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(54) **Modular floating system and a method of its manufacture**

(57) A modular floating system according to the invention comprises the sets of complementary elements designed so as to be coupled tightly into a form of void floatable containers with solid walls. The containers are equipped with the connecting means for construction of floating structures like platforms, wharfs, piers or bridges. These connecting means may provide whole structure with some resiliency that may be required to answer changing levels and movements of water. Another type of connecting means may provide rigid connections stiffening whole structure which may be preferred for the structures installed on-shore or off-shore on the floor of the sea, lake, river or channel. In the latter case the containers shall be filled with water, sand, stones, concrete, iron ore and the like. The main feature of the invention is in that particular elements constituting the containers are provided with the antijamming means preventing dismantled identical elements from jamming during storage in pile. The role of the antijamming means is twofold. Firstly, it is to prevent from direct contact between faying surfaces of the containers, resulting in adhesion of contacting surfaces. Secondly, it is to provide the passages necessary for the air flow during taking off the element from the stack. In one embodiment the container body is formed from complementary bottom part (1) and upper cover (3), where the bottom part (1) has a shape of two reversed similar truncated pyramids arranged vertically, with principally rectangular horizontal cross-sections. The upper principally rectangular base of the minor truncated pyramid is lesser in size than the lower principally

rectangular base of the bigger truncated pyramid and these two principally rectangular bases are joined by an antijamming intermediate joining part of the side wall of the bottom part (1). The upper cover (3) is principally rectangular as well, and it fits the upper base of the bigger truncated pyramid and it is provided with means securing water and air tightness of coupling.

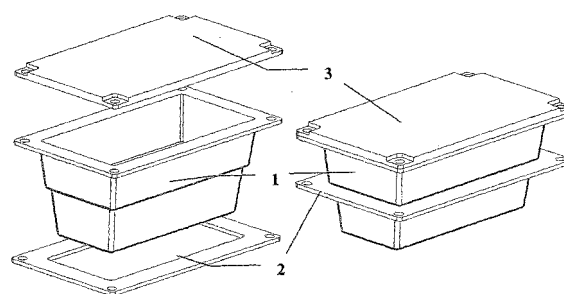


Fig. 1

## Description

**[0001]** The invention refers to a modular floating system used in various applications, and to a method of its manufacture. In particular the invention refers to the modular floating system that may be stacked on limited surfaces and transported to the destination on limited number of vehicles. The invention refers also to the appliances where the modular floating system may be used, like e.g. floating or submersible platforms, docks, bridges, wharfs, piers, and the like. The modular floating systems according to the invention may also be used, when equipped with a propulsion unit, to make the boats, pontoons, rafts, ferries and other floating appliances used in transportation.

**[0002]** Floating structures have had been developed by military engineers for long time. Nowadays also civil engineering pays attention to floating structures as their usefulness on flooded areas or in the regions destroyed by other natural disasters or wars has been proved extensively. Particular interest is paid to modular floating systems because they enable the engineers to adjust the floating structure to specific demands (expected load, topography, changes in the water level, etc.) and to design unique, optimized structure.

**[0003]** In known floating systems the deck is arranged on pontoons, which in older systems have been singular or folded multiple, usually triple units. The latter are deployed in situ into floating units of bigger dimensions. Whether singular or folded, individual units are big and because of their dimensions of several meters and considerable weight they are difficult to be handled on-shore so they have to be connected into single structure on the water. The pontoons are hermetic containers made from steel, so they are big and heavy. Both transportation and storage of these systems are expensive and troublesome, and require big trucks, good roads network accessible even during natural disaster or war, and sufficient number of trained staff. To fulfill all those conditions in emergency may be difficult. Besides, the steel containers require costly maintenance and large areas for storage. The costs generated both in usage and stacking of those floating systems may be not acceptable for civil organisations, like local communities. The examples of solutions, also modular, that belong to this older type of floating systems are described in the patent documents PL 158579 B2, PL 297453 B2, OE 312039 and utility models PL 63281 Y1 and PL 54505 Y1.

