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A Fin Plug for a Water Craft

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ABSTRACT

A fin plug for a water craft, said fin plug including:

- a top surface and a bottom surface;
- at least one fin cavity, for receiving a base element of a fin, extending inwardly from at least one opening in the top surface; and
- at least one hole extending between the top surface and the bottom surface adapted to be filled with foam.

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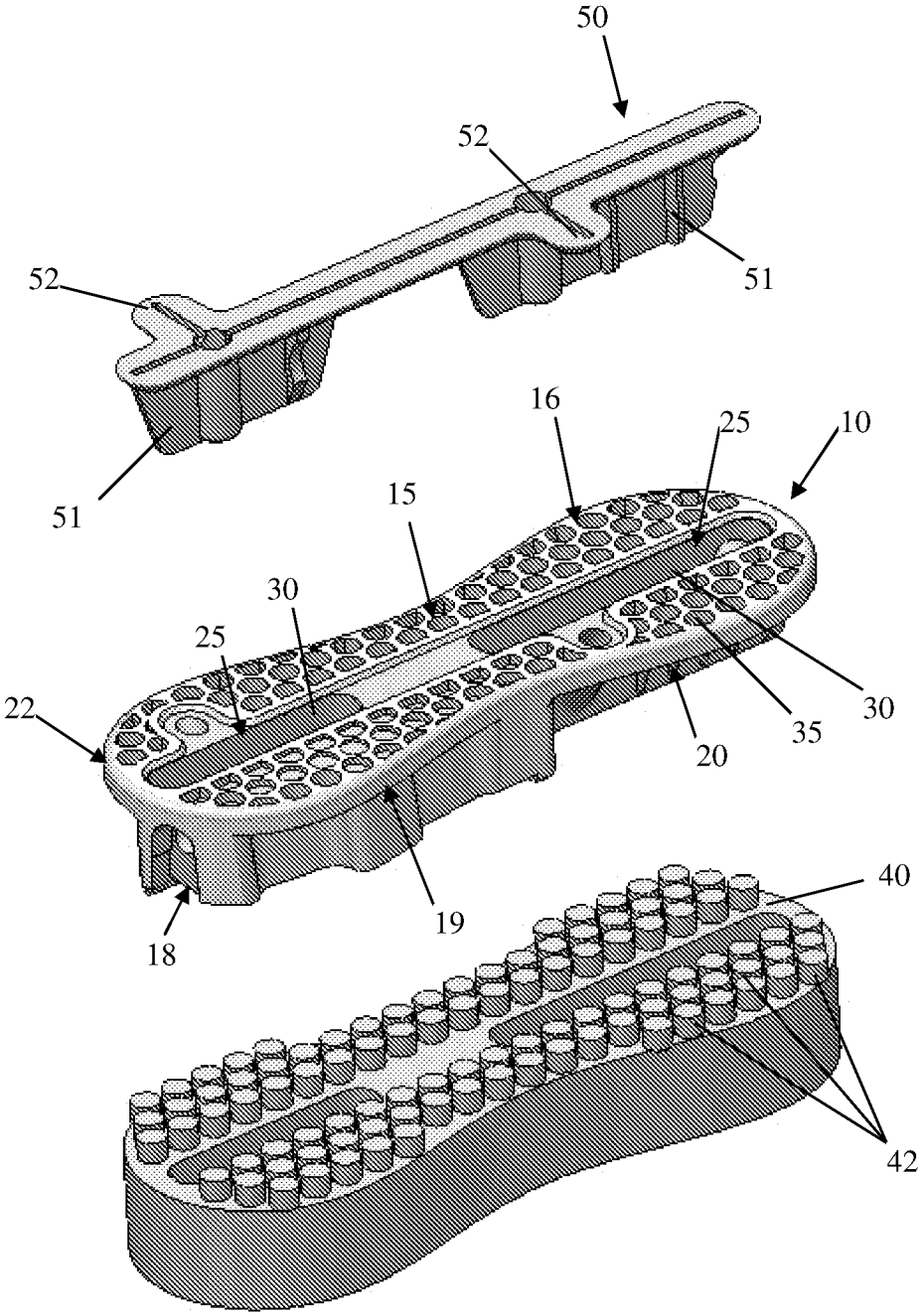

FIG 3B

A Fin Plug for a Water Craft

Field of the invention

[001] The present invention relates to a fin plug, for installation in a water craft, such as a surfboard or the like, adapted to enable a fin to be removably attached to the water craft.

Background of the invention

[002] A water craft, such as a surfcraft, particularly one on which a person stands, kneels or sits, when traversing water or riding a wave, generally has at least one fin in an underside of the craft, generally near the tail end of the craft. Such fins have a number of functions, including: enabling the craft to travel in a desired direction; facilitating the turning of the craft; preventing the craft from slipping sideways; and providing greater control over the movement of the craft, such as when riding a wave.

[003] The following discussion is directed mainly to surfcraft, such as surfboards, but it is to be understood that the discussion applies equally to other water craft (and surfcraft) which are adapted to include fins, such as sail boards, paddle boards, kite surf boards, rescue boards, surf skis, kayaks, and the like.

[004] Some surfcraft have the fins integrally formed on the surfcraft and, for many years, this was the standard means for incorporating fins into such surfcraft. In the last twenty years or so, it has become more common for surfcraft to incorporate a removeable fin or, more commonly, fin systems which include a number of removable fins. Such fin systems have numerous benefits, including enabling the fins to be removed for transportation and travelling, allowing damaged fins to be easily replaced and enabling fins of different shapes or styles to be selectively used. Such fin systems typically include at least one fin plug embedded into the underside of the surfcraft. This fin plug generally has at least one cavity adapted to receive a base portion (or a base element) of a surfcraft fin. The surfcraft fin is attached to the surfcraft by securing the base portion (or base element) of the fin into the cavity (or cavities) of the fin plug. There are numerous known fin systems which adopt this general arrangement.

[005] One such known fin system is described in US 5,464,359 in the name of Fin Control Systems Pty Ltd. This system includes fins having 2 projecting base elements (or tabs) and, for each fin, two fin plugs installed in the underside of the

surfcraft. Each of the fin plugs has a cavity for receiving one of the base elements. Each fin plug also includes means for securing the base element into the cavity.

[006] An alternative fin system is described in PCT/AU2008/001132, also in the name of Fin Control Systems Pty Ltd. This system also includes fins having 2 projecting base elements. However, these base elements are attachable to a single fin plug, having two cavities for receiving the two corresponding base elements.

[007] Other known fin systems comprise a single fin plug, with a single cavity, for each fin. Typically, such a fin system has quite a large fin plug with an elongated fin cavity for receiving the base element of the fin. The fin plug of such systems also typically includes an upper flat portion having an opening from which the fin cavity extends inwardly and a flange section extending laterally about the opening. This flange section has a particular width. Extending downwardly from an underside of the flat upper portion is a body portion which surrounds the fin cavity. The shape of such a fin plug generally requires two cavities to be routed into the underside of the surfcraft in a two step process. Firstly, a relatively wide, shallow cavity needs to be formed, the dimensions of which substantially correspond to the shape of the flange section. The depth of this first cavity will substantially correspond with the width of the flange section. Secondly, a narrow, deeper cavity needs to be formed in the first mentioned cavity, which is adapted to receive the body portion of the fin plug. As most surfcraft are designed to accommodate three fins, having to adopt this two step process for forming each fin plug cavity in the surfcraft substantially slows down the installation process.

[008] Another problem with known fin plugs is that the bond formed between the fin plug and the resinous material with which the fin plug is typically secured within a surfboard blank can be, or can become, flawed, particularly as a result of pressure placed upon the surfcraft fin (which, in use, is connected to the fin plug). The means by which a fin plug is secured within a surfcraft is typically by means of a hardenable liquid resinous material between external surfaces of the fin plug and the wall(s) of the cavity into which the fin plug is inserted.

[009] In the fin system described in US 5,464,359, each of the fin plugs has a top surface (being the surface on which the opening to the cavity is located) and following installation in the surfcraft, this top surface is exposed, being flush with the surface of the underside of the surfcraft.

[010] In the fin system described in PCT/AU2008/001132, each fin plug has a top surface (again being the surface on which the opening to each cavity is located). Following installation in the surfcraft, this top surface is not exposed but, rather, sits under a fibreglass layer. This fiberglass layer is generally coterminous with the fibreglass layer of the underside of the surfcraft. The fiberglass layer which sits over the top surface of the fin plug enhances the secure fixation of the fin plug to the surfcraft.

[011] A further problem with most known fin plugs (such as those disclosed in US5,464,359) is that, when installed in a surfcraft, they are surrounded by the relatively low density foam of which the surfcraft is formed. Such foam does not generally provide sufficient strength to support the loads placed upon the fin plug, due to forces applied to the attached fin, without some deformation or weakening of the surrounding foam over time. Such deformation or weakening of the foam can cause the fin plug to sink into the foam or to shift out of alignment, with consequential reduction in performance of the attached fin. This can also cause the fibreglass skin, in the vicinity of the fin plug, to crack or shatter. Also, when the fin plug sinks into the foam body, it can cause the top surface of the plug to separate from the adjoining fiberglass layer.

[012] Surfcraft fins can be subject to very substantial forces (especially lateral forces) when the surfcraft is undergoing a turn or upon impact with some other object and these forces are then transferred to the corresponding fin plugs to which the fins are attached. These forces can place very substantial strains on the connections (formed of hardened resinous material) between the fin plug and the surfcraft. In turn, these connections can be weakened and, in some cases, the hardened resinous material can crack). These strains upon the abovementioned connections are generally in inverse proportion to the total area of the external surfaces of the fin plug. Accordingly, the smaller this area, the greater will be the strain placed upon the relevant connection.

[013] The present invention is directed towards ameliorating at least some of the above described problems associated with prior art fin plugs and, consequently, the methods of installing these. In particular, one object of the present invention is directed towards providing a fin plug assembly which is adapted to form a stronger bond with the resinous material with which it is secured to a surfcraft.

[014] Any reference herein to known prior art does not, unless the contrary indication appears, constitute an admission that such prior art is commonly known by

those skilled in the art to which the invention relates, at the priority date of this application.

Summary of the invention

[015] According to a first aspect of the present invention, there is provided a fin plug for a water craft, said fin plug including:

- a top surface and a bottom surface;
- at least one fin cavity, for receiving a base element of a fin, extending inwardly from at least one opening in the top surface; and
- at least one hole extending between the top surface and the bottom surface adapted to be filled with foam.

[016] Preferably, the fin plug includes a plurality of said holes extending between the top surface and the bottom surface. It is further preferred that the fin plug includes a planar portion, having said top surface and bottom surface, and a base portion extending from said bottom surface and surrounding said at least one fin cavity. The planar portion of the fin plug preferably includes a flange extending laterally from said a least one opening to an external perimeter.

[017] In a preferred embodiment of this aspect of the invention, the fin plug includes two fin cavities for receiving two base elements of a water craft fin, said fin cavities extending inwardly from two openings in the top surface of said planar portion.

[018] It is particularly preferred that at least some of the holes extend through the flange of the planar portion.

[019] In one embodiment of the first aspect of the invention, the fin plug may have a honeycomb-like structure in that it has a plurality of holes extending from the top surface to a base surface of the base portion of the fin plug. In this embodiment, the holes have a length of up to about 2 cm.

[020] In an alternative embodiment, the holes are located in the planar portion of the fin plug and, in this embodiment, the holes have a length of up to about 0.5 cm. Preferably, the length of these holes is about 0.3 cm. As will be appreciated, the length of the holes is effectively the distance from the top surface to the bottom surface.

[021] It is further preferred that the base portion of said fin plug includes a plurality of rib elements on an external surface thereof. The main purpose of these rib

elements is to enhance the strength and/or structural integrity of the fin plug. The rib elements may also enhance the bonding of the fin plug to a surrounding foam body (explained later). This base portion preferably includes a wall section and a floor section which are of substantially uniform thickness. A benefit of this uniform thickness is that it reduces the risk of any deformation of these sections of the fin plug during the cooling of the fin plug (following an injection moulding manufacturing process).

[022] The fin plug will typically contain fin retention means serving to keep the fin connected to the water craft (as desired).

[023] In one preferred embodiment, the fin retention means includes a grub screw located within a screw hole which extends from the top surface and communicates with said at least one fin cavity. In an embodiment of the invention in which the fin plug contains two fin cavities, the fin retention means of the fin plug may include one grub screw located within a screw hole which extends from the top surface and communicates with one of said two fin cavities. In a variation of this embodiment, the fin retention means may include two grub screws located within two screw holes, one of which extends from the top surface and communicates with one of said two fin cavities and the other of which extends from the top surface and communicates with the other of said two fin cavities.

[024] In an alternative preferred embodiment, the fin retention means includes a biasing means adapted to impose a lateral force on the base element of the fin located in said fin cavity. This biasing means may include a resilient biasing rod and a protruding member cooperating with the biasing rod, said protruding member being adapted to abut the base portion of said fin when received in said fin cavity. If the fin plug contains two fin cavities it is preferred that the biasing means is adapted only to impose the stated lateral force on the base element of the fin in one of the fin cavities (although it is possible that such a lateral force could be applied within both of the cavities). The biasing rod may be formed of any suitable material such as titanium, steel, marine grade steel, fiberglass, carbon fiber, plastic and reinforced engineering plastic.

[025] It is possible that the fin plug may incorporate both of the fin retention means described in the above two paragraphs.

[026] In a further preferred embodiment, the fin plug may further include fin removal inhibiting means including a ledge portion, within said fin cavity, adapted to overlie a section of the base element of said fin, thereby inhibiting removal of the fin.

[027] The fin plug may be formed of any suitable material, although plastic and thermoplastic materials will generally be preferred. Suitable thermoplastic materials include polyamide ('nylon'), acrylonitrile butadiene styrene ('ABS'), polyurethane, polyvinyl chloride ('PVC'), polybutylene terepthalate ('PBT') and polyethylene terephthalate ('PET').

[028] According to a second aspect of the present invention, there is provided a fin plug assembly including:

- a fin plug as described above; and
- at least one foam in-fill within the at least one hole extending between the top surface and the bottom surface of said fin plug.

[029] Preferably, the fin plug of the above fin plug assembly includes a plurality of said holes extending between the top surface and the bottom surface and foam in-fills located in at least some of the plurality of holes.

[030] In a preferred embodiment, the foam in-fills are integrally formed with a foam body which underlies the planar portion of the fin plug. Preferably, this foam body substantially surrounds the base portion of the fin plug. In a particularly preferred embodiment, this foam body includes a sidewall which has a profile which is substantially identical to the external perimeter of the flange of the planar portion. The sidewall is preferably a continuous sidewall which extends about the foam body.

[031] It is generally preferable that the foam body has a thickness which is substantially equivalent to the distance from the bottom surface of the planar portion to a base surface of the base portion of the fin plug.

[032] In a particularly preferred embodiment of this aspect of the invention, an upper end of each in-fill (or at least most of the in-fills) is substantially flush with said top surface. A benefit of this feature is that it results in enhanced bonding between the fin plug assembly and a superimposed layer of fibreglass and resinous material (during the process of installing the fin plug assembly in a water craft, such as a surfboard).

[033] It is preferred that the foam body and foam infills are formed of a high density foam, such as polyurethane foam, epoxy foam, EPS foam, PVC foam or PET foam. Preferably, the high density foam body has a density of at least 70 kg/m^3.

[034] According to a further aspect of this invention, there is provided a method of manufacturing a fin plug assembly, as described above, said method including the steps:

- provide a fin plug as described above;
- block up each fin cavity of the fin plug to inhibit fluid material entering into said cavity;
- insert the fin plug into an injection mould chamber and inject liquid foam into the chamber so that liquid foam enters into the holes of the fin plug and a foam body forms around the base portion of the fin plug;
- allow the liquid foam to expand and cure so that a fin plug assembly (including the fin plug and cured foam) is formed; and
- remove the fin plug assembly from the chamber.

[035] It is preferred that the above method includes the further step of cutting excess foam from the fin plug plus foam block so that the top surface of the planar portion and the base surface of the base portion of the fin plug are exposed.

[036] In a preferred embodiment of the above method, a further preferred step is the cutting of excess foam from the fin plug plus foam block so as to form a sidewall of the fin plug assembly which has a profile which is substantially identical to the external perimeter of the flange of the planar portion.

[037] In an alternative embodiment of the above method the mould chamber has a shape adapted to form a sidewall of the fin plug assembly which has a profile which is substantially identical to the external perimeter of the flange of the planar portion. This can avoid the need to cut away excess foam from the fin plug plus foam block around the sidewall thereof.

[038] Preferably, the liquid foam is formed of polyurethane foam, epoxy foam, EPS foam, PVC foam or PET foam. It is further preferred that the liquid foam is adapted to form solid foam when cooled to about room temperature, said solid foam

being a high density foam. It is particularly preferred that the high density foam has a density of at least 70 kg/m^3.

[039] According to another aspect of this invention, there is provided a method of installing in a water craft a fin plug assembly, as described above, said method including the steps:

- provide a fin plug assembly as described above;
- provide a shaped foam water craft blank;
- make position markings on underside of the water craft blank corresponding to the desired positions for the fin plug in the water craft blank;
- cut out plug hole in underside of water craft blank, said plug hole adapted to receive the fin plug assembly and being of substantially corresponding shape to that of the fin plug assembly;
- pour an amount of resinous material into the plug hole sufficient to form a layer of resinous material between the walls of the plug hole and the corresponding surfaces of the fin plug assembly;
- insert fin plug assembly into plug hole so that the top surface of the fin plug is substantially flush with the underside of the water craft blank;
- apply fibreglass and coating of resinous material to external surfaces of water craft blank, including over top surface of fin plug;
- perform sanding of the surface of the water craft as required; and
- route out layer of fibreglass and resinous material above each fin cavity and the material used to cover or block each fin cavity.

[040] In order to inhibit unwanted resinous material from entering into the fin cavity (or fin cavities) of the fin plug assembly, it is preferred that said cavities are covered or blocked. For instance, any such cavity may be blocked by having (removable) plastic in-fills inserted into them.

[041] Preferably, prior to the abovementioned step of pouring an amount of resinous material into the plug hole, the following steps are included:

- connect a dummy jig to the fin plug assembly by inserting one or more tabs of said dummy jig into the at least one fin cavity of the fin plug;
- adjust cant angle and toe angle of the fin as desired and secure dummy jig in desired orientation;
- once resinous material has set, remove the dummy jig;

[042] When the above preferred steps are involved, then the covering or blocking of the of the fin cavities is undertaken after these steps have been taken.

[043] Preferably, the material used to block up each cavity is a cavity in-fill which may be formed of the same material as the fin plug.

[044] Typically, the water craft is a surfboard and the shaped foam water craft blank will be a shaped foam surfboard blank.

[045] According to a further invention, there is provided a fin plug assembly for a water craft, said fin plug assembly including:

- a fin plug having a top surface, a bottom surface and at least one fin cavity for receiving a base element of a fin, said find cavity extending inwardly from at least one opening in the top surface;
- a first foam layer underlying said bottom surface; and
- a second foam layer overlying said top surface, said second foam layer including at least one aperture aligned with, and forming an opening to, said at least one fin cavity.

[046] Accordingly to a still further invention, there is provided a fin plug assembly for a water craft, said fin plug assembly including:

- a fin plug having a top surface, a bottom surface, a perimeter surface and at least one fin cavity for receiving a base element of a fin, said fin cavity extending inwardly from at least one opening in the top surface; and
- a foam body having a plug cavity in which said fin plug is positioned, said foam body including an upper peripheral ridge which extends about the perimeter surface of the fin plug.

Brief description of the drawings

[047] A detailed description of preferred embodiments of the first aspect and the second aspect of the present invention are given hereinafter, while referring to Figures 1 and 2.

[048] Figures 1A and 1B are top perspective views of an example fin plug according to a preferred embodiment of the first aspect of this invention;

[049] Figures 2A and 2B are further top perspective views of the example fin plug of Figures 1A and 1B.

[050] Figures 2C and 2D are bottom perspective views of the example fin plug of Figures 2A and 2B;

[051] Figure 2E is a top plan view of the example fin plug of Figures 2A and 2B;

[052] Figure 2F is a bottom view of the example fin plug of Figures 2A and 2B;

[053] Figure 2G is a front view of the example fin plug of Figures 2A and 2B;

[054] Figure 2H is a side view of the example fin plug of Figures 2A and 2B;

[055] Figure 3A is an exploded perspective view of an example fin plug assembly according to a preferred embodiment of the second aspect of this invention and including a cavity insert for attachment to the fin plug assembly;

[056] Figure 3B is another exploded perspective view of an the example fin plug assembly shown in Figure 3A, again showing the cavity insert for attachment to the fin plug assembly;

[057] Figures 3C and 3D show further exploded views of another example of a fin plug assembly;

[058] Figures 4A and 4B are top perspective views of an example cavity insert which can be used with the fin plug and/or fin plug assembly described herein;

[059] Figure 4C is a top view of the example cavity insert of Figures 4A and 4B;

[060] Figure 4D is a side view of the example cavity insert of Figures 4A and 4B;

[061] Figure 4E is a bottom view of the example cavity insert of Figures 4A and 4B;

[062] Figure 4F is a bottom perspective view of the example cavity insert of Figures 4A and 4B;

[063] Figures 4G and 4H are front end and rear end views of the example cavity insert of Figures 4A and 4B;

[064] Figure 5A is a top plan view of an example fin plug assembly prior to installation into a surf craft;

[065] Figure 5B is a top plan view of the example fin plug assembly of Figure 5A installed within a section of a surf craft.

