 7), the fluid does not encounter obstacles, and tends to distribute uniformly. On the contrary, in other sections, for example, in the section along the plane VI-VI (in Fig. 6), the fluid is deflected by the bulges 10 projecting within the cavity 3 and shaping it in a particular manner.

In this manner, therefore, the second connecting portions 10 (i.e., the bulges 10, in the illustrated examples) implement an easy and efficient way to impose a "sinuous" path to the thermal conductive fluid, without having to manufacture complex tortuous or serpentine tubes.

On the other hand, further embodiments of a collector element 1 according to the present invention provide for a different inner shaping of the cavity 3, determined by bulges with morphologies that are different compared to those hereto illustrated.

For example, as illustrated in Fig. 14, a bulge 40 can be obtained on a sheet so as to have a "continuous" and serpentine-like development; or, as shown in Fig. 15, the bulges 50 can be bar-shaped parallel segments, of

different length; or again, as illustrated in Fig. 16, the bulges 60 can be implemented by alternating long segments and pairs of short segments; or, as shown in Fig. 17, the bulges 70 can be implemented as mutually non-parallel segments; or again, in non-shown embodiments, the bulges are of a rhomboidal, almond-like, rectangular shape.

According to a further embodiment, not shown, of the collector element 1, the body 2 comprises a single one sheet suitably folded on itself along an axis defined on the sheet itself, to form an upper portion and a lower portion that are quite similar to the first and the second sheets, respectively, described before. The plurality of connecting portions (bulges) can be distributed on one or both the portions of the folded sheet.

Referring now to Figs. 10 and 11, a collector element is described, indicated with the reference 11, according to a further example of the invention.

The collector element 11 comprises a first sheet 16, suitable to be exposed to solar irradiation and therefore operating as a sheet for the collection of heat, and a second sheet 17, provided with bulges 20, and therefore operating as a sheet for the deflection of the thermal conductive fluid.

The collector element 11 is completely similar to the collector element 1 described in Fig. 1, except for the fact that it does not provide for a raised rib 8 on the upper part of its first sheet 16. Such collector element 11 is such as to minimize its size perpendicular to the development plane of its sheets, so as to adapt to a different type of roofing tile.

Referring now to Fig. 12, a collector element 21 according to a further example of the invention is described. The collector element 21 is completely similar to the collector element 11 described in Fig. 10, except for the fact that it has a pair of inlet ducts 24 (instead of a single inlet duct) to allow the thermal conductive fluid to enter the collector element 21 inner cavity; and a pair of outlet ducts 25 (instead of a single outlet duct) to allow the thermal conductive fluid to exit the collector element 21 inner cavity.

Fig. 13 illustrates a collector element 31, according to another example of the invention, analogous to the above-mentioned element 11 of Fig. 10, except for the fact that the inlet duct 34 and the outlet duct 35 have sections of elongated shape, instead of a circular one.

In accordance with further embodiments, not shown, the collector element has more than two inlet ducts.

In accordance with further embodiments, not shown, the collector element has more than two outlet ducts.

In accordance with further embodiments, not shown, the collector element has inlet ducts with sections of a different shape, for example, ellipsoidal, polygonal, and so on.

In accordance with further embodiments, not shown, the collector element has outlet ducts with sections of a different shape, for example, ellipsoidal, polygonal, and so on.

With reference to Fig. 21, a collector element 81 according to a further example of the invention is now described. The collector element 81 has a body formed in a single piece, for example, by blowing or thermoforming

or injection of synthetic material in one or more suitable mould, which methods are per se known. In it, furthermore, the first connecting portion between the walls along the whole perimetrical edge is obtained thanks to the fact that the body of the collector element 81 is in a single piece. It shall be noted that also the inlet 84 and outlet 85 ducts are manufactured integrally to the above-mentioned single piece. In addition, such inlet 84 and outlet 85 ducts have a shape such as to allow the direct geometrical coupling thereof, as will be illustrated below.

It shall be noticed that for the other aspects, except for the above-mentioned aspects, the collector element 81 is analogous to the collector element 11 described in Figs. 10 and 11. Particularly, it has an inner cavity in which bulges 80 (not shown in Fig. 21) are present, which are completely similar, morphologically and functionally, to the bulges 20 of Fig. 11.

In accordance with a further embodiment, illustrated in Fig. 22, the collector element 91 is made of a synthetic material starting from two distinct walls 96, 97, which are mutually welded by ultrasounds or other welding techniques.

According to a further embodiment, the collector element according to the invention is implemented as a thermal exchange device including an inner volume, suitable to hold a fluid, an inlet duct, suitable to allow the supply of the fluid to the inner volume and, in addition, an outlet duct, suitable to allow the outlet of the fluid from the inner volume. Such thermal exchange device further comprises two sheets that are mutually

connected along a plurality of connecting portions defining the inner volume, which mainly extends along a development plane.

Considering a collector element according to the present invention, for example, the embodiment illustrated in Fig. 1, it shall be appreciated that such collector element has a shape with dimensions suitable to make it housable in a single roofing tile of a modular type, associable to other roofing tiles of a modular type for the covering of a roof.

The footprint of such element, comparable to the surface of the sheets 6 and 7, which, as already stated, amounts to some dm^2 , is compatible with the possibility to house such element in roofing tiles that are dimensionally quite similar to most of the roofing tiles typically used to cover roofs.

The substantially rectangular surface shape of such element is, in turn, morphologically suitable to the above-mentioned purpose.

The thickness of such element, which, as already stated, may be in the range of some millimetres, is such as to not disturb either aesthetically or functionally a roofing tile to which it is geometrically coupled.

The first sheet 6, as shown in Fig. 1, may have an upper rib 8 such as to follow, once it has been assembled on a suitable roofing tile, the profile of the roofing tile itself.

The adaptability of the collector element to a proper roofing tile, which is dimensionally compatible with commonly used roofing tiles, is a property that applies also to the other embodiments of a collector element according to the invention, for example, those

illustrated by way of non-limiting example in Figs. 10 to 19, 21, and 22.

A further particularly important aspect is the fact that the inner cavity of the solar energy collector element is suitable to be put into communication with the inner cavity of at least one further solar energy collector element structurally analogous and arranged adjacent, through a connection between the respective inlet and outlet ducts, so as to define an enlarged volume for containing, conveying and heating the thermal conductive fluid.

This property, related to the modularity of the collector element, is achieved, for example, thanks to the fact that the inlet and outlet ducts are arranged so as to allow the alignment with respective inlet and outlet ducts of an analogous solar collector element that is arranged adjacent. Such inlet and outlet ducts, as already illustrated, extend substantially perpendicularly to the development plane of the sheets; once they have been aligned, an inlet or outlet duct of a collector element and an outlet or inlet duct, respectively, of an analogous solar collector element that is arranged adjacent can be connected, for example, by the use of a connecting sleeve 79, as illustrated in Fig. 20.

It shall be noticed that the connecting sleeve 79 results to be advantageously manufactured in a synthetic material which fits well the thermal dilatation clearance to which the inlet and outlet ducts of the covering elements are subject.

In accordance with a further embodiment, such as, for example, the one shown in Fig. 21, the connection between an outlet duct and an inlet duct belonging to two

mutually adjacent collector elements is implemented by geometrical coupling between the outlet and inlet ducts, thanks to the particular shape of such ducts, which incorporate the connection function typical of a sleeve.

According to an embodiment, the collector element is painted in a black or dark colour, to increase the energy absorption efficiency thereof.

According to a further embodiment, the collector element is painted in a colour that is similar to that of a roofing tile on which it is housable, to improve the aesthetical appearance.

Referring now to Fig. 23, an exemplary embodiment of a roofing tile 100 that is object of the present invention is described.

It shall be noticed that the roofing tile 100 is completely similar as regards the dimensions, manufacturing material, aesthetics, to ordinary roofing tiles commonly used to cover roofs. Furthermore, it is a roofing tile of a modular type, associable to other modular roofing tiles to cover a roof, for example, by partial overlapping, according to different and known types of geometrical schemes.

On the other hand, it has peculiarities that make it suitable to house, and to be operatively associated to, a solar energy collector element, having a shape with dimensions suitable to make it housable in a single roofing tile of a modular type; particularly, to a collector element having a substantially plate-like body formed by two walls facing one another and mutually connected by a plurality of connecting portions, which define an inner cavity mainly extending along a development plane, suitable to receive, to contain and to

convey a thermal conductive fluid, which enters and exits the cavity through an inlet duct and an outlet duct with which said element is provided.

In particular, as illustrated in Fig. 23, the roofing tile 100 comprises a seat 101 suitable to receive by geometrical coupling at least one portion of the solar energy collector element body. In the shown example, the seat 101 has a surface and a height that are substantially equal or slightly greater than the surface and thickness of said collector element, and such seat is therefore arranged to hold the whole body of the collector element.

Furthermore, such geometrical coupling is improved by the profile 108, which is purposely arranged to be geometrically coupled to the rib 8 that is present in the collector element 1. Advantageously, such profile 108 is arranged in that part of the roofing tile 100 which is intended to be at the bottom, when the roofing tile is installed in an inclined roof.

In addition, as shown also in Fig. 23, the roofing tile 100 comprises a through hole (or, more simply, hole) 105, suitable to be geometrically coupled to the outlet duct 5 of a collector element 1 suitable to be housed in, and operatively associated to, the roofing tile 100.

It shall be noted that the hole 105, in the roofing tile 100, is suitably arranged in a peripheral portion, intended to be overlappable to a corresponding peripheral portion of an adjacent roofing tile, under the correct installation conditions in a roof. Particularly, the position of the hole 105 in the roofing tile 100 is exactly the one that allows the hole 105 to be overlappable to the inlet duct of the associable

collector element that is housable in said adjacent roofing tile.

According to an embodiment, the hole 105 is arranged near to a vertex of the roofing tile 100 edge.

The hole 105 has a preferably circular shape.

According to other embodiments, not shown, the hole 105 has shapes that are different from the circular one, for example, elongated, ellipsoidal, polygonal, so as to adapt in any case to the outlet duct of the collector element intended to be housed in the roofing tile, thus allowing a suitable coupling.

According to other embodiments, not shown, the roofing tile 100 comprises a plurality of holes, in such number as to be suitably coupled to a plurality of outlet ducts with which the collector element intended to be housed in the roofing tile may be provided.

The roofing tile 100 is preferably manufactured by brick material.

In accordance with an alternative embodiment, the roofing tile 100 is made of synthetic material.

According to further embodiments, the roofing tile 100 is made of other materials, such as, for example, metal materials, cement, or any other building material typically used to manufacture roofing tiles.

Further embodiments of a roofing tile according to the present invention, indicated with the references 110, 120, 130, 140, respectively, are illustrated in Figs. 27, 29, 30, 31, which will be described below.

With reference to Figs. 24, 25, and 26, a covering element for roofs 200 is now described, which is arranged for the transport of a thermal conductive fluid or liquid, according to an example of the invention.

The covering element 200 comprises a collector element 1, such as that illustrated in Fig. 1, and a roofing tile 100, such as that illustrated in Fig. 23. In the covering element 200, the collector element 1 is housed in the roofing tile 100; furthermore, the collector element 1 is operatively associated to the roofing tile 100 so that the collector element outlet duct results to be arranged in a position corresponding to the hole 105 of the roofing tile.

Particularly, as illustrated in Fig. 25, the collector element 1 results to be arranged above the roofing tile 100, i.e., arranged in contact with a surface of the roofing tile 100 opposite a resting surface of the same roofing tile on a building roof, on which the covering element 200 is installed.

The geometrical coupling between the collector element 1 and the roofing tile 100, in the covering element 200, is ensured by the housing of the collector element 1 in the proper seat 101 and by the coupling of the outlet duct 5 of the collector element 1 with the hole 105 of the roofing tile 100.

A further coupling can be further ensured by the geometrical coupling between the rib 8 of the collector element 1 and the profile 108 of the roofing tile 200, as shown in Fig. 24.

According to another embodiment, not shown, the coupling between the collector element 1 and the roofing tile 100 can be further favoured by the mutual engagement between one or more notches projecting from the housing 101 and one or more corresponding notches "dug" in the lower part of the collector element 1.

According to a further embodiment, illustrated in

Figs. 27 and 28, the covering element 210 comprises a roofing tile 110, analogous to the already described roofing tile 100 except for the fact that it does not provide for the profile 108; and further comprises a collector element 11, such as the one described in Fig. 10, and a tile 215.