**[0004]** Development of plastics technology made it possible to replace steel with weather resistant and lighter plastic. However, hermetic containers of big dimensions still have been making difficulties and generating excessive costs in transportation, handling, and storage both in situ and in the storage area. The examples of floating systems consisting of plastic hermetic containers were presented in the patent documents GB 2170760 A, FR 2699495 A1 and FR 2699496 A1. An alternative to hermetic containers are the modules filled with a foam,

like in the patent document US 6230644 B1. Naturally foam-filled modules are as unhandy in storage and transportation as the other systems mentioned above.

**[0005]** The next revolutionary step in the floating systems was to exchange the pontoons with universal containers that can be freely arranged and to "dehermetize" the containers so that they can be combined from separate elements in situ. When unused, the elements of the containers may be stacked in pile in the storage area, which requires a fraction of the area needed before. They are also much more handy in transportation, because several dismantled containers can be loaded on one truck. The examples of these floating systems were disclosed in the patent documents EP 1733964 A1, FR 2198450 A5, or US 3897741 A.

**[0006]** Present-day methods of manufacture of plastic objects of big dimensions are so sophisticated that the shape control and repeatability of parameters in fabrication of the containers elements stays no more for a technological barrier. The manufacturer is able to supply practically identical elements. In some cases this high quality is a source of unexpected problems in storage. The container elements fit so well that separation of the elements stored in pile may require very big forces to be applied and the element on top of the pile may have to be intentionally deformed to be separated from the lower one, which may cause its damage. In worse case the container assembled from damaged elements may lose water tightness and sink, which is very dangerous during exploitation of the floating structure. The problem of jamming of the container elements may arise unexpectedly, e.g. after rain falling on the pile stored at open air or after stacking in pile wet elements, with some quantity of water inside, which obviously happens after dismantling of temporary floating structure. Jamming of the containers elements may considerably delay development of the floating structure, which is particularly dangerous in emergency conditions.

**[0007]** Relatively flat elements, i.e. with moderately sloped walls (the slope value lesser than about 3), are resistant to jamming. The slope is understood here to be the ratio of the wall height to the wall horizontal projection. In other words, the slope equals to the tangent of an angle between the wall and the horizontal plane. However, moderately sloped walls decrease the volume of air closed inside the container thus decreasing the displacement of the floating structure and in consequence significantly limiting allowable load. On the other hand the container elements with almost vertical walls, i.e. with the slope close to maximum which is the ratio of the wall height to the wall thickness, maximize the volume of air closed inside the container. Note that behind this slope maximal value the container elements can not be stacked one inside another. Unfortunately these "vertical" containers are very susceptible for jamming. This undesirable effect can prevent the civil and military engineers, designers, manufacturers and crisis management services from considering the floating systems based on the

containers with almost vertical walls.

**[0008]** To the best knowledge of the Inventors the problem of jamming of stacked big objects has not been addressed directly. There are no suggestions nor even hints in the state of the art how to prevent stacked big elements of floating containers used in the modular floating structures from jamming. The Inventors have been successful in solving this problem and the invention disclosed below summarises this solution.

**[0009]** A modular floating system according to the invention comprises the sets of complementary elements designed so as to be coupled tightly into a form of void containers with solid walls. The air closed hermetically inside the containers makes them floatable irrespective of waves, rains, etc. The containers are equipped with the connecting means for construction of floating structures like platforms, wharfs, piers or bridges. These connecting means may provide whole structure with some resiliency that may be required to react to changing levels and movements of water caused e.g. by waves, tides, floods. If desired, another type of connecting means may provide rigid connections stiffening whole structure which may be preferred for the structures installed on-shore or off-shore on the floor of the sea, lake, river or channel. In the latter case the containers shall be filled with water, sand, stones, concrete, iron ore and the like.

**[0010]** The modular floating system may also be used, if equipped with a propulsion unit, to make the boats, pontoons, rafts, ferries and other floating appliances used in transportation. It shall be noted, that large sections of whole floating structure can be transported to the destination on the water surface in the form of the rafts.