[066] Figure 5C is a side cross-sectional view of the example fin plug assembly as installed in Figure 5B;

[067] Figure 5D is another side cross-sectional view of the fin plug assembly as shown in Figure 5C, the fin plug having undergone a glass routing process;

[068] Figures 6 and 7 are photographs of example fin plugs according to an embodiment of the first aspect of this invention;

[069] Figures 8 and 9 are photographs of example fin plug assemblies installed within a surf craft as part of the installation process;

[070] Figure 10A is an exploded perspective view of another example fin plug assembly according to an embodiment of the second aspect of this invention;

[071] Figure 10B is a front perspective view of the example fin plug assembly of Figure 10A;

[072] Figure 10C is a back perspective view of the example fin plug assembly of Figure 10A;

[073] Figure 10D is a top plan view of the example fin plug assembly of Figure 10A;

[074] Figure 10E is a side view of the example fin plug assembly of Figure 10A;

[075] Figure 10F is a bottom view of the example fin plug assembly of Figure 10A;

[076] Figures 10G and 10H are front end and rear end views of the fin plug of Figure 10A;

[077] Figure 11A is an exploded perspective view of another example fin plug assembly as described herein;

[078] Figure 11B is a top perspective view of the example fin plug assembly of Figure 11A;

[079] Figure 11C is a bottom perspective view of the example fin plug assembly of Figure 11A;

[080] Figure 11D is top plan view of the example fin plug assembly of Figure 11A;

[081] Figures 11E and 11G are side views of the example fin plug assembly of Figure 11A;

[082] Figure 11F is a bottom view of the example fin plug assembly of Figure 11A;

[083] Figure 11G is a side view of the example fin plug assembly of Figure 11A;

[084] Figure 11H is a front end view of the example fin plug assembly of Figure 11AI

[085] Figure 12A is an exploded perspective view of another example fin plug assembly as described herein;

[086] Figure 12B is a top perspective view of the example fin plug assembly of Figure 12A;

[087] Figure 12C is a top plan view of the example fin plug assembly of Figure 12A;

[088] Figures 12D and 12F are side views of the example fin plug assembly of Figure 12A;

[089] Figure 12E is a bottom view of the example fin plug assembly of Figure 12A;

[090] Figure 12G is a front end view of the example fin plug of Figure 12A;

[091] Figures 13A to 13G show a further example of a fin plug according to an alternative embodiment of the first aspect of this invention. In particular, Figure 13A is a top perspective view, Figure 13B is a plan view, Figure 13C is an end front view, Figure

13D is a side view from the left, Figure 13E is an end rear view, Figure 13F is a bottom perspective view, and Figure 13G is a bottom view;

[092] Figures 14A to 14G show yet a further example of another fin plug according to another alternative embodiment of the first aspect of this invention. In particular, Figure 14A is a top perspective view, Figure 14B is a view from below; Figure 14C is a front end view, Figure 14D is a side view, Figure 14E is a back end view, and Figure 14F is a plan view;

[093] Figure 15A to 15J show yet another example of another fin plug according to another alternative embodiment of the first aspect of this invention. In particular, Figure 15A is a top perspective view, Figure 15B is a view from below, Figure 15C is another top perspective view, Figure 15D is a front end view, Figure 15E is a side view from the left, Figure 15F is rear end view, Figure 15G is another side view from the right, Figure 15H is a bottom perspective view, Figure 15I is a plan view, and Figure 15J is another bottom perspective view;

[094] Figure 16A is an exploded perspective view of another example of the fin plug assembly according to an alternative embodiment of the second aspect of this invention, incorporating the fin plug of Figures 15A to 15J;

[095] Figures 16B to 16H show the example fin plug assembly of Figure 16A, once formed. In particular, Figure 16B is a top perspective view, Figure 16C is a bottom perspective view, Figure 16D is a side view from the left, Figure 16E is a plan view, Figure 16F is a side view from the right, Figure 16G is an end view, and Figure 16H is a bottom view; and,

[096] Figures 17A to 18G are views of example cavity inserts which may be used, in certain circumstances (as described further below), in some embodiments of the invention. In particular, Figure 17A is a rear perspective view of an example cavity insert, Figure 17B is a front perspective view, Figure 17C is a bottom view, Figure 17D is a plan view, Figure 17E is a left side view, Figure 17F is a right side view, and Figure 17G is an end view of the example cavity insert of Figure 17A. Further, Figure 18A is a back perspective view of an example cavity insert with a tag, Figure 18B is an example front perspective view, Figure 18C is a plan view, Figure 18D is a left side view, Figure 18E is a right side view, Figure 18F is an end view, and Figure 18G is a bottom view of the example cavity insert of Figure 18A.

Detailed description of the embodiment or embodiments

[097] An example fin plug 10 is shown in Figures 1A, 1B, and 2A to 2H.

[098] The fin plug 10 of Figure 1A and 1B includes a top surface 15 and a bottom surface 20. The fin plug 10 further includes at least one fin cavity 25 for receiving a base element of a surfcraft fin (not shown). The at least one cavity 25 typically extends inwardly from at least one opening 30 in the top surface 15. The fin plug 10 also includes at least one hole 35 extending between the top surface 15 and the bottom surface 20, where the hole 35 us adapted to be filled with foam 40.

[099] Figures 1A and 1B also show that the fin plug 10 can include a plurality of holes 35 which extend between the top surface 15 and the bottom surface 20. Furthermore, Figures 2A to 2C show that the fin plug 10 can have a planar portion 16 which includes the top surface 15 and the bottom surface 20. The fin plug 10 can also include a base portion 18 which extends from the bottom surface 20 and surrounds the at least one fin cavity 25.

[0100] In one particular example, the planar portion 16 can include a flange 19 extending laterally from the at least one opening 30 to an external perimeter 22 of the fin plug 10. Thus, in this particular example, one or more holes 35 can extend through the flange 10 of the planar portion 16.

[0101] It will further be appreciated that the fin plug 10 can include two fin cavities 25 which extend inwardly from two separate openings 30 in the top surface 15 of the planar portion 16.

[0102] According to one particular example, the one or more holes 35 are located in the planar portion and have a length of up to 0.5 cm. And yet in a further example, the holes can have a length of about 0.3 cm. As can be seen, the lengths of the holes are substantially equivalent to the distance between the top surface and the bottom surface.

[0103] Figures 2C and 2D further show that the base portion 18 of the fin plug 10 can include a plurality of rib elements 24 on an external surface 26 of the base portion 18. Notably, the base portion 18 can also include a wall section and a floor section which are of substantially uniform thickness.

[0104] The fin plug 10 can also include a fin retention means. In one particular example, as shown in Figures 1A, 1B, 2A, and 2B the fin retention means can include a grub screw (not shown) which is configured to be inserted and located into a screw hole 28, which typically extends from the top surface 15 and communicates with the at least one fin cavity 25 to hold a fin of a surfcraft therein.

[0105] Notably, there can be provided two or more grub screws located within respective two or more screw holes 28. In this particular example, one of the grub screws can extend from the top surface 15 and communicate with one of said two fin cavities 25 and the other of the grub screws can extend from the top surface 15 and communicates with the other of said two fin cavities 25.

[0106] The inclusion of the screw holes 28 (and the grub screws) in the fin plug described above are optional inclusions and may be done, primarily, to accommodate certain known surf craft fins which have fin tabs which extend into the fin cavities 25 and which are typically held in place by means of the grub screws. When such known surf craft fins are secured to the fin plug, the fin tabs may not entirely fill the fin cavities and, consequently, there may be an empty space in the relevant fin cavity. In order to minimise or avoid the presence of any such empty space, a small cavity insert may (optionally) be inserted into the fin cavity to 'fill in' any such space. Examples of such cavity inserts are shown in Figures 13A to 14G.

[0107] In yet a further example, as shown particularly in Figure 1B, the fin retention means can also include a biasing means 45 (not shown), which is configured to impose a lateral force on the base element of a fin (not shown) which is located in the cavity 25.

[0108] Typically, the biasing means 45 includes a resilient biasing rod and a protruding member 46 (as shown in Figure 1B) which cooperates with the biasing rod. The protruding member is typically configured to abut the base portion of the fin, when the fin is received in the fin cavity 25. According to one particular example, the resilient biasing rod is formed of material selected from titanium, steel, marine grade steel, fiberglass, carbon fibre, plastic and reinforced engineering plastic.

[0109] In yet a further example, the fin plug 10 can also include a fin removal inhibiting means (not shown) which can have a ledge portion, within said fin cavity 25, where the ledge portion is configured to overlie a section of the base element of the fin,

when the fin is inserted within the cavity 25. Thus it can be appreciated that the fin removal inhibiting means can substantially inhibit the removal of the fin from within the cavity 25, once inserted therein.

[0110] It will be appreciated by persons skilled in the art that the fin plug can be formed of a thermoplastic or plastic material, including but not limited to polyamide ('nylon'), acrylonitrile butadiene styrene ('ABS'), polyethylene, polyvinyl chloride ('PVC') and polyethylene terephthalate ('PET').

[0111] It will be appreciated that, when in the final stages of manufacturing the surf craft, as described, an cavity insert 50 can be used to inhibit resinous material from entering the cavities 25 from the final stages of the manufacturing process. The final stages often includes inserting the fin plug 10 or the fin plug assembly (as described herein) into the underside of a surf craft and then pouring resinous material over the surface of the underside of the surf craft and, consequently, over the fin plug 10 or fin plug assembly. Thus, by inserting an cavity insert 50 into the cavities 25, prior to the pouring of the resinous material, the resinous material can be kept out of the cavities. The cavity inserts can subsequently be removed (e.g. by sanding or routing) enabling the cavities to be revealed.

[0112] Figures 4A to 4H show various views of the cavity insert 50, and Figures 3A and 3B show examples of how the cavity insert 50 can be inserted into the cavities 25. Thus, in this particular example, the cavity insert 50 is formed to have legs 51, which are formed so as to be received in the corresponding cavities 25, for instance by way of a friction fit or snap-fit..

[0113] Furthermore, as shown in Figures 3A to 4G, the cavity insert 50 can be elongate and is formed to cover both cavities 25, and further can also include a necked portion 52 to cover holes where grub screws or the like are to be inserted into. However, it will be appreciated that two separate cavity inserts (one for each cavity 25) can also be used.

[0114] Figure 5A shows an example fin plug assembly before installation into a surfcraft. Figures 5B and 5C show an example of the fin plug 10 once installed, where glass 60 (which can be a layer or coating of fibreglass) covers the whole of the fin plug 10. It will be appreciated that the holes 35 together with the foam 40 create a surface which can better adhere to the glass 60. Figure 5D shows an example of the fin plug 10

post a glass routing process. It will be appreciated that the process of installation and manufacture, as described below can allow for bonding to the foam rather than plastic, more glass to cover the plug 10 and a flat installation (where there is no or limited tenting of the glass).

[0115] Notably, the fin plug 10 as described herein can include a ramp 70 or the like formed at least partially or wholly around the surface of the cavity 25. Thus, the ramp 70 includes a slightly raised surface from the top surface 15 of the fin plug 10. The ramp 70 forms a small ridge about each fin cavity which helps to inhibit resinous material entering the cavity when the resin is poured thereon, in the manufacturing process.

[0116] Although Figures 10A to 10H show that the ramp 70 can be integrated with the fin plug 10, it will be appreciated that the fin plug 10 can also include a cap which forms the ramp (that is, as a part of the cavity insert), and thus the fin plug 10 can include a flat top surface 15 with a cap which forms the ramp 70, or alternatively, the top surface with the cap can be completely flat and the cavities are routed after the board has been glassed.

[0117] Further examples of possible manufacturing and installation techniques of the fin plugs shown in the Figures are described below.

[0118] Figure 10A is an exploded view of the fin plug assembly according to a preferred embodiment of the second aspect of this invention. This fin plug assembly includes a fin plug 10 and a foam body 40. As described above, the fin plug 10 includes a plurality of holes 35 extending between the top surface 15 and the bottom surface 22. As shown in Figure 10A, the foam body includes a plurality of hole in-fills 42. These in-fills 42 are positioned in the corresponding holes 35 of the fin plug 10.

[0119] Figures 10B to 10H show examples of the composite fin plug assembly 90 including the fin plug10 and the foam body 40, in which the foam in-fills 42 of the foam body 40 are located within corresponding holes 35 in the fin plug 10.

[0120] The fin plug assembly 90 is typically formed by inserting the fin plug 10 into a mould and liquid foam is injected into the mould so as to enable the foam to form around the underside of the fin plug 10 and into the holes 35. The foam is then allowed to cool (solidify), thereby forming the fin plug assembly. The foam body is therefore, typically, moulded around the underside of the fin plug 10. Thus, as described herein,

together the foam body 40 and the fin plug 10 form a fin plug assembly 90 (as shown in Figures 10B to 10H).

[0121] The foam in-fills 42 occupy the holes 35 and, as shown in Figures 10B and 10D, the top end 44 of the in-fills 42 are, essentially, coterminous with the top surface 15 of the fin plug 10. The exposed top ends 44 of the in-fills result in improved adhesion with resinous material which is subsequently placed over the fin plug assembly 90. This is because resinous material generally forms a stronger bond with foam than with the hard plastic-type material typically used for a fin plug.

[0122] As can be seen from the Figures 10B to 10H, the fin plug assembly 90 has exposed foam surfaces at the top and at the bottom of the assembly as well as around the sidewall(s) of it. These exposed foam surfaces enhance the ability of the fin plug assembly to bond with resinous material, which is typically located about the fin plug assembly 90 when it is being installed in a surf craft.

[0123] Figures 11A to 11H show an alternative fin plug assembly 100, in which the fin plug 110 includes first foam section 40A and a second foam section 40B. Thus, in this particular example, a rigid (e.g. plastic) fin plug 110 is sandwiched between, or encapsulated by, foam sections 40A and 40B. The first foam section 40 has holes 25A there through which align with the fin cavities 25 of the fin plug 110. The second foam section 40B has recesses 18A adapted to receive base portions 18A of the fin plug 110. The fin plug 110 may be adhered to the foam sections 40A and 40B by means of a resinous material (or any other suitable adhesive material). As can be seen from the Figures 11A to 11H, the fin plug assembly 100 has exposed foam surfaces at the top and at the bottom of the assembly as well as around the sidewall(s) of it. These exposed foam surfaces enhance the ability of the fin plug assembly to bond with resinous material, which is typically located about the fin plug assembly 100 when it is being installed in a surf craft.

[0124] It will be appreciated that the fin plug assembly 100 shown in Figures 11A to 11H can be achieved by forming foam around the fin plug 110 (e.g. in a mould) or by bonding two pre-cut pieces of foam to the fin plug 10.

[0125] Figures 12A to 12G show a further alternative fin plug assembly 200, having a fin plug 210 and a foam body 240. The foam body 240 has a plug cavity 250 adapted to receive the fin plug 210. As can be seen from Figure 12A, the plug cavity

includes a shallow cavity 250A, for receiving a planar portion 16C of the fin plug 210, and a a deeper cavity 250B, for receiving a base portion 18C in which the fin plug 210. The fin plug 210 is positioned in the foam body 240 such that the foam body forms a wall of foam 244 around the fin plug 210. The fin plug 210 may be adhered to the foam body 240 by means of a resinous material (or any other suitable adhesive material). As can be seen from the Figures 12A to 12G, the fin plug assembly 200 has exposed foam surfaces at the top of the foam wall 244 and at the bottom of the assembly as well as around the sidewall(s) of it. These exposed foam surfaces enhance the ability of the fin plug assembly to bond with resinous material, which is typically located about the fin plug assembly 200 when it is being installed in a surf craft.

[0126] Figures 13A to 13G show another example of a fin plug 310. In this particular example, the holes 35 form a honeycomb like structure when the fin plug 310 is viewed from above (as in Figure 13B, for example). Further, this particular example has a skirting 311 which forms around the external perimeter 22 of the fin plug 310. The skirting comprises a plurality of skirting elements 320 and a plurality of voids 321 between the skirting elements. As can be seen, the skirting 311 extends from the top surface 15 down at a length which is similar to the length of the cavities 25 within the base portion 18A (for securing the fins of a surf craft). It will be appreciated that in this particular example, when filled with the foam, the foam can fill in the voids 321 between the skirting elements 320. Once filled, the outer perimeter 22 may have a rough surface of plastic skirting elements 320 and foam (in the adjoining voids).

[0127] In yet a further example, Figures 14A to 14G show an example of a fin plug 410, having a plurality of holes 35, in which the fin plug has a solid border or perimeter 22. In this particular example, when the holes 35 of the fin plug 410 is filled with foam, the foam is only visible on the top surface 15 and the bottom surface 20.

[0128] Figures 15A to 15J show further examples of a fin plug 510 having a plurality of holes 35. In this particular example, the holes of the fin plug 510 are configured to be filled with the foam 540 as shown in Figure 16A. Figures 16B to 16H show an example of a fin plug assembly 500 formed when the foam fills the holes of the fin plug 510 forming a foam body 540.

[0129] In this example, the foam body 540 includes one or more channels 541 in a sidewall thereof. The channels 541 are moulded into the foam body 540 such that when the fin plug assembly 500 is inserted into the surf craft, any extra resin may flow

through the channels 541 and can be directed away. It will further be appreciated that the one or more channels 541 are formed to make it easier for the assembly 500 to be inserted into the surf craft as the space in the channels 541 forms vacuum when the fin plug assembly 500 is inserted. As shown in the examples, the channels 541 can include a ramped portion 543.

Example Manufacturing technique of the fin plug in Figures 1A and 1B

[0130] Steps which can be taken in manufacturing the fin plug of Figure include:

1) Injection mould plug in a rigid thermoplastic (considering Nylon and ABS).
2) Assemble components for tool-less mechanism application
3) Injection mould cavity insert out of a rigid thermoplastic (e.g Nylon,ABS, polyethylene)
4) Snap fit the cavity insert into the plug
5) Insert into secondary mould and blow foam around the assembled plug and infill (considering Polyurethane and Epoxy foam). The foam fills all the exposed voids/ holes in the plug.
6) Machine/ cut the excess foam from the plug so that the upper and lower surface of the plug is exposed and the peanut shaped outline is revealed.

Example Installation technique for the Fin Plug of Figure 1

[0131] Typically at this stage the surfboard blank has been shaped (predominantly PU or EPS foam) and the fin position has been marked on the underside. Thus, the steps which can be taken include:

1) Route out the peanut shaped holes in the surfboard blank, referencing the fin position marks using the specific router jig.
2) Insert a 'dummy jig' into the holes of the infill and used to adjust cant and toe angle of the fins. Tape in place until resin is set
3) Pour a mix of resin and filler (cabosil, milled fibres, etc) into the cavity routed and press the plug in so that the top surface is flush with surface of the board.
4) Once resin has set remove dummy jigs and continue to glass the board as per normal process- Glass both sides, filler coat and final sand

5) Using the cross hair marks on the infill align the second router jig over the plug
6) Adjust depth of router cuter (I'm still working on this step)
7) Route out the glass and top of the infill to expose the tab cavities
8) Remove the remaining parts of the infill and finish board as required (wet rub, gloss coat,etc)

Example advantages of the fin plug manufacturing process for the example shown in Figure 1:

[0132] The following advantages may be provided:

- No stickers required to cover the tab inserts which are fiddly and time consuming.

- As the plug sits flush with the surface of the board it is quicker and easier to glass. More attention is required to remove air bubbles and position the glass around plugs which have a ramp- like the 'Fusion' and Future plugs.
- Easier to sand fibreglass laps during glassing process and final sanding process
- Glass covers the whole surface of the plug except the tab cavities which we anticipate will be stronger. Current plugs with a ramp cause the glass to recede / feather away from the tab cavities when sanded.
- Chemical and mechanical bond of the resin to the foam is better than bonding to a plastic surface (like 'Fusion' and Futures)
- Infill facilitates the use of a 'dummy jig' to adjust the cant and toe angle of the fin
-Aesthetic qualities of having the structural foam becoming a feature.

Example Manufacturing technique of the Fin Plug of Figure 2

[0133] Steps which can be taken in manufacturing the fin plug of Figure include:

1) Injection mould plug in a rigid thermoplastic (considering Nylon and ABS)
2) Assemble components for tooless mechanism-refer to 'fin plug for surfboard' patent application
3) Injection mould two cavity inserts out of a thermoplastic (considering Nylon,ABS and Polyethylene)
4) Snap fit one cavity insert into the plug- this is a sacrificial component

5) Insert into secondary mould and blow foam around the assembled plug and cavity insert (considering Polyurethane and Epoxy foam). The foam fills all the voids/ holes in the plug.

6) Machine/ cut the excess foam from the plug so that the upper and lower surface of the plug is exposed and the peanut shaped outline is revealed. Remove the sacrificial cavity insert

7) Snap fit the second cavity insert into the plug

Example Installation technique for the Fin Plug of Figure 2

[0134] Typically, at this stage the surfboard blank has been shaped (predominantly PU or EPS foam) and the fin position has been marked on the underside. Thus, the steps which can be taken include:

1) Route out the peanut shaped holes in the surfboard blank referencing the fin position marks using the specific router jig.

2) Pour a mix of resin and filler (cabosil, milled fibres, etc) into the cavity routed and press the plug in so that the plug flange is flush with surface of the board.

3) Insert the 'dummy jig' (yet to be designed) into the holes of the infill and used to adjust cant and toe angle of the fins. Tape in place until resin is set

4) Once resin has set remove dummy jigs and continue to glass the board as per normal process- Glass both sides, filler coat.

5) The final sand will remove the top surface of the infill.

6) Remove the remaining parts of the infill and finish board as required (wet rub, gloss, etc)

Example advantages of the fin plug manufacturing process for the example shown in Figure 2:

[0135] The following advantages may be provided:

- No stickers required to cover the tab inserts which are fiddly and time consuming.
- Chemical and mechanical bond of the resin to the foam is better than bonding to a plastic surface (like 'Fusion' and Futures)
- Infill facilitates the use of a 'dummy jig' to adjust the cant and toe angle of the fin
-Aesthetic qualities of having the structural foam becoming a feature.

[0136] Where ever it is used, the word “comprising” is to be understood in its “open” sense, that is, in the sense of “including”, and thus not limited to its “closed” sense, that is the sense of “consisting only of”. A corresponding meaning is to be attributed to the corresponding words “comprise”, “comprised” and “comprises” where they appear.

[0137] It will be understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text. All of these different combinations constitute various alternative aspects of the invention.

[0138] While particular embodiments of this invention have been described, it will be evident to those skilled in the art that the present invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present embodiments and examples are therefore to be considered in all respects as illustrative and not restrictive, and all modifications which would be obvious to those skilled in the art are therefore intended to be embraced therein.

Claims

1. A fin plug for a water craft, said fin plug including:
    - a top surface and a bottom surface;
    - at least one fin cavity, for receiving a base element of a fin, extending inwardly from at least one opening in the top surface; and
    - at least one hole extending between the top surface and the bottom surface adapted to be filled with foam.

2. A fin plug according to claim 1, including a plurality of said holes extending between the top surface and the bottom surface.