The tile 215 has dimensions corresponding to those of the collector element 11, and is provided with a hole 216 intended to be geometrically coupled to the inlet duct 14 of the collector element 11. In this manner, the tile 215 can overlap the collector element 11, thus constituting a covering thereof.

On the other hand, the tile 215 is preferably manufactured with the same material of the roofing tile, for example, brick material, thereby constituting a camouflage finishing capable of making the covering element 210 exactly equal, from an aesthetical point of view, to a conventional roofing tile.

In accordance with a further embodiment, a covering element according to the invention comprises the roofing tile 110 and the collector element 11, but not the tile 215.

Referring now to Figs. 29, 30, and 31, further embodiments of the covering element, comprising the collector element 81 of the type shown in Fig. 22, are respectively illustrated by sectional views.

In the covering element 220 of Fig. 29, the collector element 81 overlap the roofing tile 120, which is provided with a suitable seat in the upper part thereof (analogous, for example, to the seat 101 of the roofing tile 100 of Fig. 24).

In the covering element 230 of Fig. 30, the

collector element 81 is arranged within the roofing tile 130, which results to be in this regard provided with an inner seat 131, suitable to house the collector element 81. In this case, the roofing tile 130 is further provided with a hole 135 arranged to receive the inlet duct 84 of the collector element 81.

In the covering element 240 of Fig. 31, the collector element 81 is placed below the roofing tile 140, i.e., arranged in a suitable seat 141, with which the roofing tile 140 is provided, arranged between the resting surface of the roofing tile 140 on the roof, and the roof itself. In this case, the roofing tile 140 is further provided with a hole 145 arranged to receive the inlet duct 84 of the collector element 81.

It shall be observed that, in the covering elements according to the present invention, to an embodiment of the collector element a corresponding embodiment of the roofing tile, intended to house said collector element, corresponds so that the collector element and the roofing tile cooperate in a suitable manner.

For example, if the collector element is provided with a plurality of outlet ducts of the thermal conductive fluid, with a given shape, the corresponding roofing tile will result to be preferably provided with a plurality of holes, of the same shape of the outlet ducts, each corresponding to a duct of the above-mentioned plurality of outlet ducts.

Furthermore, if the covering element is of the type illustrated in Figs. 30 and 31, and the collector element is provided with a plurality of inlet ducts of the thermal conductive fluid, with a given shape, the corresponding roofing tile will result to be preferably

further provided with a plurality of holes, of the same shape of the inlet ducts, each corresponding to a duct of the above-mentioned plurality of inlet ducts.

Referring now to Figs. 32 and 33, the way by which adjacent covering elements, which are completely similar to one another (for example, 200 and 200', or 200' and 200'') are suitable to cooperate with one another is illustrated, similarly to what has been already described with reference to the collector elements that are housed therein.

Advantageously, under the desired installation conditions, the outlet duct 5 of the collector element 1 of the covering element 200 results to be overlapped to the inlet duct 4' of the collector element 1' of the covering element 200'; the outlet duct 5' of the collector element 1' of the covering element 200' results to be overlapped to the inlet duct 4'' of the collector element 1'' of the covering element 200''; and so on.

The assembling between two adjacent covering elements (for example 200 and 200', or 200' and 200'') can be implemented by the use of a connecting sleeve 79 (or 79', respectively) as already shown in Fig. 20.

In this manner, the thermal conductive fluid exiting the outlet duct 5 of the collector element 1 is allowed to leave the covering element 200 and to reach the inlet duct 4' of the collector element 1' comprised in the covering element 200' by free fall.

It shall be noted that mutually similar covering elements, including mutually similar collector elements, according to any one of the illustrated embodiments, can cooperate in an exactly analogous way to what has been described above for the covering element 200 comprising

the collector element 1.

Particularly, if the covering element has a plurality of inlet ducts and a plurality of outlet ducts, the number of the inlet ducts will be preferably equal to the number of the outlet ducts, so that an inlet element of an analogous adjacent covering element corresponds to each outlet duct of a covering element.

An example of operative conditions of a covering element for roofs according to the present invention is now described, with reference to Fig. 33 and to the embodiment illustrated in Figs. 1 and 24. However, it shall be noticed that such description applies to any one of the embodiments illustrated before.

The inlet and outlet ducts of each collector element 200, 200', 200'' are in communication, through the aid of the through holes that are present on the roofing tile, and create a continuous system of channels that, through the roof ridge (not reported in the Figure) is supplied with thermal conductive fluid. The latter, by flowing downwards (for example, by the action of gravity, also without the need of overpressure), is heated by the plurality of collector elements, which are in turn heated by solar radiation on the roof or by the heat of the surrounding environment.

In this regard, it is pointed out that the inlet and outlet ducts are to be arranged so that the fluid, by exploiting the force of gravity, may flow downwards. Once it has been heated, the thermal conductive fluid accumulates in a collection device (not shown in the Figure) placed at the roof lower end, and is subsequently conveyed to a special system such as, for example, a heat pump. Once the energy accumulated by the thermal

conductive fluid has been subtracted, the latter is again pumped up to the height of the roof ridge, then flowing again in the channel.

With reference to what occurs in each of the collector elements, the thermal conductive fluid enters the collector element 1 through the inlet duct 4. The thermal conductive fluid flows in the element inner cavity according to the gravitational gradient, and reaches the outlet duct 5. During the transit in the inner volume of the thermal exchange body, the thermal conductive fluid is continuously deflected by the connecting portions 10 (bulges), so as to create turbulences that "slow down" the transit through the thermal exchange body. During the transit time, the thermal conductive fluid acquires heat from the sheets, which are in turn heated, particularly, by solar irradiation.

It shall be noticed that the bulges expand the surface of the sheets, and therefore achieve a high thermal exchange also in the presence of relatively reduced plane dimensions.

As regards solar irradiation, it is pointed out that the sunbeams heat in particular the first sheet 6, which results to be preferably coloured in dark (black, or a colour that is similar to that of the covering body, for a mere aesthetic purpose) to better keep the solar irradiation. The first sheet 6, in turn, heats the second sheet 7 by contact along the connecting portions (bulges).

It shall be observed that, to the purposes of the present invention, by "solar energy" is meant the energy that can be directly or indirectly obtained from the sun-

heated environment. In fact, the collector element 1 is capable of picking up, besides the direct solar energy, also the "environmental" energy, for example related to rain, snow, wind, provided that the system on the whole comprises a suitable thermal pump and a suitable thermal exchanger.

Furthermore, it shall be noticed that the collector element 1 is capable of collecting energy not only by picking up the direct solar irradiation, but also by absorbing the thermal energy accumulated in the brick material constituting the covering element on the whole, in turn exposed to the sunbeams.

While keeping what has been set forth above into account, it is possible to understand the acceptable functionality level of the embodiments where the collector element is covered by the roofing tile itself (Figs. 30 and 31) or by a tile (Fig. 27). In such cases, of course, it is preferred that said roofing tile or said tile have a high thermal conductivity.

As it shall be noticed from the previous description, the collector element 1, the roofing tile 100, and the covering element 200 (or any one of the other different embodiments illustrated) have a number of advantages, and allow on the whole to overcome the set of above-mentioned drawbacks affecting the prior art.

In particular, the collector element 1 is modular, and easy to be manufactured.

Furthermore, the roofing tile 100, although it has to be "designed" in a suitable manner to be operatively associated to a particular collector element 1, is substantially analogous from the point of view of the manufacturing methods to a conventional (and relatively

not expensive) roofing tile for roofs.

Again, the assembling of the two modular elements set forth above (the collector element 1 and the roofing tile 100) in a further bi-functional modular element (the covering element 200) results to be easy, as it may be inferred from what has been described. It shall be noted that the covering element 200 is bi-functional, since it provides a covering function and a solar energy collection function.

In addition, the installation of a plurality of the above-mentioned covering elements to form an inclined roof is relatively easy, since the above-mentioned elements are modular, and the installation requires for a few and simple operations in addition to a conventional installation (for example, the assembling of inlet/outlet ducts by a sleeve; or, still more simply, in some embodiments, the geometrical coupling of an outlet duct and an inlet duct).

Furthermore, the suitable installation for a modular covering functionality ensures per se also a modular functionality of solar energy collection. In other words, the modularities of the collector element and the roofing tile are mutually "coupled", advantageously, in the sense that the series of roofing tiles that form the roof coverage acts per se as a duct for the transport of the thermal conductive fluid. More particularly, the installation of the covering elements according to the ordinary rules used in the implementation of the roofs involves, in the present invention, thanks to the peculiarities of the elements that are used, the possibility to implement large modular solar collectors, with predefined power and dimension,

characterized by large volumes for containing, conveying and heating a thermal conductive fluid, such volumes being composed of a number of cavities of individual collector elements that are mutually intercommunicating.

Finally, it shall be noticed that the covering elements according to the present invention can be used as a replacement of a plurality of different types of conventional roofing tiles, for example, for the covering of inclined roofs, and can be even used in a modular manner to replace conventional roofing tiles only in some areas of a roof, where it is more convenient.

To the embodiments of the solar collector element, the roofing tile, and the covering element described above, those of ordinary skill in the art, in order to meet contingent needs, will be able to make modifications, adaptations, and replacements of elements with functionally equivalent other ones, without departing from the scope of the following claims. Each of the characteristics described as belonging to a possible embodiment can be implemented independently from the other embodiments described.

CLAIMS

1. A solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91), of a modular type, comprising:

- a substantially plate-like body (2), having a first wall (6; 16; 26; 36; 86; 96) and a second wall (7; 17; 27; 37; 87; 97) facing one another and connected by a plurality of connecting portions (9, 10; 20; 40; 50; 60; 70; 80; 90), so as to define an inner cavity (3) suitable to receive, to contain and to convey a thermal conductive fluid, said cavity (3) mainly extending along a development plane substantially parallel to at least one of said first wall and second wall;

- at least one inlet duct (4; 4'; 4''; 14; 24; 34; 84) for the inlet of the thermal conductive fluid in said cavity (3); and at least one outlet duct (5; 5'; 5''; 15; 25; 35; 85) for the outlet of the thermal conductive fluid from said cavity (3);

said solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91) having shape and dimensions suitable to make it housable in a single roofing tile (100; 100'; 100''; 110; 120; 130; 140) of a modular type, associable to other roofing tiles of a modular type for the covering of a roof,

said inner cavity (3) of the solar energy collector element (1) being suitable to be put into communication with an inner cavity of at least one further solar energy collector element (1'; 1'') that is structurally analogous and arranged adjacent, by connection between the respective inlet (4; 4'; 4'') and outlet (5, 5'; 5'') ducts, so as to define an enlarged volume for containing, conveying and heating the thermal conductive fluid.

2. The collector element (81) according to claim 1,

wherein said body (2) is formed in a single piece.

3. The collector element (1; 1'; 1''; 11; 21; 31; 91) according to claim 1, wherein said body (2) is realized by a first sheet (6; 16; 26; 36; 96) and a second sheet (7; 17; 27; 37; 97), manufactured separately, and subsequently connected.

4. The collector element (1; 1'; 1''; 11; 21; 31; 81; 91) according to any one of the preceding claims, wherein the body (2) is in metal material or synthetic material.

5. The collector element (1; 1'; 1''; 11; 21; 31; 81; 91) according to any one of the preceding claims, wherein the plurality of connecting portions between the first wall (6; 16; 26; 36; 86; 96) and the second wall (7; 17; 27; 37; 87; 97) comprises a first connecting portion (9) extending along the perimetrical edge of said first wall and second wall.

6. The collector element (1; 1'; 1''; 11; 21; 31; 81; 91) according to any one of the preceding claims, wherein the plurality of connecting portions between the first wall and the second wall comprises second connecting portions (10; 20; 40; 50; 60; 70; 80; 90) arranged within the inner cavity (3) of the solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91).

7. The collector element (1; 1'; 1''; 11; 21; 31; 81; 91) according to claim 6, wherein said second connecting portions comprise bulges (10; 20; 40; 50; 60; 70; 80; 90), which are present on the inner surface of at least one of said first wall (6; 16; 26; 36; 86; 96) and second wall (7; 17; 27; 37; 87; 97), said bulges being suitable to deflect the thermal conductive fluid and to homogenize the flow thereof.