**[0011]** The main feature of the invention is in that particular elements constituting the containers are provided with the antijamming means preventing dismantled identical elements from jamming during storage in stack. These antijamming means may be constituted by any details of shape of the container elements that separate adjacent surfaces of walls of stacked elements. The role of the antijamming means is twofold. Firstly, it is to prevent from direct contact between facing surfaces of the containers, resulting in adhesion of contacting surfaces, particularly when these are wet, e.g. after being dismantled and stacked on the field. Secondly, it is to provide the passages necessary for the air flow during taking off the element from the stack.

**[0012]** An example of the antijamming means is a set of ribs made preferably on the inner side of the wall, however external ribs may be advantageous in some applications. The antijamming means, like the ribs, may also play a role of the means stiffening the element of the container. The separation between the surfaces of stacked elements of the containers preferably shall be comprised in range from about 5 mm to about 30 mm or more in case of very big elements stacked.

**[0013]** In first embodiment of the invention the body of said container is formed from two complementary elements, namely the bottom part and the upper cover,

where the bottom part may have a shape of two similar truncated pyramids or truncated cones with an intermediate part of the side walls that connects both shapes. This intermediate part of the side walls has a character of the antijamming means, because it prevents the bottom part of one container to fall too deeply into the bottom part of another container when stacked. In other words this intermediate part of the side walls of one container supports another container (precisely: its bottom part) in the pile. The upper base of the minor truncated pyramid or truncated cone is lesser in size than the lower base of the bigger truncated pyramid or truncated cone. These two bases are joined by mentioned antijamming, intermediate joining part of the side wall of the container bottom part.

**[0014]** The upper cover of the container fits the upper base of the bigger truncated pyramid or truncated cone and it is provided with the means securing water and air tightness of the coupling. These tightening means are for example a groove on the bottom side of the upper cover, optionally provided with a gasket, e.g. a rubber gasket, and an edge of the bottom part, this groove fitting tightly with specified tolerances the upper edge of the bottom part. Full tightness is reached when both parts of the container, i.e. the bottom part and the upper cover, are fastened together circumferentially, e.g. with screw-and-nuts inserted into the holes in the connecting flanges. The number of holes equals at least the number of corners in polygonal elements, and it is no less than three in case of circular shapes. In the latter case the holes shall be distributed in vertices of a regular polygon.

**[0015]** In particular the slope of the intermediate, antijamming joining part of the side wall of the bottom part is flatter than the slope of adjacent lower and upper side walls of truncated pyramids or truncated cones, thus forming a sloped step between lower and upper segments of the container side walls. In a very particular case this slope may equal to zero, making this joining part of the side wall horizontal. It shall be noted that a horizontal step in the container side wall may additionally help manoeuvring the element (support for the lifting sling, spreader beam, etc.).

**[0016]** Alternatively the antijamming joining part of the side wall of the bottom part may be provided with at least one antijamming protrusion facing the interior or the exterior of the bottom part. When stacked, the external side of the upper container wall is supported by such protrusion thereby being separated from the internal side of the lower container wall by the thickness of the protrusion.

**[0017]** In strongly advised solution the antijamming protrusion facing the interior or the exterior of the bottom part shall have a shape of half-round moulding.

**[0018]** In case of relatively light containers the antijamming protrusion facing the interior or the exterior of the bottom part is an indentation in the joining part of the side wall of the bottom part. Mechanically such indentation is not as resistant as the mouldings described hereinbefore, thus this solution is particularly recommended for smaller

containers, preferably with dimensions of up to about 2 m, however bigger elements may be endowed with the indentations as well if their walls have sufficient thickness. The advantage of this solution is lower cost of manufacture of containers with indentations in the side walls.

**[0019]** Each container may be additionally complemented with separate strengthening flange fitting the intermediate, joining part of the side wall of the bottom part. This strengthening flange is provided with the bolt holes, preferably tapped to receive the screws, and spaced identically as the bolt holes in the upper cover. The upper cover and the strengthening flange are joined by bolts or screw-and-nuts, or other screw fasteners such as simple screws passing through respective bolt holes. In the latter case the holes in the strengthening flange are threaded. To ensure appropriate stiffness of the structure the holes of the container are separated from those of the strengthening flange by the spacing sleeves.