3. A fin plug according to claim 1 or claim 2, wherein said fin plug includes a planar portion, having said top surface and said bottom surface, and a base portion extending from said bottom surface and surrounding said at least one fin cavity.

4. A fin plug according to claim 3, wherein the planar portion includes a flange extending laterally from said a least one opening to an external perimeter.

5. A fin plug according to claim 3 or claim 4, wherein said fin plug includes two fin cavities for receiving two base elements of a surfcraft fin, said fin cavities extending inwardly from two openings in the top surface of said planar portion.

6. A fin plug according to claim 4 or claim 5, wherein at least some of the holes extend through the flange of the planar portion.

7. A fin plug according to any one of claims 1 to 6, wherein the holes have a length of up to 2 cm.

8. A fin plug according to claim 7, wherein the holes are located in the planar portion and have a length of up to 0.5 cm.

9. A fin plug according to claim 8, wherein the holes have a length of about 0.3 cm.

10. A fin plug according to any one of claims 3 to 9, wherein the base portion of said fin plug includes a plurality of rib elements on an external surface thereof.

11. A fin plug according to any of claims 3 to 10, wherein the base portion includes a wall section and a floor section which are of substantially uniform thickness.

12. A fin plug according to any one of claims 1 to 11, further including fin retention means.

13. A fin plug according to claim 12, wherein the fin retention means includes a grub screw located within a screw hole which extends from the top surface and communicates with said at least one fin cavity.

14. A fin plug according to claim 12 or claim 13, wherein the fin retention means includes a biasing means adapted to impose a lateral force on the base element of the fin located in said fin cavity.

15. A fin plug according to claim 14, wherein the biasing means includes a resilient biasing rod and a protruding member cooperating with the biasing rod, said protruding member being adapted to abut the base portion of said fin when received in said fin cavity.

16. A fin plug according to claim 15, wherein the resilient biasing rod is formed of material selected from titanium, steel, marine grade steel, fiberglass, carbon fibre, plastic and reinforced engineering plastic.

17. A fin plug according to any one of claims 12 to 16, further including fin removal inhibiting means including a ledge portion, within said fin cavity, adapted to overlie a section of the base element of said fin.

18. A fin plug according to any one of claims 13 to 17, wherein the fin retention means of the fin plug includes said grub screw located within said screw hole which extends from the top surface and communicates with one of said two fin cavities.

19. A fin plug according to claim 18, wherein the fin retention means of the fin plug includes two of said grub screws located within two screw holes, one of which extends from the top surface and communicates with one of said two fin cavities and the other of which extends from the top surface and communicates with the other of said two fin cavities.

20. A fin plug according to any one of claims 14 to 19, wherein the fin retention means of the fin plug includes said biasing means which is adapted to impose said lateral force on the base element of the fin located in one of said fin cavities.

21. A fin plug according to any one of claims 1 to 20, wherein the fin plug is formed of a thermoplastic or plastic material.

22. A fin plug according to claim 21, wherein the thermoplastic material is selected from polyamide ('nylon'), acrylonitrile butadiene styrene ('ABS'), polyurethane polyvinyl chloride ('PVC'), polybutylene terepthalate ('PBT') and polyethylene terephthalate ('PET').

23. A fin plug assembly including:

- a fin plug according to any one of claims 1 to 22; and
- at least one foam in-fill within the at least one hole extending between the top surface and the bottom surface of said fin plug.

24. A fin plug assembly according to claim 23, wherein said fin plug includes a plurality of said holes extending between the top surface and the bottom surface and foam in-fills located in at least some of the plurality of holes.

25. A fin plug assembly according to claim 24, wherein the foam in-fills are integrally formed with a foam body which underlies the planar portion of the fin plug.

26. A fin plug assembly according to claim 25, wherein the foam body substantially surrounds the base portion of the fin plug.

27. A fin plug assembly according to claim 25 or claim 26, wherein the foam body includes a sidewall which has a profile which is substantially identical to the external perimeter of the flange of the planar portion.

28. A fin plug assembly according to claim 27, wherein said sidewall is a continuous sidewall which extends about the foam body.

29. A fin plug assembly according to any of claims 25 to 28, wherein the foam body has a thickness which is substantially equivalent to the distance from the bottom surface of the planar portion to a bottom surface of the base portion of the fin plug.

30. A fin plug assembly according to any one of claims 23 to 29, wherein an upper end of each in-fill is substantially flush with said top surface.

31. A fin plug assembly according to any one of claims 23 to 30, wherein the foam body and foam infills are formed of polyurethane foam or epoxy foam.

32. A method of manufacturing a fin plug assembly, of any one of claims 23 to 31, said method including the steps:

- provide a fin plug according to any one of claims 1 to 22;

- block up each fin cavity of the fin plug to inhibit fluid material entering into said cavity;
- insert the fin plug into an injection mould chamber and inject liquid foam into the chamber so that liquid foam enters into the holes of the fin plug and forms around the base portion of the fin plug;
- allow the liquid foam to expand and cure so that a fin plug plus foam block is formed; and
- remove the fin plug assembly from the chamber.

33. A method of manufacturing a fin plug assembly according to claim 32, further including the step of cutting excess foam from the fin plug plus foam block so that the top surface of the planar portion and the bottom surface of the base portion of the fin plug are exposed.

34. A method of manufacturing a fin plug assembly according to claim 33, further including the step of cutting excess foam from the fin plug plus foam block so as to form a sidewall of the fin plug assembly which has a profile which is substantially identical to the external perimeter of the flange of the planar portion.

35. A method of manufacturing a fin plug assembly according to claim 33, wherein the mould chamber has a shape adapted to form a sidewall of the fin plug assembly which has a profile which is substantially identical to the external perimeter of the flange of the planar portion.

36. A method of installing into a water craft a fin plug assembly, of any one of claims 23 to 31, said method including the steps:

- provide a fin plug according to any one of claims 1 to 22;
- block up each fin cavity of the fin plug with material to inhibit fluid material entering into said cavity;
- provide a shaped surfboard blank;
- make position markings on underside of surfboard blank corresponding to the desired positions for the fin plug in the surfboard blank;
- route out plug hole in underside of surfboard blank, said plug hole adapted to receive the fin plug assembly and being of substantially corresponding shape to that of the fin plug assembly;

- pour an amount of resinous material into the plug sufficient to form a layer of resinous material between the walls of the plug hole and the corresponding surfaces of the fin plug assembly;
- insert fin plug assembly into plug hole so that the top surface of the fin plug is flush with the underside of the surfboard blank;
- connect a dummy jig to the fin plug assembly by inserting one or more tabs of said dummy jig into the at least one fin cavity of the fin plug;
- adjust cant angle and toe angle of the fin as desired and secure dummy jig in desired orientation;
- once resinous material has set, remove the dummy jig;
- apply fibreglass and coating of resinous material to external surfaces of surfboard blank, including over top surface of fin plug;
- perform sanding of the surface of the surfboard as required; and
- route out layer of fibreglass and resinous material above each fin cavity and the material used to block up each fin cavity;

37. A method of installing a fin plug assembly into a surfboard according to claim 36, wherein the material used to block up each cavity is a cavity plug.

38. A method of installing a fin plug assembly into a surfboard according to claim 37, wherein the cavity plug is formed of a material which has poor adhesion to resinous material.

39. A fin plug for a water craft, substantially as hereinbefore described, with reference to the accompanying Figures.

40. A fin plug assembly substantially as hereinbefore described with reference to the accompanying Figures.

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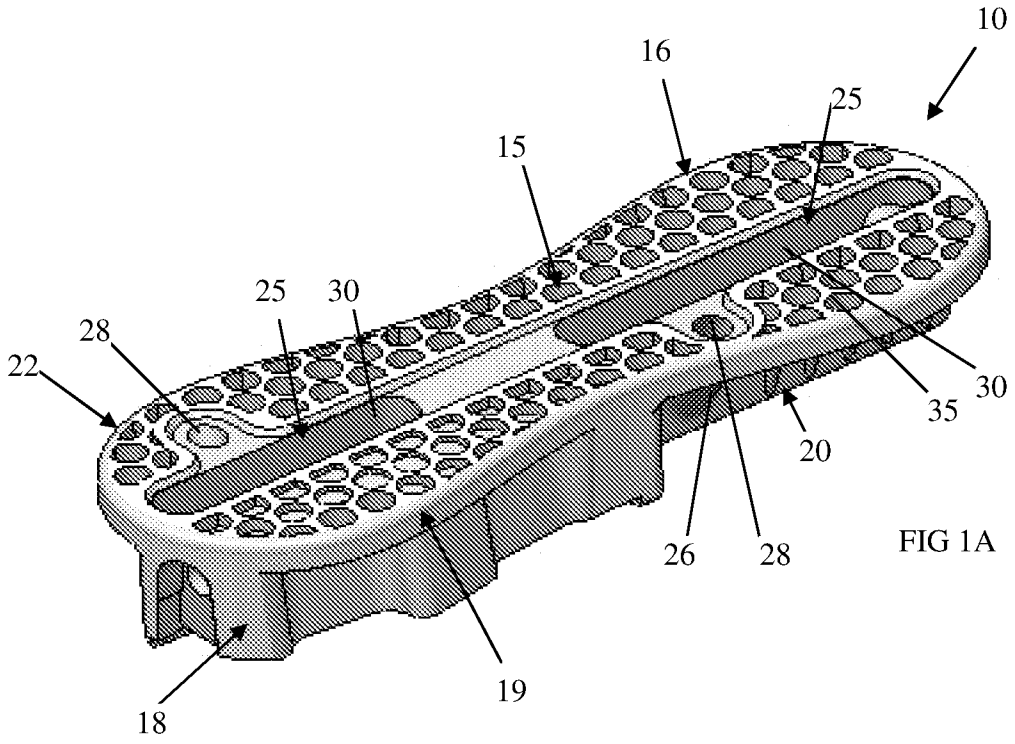

FIG 1A

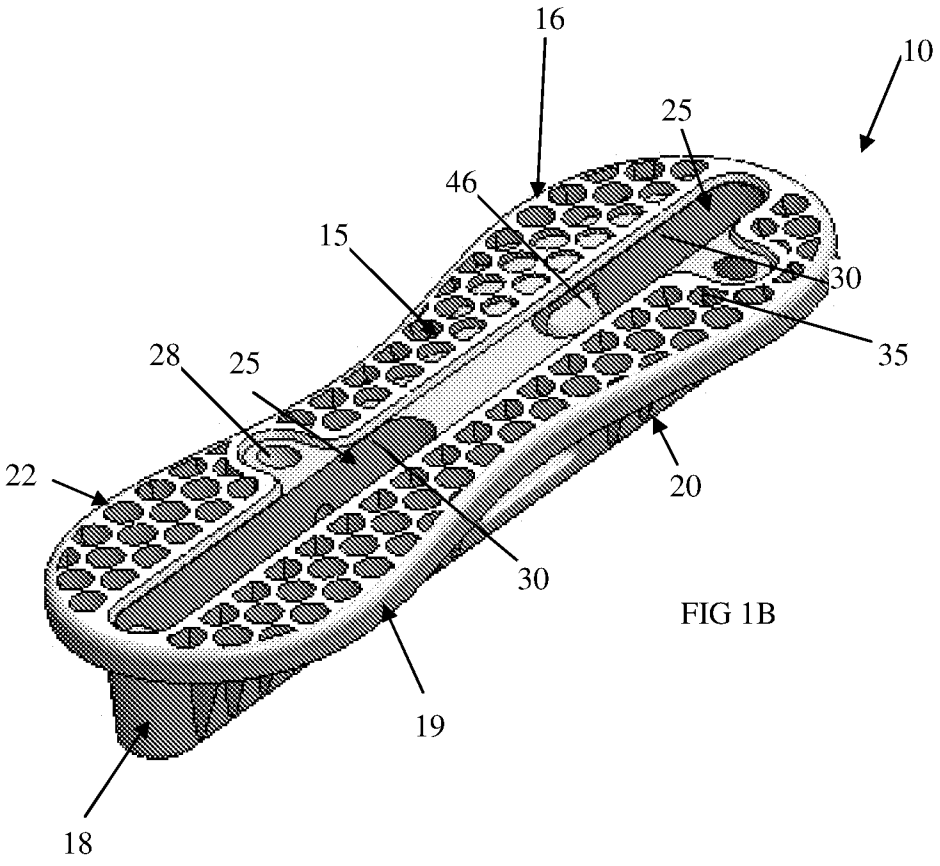

FIG 1B

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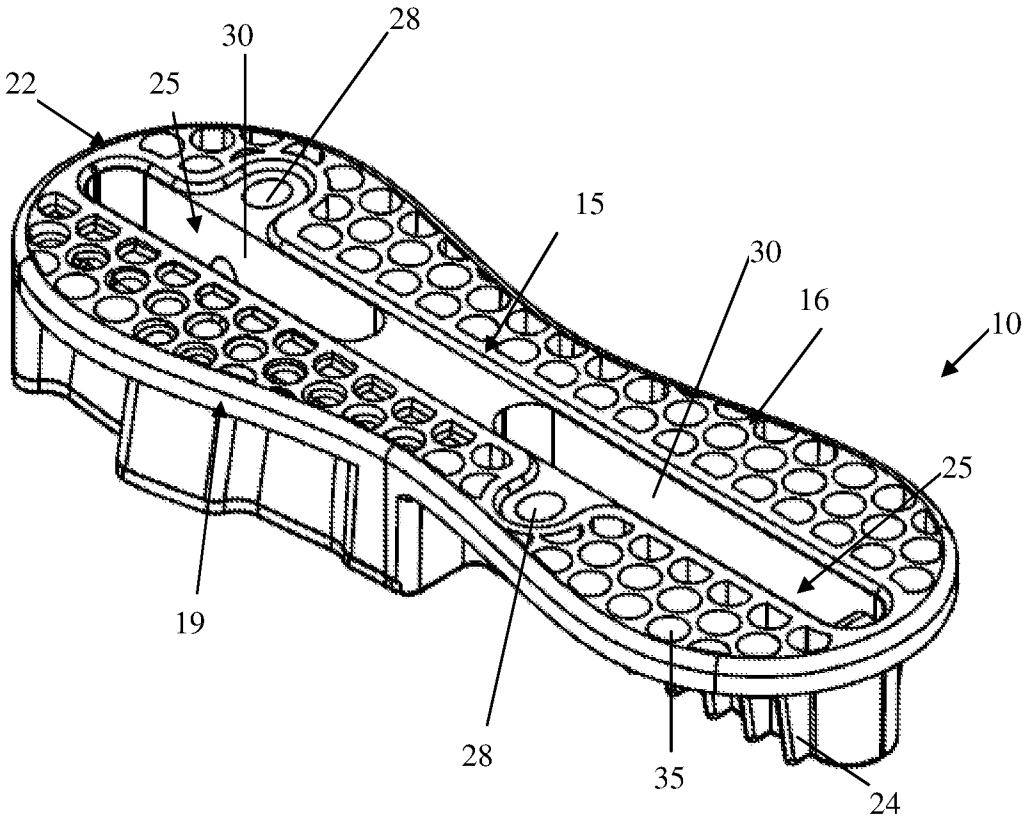

FIG 2A

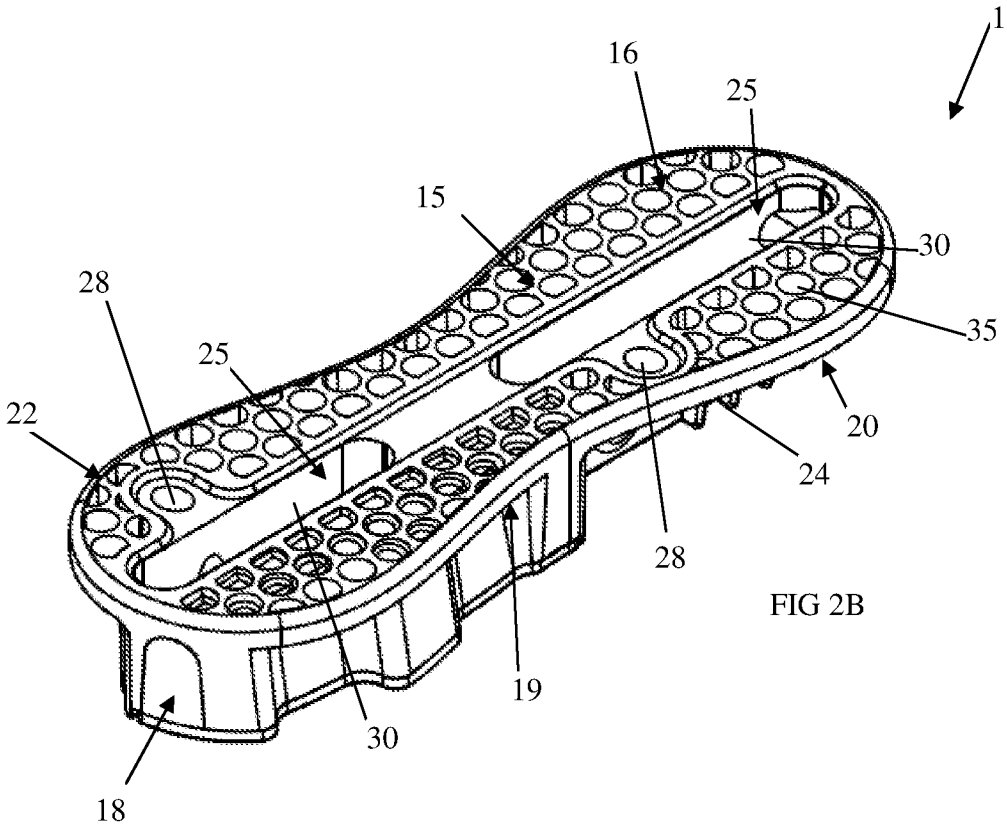

FIG 2B

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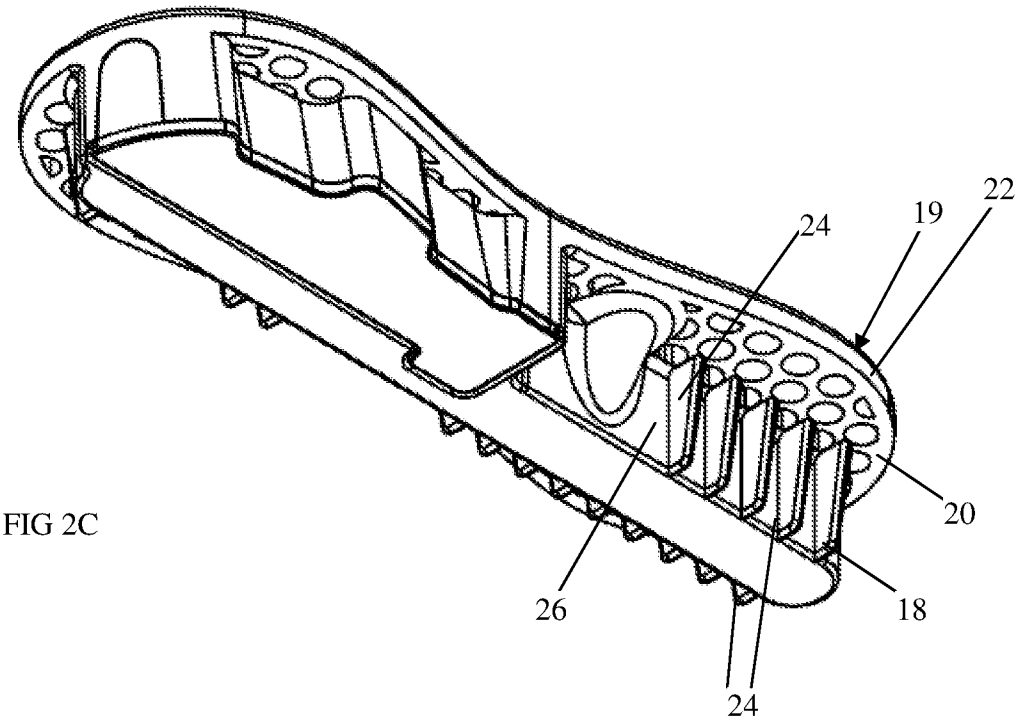