8. The collector element (1; 1'; 1''; 11; 21; 31; 81;

91) according to claim 7, wherein said bulges (10; 20; 40; 50; 60; 70; 80; 90) are on the surface of both the first wall and the second wall, said bulges being mutually connected so as to constitute said second connecting portions.

9. The collector element (1; 1'; 1''; 11; 21; 31; 81) according to any one of the preceding claims, wherein:

the at least one inlet duct (4; 4'; 4''; 14; 24; 34; 84) and the at least one outlet duct (5; 5'; 5''; 15; 25; 35; 85) of the thermal conductive fluid project from the first wall (6; 16; 26; 36; 86) and second wall (7; 17; 27; 37; 87), respectively, in a direction substantially perpendicular to the development plane of the cavity (3), said at least one inlet duct and at least one outlet duct being so arranged as to allow the alignment with respective inlet and outlet ducts of an analogous solar collector element that is arranged adjacent.

10. The collector element (1; 1'; 1''; 11; 21; 31) according to claim 9, wherein the connection between two corresponding aligned ducts, respectively belonging to two analogous adjacent solar energy collector elements, is implemented by a sleeve connection (79).

11. The collector element (81; 91) according to claim 9, wherein the two corresponding aligned ducts (84, 85), respectively belonging to two analogous adjacent solar energy collector elements, are suitable to be directly joined by geometrical coupling.

12. A roofing tile (100; 100'; 100''; 110; 120; 130; 140) of a modular type, associable to other modular roofing tiles for the covering of a roof, suitable to house a solar energy collector element (1; 1'; 1''; 11;

21; 31; 81; 91) having shape and dimensions suitable to make it housable in a single roofing tile of a modular type,

said solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91) comprising a substantially plate-like body (2), having a first wall (6; 16; 26; 36; 86; 96) and a second wall (7; 17; 27; 37; 87; 97) facing one another and connected by a plurality of connecting portions (9; 10; 20; 40; 50; 60; 70; 80; 90), so as to define an inner cavity (3) suitable to receive, to contain and to convey a thermal conductive fluid, said cavity mainly extending along a development plane that is substantially parallel to at least one of said first wall and second wall;

said solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91) further comprising at least one inlet duct (4; 4'; 4''; 14; 24; 34; 84) and at least one outlet duct (5; 5'; 5''; 15; 25; 35; 85) to allow the inlet and outlet of the thermal conductive fluid to and from said cavity (3), respectively; said inner cavity (3) being suitable to be put into communication with an inner cavity of at least one further solar energy collector element structurally analogous and arranged adjacent, by connection between the respective inlet and outlet ducts, so as to define an enlarged volume for containing, conveying, and heating the thermal conductive fluid;

being such roofing tile (100; 100'; 100''; 110; 120; 130; 140) characterized in that it comprises:

- a seat (101; 131; 141) suitable to receive by geometrical coupling at least one portion of the body (2) of the solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91);

- at least one hole (105; 135; 145) suitable to be

geometrically coupled to the at least one inlet duct (4; 4'; 4''; 14; 24; 34; 84) or the at least one outlet duct (5; 5'; 5''; 15; 25; 35; 85) of the solar energy collector element;

said at least one hole (105; 135; 145) being arranged so as to be overlappable to the at least one outlet duct (5; 5'; 5''; 15; 25; 35; 85) or the at least one inlet duct (4; 4'; 4''; 14; 24; 34; 84) of the associable solar energy collector element (1'; 1'') housable in a further roofing tile (100'; 100'') arranged adjacent.

13. A covering element (200; 200'; 200''; 210; 220; 230; 240) for roofs comprising:

- a solar energy collector element (1; 1'; 1''; 11; 21; 31; 81; 91) according to any one of the claims 1 to 11;

- a roofing tile (100; 100'; 100''; 110; 120; 130; 140) according to claim 12;

said roofing tile being operatively associated by geometrical coupling to said collector element.

14. The covering element (200; 200'; 200''; 210; 220) according to claim 13, wherein the collector element (1; 1'; 1''; 11; 21; 31; 91) is arranged above the roofing tile (100; 100'; 100''; 110; 120).

15. The covering element (230; 240) according to claim 13, wherein the collector element (81) is arranged internally to the roofing tile (130) or below the roofing tile (140).

16. A roof comprising a plurality of covering elements (200; 200'; 200''; 210; 220; 230; 240), according to any one of the claims 13 to 15, such plurality being suitable to constitute a modular solar energy collector with

predefined power and dimension.

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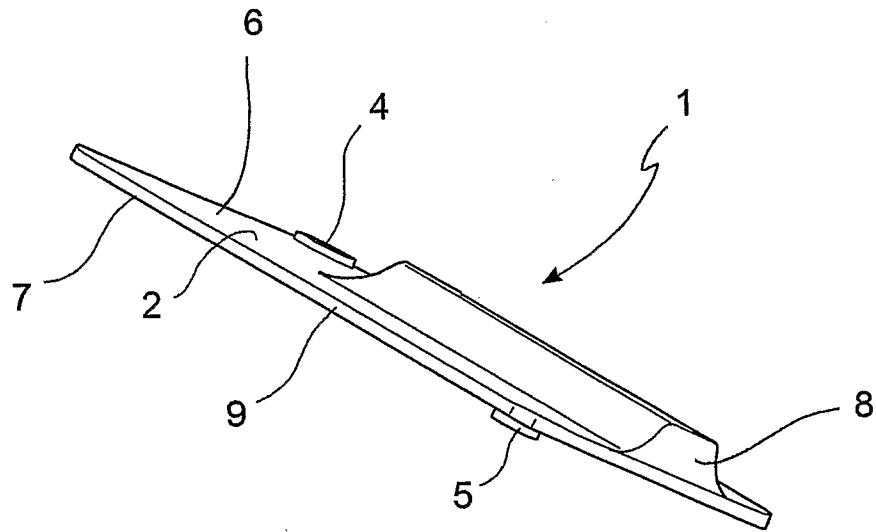