**[0020]** To develop extended floating structure the neighbouring containers are joined with the hinged connectors, preferably folding along two perpendicular axis, and provided with the bolt holes spaced according to the spacing between the bolt holes of neighbouring containers. According to the users needs this spacing may equal to the spacing of conterminous containers, thereby limiting elasticity of the structure. Bigger spacings provide the structure with some elasticity and facilitate the task of constructing the structure, which might be advantageous in straitened circumstances in the field.

**[0021]** In another embodiment of the modular floating system each container comprises two cups with the shape of truncated pyramid or truncated cone provided with the antijamming cylindrical collar. When stacked in pile, the cups are supported by cylindrical collars of lower cups. To complete a container other parts may be necessary.

**[0022]** In particular the container may consist of two cups, namely the bottom cup and the upper cup. The bottom cup is provided with the antijamming upper cylindrical threaded collar and the complementary upper cup is provided with complementary antijamming lower cylindrical threaded collar. The threaded collars provide tight coupling of the bottom cup with the upper cup. The collar with internal thread (female) may optionally be endowed with a gasket, preferably a rubber gasket, ensuring tight coupling.

**[0023]** To enable joining the containers into extended floating structure the bottom cup is provided with the connecting flanges provided with the bolt holes and spaced circumferentially below the cylindrical threaded collar on different levels offset relatively by the thicknesses of said connecting flanges. The connecting flanges of neighbouring bottom cups in complete containers are joined by bolts or screw-and-nuts, or screw fasteners passing through respective bolt holes.

**[0024]** In another particular solution the container body is formed by connecting two identical cups through a ring-shaped coupling element fitting the antijamming cylindrical

collars either on larger bases of the cups or on smaller bases of the cups. In extended floating structures both kinds of couplings may be applied alternately, making the structure compact.

**[0025]** In a particular embodiment the ring-shaped coupling element is threaded with a thread complementary to the threads on the antijamming cylindrical collars of both cups. The threads provide tight coupling of the cups with the coupling element which additionally may be fit out with a gasket, preferably a rubber gasket.

**[0026]** The extended floating structures are made from one or more layers of the containers. None of the container elements presented above, i.e. neither the cup nor the ring-shaped coupling element is provided with any joining means. Therefore the adjacent containers are coupled by the flat connectors with polygonal or circular orifices fitting the dimensions of the side wall outer cross-section preferably in the middle of the cup. The flat connectors connect the containers within single layer as well as the containers belonging to adjacent layers. The structures can be made from two or more layers, depending from desired displacement and anticipated load.

**[0027]** The modular floating systems as specified above are preferably made from plastic, e.g. polyethylene, reinforced polyethylene, or other polymeric materials suitable for production of mechanically resistant and waterproof large objects. The walls and other elements of the container may be reinforced with fibrous material, like the fiberglass mat, fibrous web, etc. However the containers elements can be made from metal as well. Plastic elements constituting the containers are made in the process of casting, preferably pressure casting, or light-section casting, or heavy-section casting, or shell casting, or centrifugal casting, or compound casting, or injection moulding, preferably runnerless injection moulding.

**[0028]** Preferred embodiments of the modular floating system according to the invention are schematically shown on the drawing, where:

Fig. 1 shows the elements of the first embodiment of the container in exploded view and assembled container in perspective view,

Fig. 2 illustrates coupling of the containers from Fig. 1 in perspective view,

Fig. 3 and Fig. 4 show the containers and the couplings from Fig. 2 in front, end and top views, with the slope of antijamming part of the side wall equal to zero,

Fig. 5 presents the elements of next embodiment of the container in exploded view and assembled container in perspective view,

Fig. 6 and Fig. 7 show the details from Fig. 5 in side and top views,

Fig. 8 shows the elements of another embodiment of the container in exploded view,

Fig. 9 shows the containers from Fig. 8 assembled and joined in the form of a floating structure in front and top views,

Fig. 10 presents perspective view of the floating structure and shows preferable compact arrangement of containers,

Fig. 11 shows the arrangement from Fig. 10 with flat connectors connecting the containers and a modular deck covering the modular floating structure,

Fig. 12 presents top and front views on the arrangement from Fig. 11,

Fig. 13 shows top and perspective views of the flat connector,

Fig. 14 to 19 show perspective views of the embodiments presented on Fig. 1 to 13, with a modular deck covering modular floating structure illustrated on Fig. 19.