FIG 2C

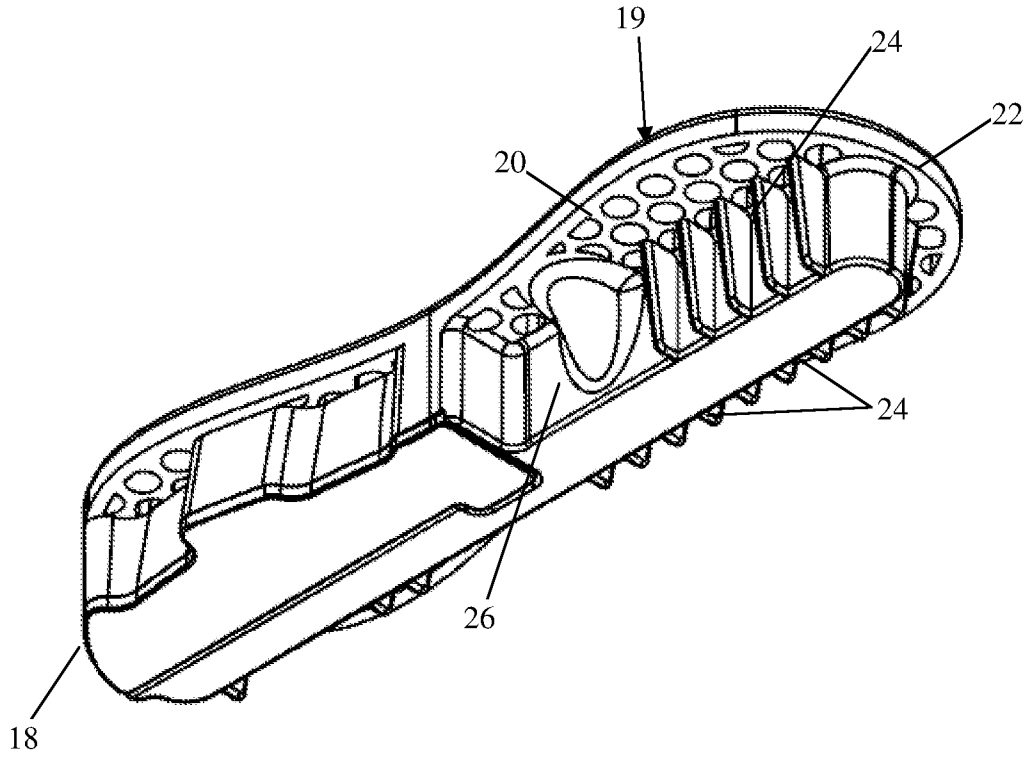

FIG 2D

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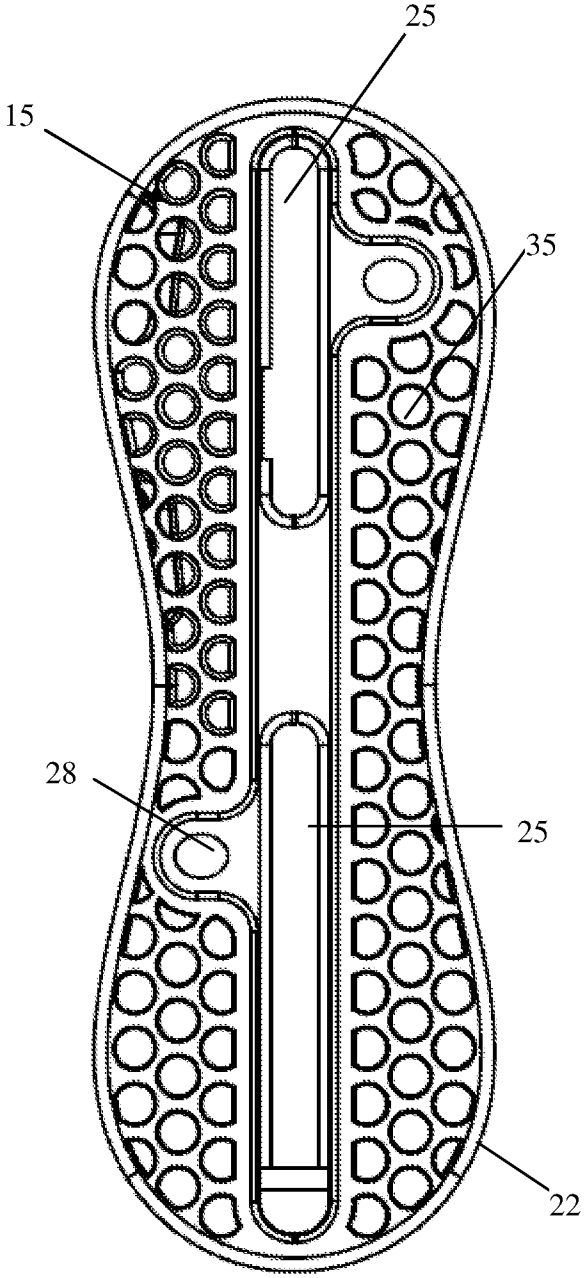

FIG 2E

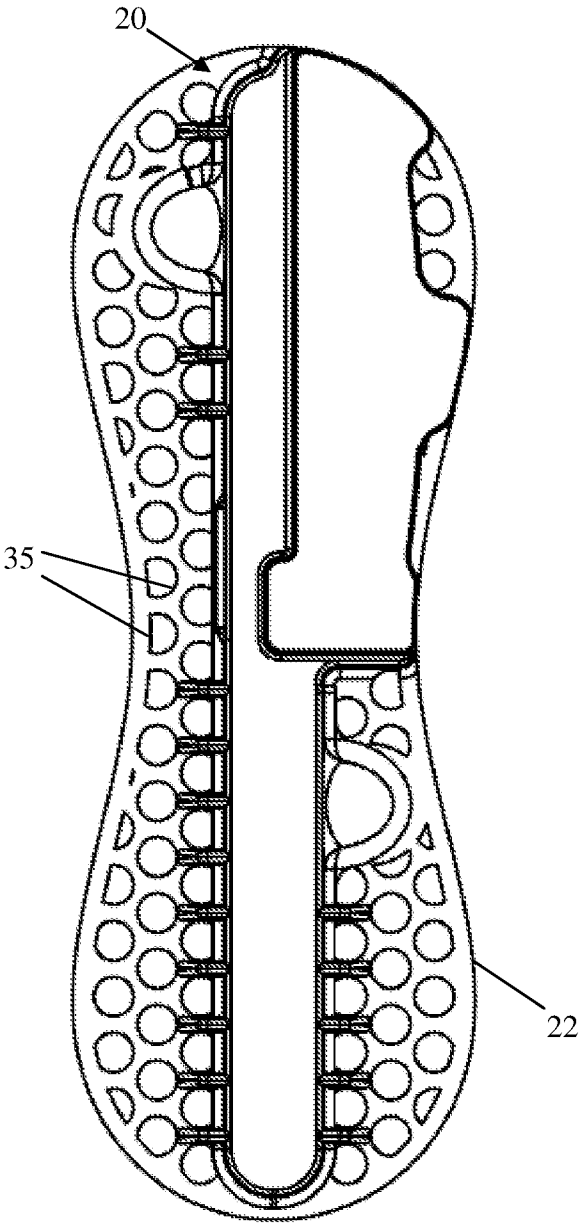

FIG 2F

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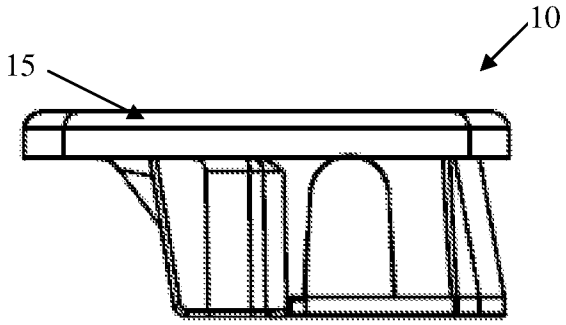

FIG 2G

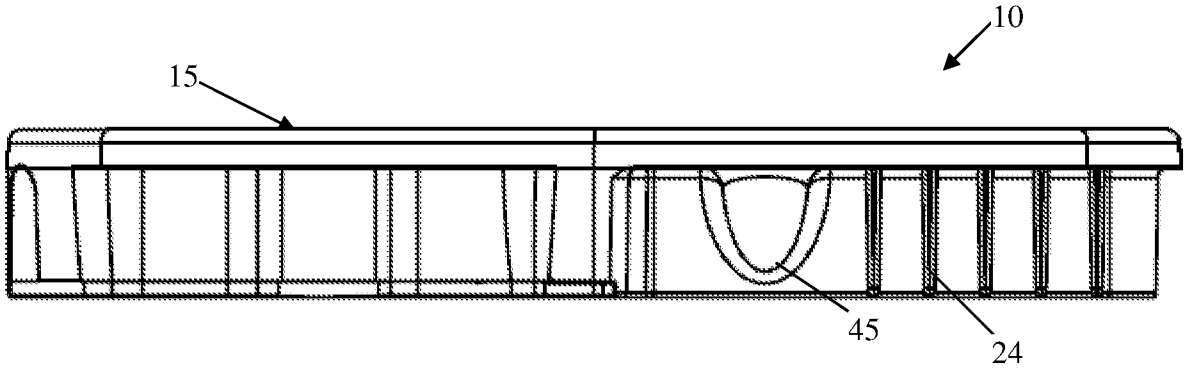

FIG 2H

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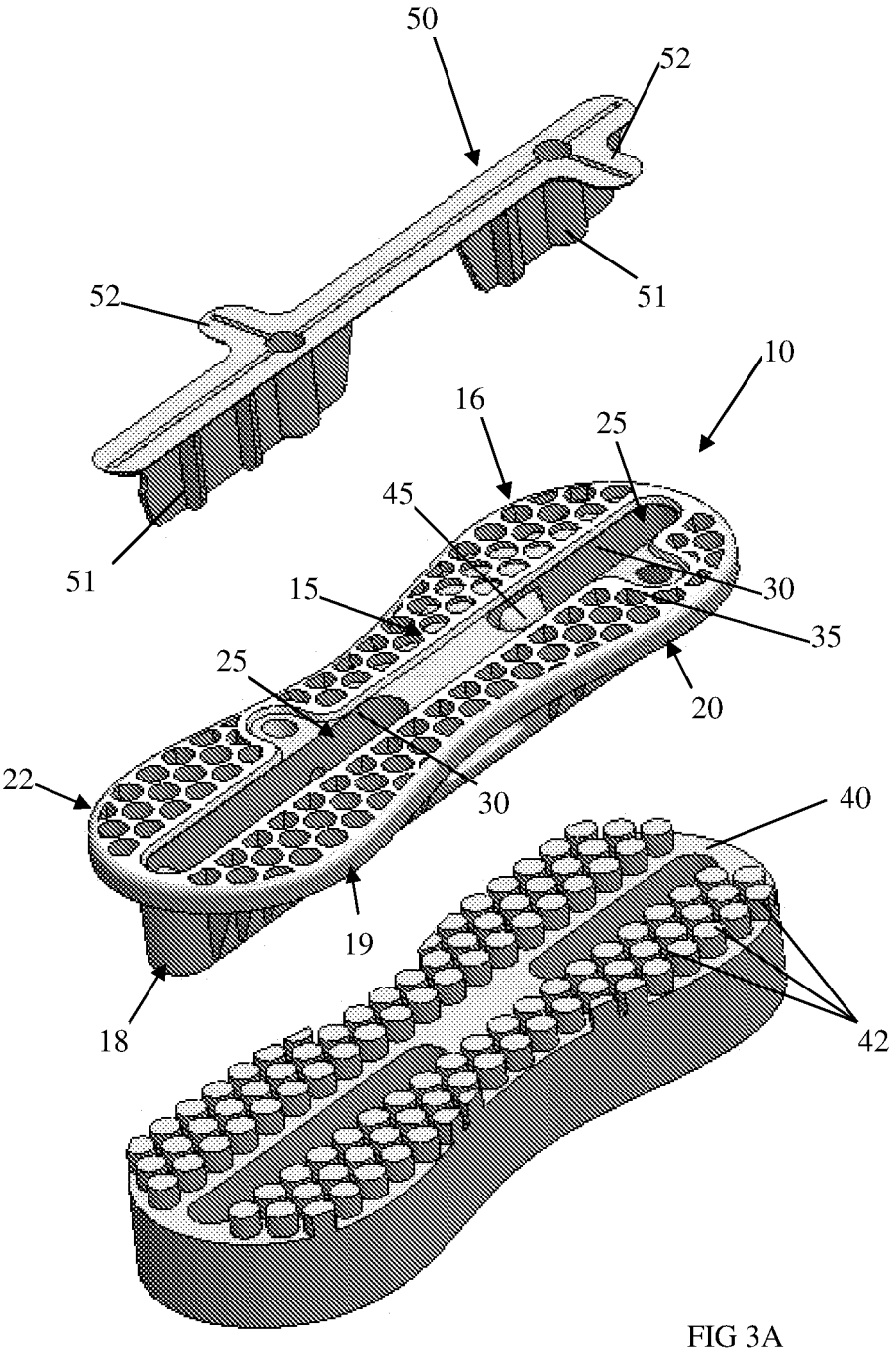

FIG 3A

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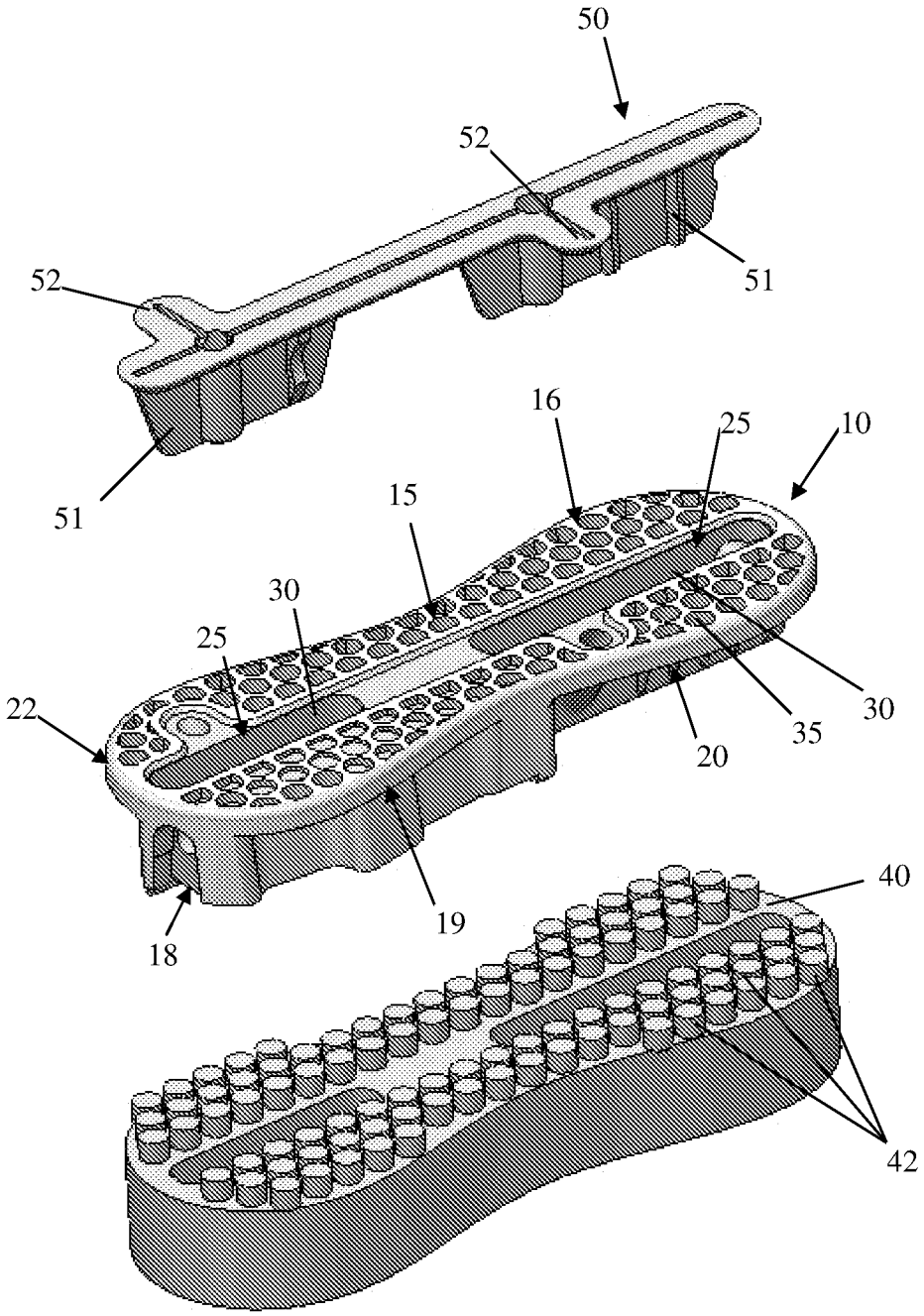

FIG 3B

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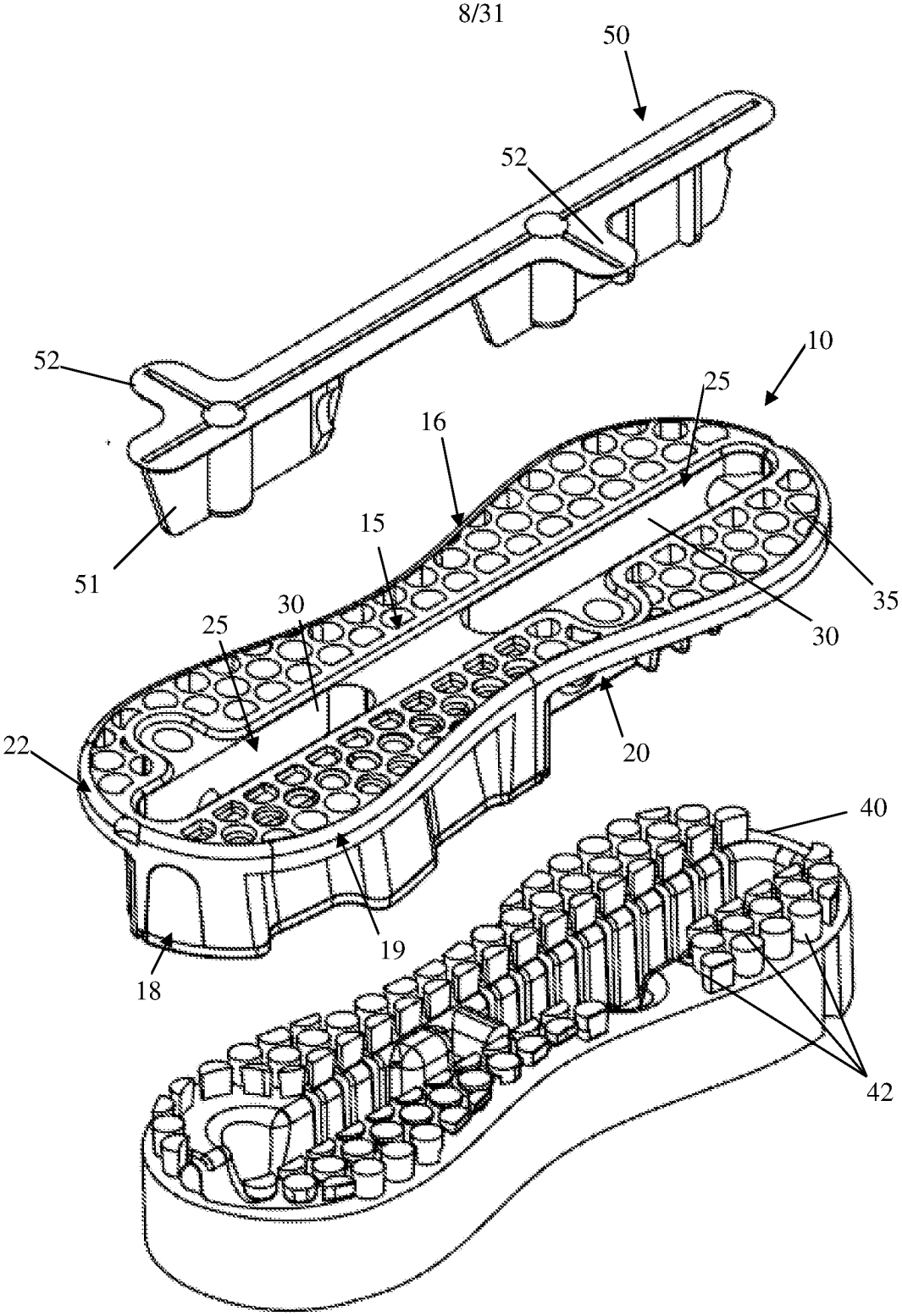

FIG 3C

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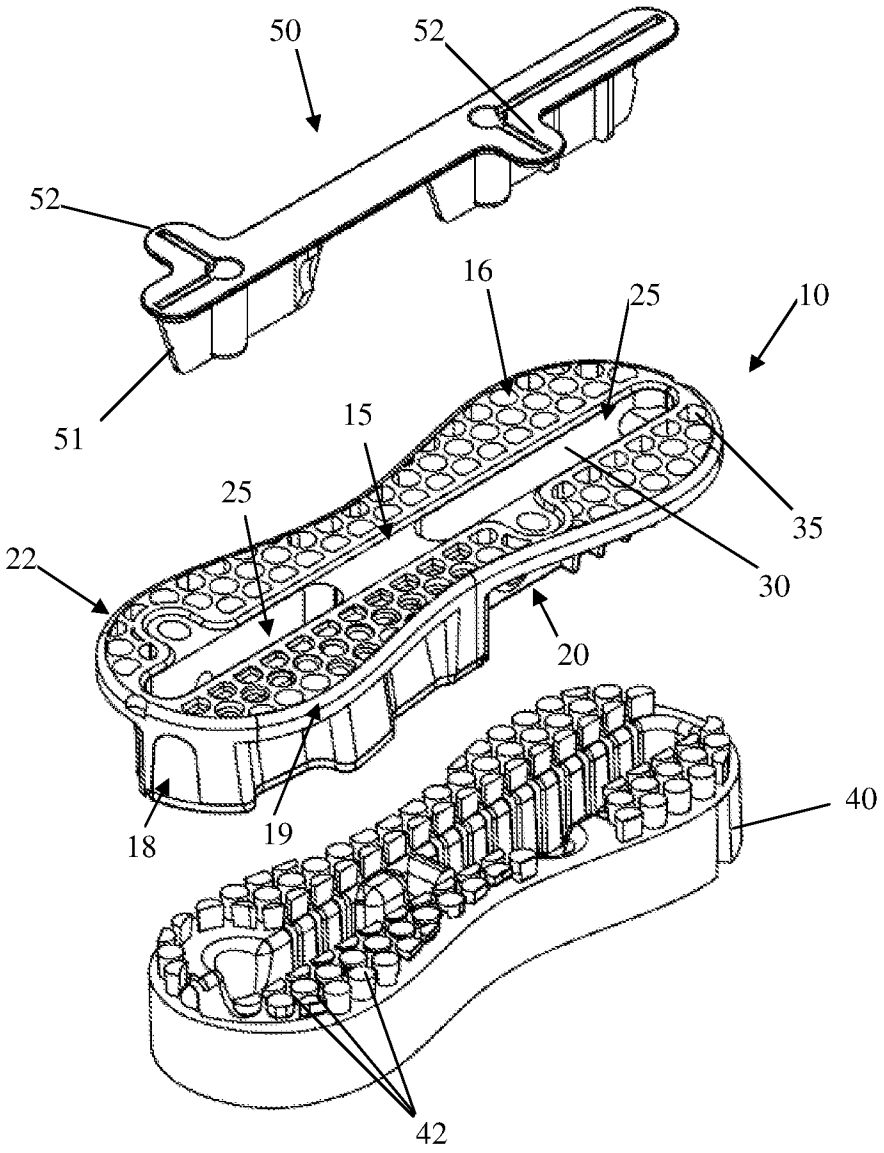