FIG. 1

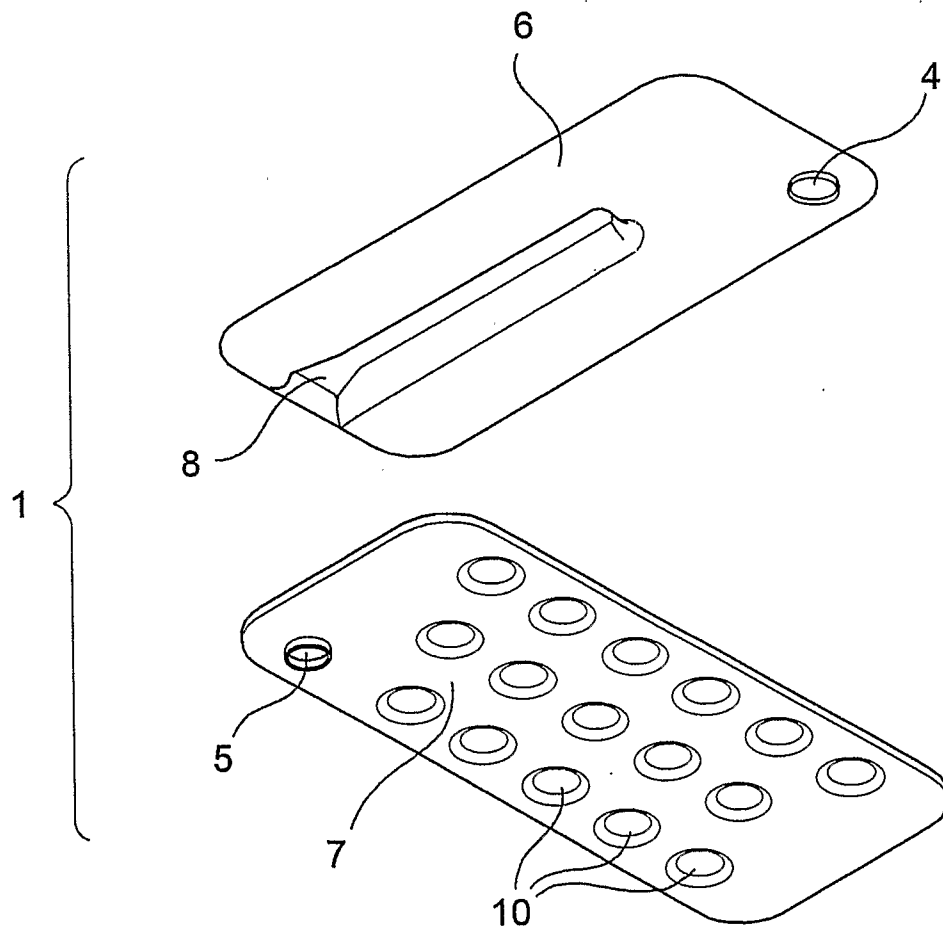


FIG. 2

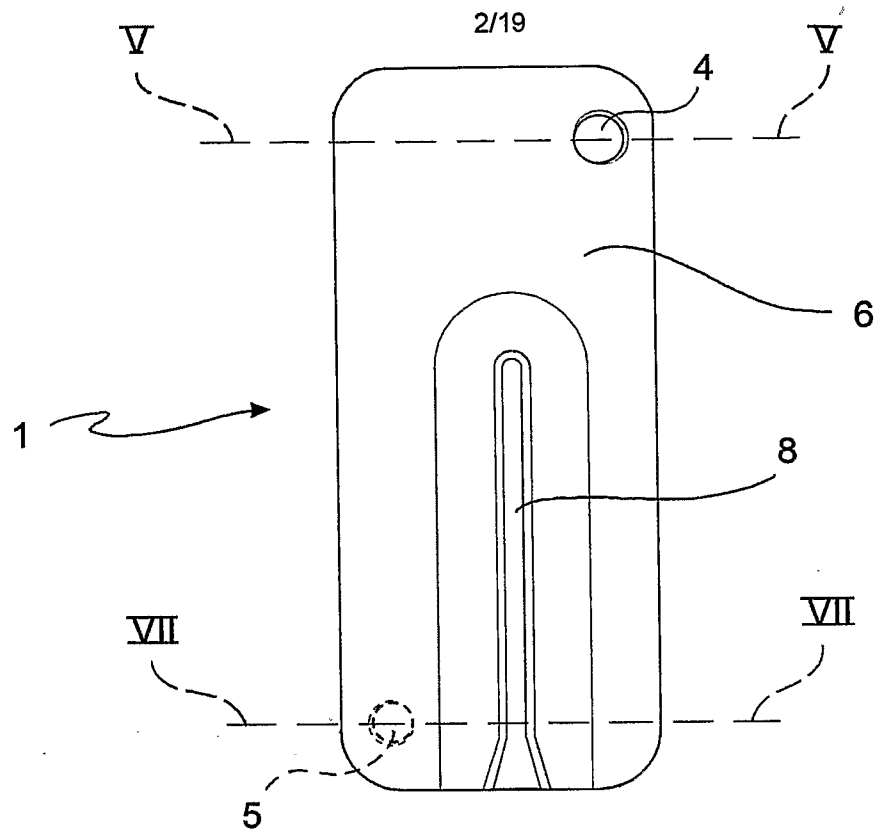


FIG. 3

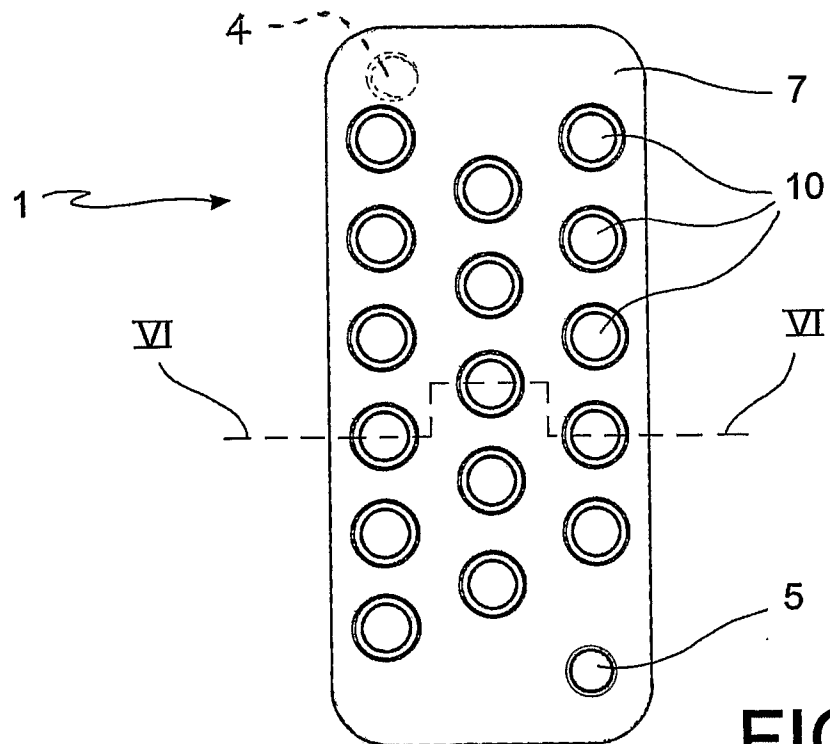


FIG. 4

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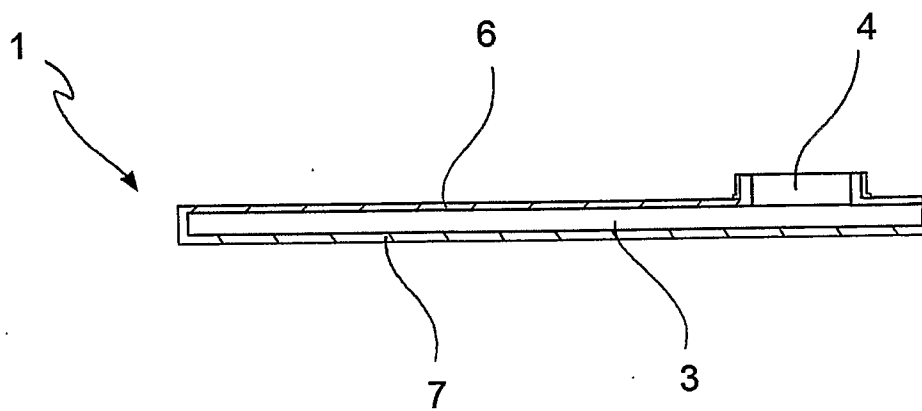


FIG. 5

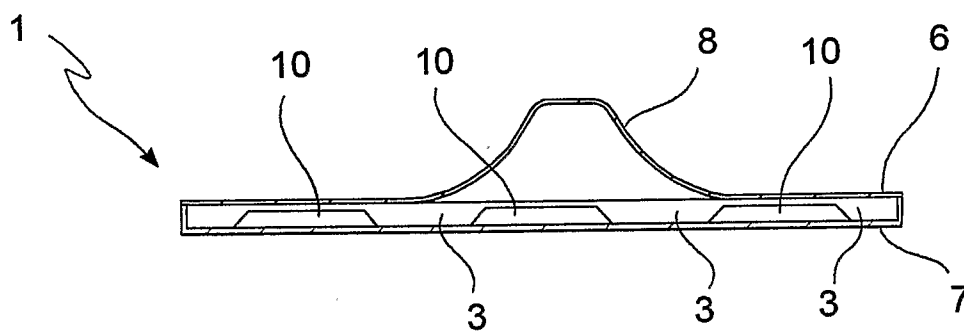


FIG. 6

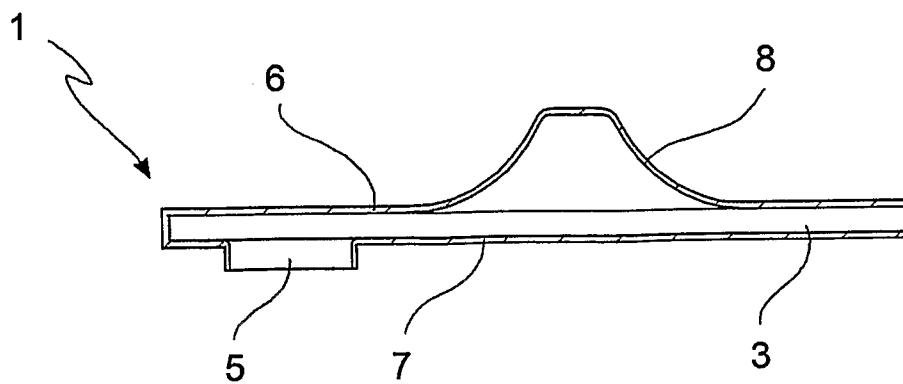


FIG. 7

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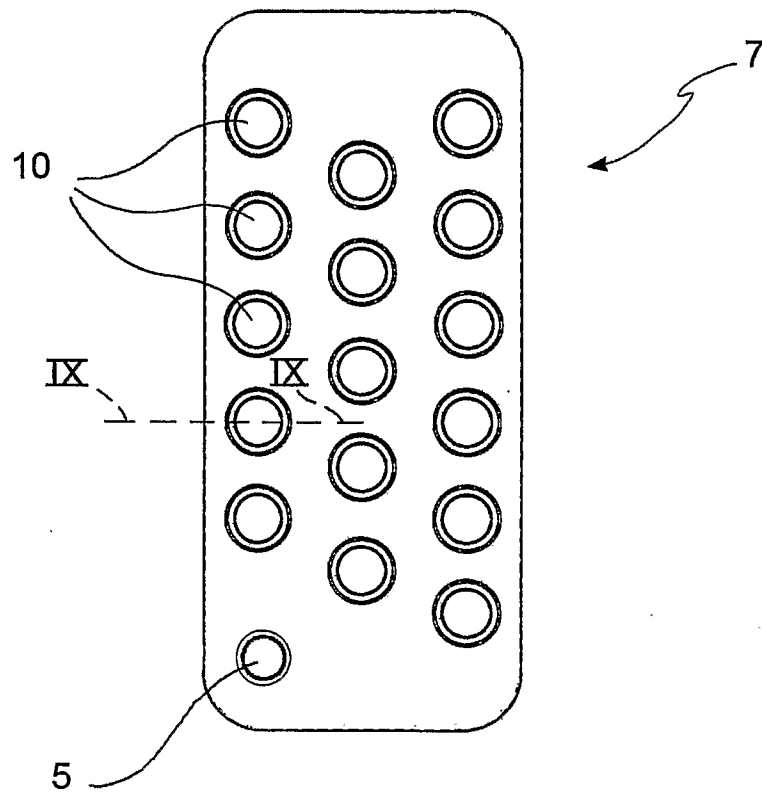


FIG. 8

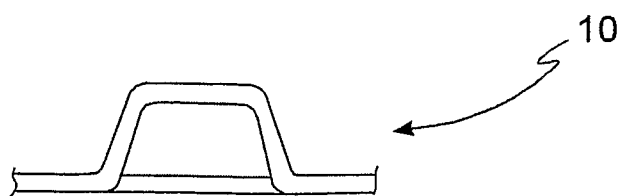


FIG. 9

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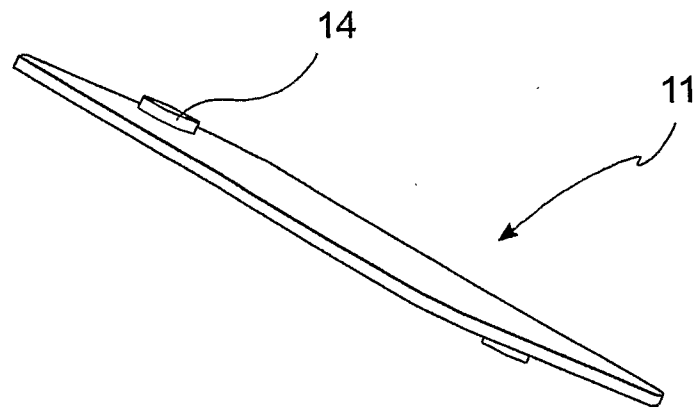