**[0029]** In all presented examples of embodiments the modular floating systems comprise the sets of complementary elements which when coupled form void containers with solid walls which are suitable for construction of floating structures. The elements constituting the containers are provided with the antijamming means preventing dismantled identical elements from jamming during storage in pile.

**[0030]** In one embodiment the body of said container is formed from two complementary elements, namely the bottom part (1) and the upper cover (3), where the bottom part (1) has a shape of two reversed similar truncated pyramids arranged vertically, with principally rectangular horizontal cross-sections. The upper principally rectangular base of the minor truncated pyramid is lesser in size than the lower principally rectangular base of the bigger truncated pyramid and these two principally rectangular bases are joined by an antijamming intermediate joining part of the side wall of the bottom part (1). The upper cover (3) is principally rectangular as well, and it fits the upper base of the bigger truncated pyramid and it is provided with means securing water and air tightness of coupling. The upper cover, preferably strengthened and lined on the top, may play a role of a deck for small and moderate loads.

**[0031]** In one version the slope of said antijamming intermediate joining part of the side wall of the bottom part (1) is flatter than the slope of neighbouring side walls of truncated pyramids. In particular the slope equals to zero and this case is illustrated on Fig. 3 and Fig. 4. The breadth of horizontal section in the antijamming intermediate joining part of the side wall advantageously is no

less than 1% of the container length, preferably no less than 2% of the container length, and at least equals about 5 cm. These minimal values enable the operators to safely lift on and handle the container elements.

**[0032]** In another version the antijamming intermediate joining part of the side wall of the bottom part (1) is provided with at least one antijamming protrusion (not shown on the drawing) facing the interior or the exterior of the bottom part (1). Advantageously this at least one antijamming protrusion has a shape of half-round moulding.

**[0033]** Also preferably said at least one antijamming protrusion facing the interior or the exterior of the bottom part (1) is an indentation in the joining part of the side wall of the bottom part (1).

**[0034]** The container is provided with separate strengthening flange (2) fitting the joining part of the side wall of the bottom part (1). The strengthening flange (2) is provided with the bolt holes, preferably the tapped holes, spaced identically as the bolt holes (7) in the upper cover (3). The upper cover (3) and the strengthening flange (2) are joined by bolts or screw-and-nuts (4), or screw fasteners passing through respective bolt holes. Both elements are separated by the spacing sleeves (6).

**[0035]** An extended floating structure is developed by joining neighbouring containers with the hinged connectors (5), preferably folding along two perpendicular axis, and provided with the bolt holes spaced according to the spacing between the bolt holes (7) of neighbouring containers.

**[0036]** In another embodiment the container comprises two cups (8, 9, 12) with the shape of truncated cone provided with the antijamming cylindrical collar.

**[0037]** In one version of this embodiment the bottom cup (8) is provided with the antijamming upper cylindrical threaded collar and the complementary upper cup (9) is provided with complementary antijamming lower cylindrical threaded collar. Both threaded collars provide tight coupling of the bottom cup (8) with the upper cup (9).

**[0038]** The bottom cup (8) is fit out with the connecting flanges provided with the bolt holes (11) and spaced circumferentially below the cylindrical threaded collar on different levels. The connecting flanges are offset vertically by their thickness. The connecting flanges of neighbouring bottom cups (8) in complete containers are joined by bolts or screw-and-nuts (10), or screw fasteners passing through respective bolt holes (11).

**[0039]** In another version of this embodiment the body of the container is formed by connecting two identical cups (12) with a ring-shaped coupling element (13) fitting the antijamming cylindrical collars either on larger bases of the cups (12) or on smaller bases of the cups (12). Preferably the ring-shaped coupling element (13) is threaded with a thread complementary to the thread on the antijamming cylindrical collar of the cup (12). The threads provide tight coupling of the cups (12) with the coupling element (13).