FIG 3D

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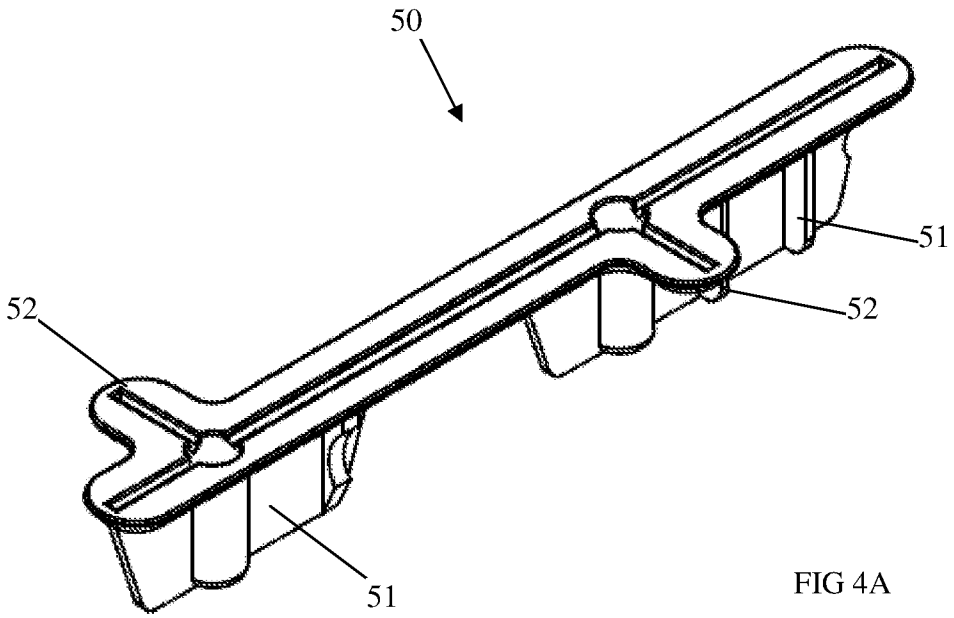

FIG 4A

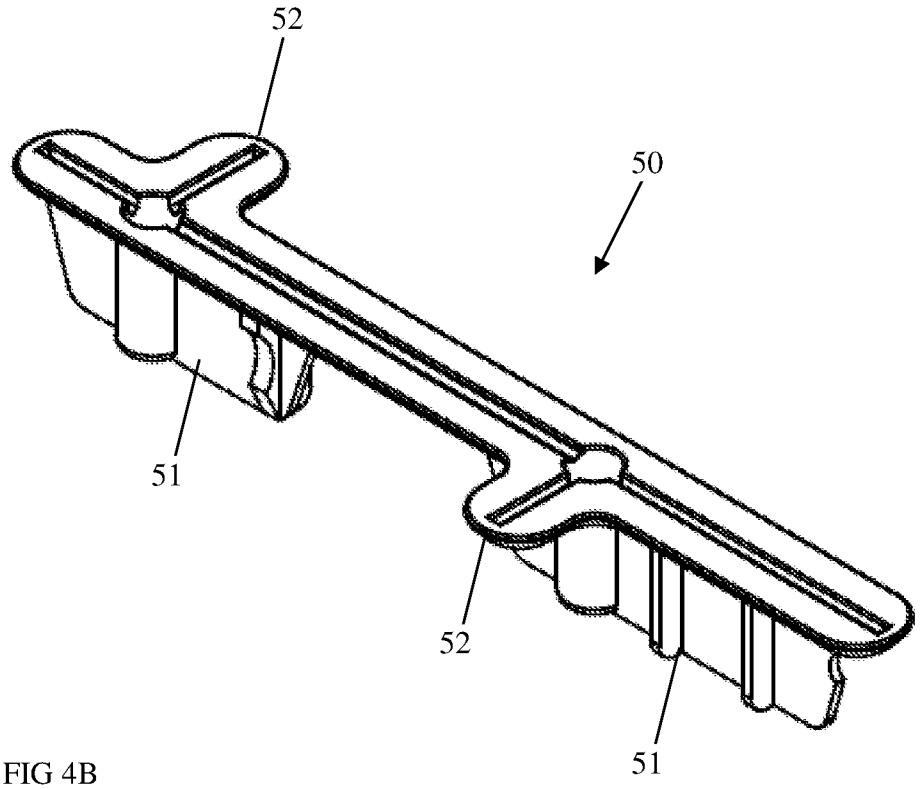

FIG 4B

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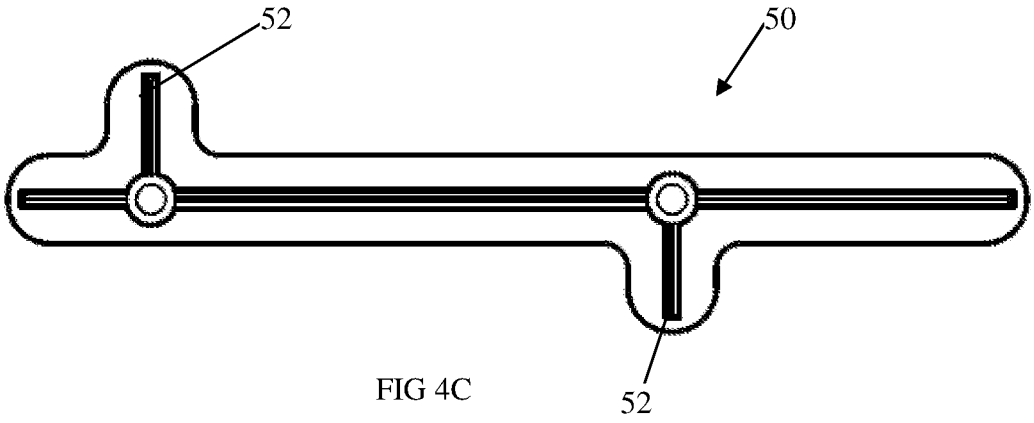

FIG 4C

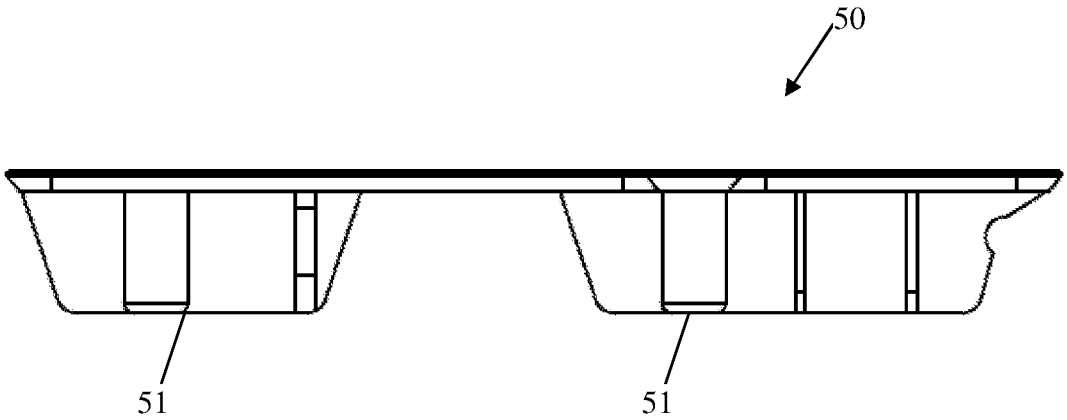

FIG 4D

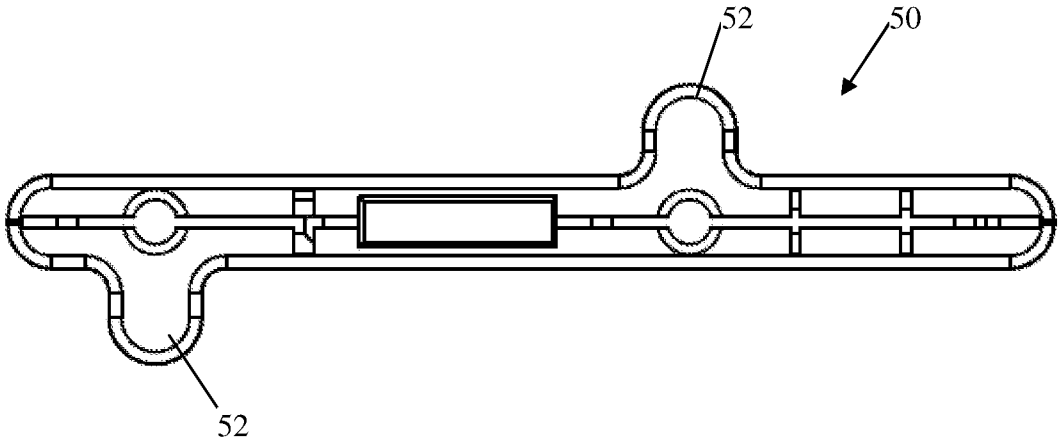

FIG 4E

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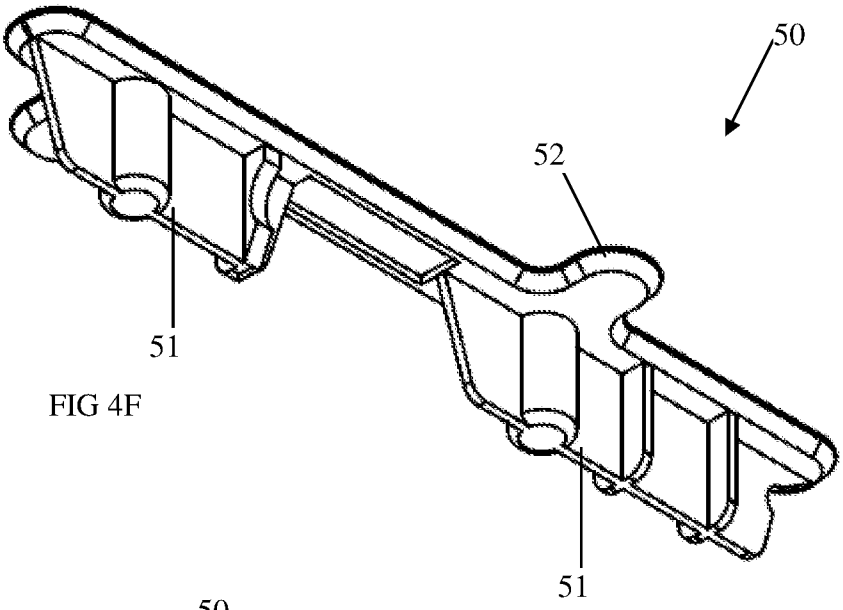

FIG 4F

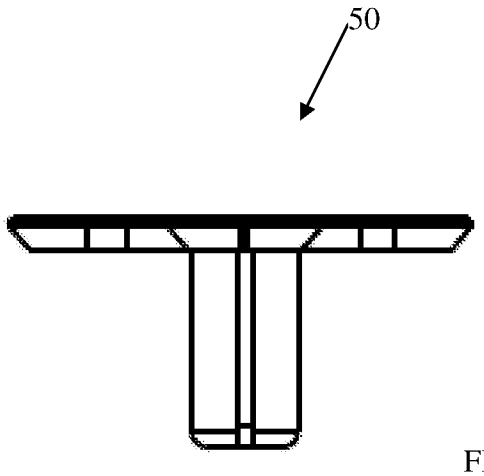

FIG 4G

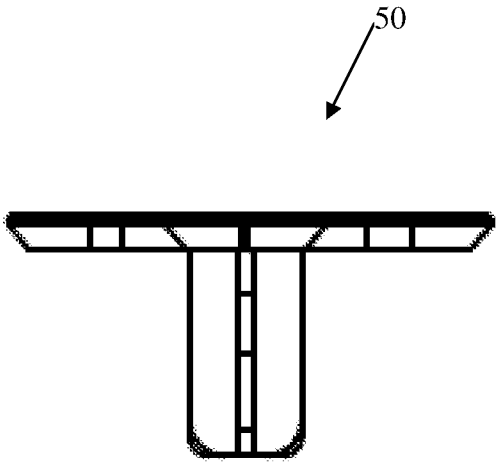

FIG 4H

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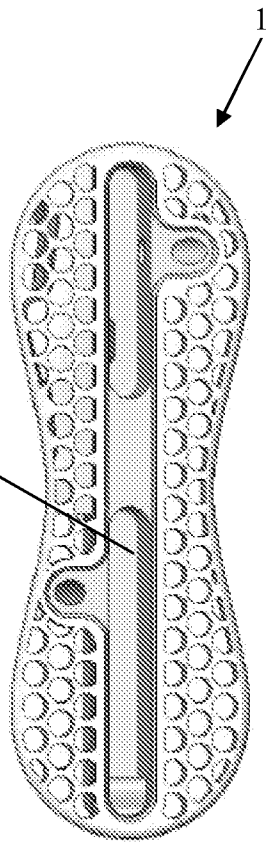

FIG 5A

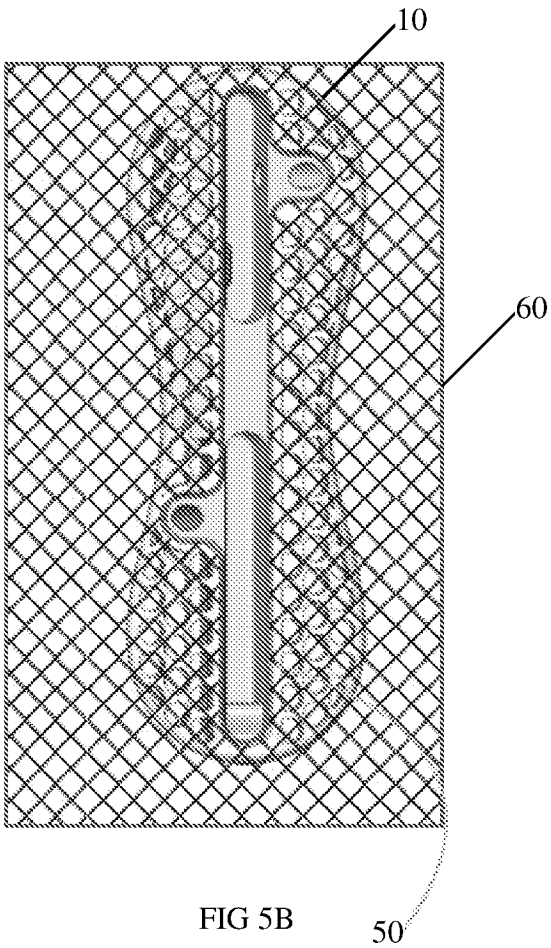

FIG 5B

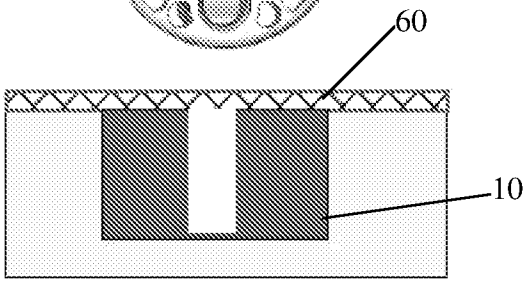

FIG 5C

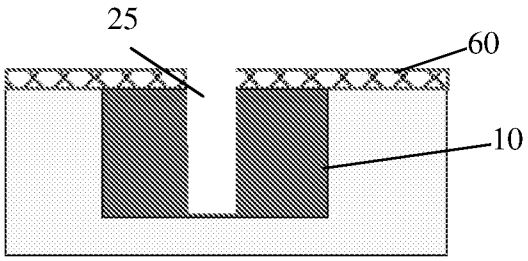

FIG 5D

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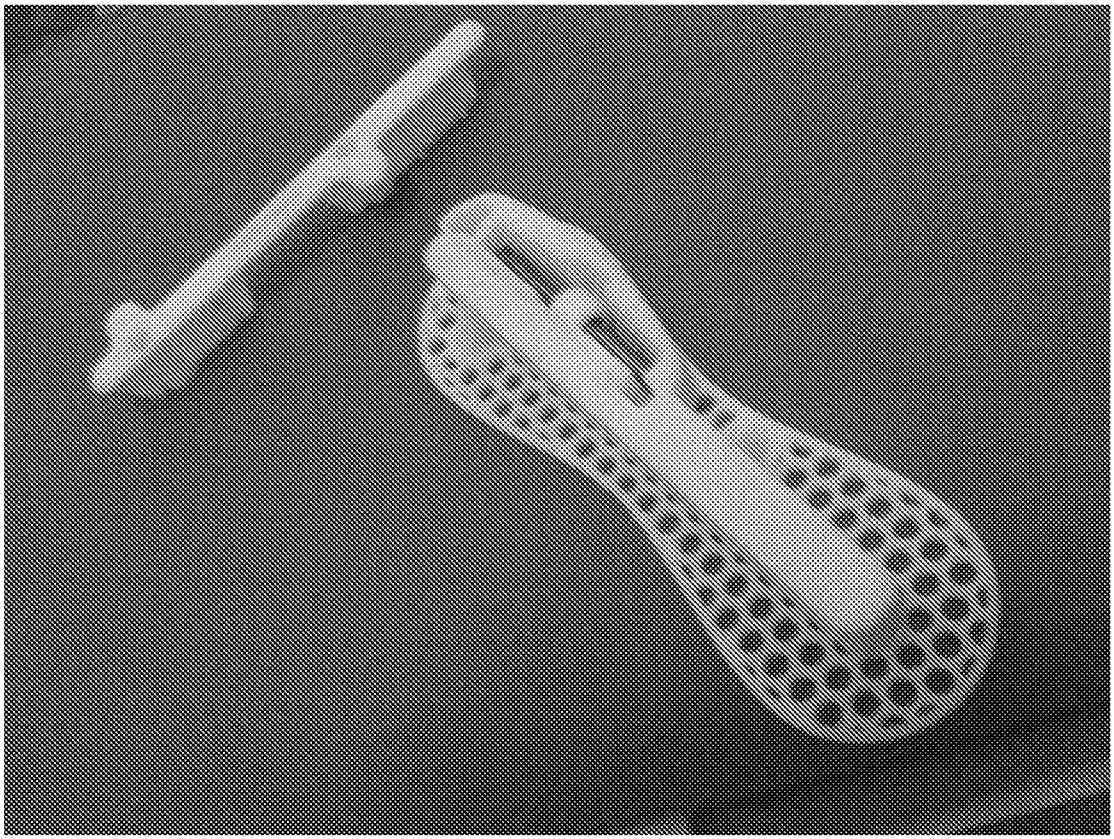

FIG 6

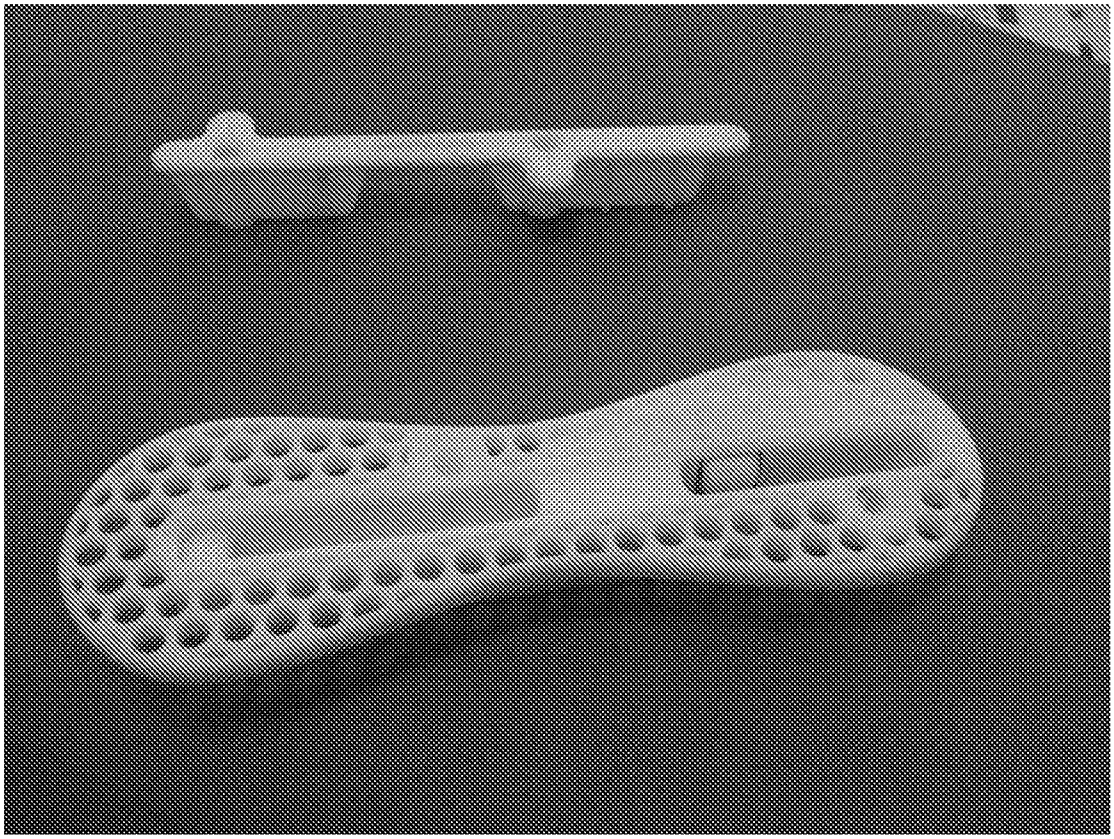

FIG 7

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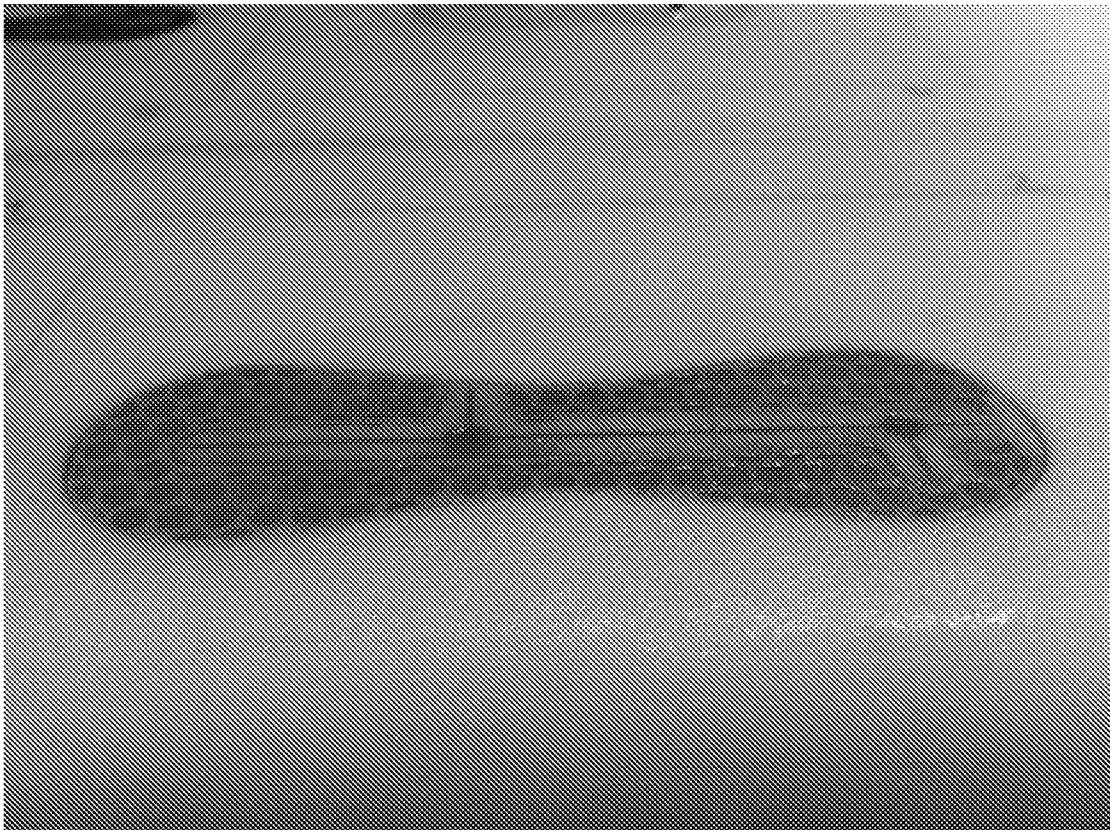