FIG. 10

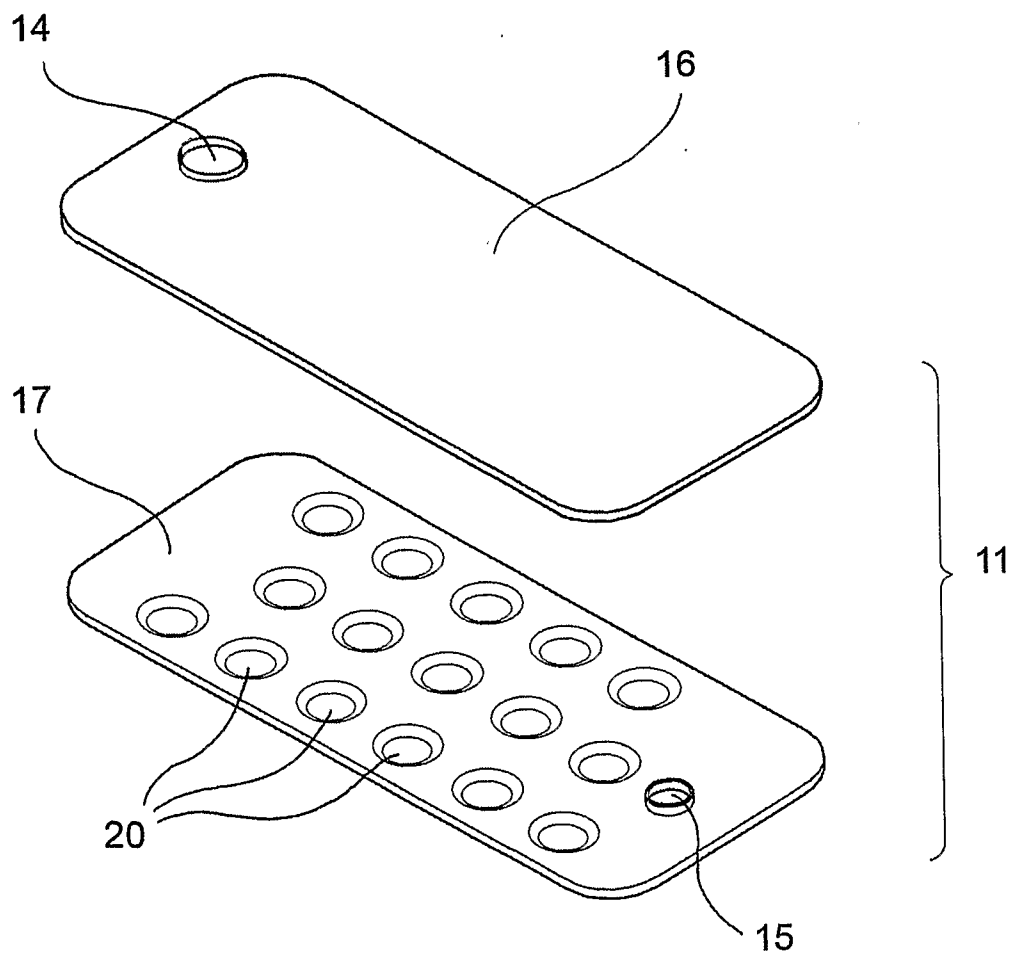


FIG. 11

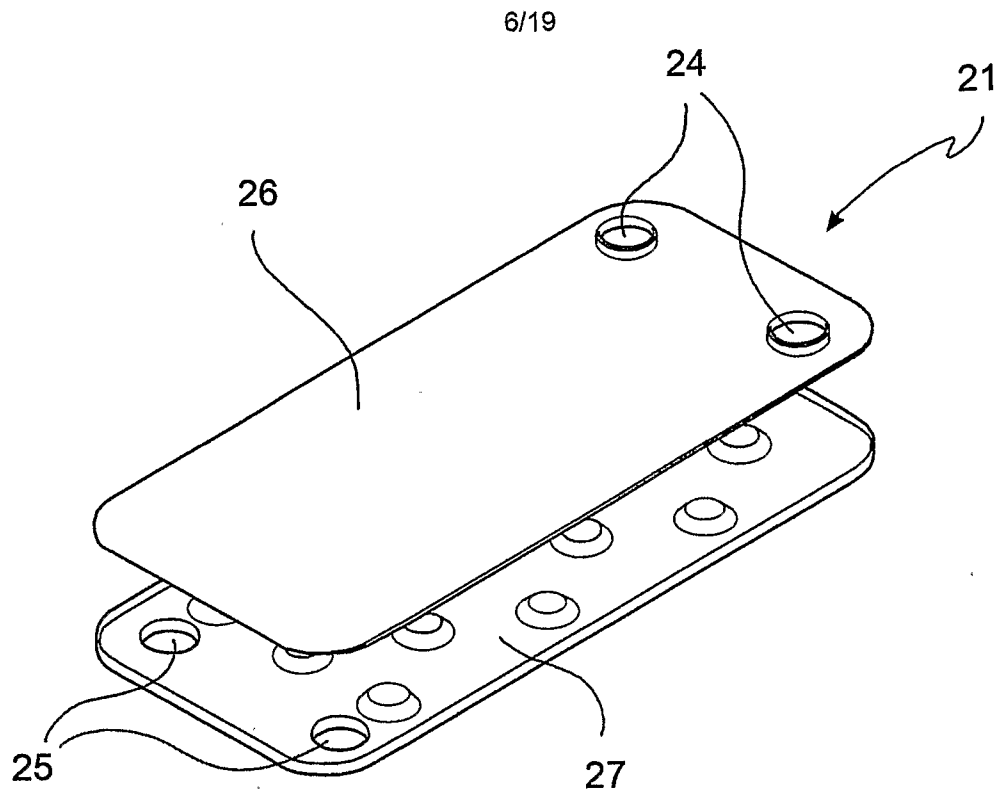


FIG. 12

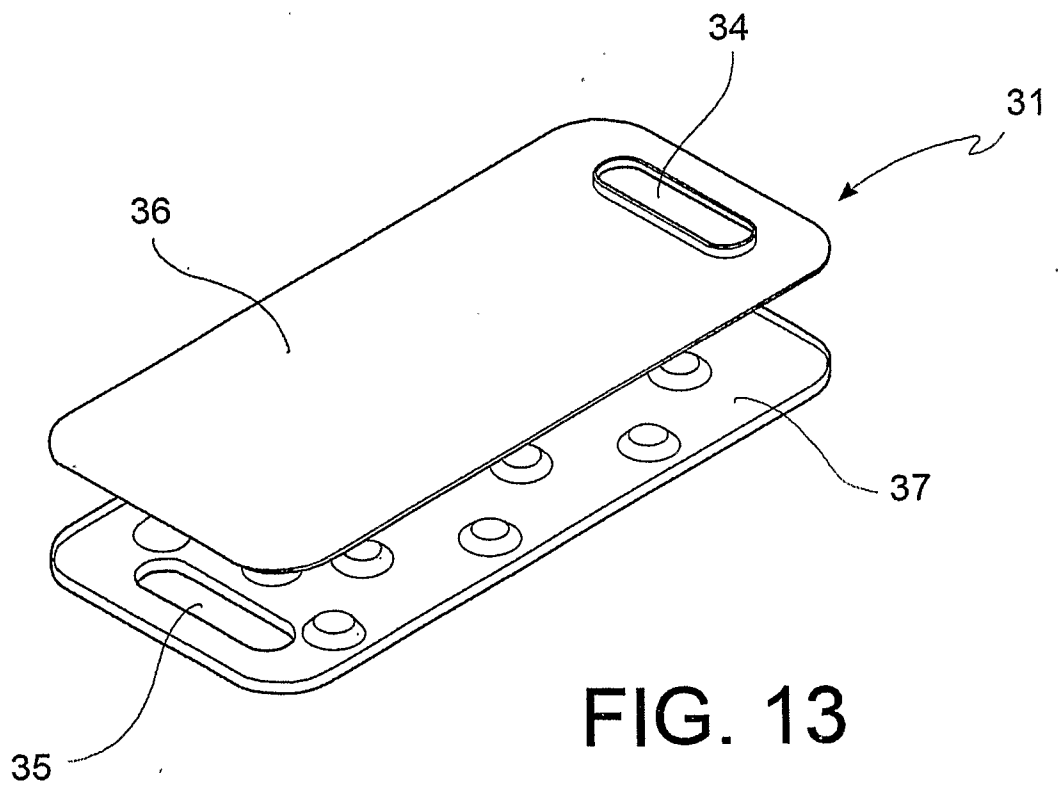


FIG. 13

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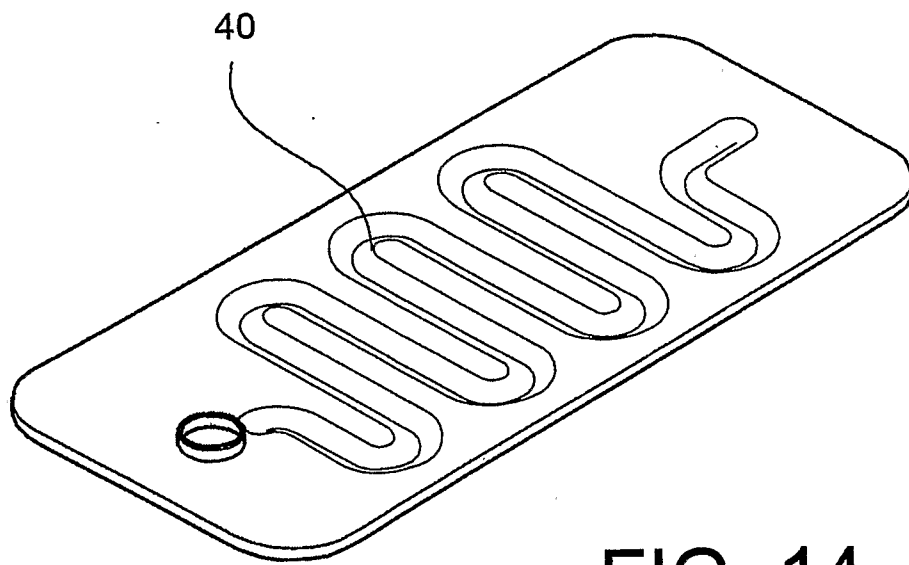


FIG. 14

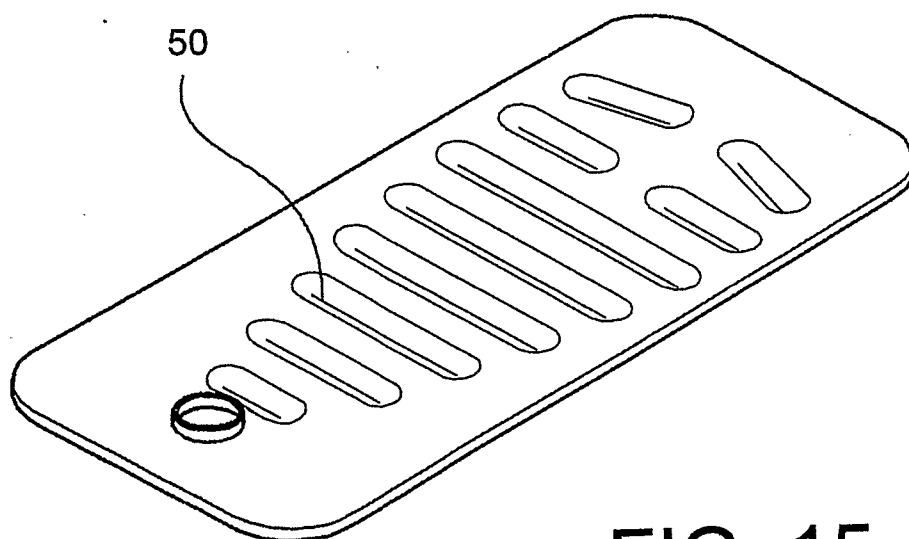
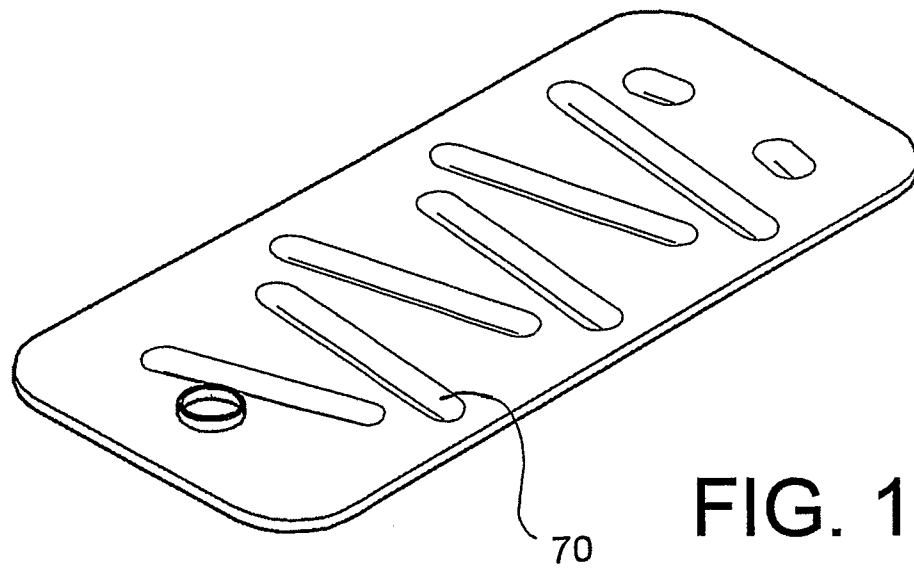
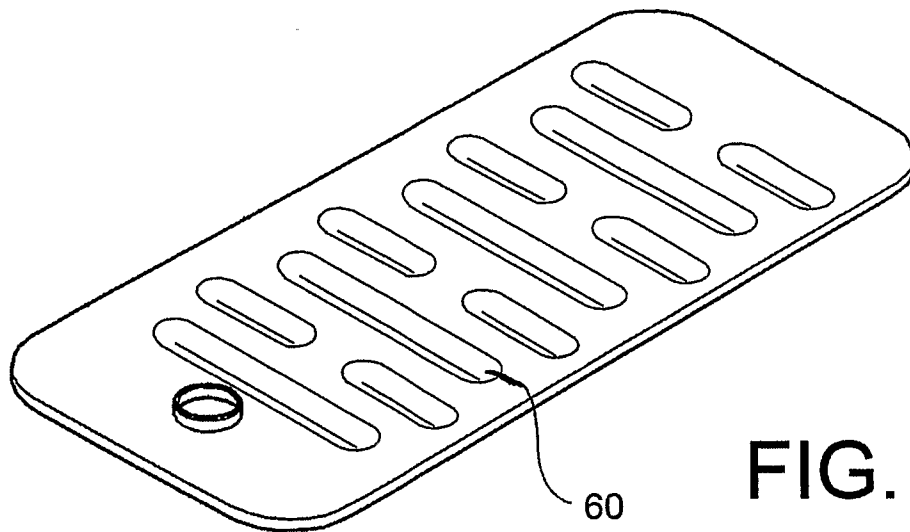


FIG. 15

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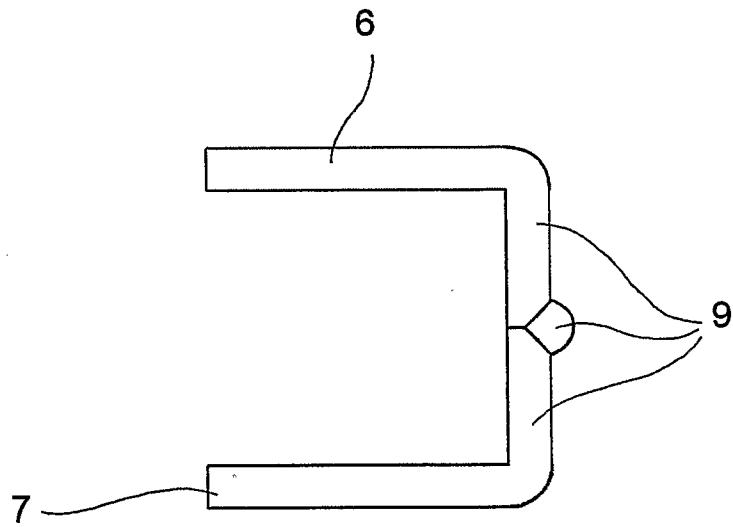