FIG 8

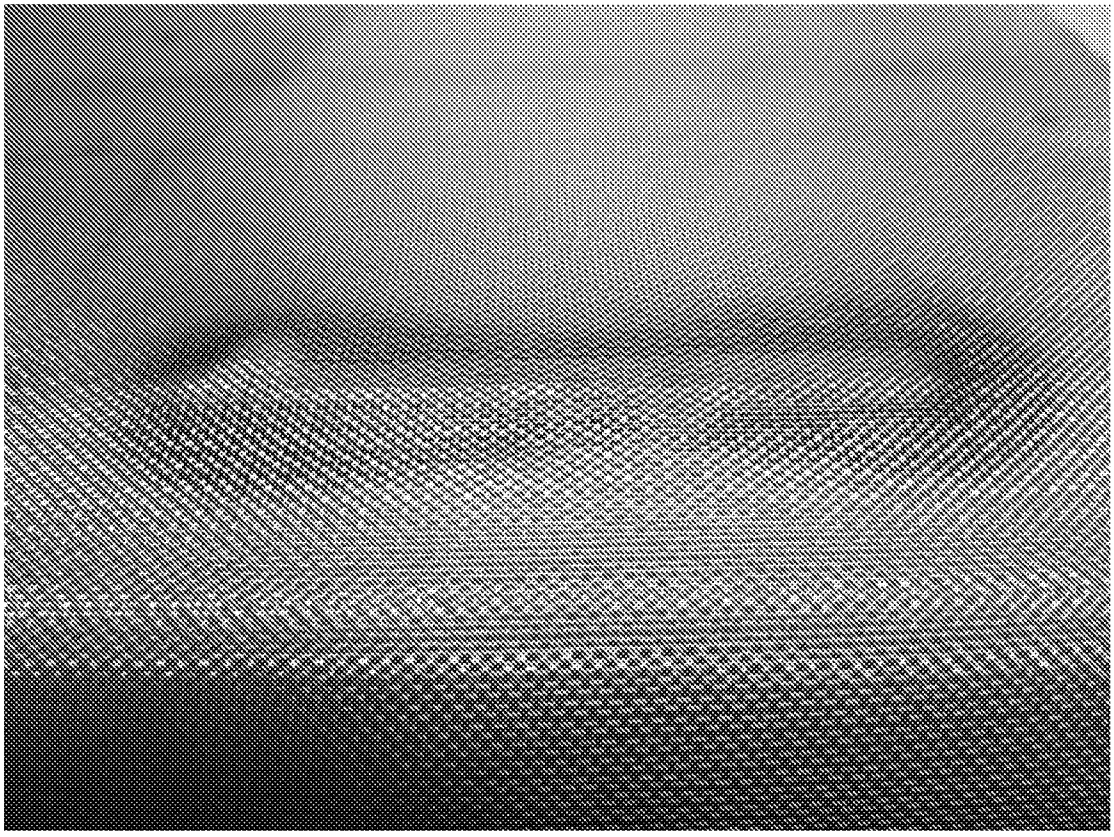

FIG 9

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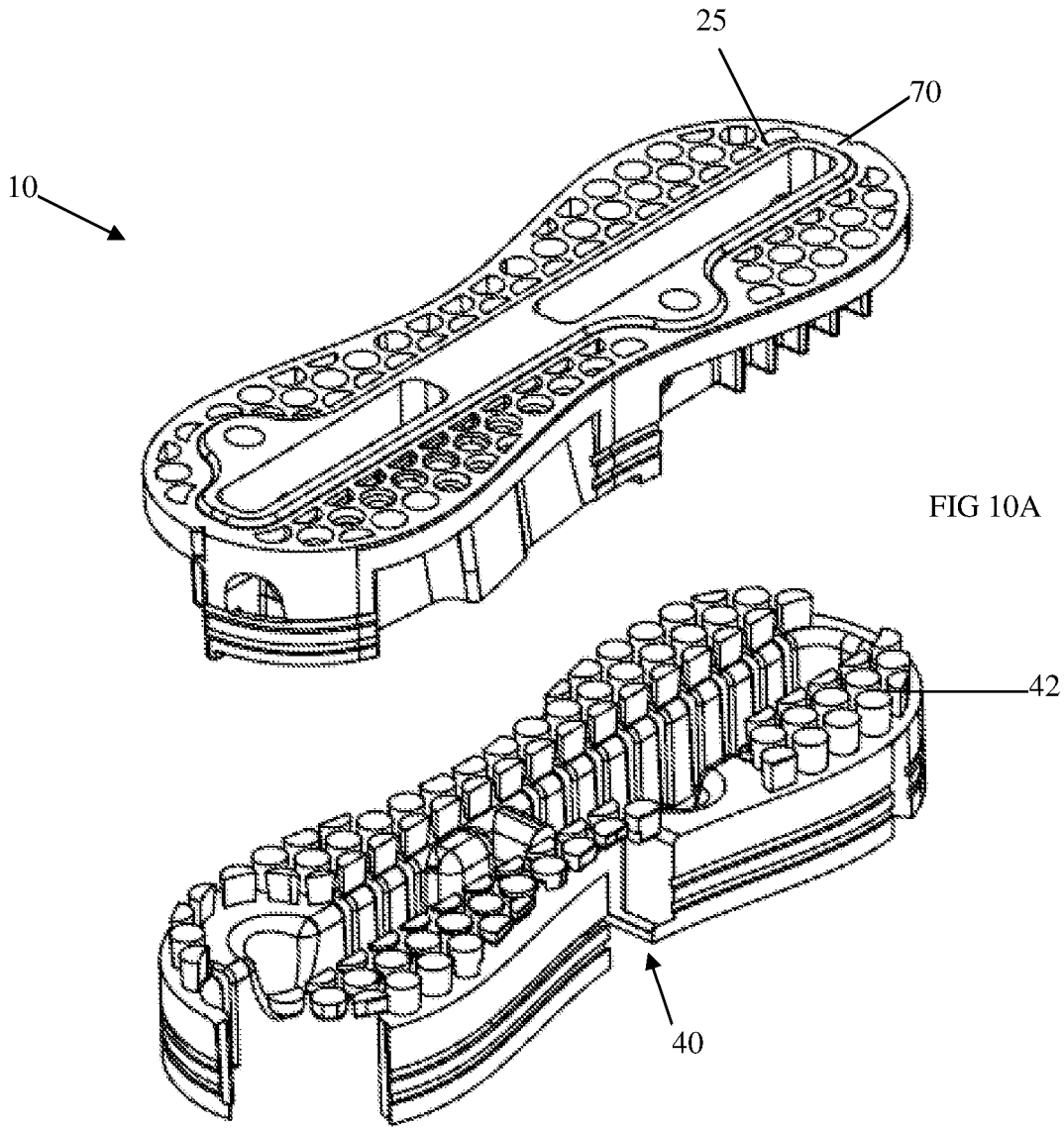

FIG 10A

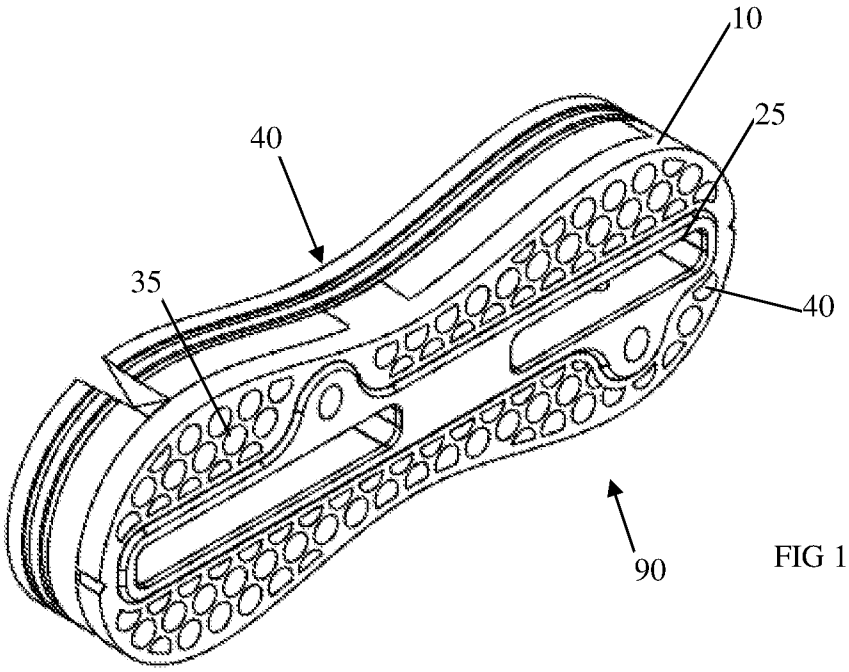

FIG 10B

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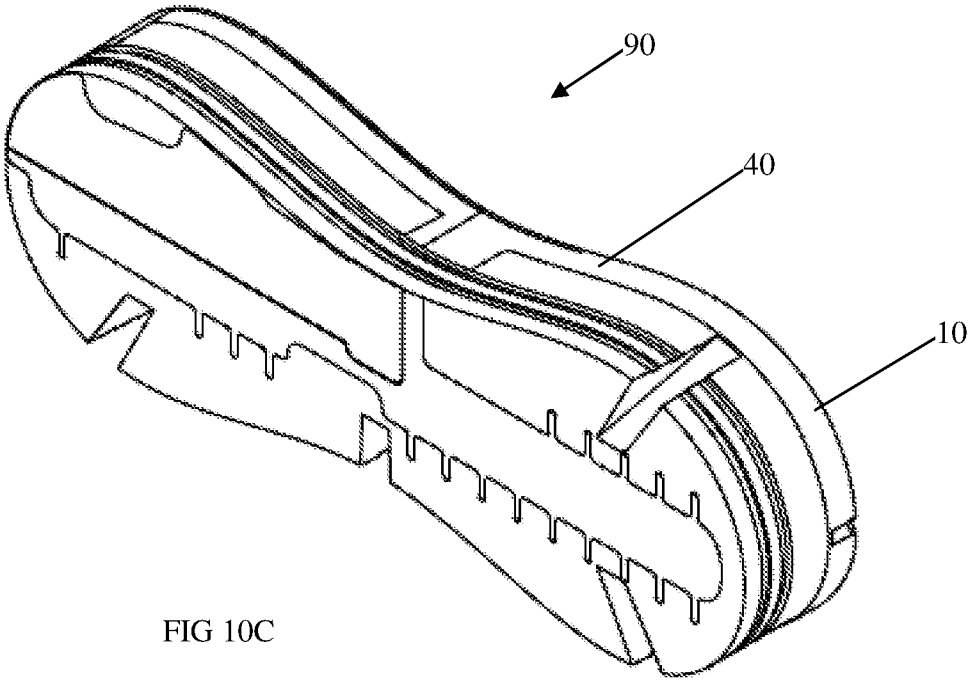

FIG 10C

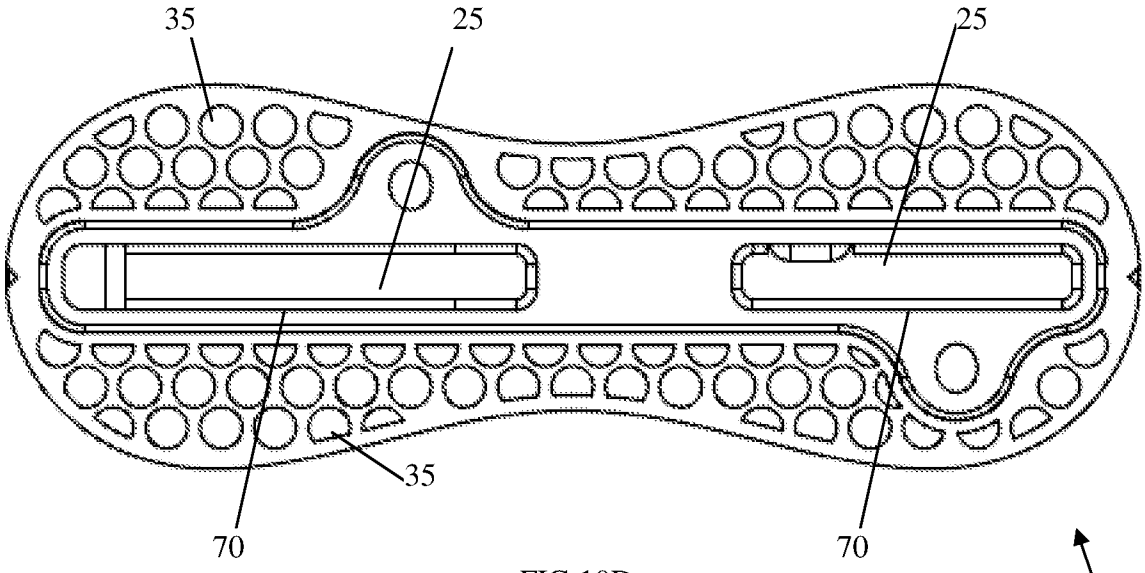

FIG 10D

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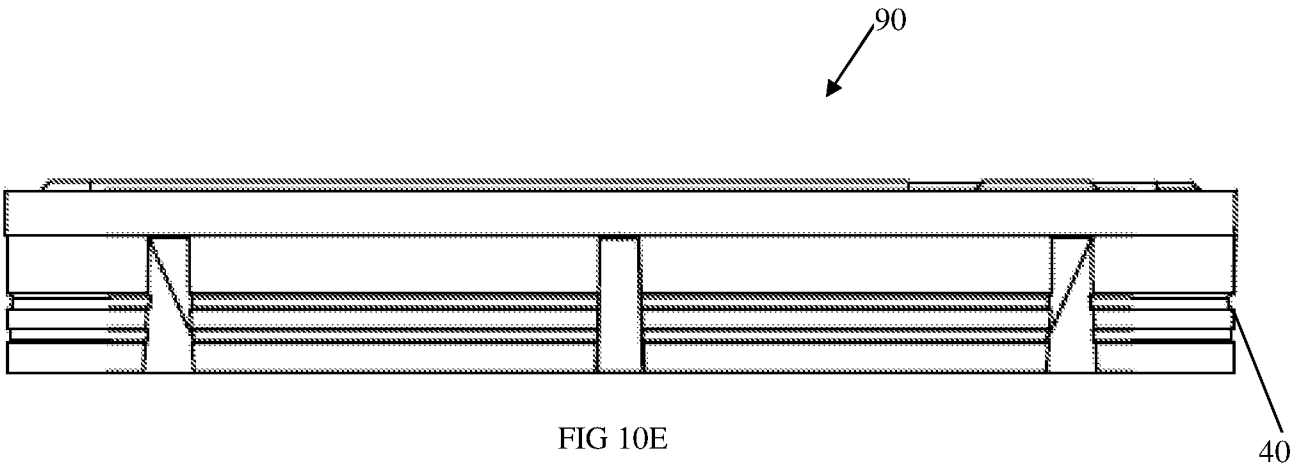

FIG 10E

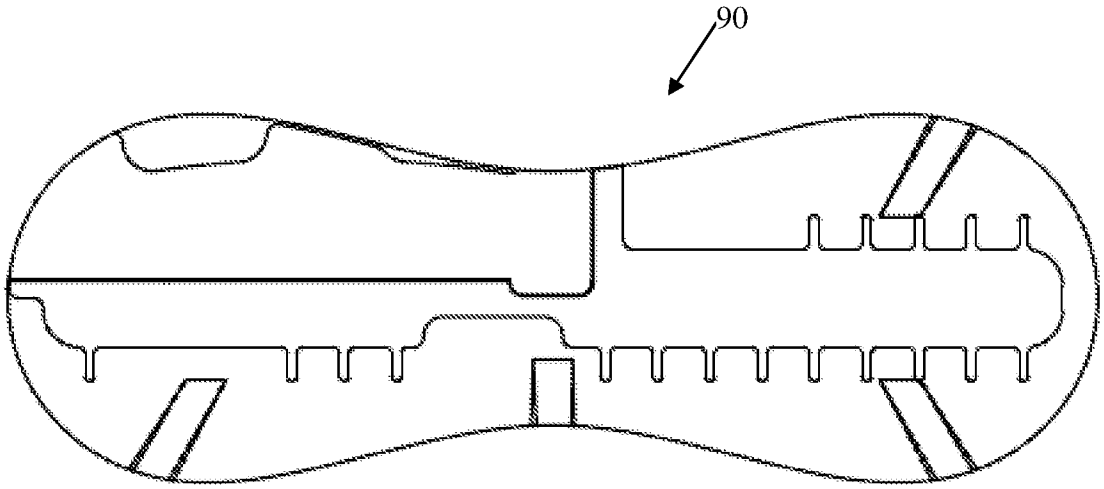

FIG 10F

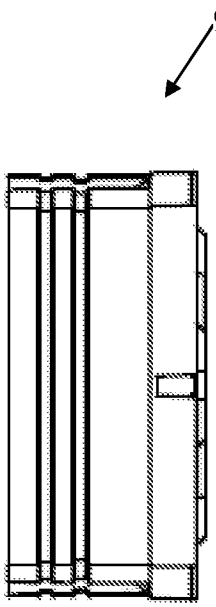

FIG 10G

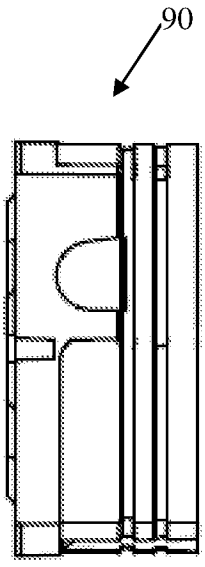

FIG 10H

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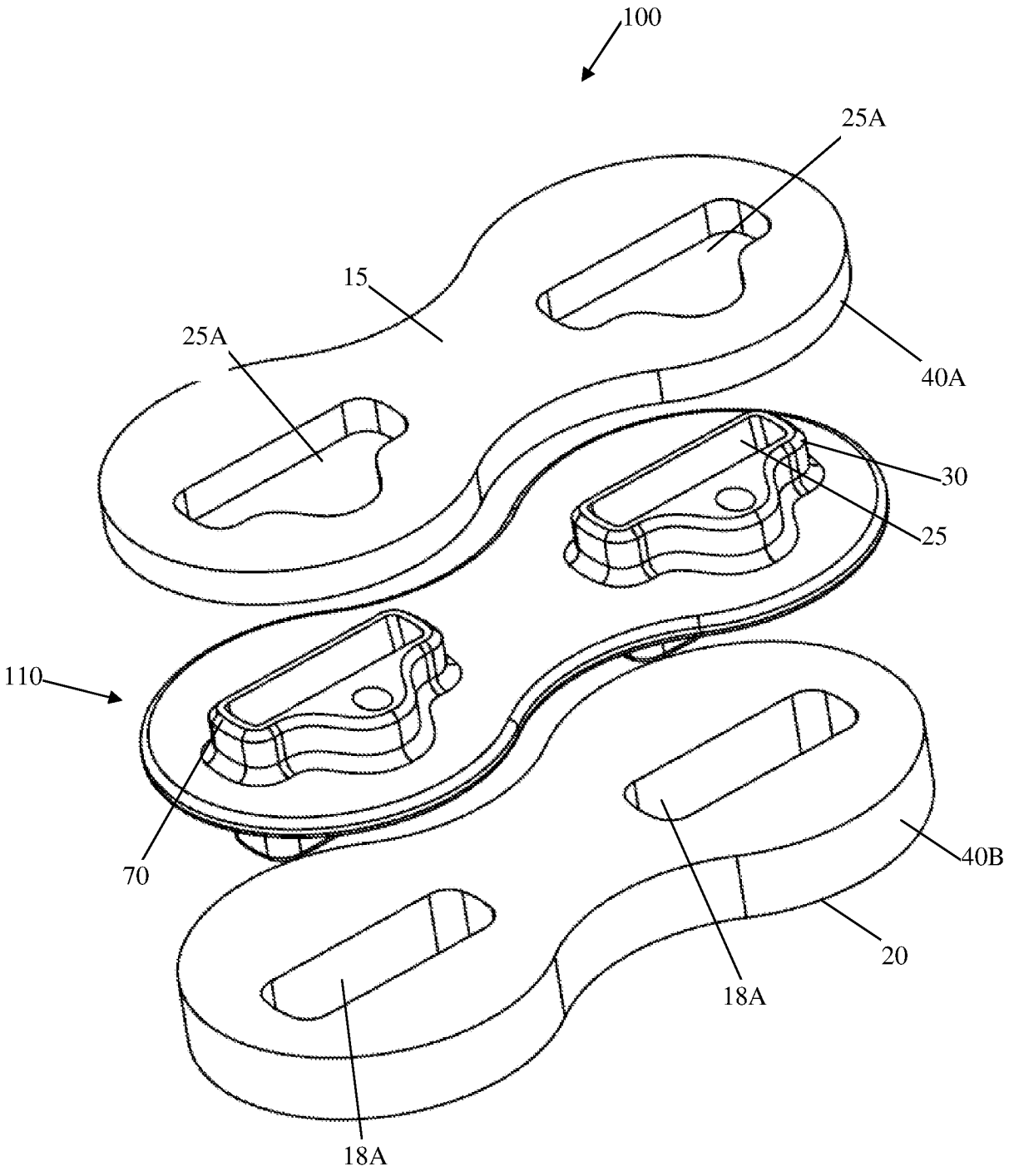

FIG 11A

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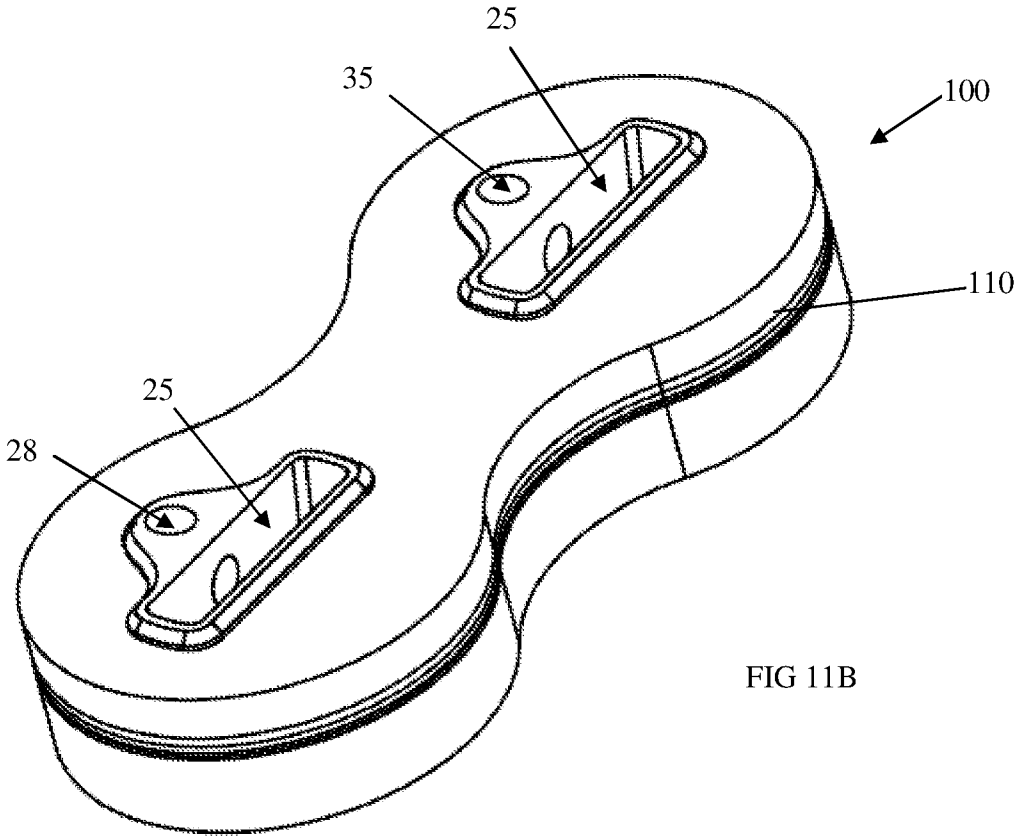

FIG 11B

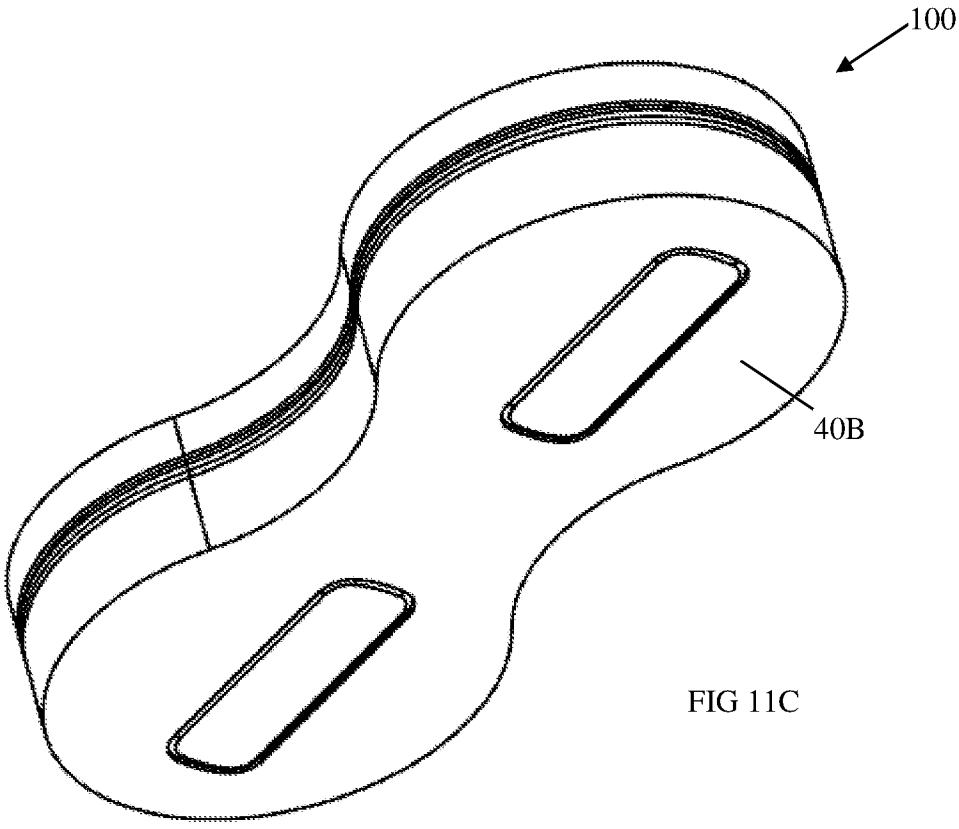

FIG 11C

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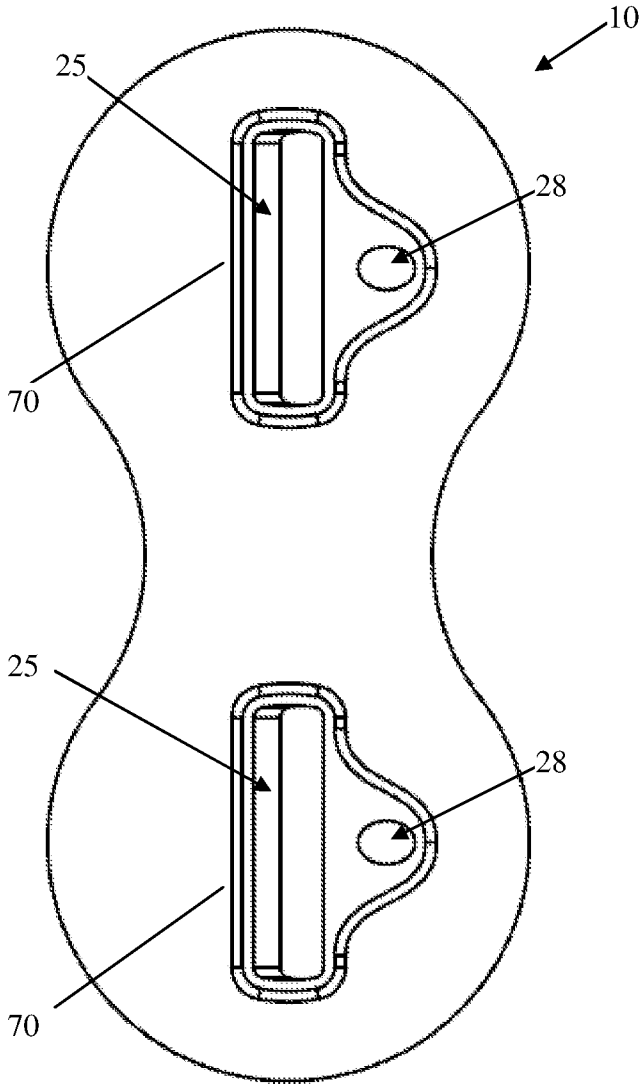

FIG 11D

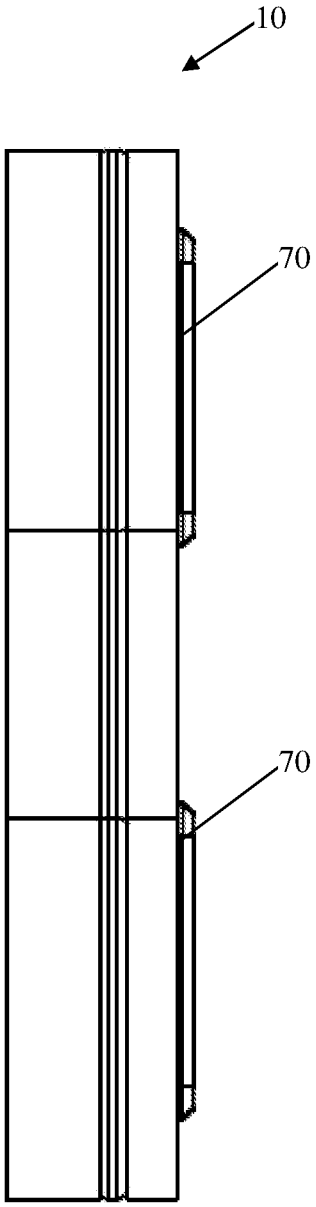

FIG 11E

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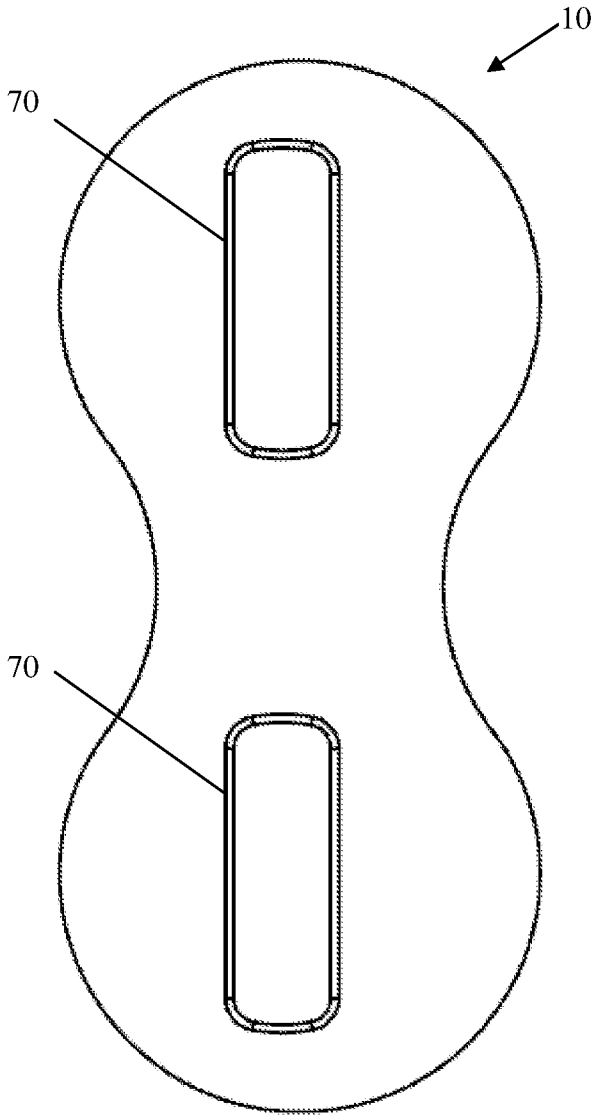

FIG 11F

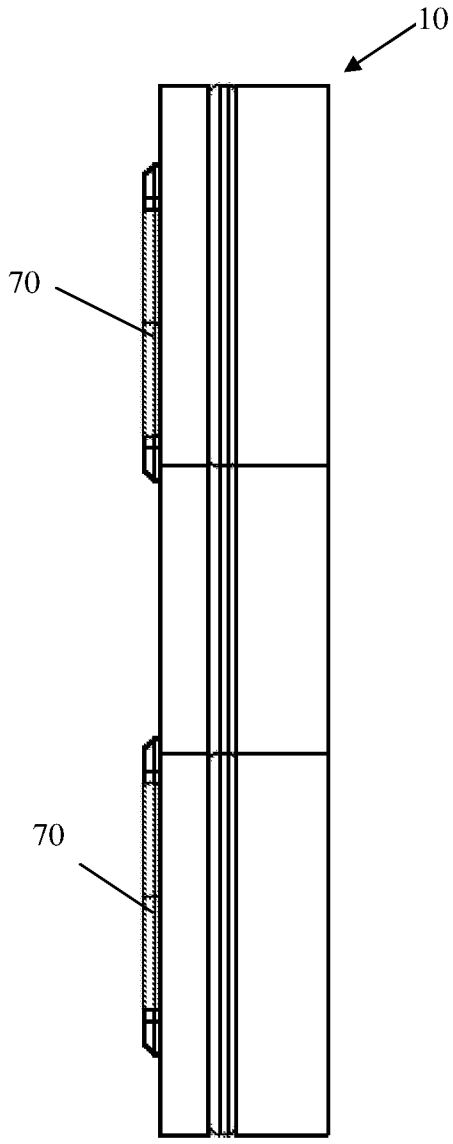

FIG 11G

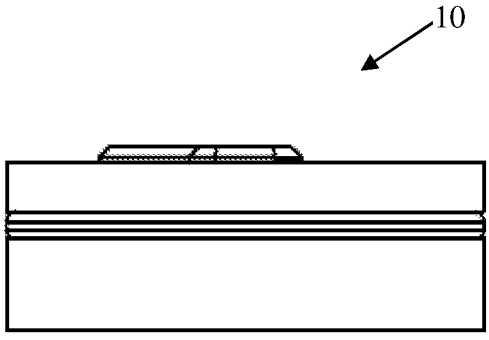

FIG 11H

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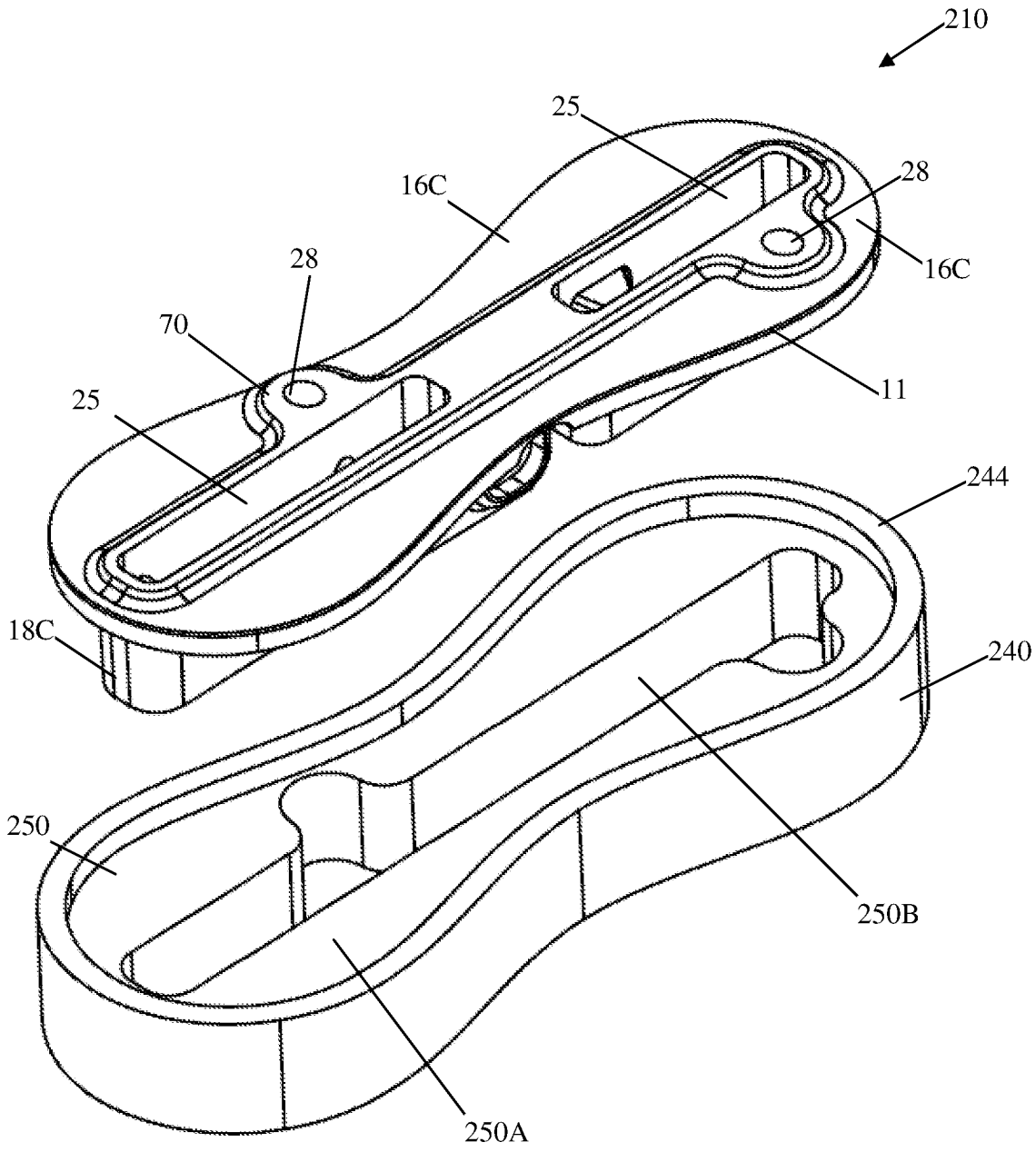

FIG 12A

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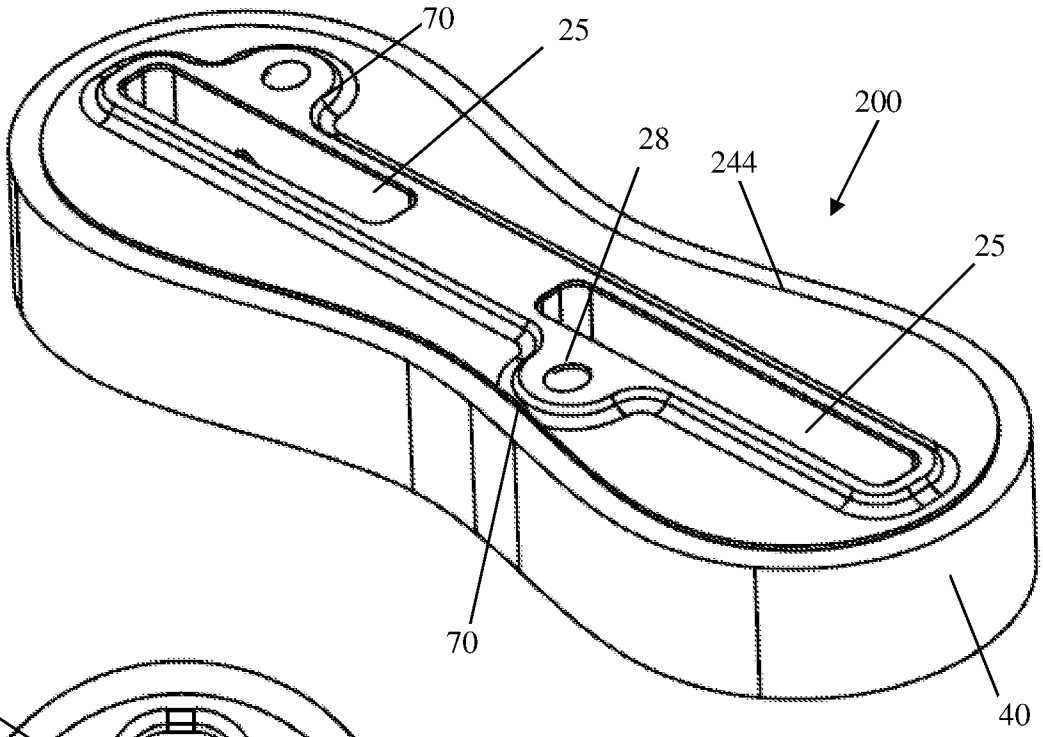

FIG 12B

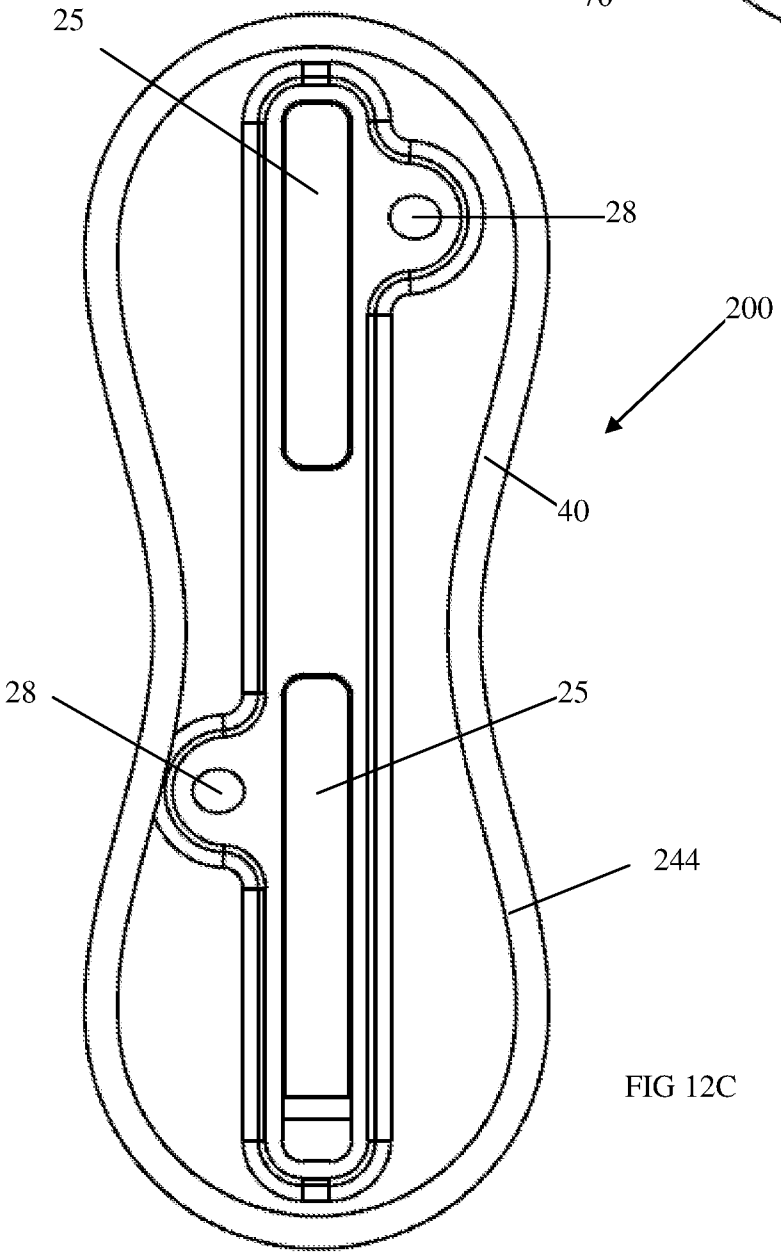

FIG 12C

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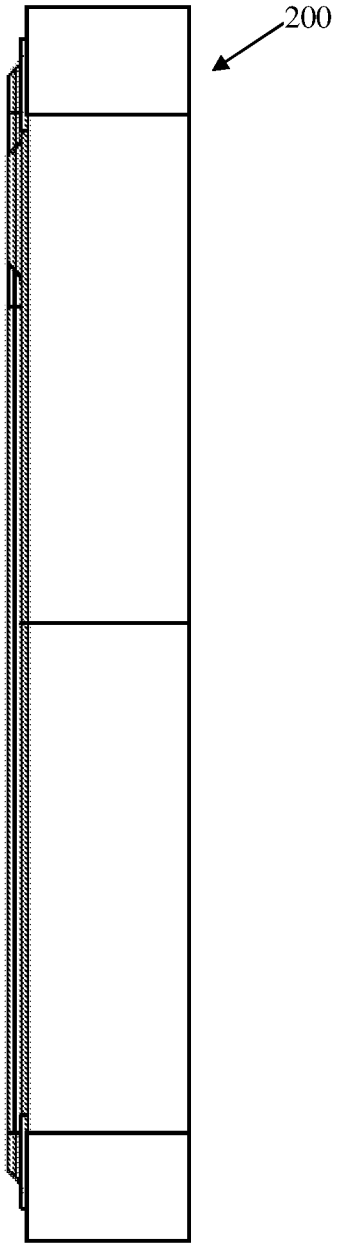