FIG. 18

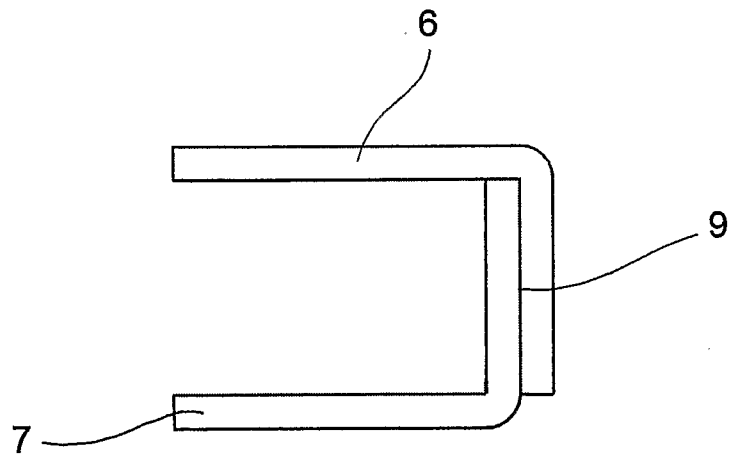


FIG.19

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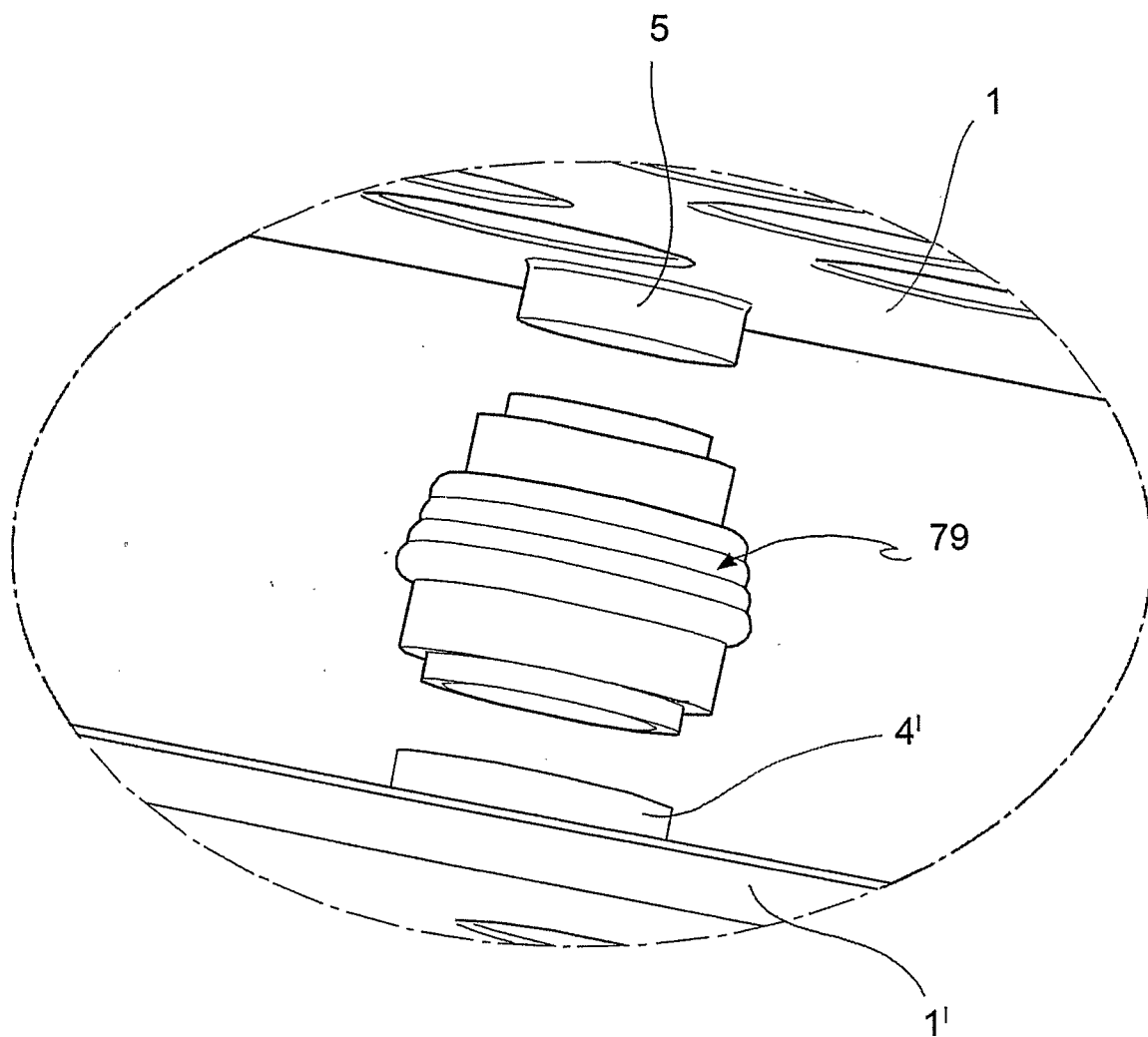
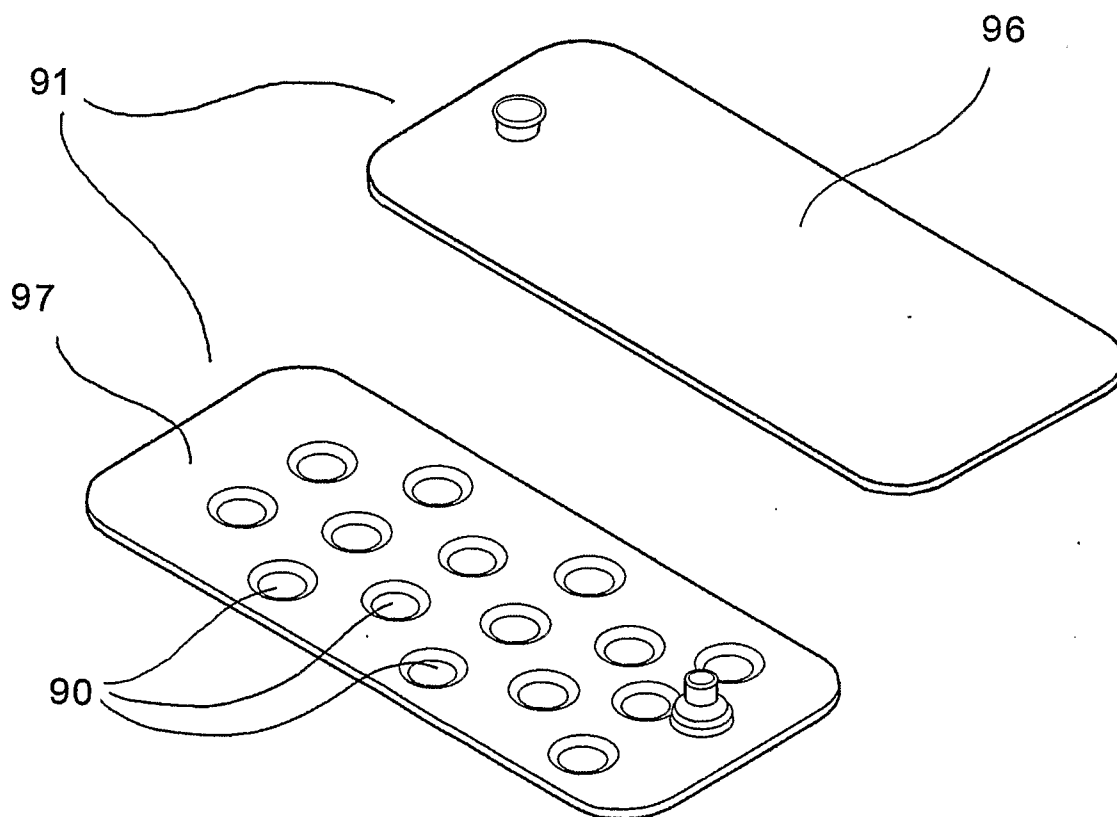
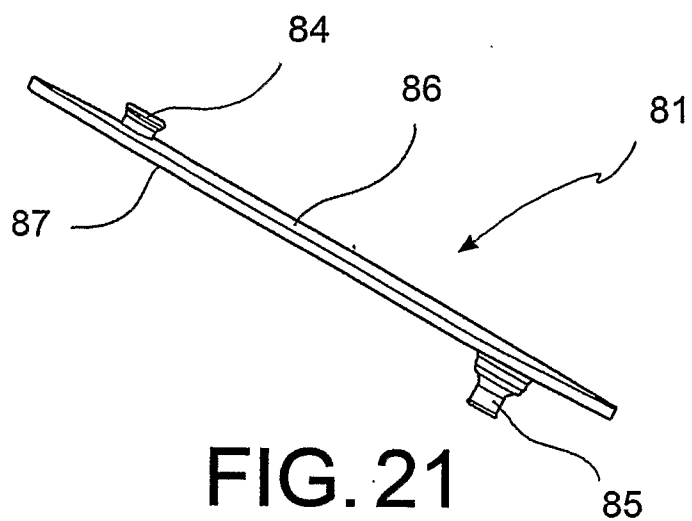


FIG. 20

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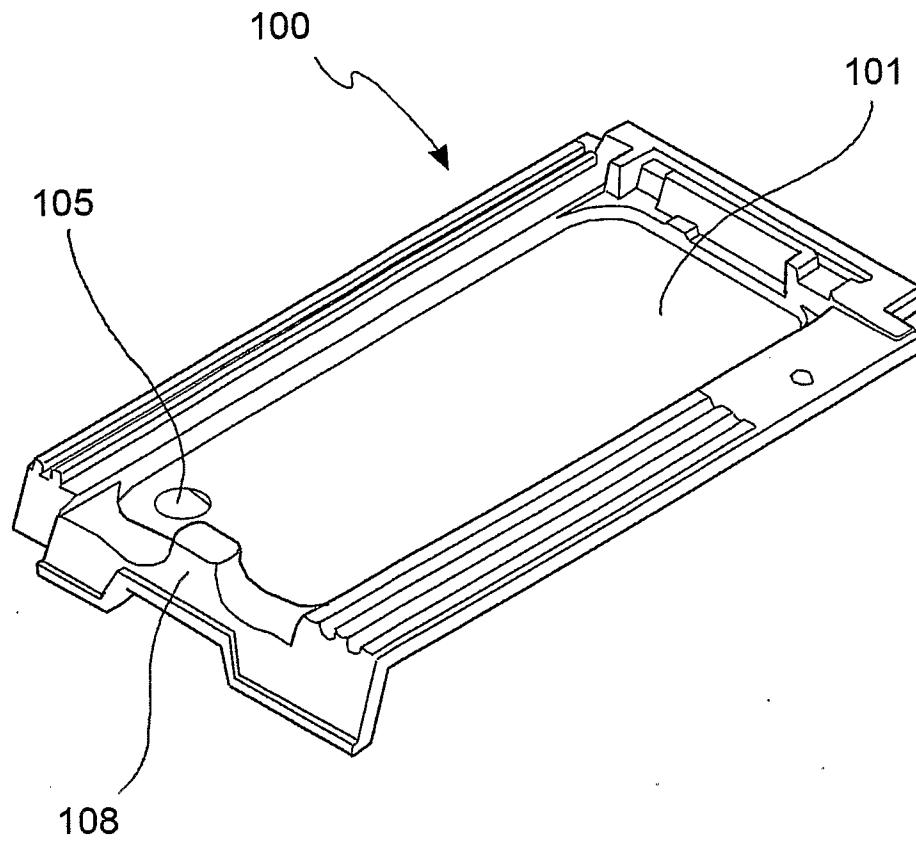


FIG. 23

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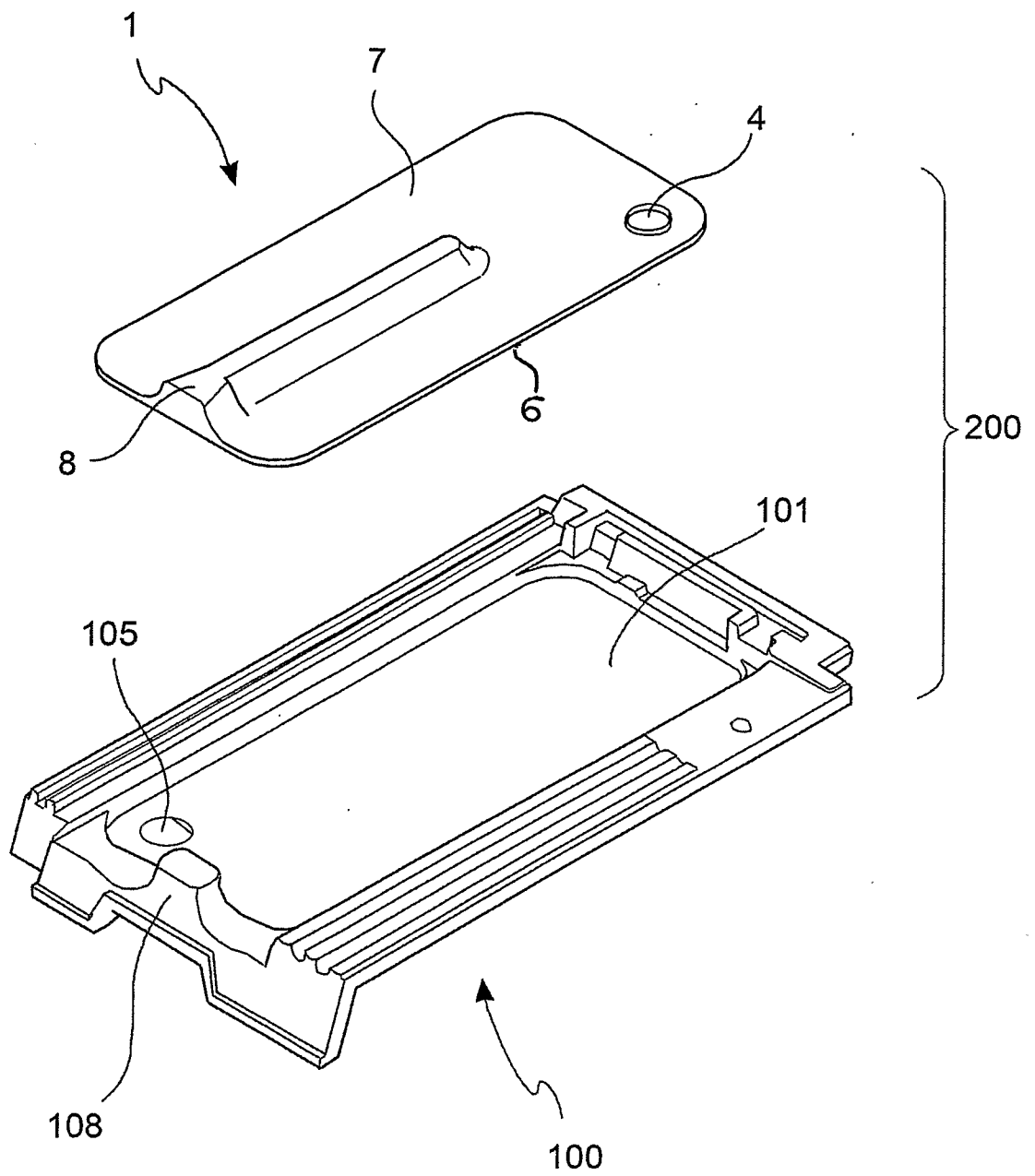


FIG. 24

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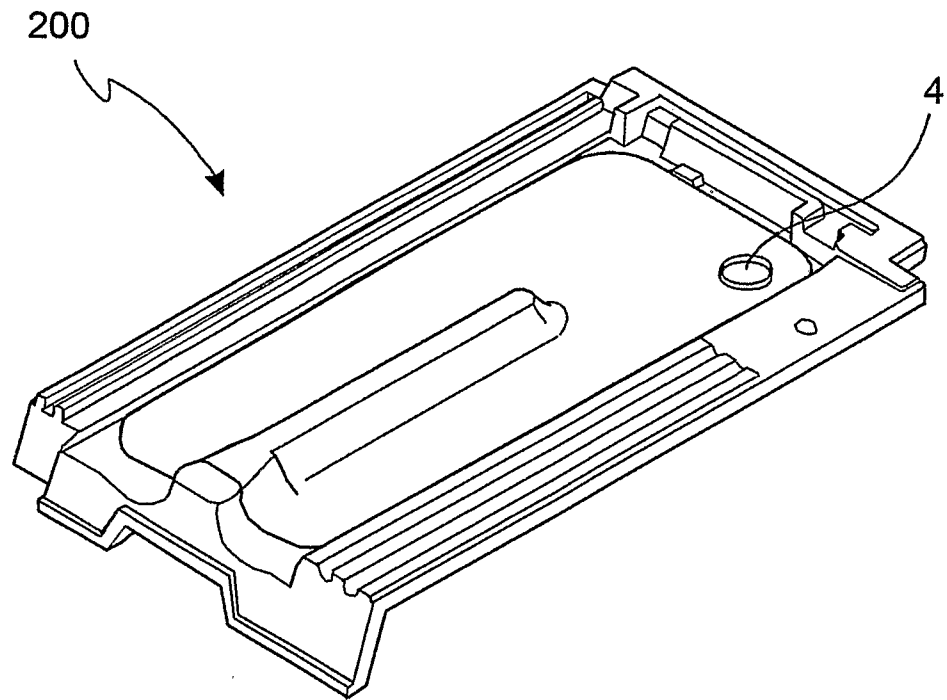


FIG. 25

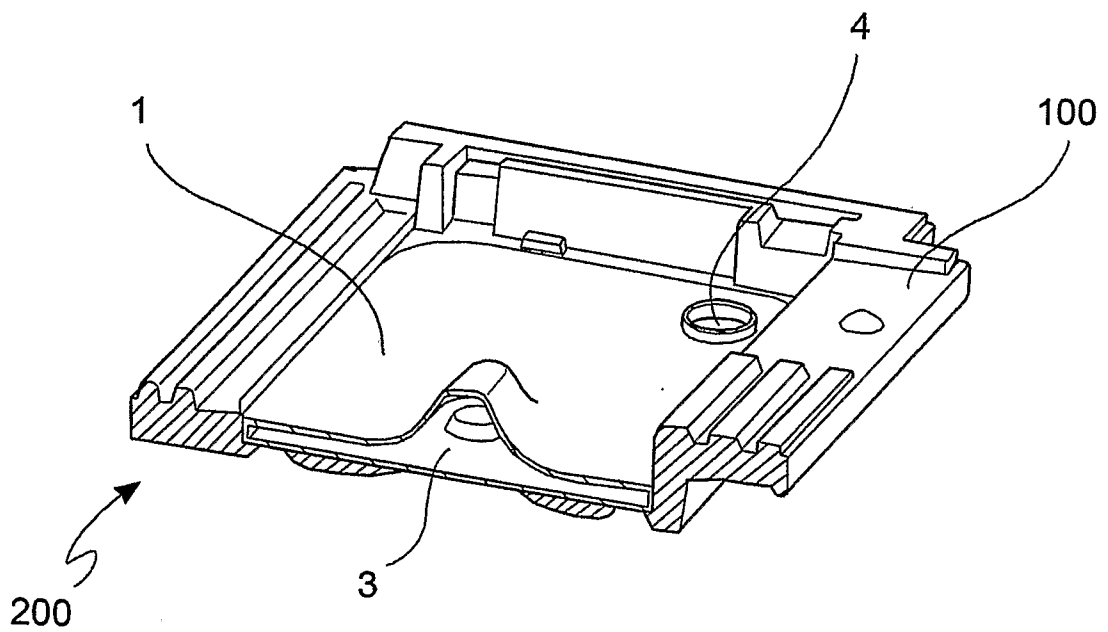


FIG. 26

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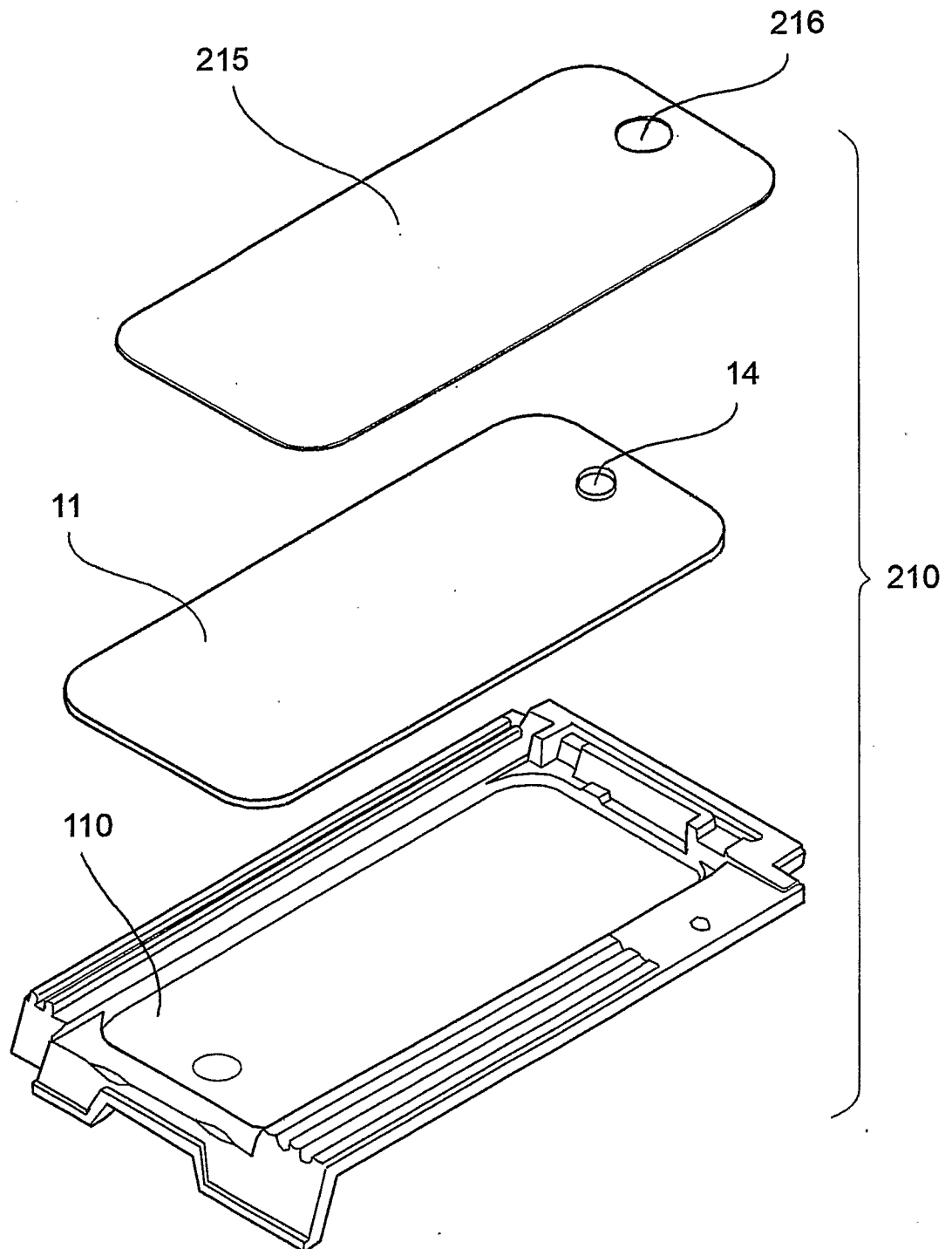


FIG. 27

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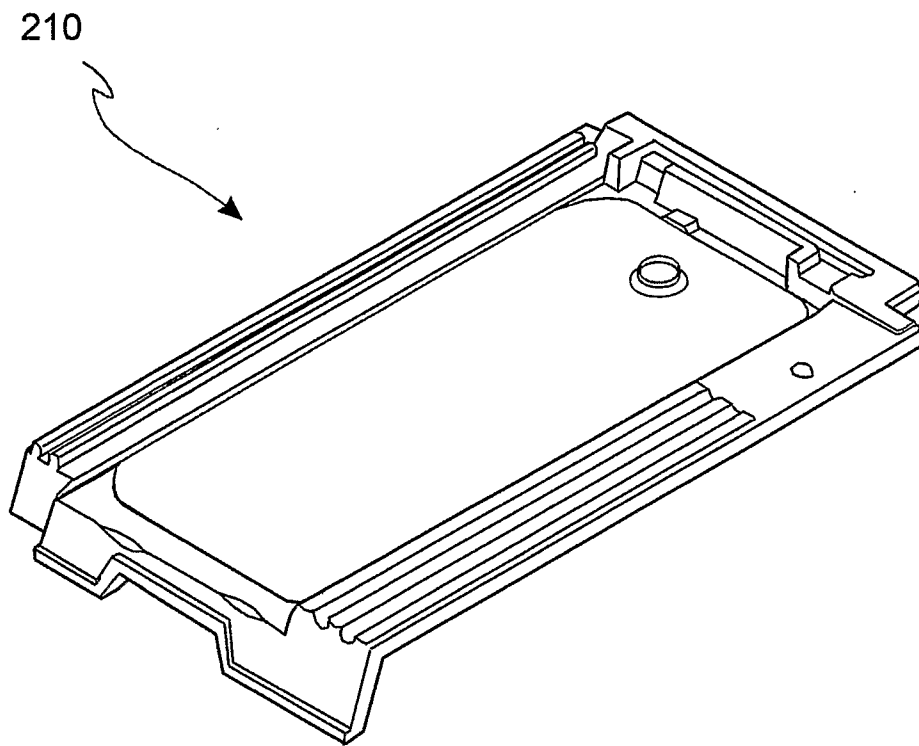