FIG 12D

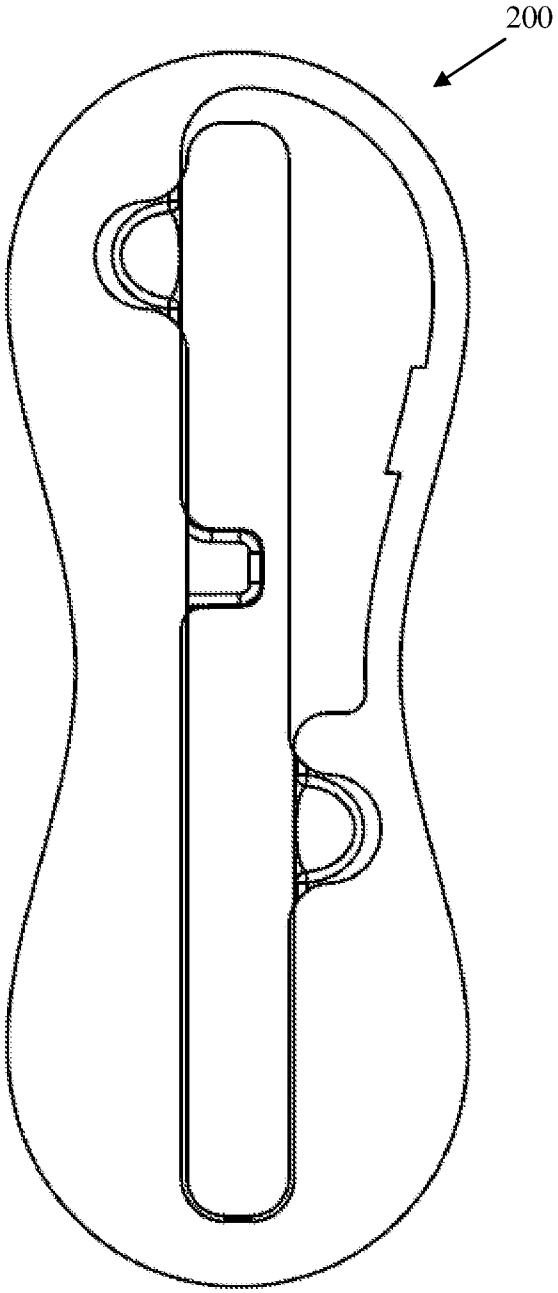

FIG 12E

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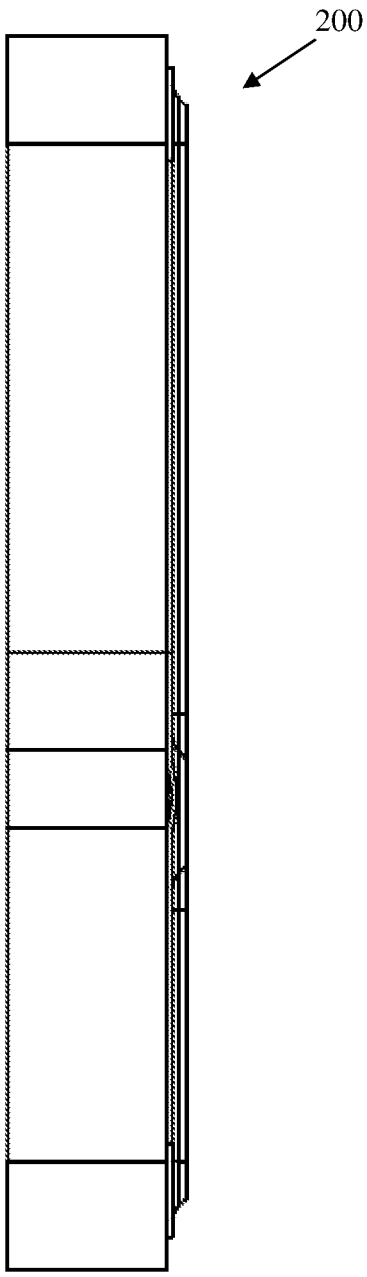

FIG 12F

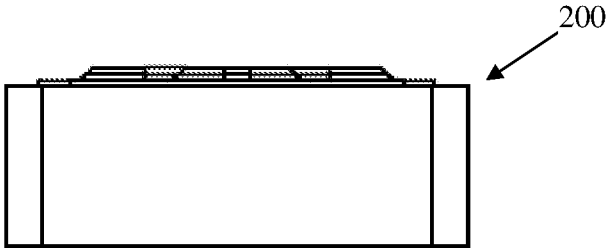

FIG 12G

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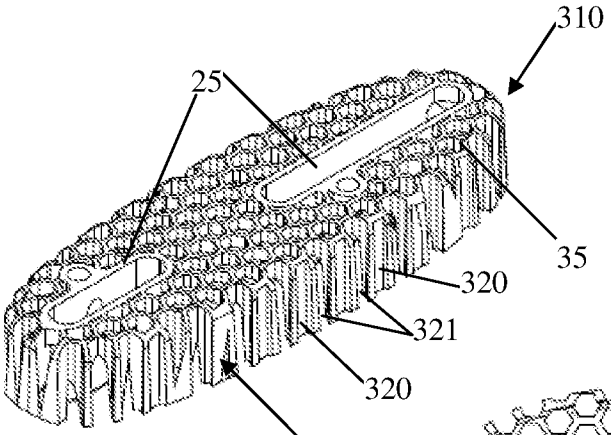

FIG 13A

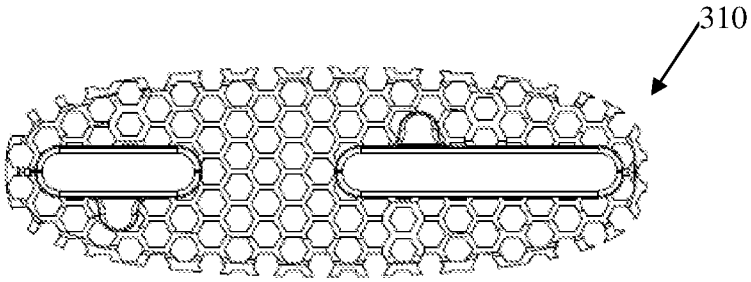

FIG 13B

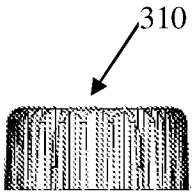

FIG 13C

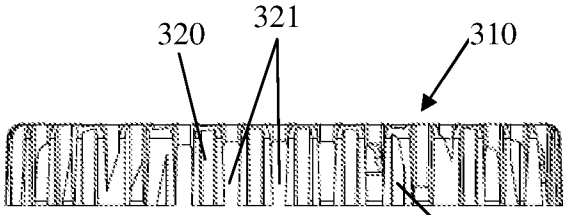

FIG 13D

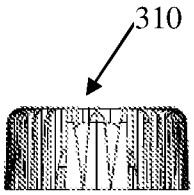

FIG 13E

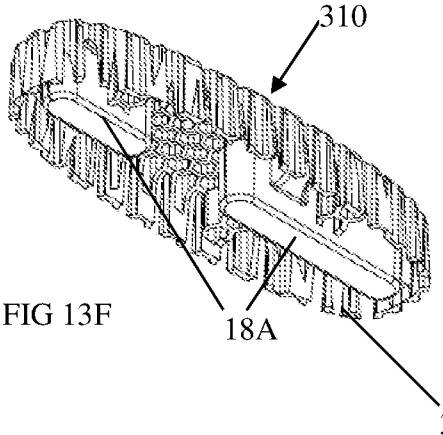

FIG 13F

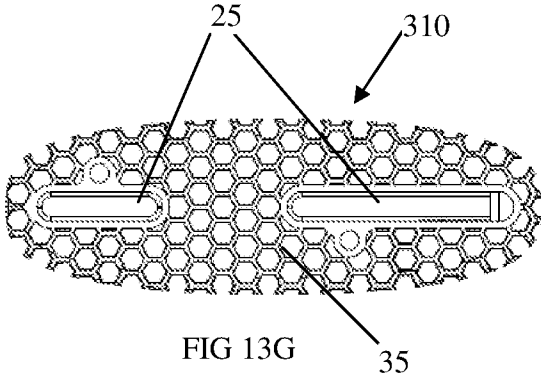

FIG 13G

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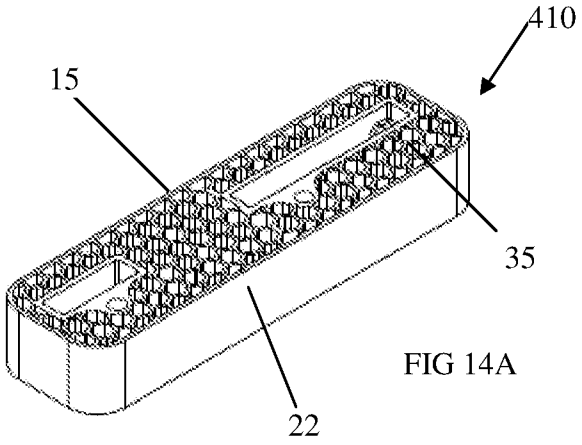

FIG 14A

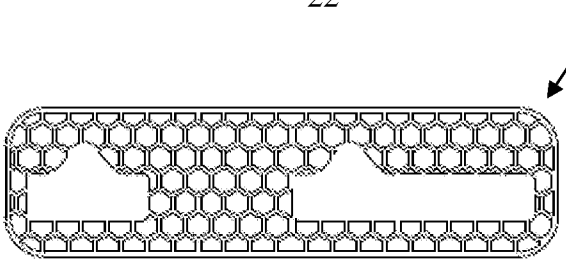

FIG 14B

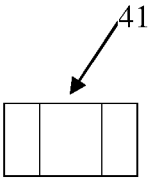

FIG 14C

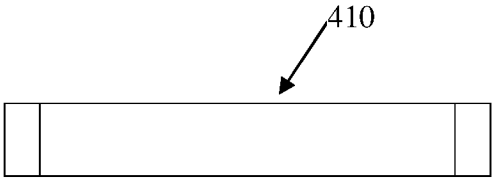

FIG 14D

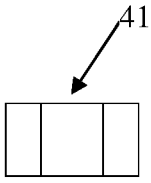

FIG 14E

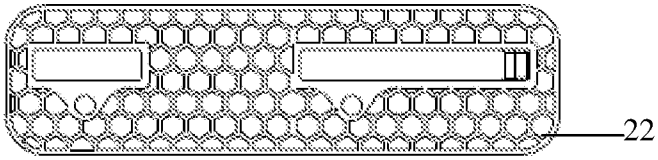

FIG 14F

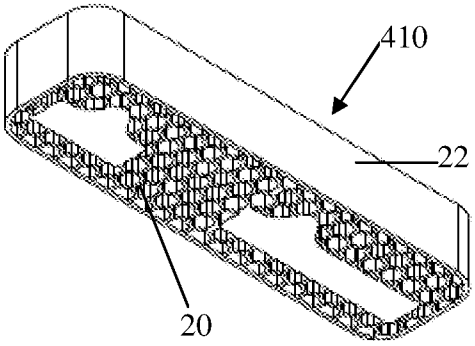

FIG 14G

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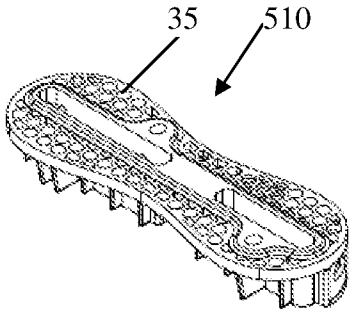

FIG 15A

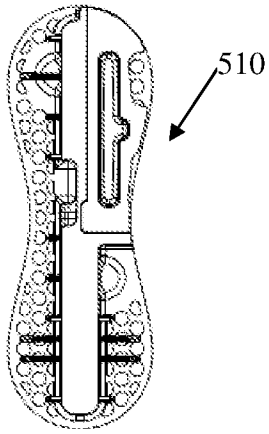

FIG 15B

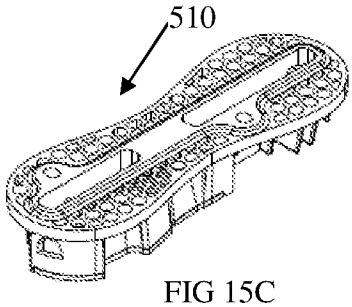

FIG 15C

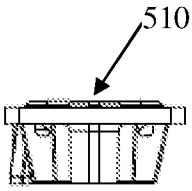

FIG 15D

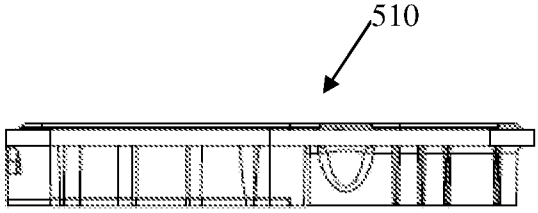

FIG 15E

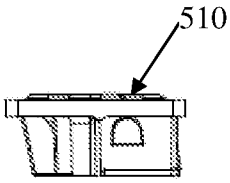

FIG 15F

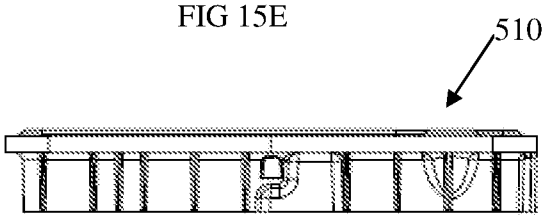

FIG 15G

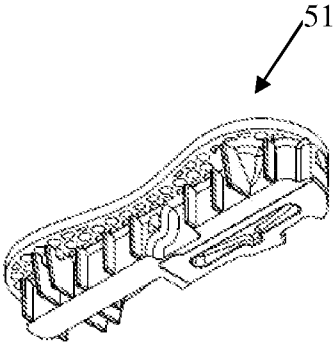

FIG 15H

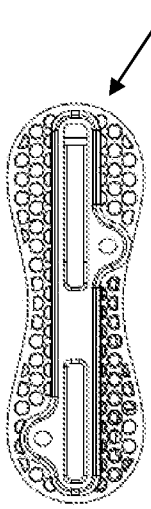

FIG 15I

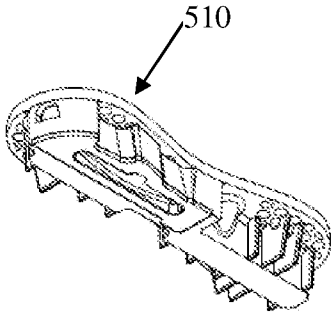

FIG 15J

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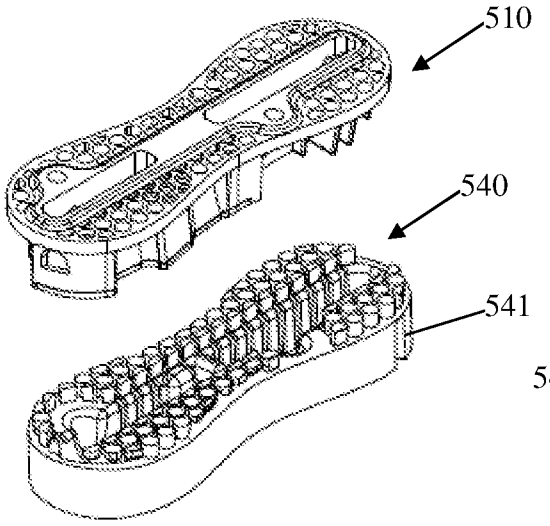

FIG 16A

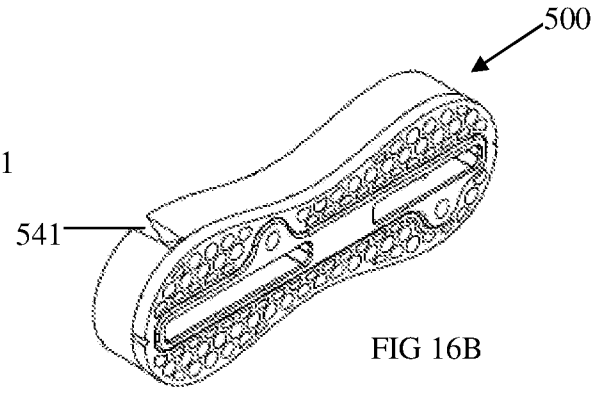

FIG 16B

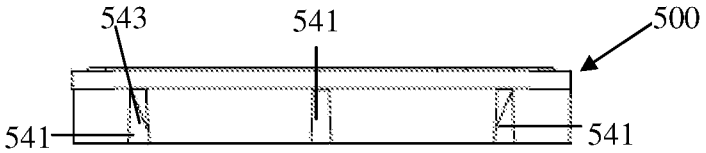

FIG 16D

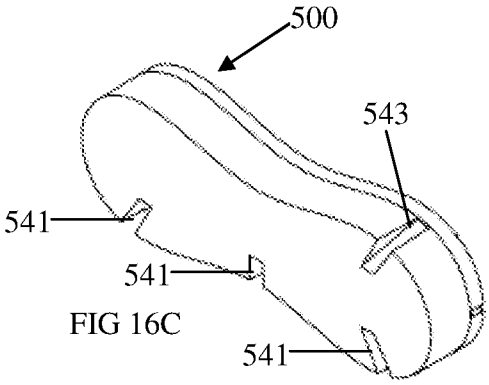

FIG 16C

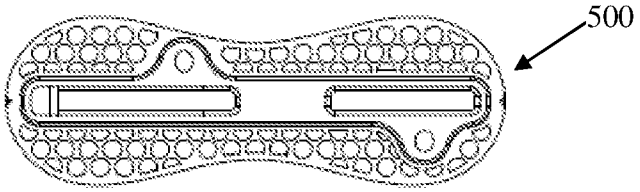

FIG 16E

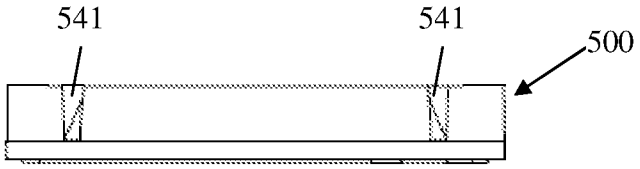

FIG 16F

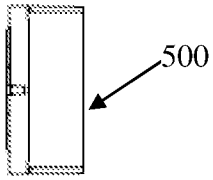

FIG 16G

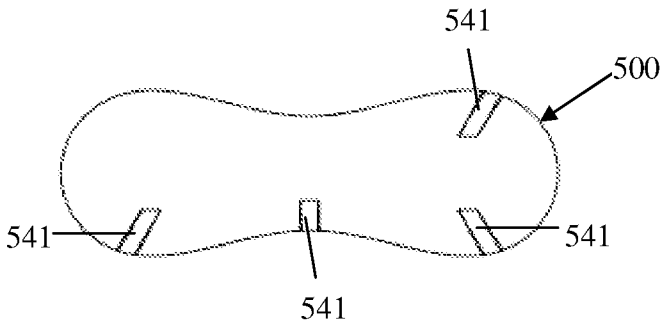

FIG 16H

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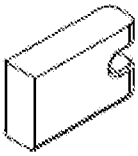

FIG 17A

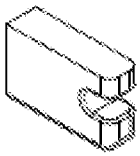

FIG 17B

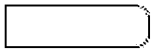

FIG 17C

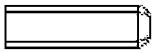

FIG 17D

FIG 17E

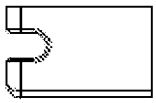

FIG 17F

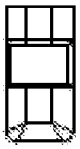

FIG 17G

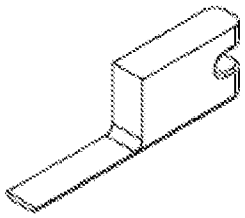

FIG 18A

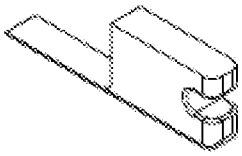

FIG 18B

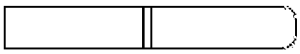

FIG 18C

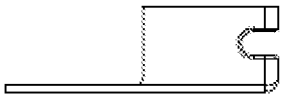

FIG 18D

FIG 18F

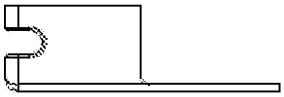

FIG 18E

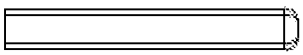

FIG 18G