FIG. 28

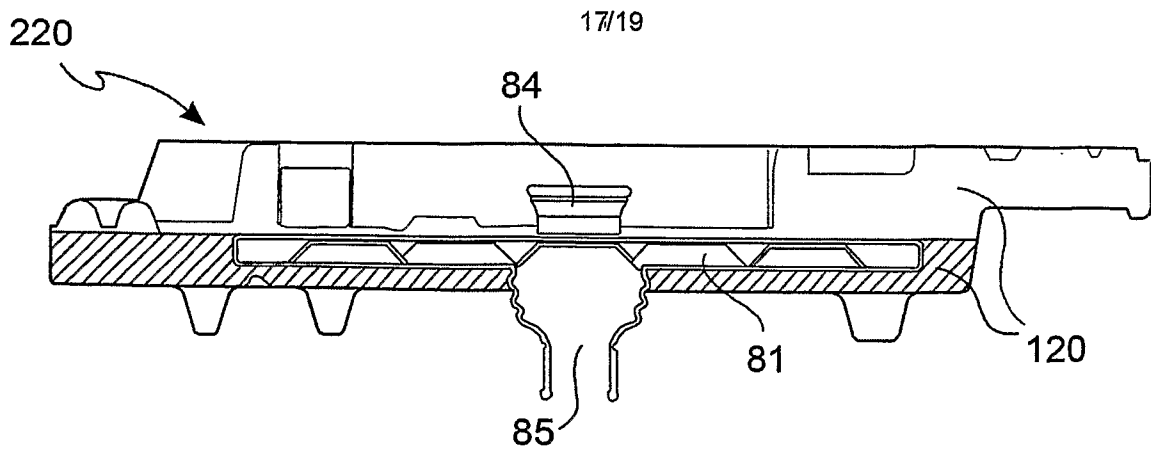


FIG. 29

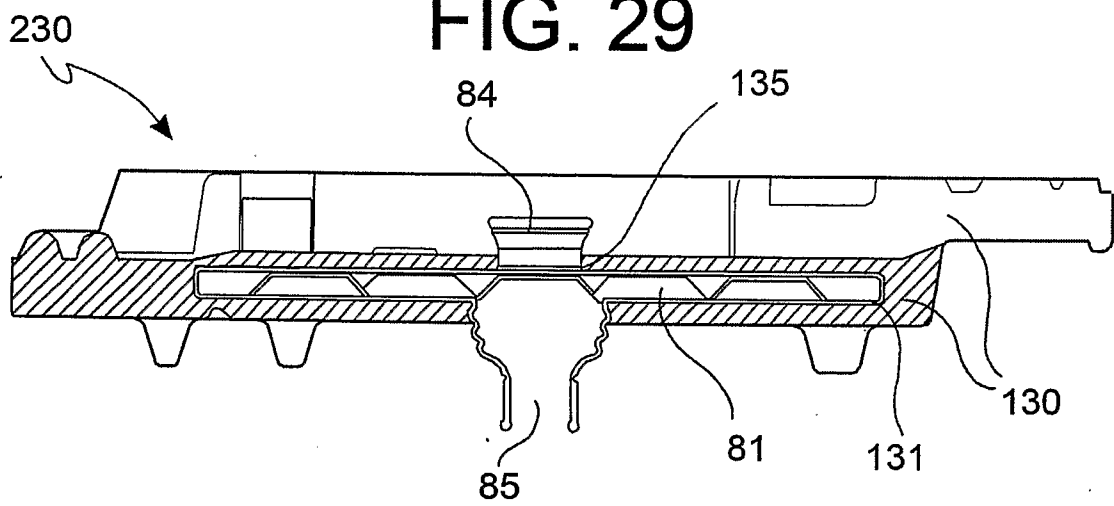


FIG. 30

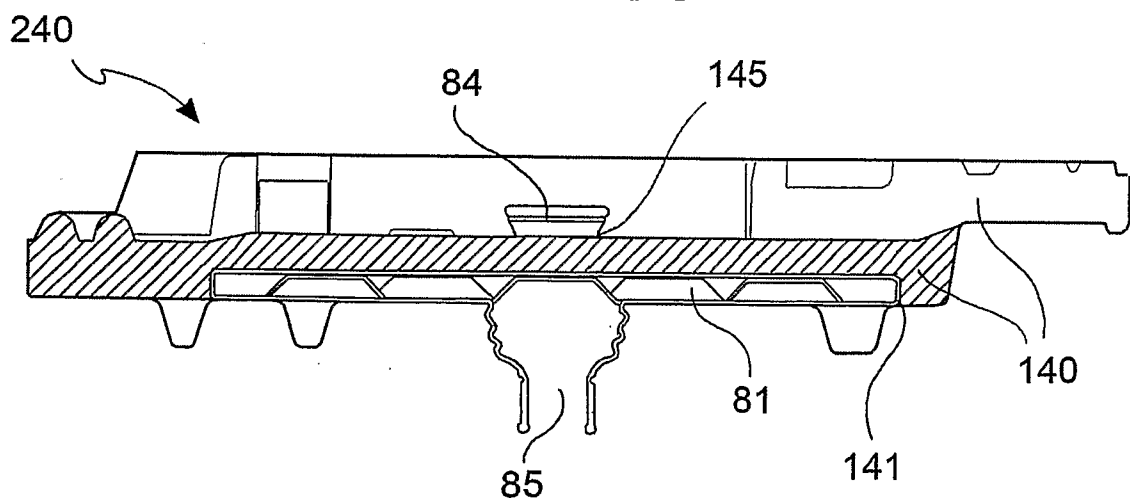


FIG. 31

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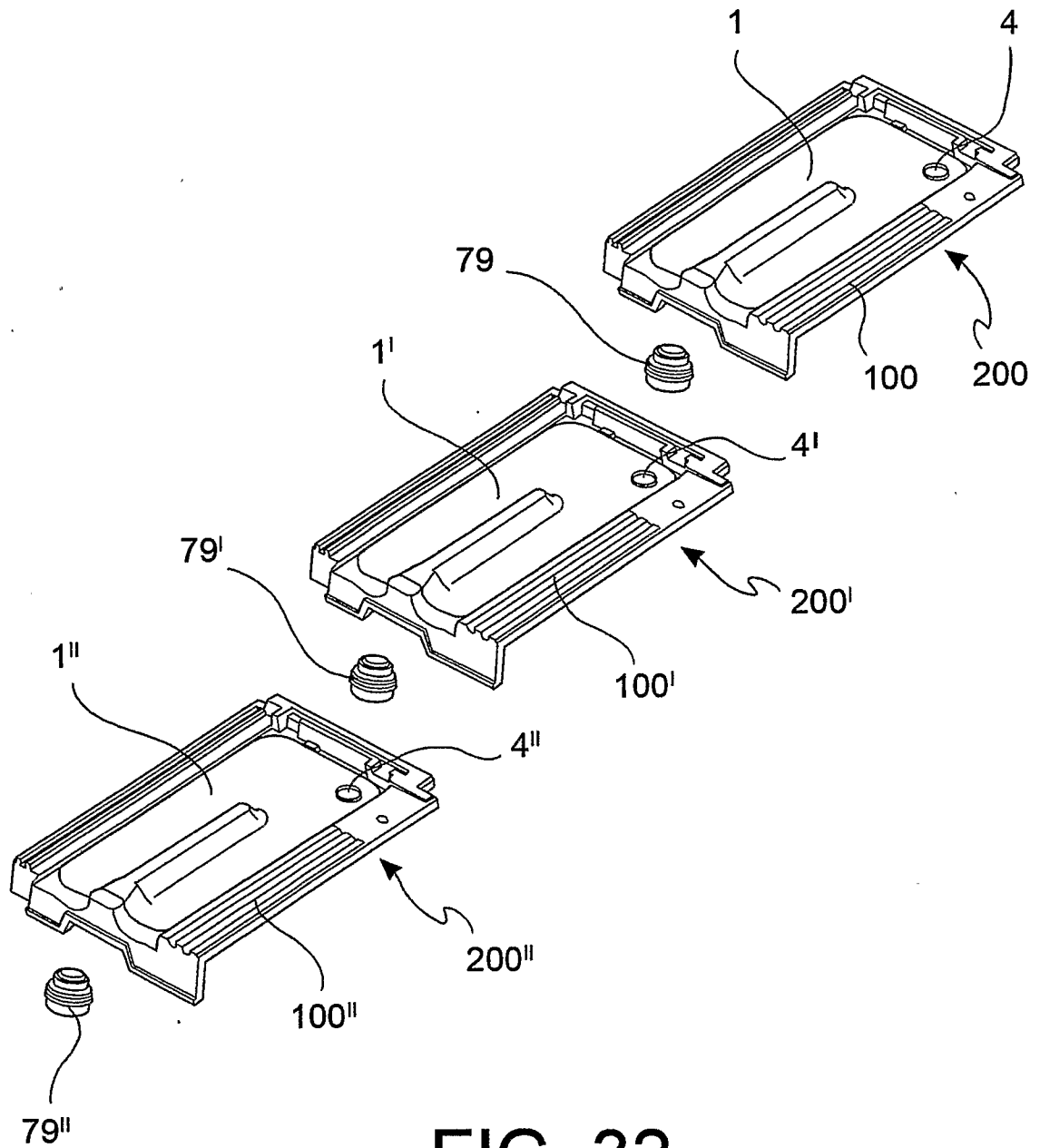


FIG. 32

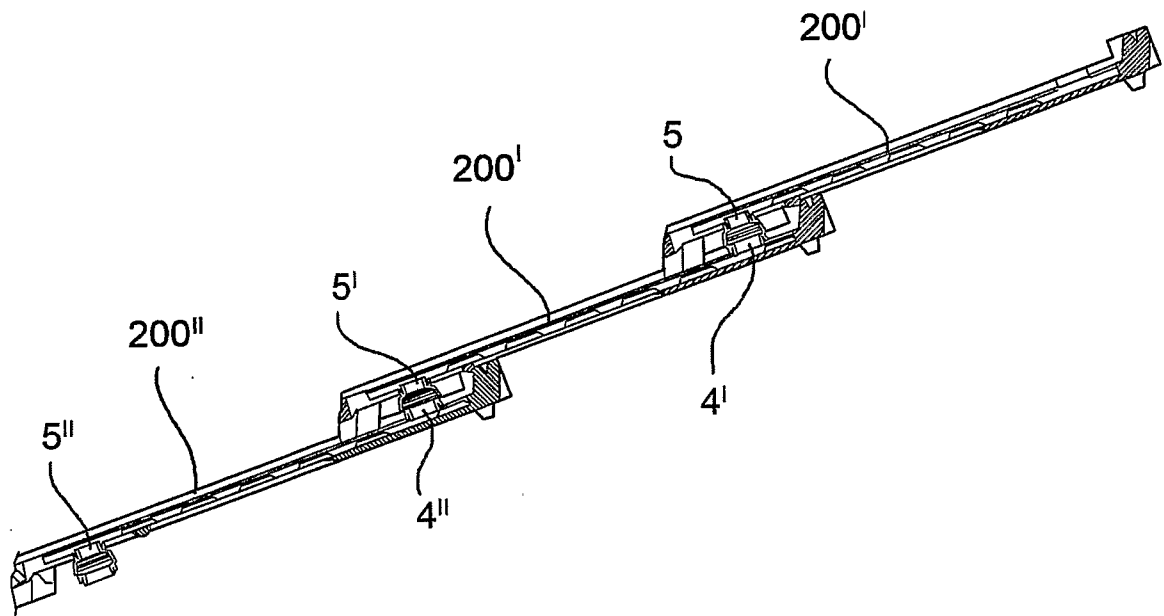


FIG. 33