**[0040]** Since in this version of the embodiment the

cups (12) are not fit out with any connecting elements, the neighbouring containers are coupled by separate flat connectors (14) with circular orifices fitting the dimensions of the side wall outer cross-section, preferably in the middle of the cup (12).

**[0041]** In preferred method of manufacture of the modular floating system the elements constituting the containers are made from plastic in the process of injection moulding.

### Claims

1. A modular floating system comprising the sets of complementary elements which when coupled form void containers with solid walls and suitable for construction of floating structures **characterised in that** the elements constituting the containers are provided with the antijamming means preventing dismantled identical elements from jamming during storage in stack.
2. The system according to claim 1 **characterised in that** the body of said container is formed from two complementary elements, namely the bottom part (1) and the upper cover (3), where the bottom part (1) has a shape of two similar truncated pyramids or truncated cones where the upper base of the minor truncated pyramid or truncated cone is lesser in size than the lower base of the bigger truncated pyramid or truncated cone and these two bases are joined by an antijamming joining part of the side wall of the bottom part (1), and where the upper cover (3) fits the upper base of the bigger truncated pyramid or truncated cone and it is provided with means securing water and air tightness of coupling.
3. The system according to claim 2 **characterised in that** the slope of said antijamming joining part of the side wall of the bottom part (1) is flatter than the slope of neighbouring side walls of truncated pyramids or truncated cones.
4. The system according to claim 2 **characterised in that** said antijamming joining part of the side wall of the bottom part (1) is provided with at least one antijamming protrusion facing the interior or the exterior of the bottom part (1).
5. The system according to claim 4 **characterised in that** said at least one antijamming protrusion facing the interior or the exterior of the bottom part (1) has a shape of half-round moulding.
6. The system according to claim 4 **characterised in that** said at least one antijamming protrusion facing the interior or the exterior of the bottom part (1) is an indentation in the joining part of the side wall of the

bottom part (1).

7. The system according to claims from 2 to 6 **characterised in that** said container is provided with separate strengthening flange (2) fitting the joining part of the side wall of the bottom part (1), said strengthening flange (2) being provided with the bolt holes, preferably the tapped holes, spaced identically as the bolt holes (7) in the upper cover (3), the upper cover (3) and the strengthening flange (2) being joined by bolts or screw-and-nuts (4), or screw fasteners passing through respective bolt holes separated by the spacing sleeves (6).
8. The system according to claims from 2 to 7 **characterised in that** neighbouring containers are joined with the hinged connectors (5), preferably folding along two perpendicular axis, and provided with the bolt holes spaced according to the spacing between the bolt holes (7) of neighbouring containers.
9. The system according to claim 1 **characterised in that** said container comprises two cups (8, 9, 12) with the shape of truncated pyramid or truncated cone provided with the antijamming cylindrical collar.
10. The system according to claim 9 **characterised in that** the bottom cup (8) is provided with the antijamming upper cylindrical threaded collar and the complementary upper cup (9) is provided with complementary antijamming lower cylindrical threaded collar, said threaded collars providing tight coupling of the bottom cup (8) with the upper cup (9).
11. The system according to claim 10 **characterised in that** the bottom cup (8) is provided with the connecting flanges provided with the bolt holes (11) and spaced circumferentially below the cylindrical threaded collar on different levels offset relatively by the thicknesses of said connecting flanges, the connecting flanges of neighbouring bottom cups (8) in complete containers being joined by bolts or screw-and-nuts (10), or screw fasteners passing through respective bolt holes (11).
12. The system according to claim 9 **characterised in that** the body of said container is formed by connecting two identical cups (12) with a ring-shaped coupling element (13) fitting the antijamming cylindrical collars either on larger bases of the cups (12) or on smaller bases of the cups (12).
13. The system according to claim 12 **characterised in that** the ring-shaped coupling element (13) is threaded with a thread complementary to the thread on the antijamming cylindrical collar of the cup (12), said threads providing tight coupling of the cups (12) with the coupling element (13).

14. The system according to claims 12 and 13 **characterised in that** the neighbouring containers are coupled by the flat connectors (14) with polygonal or circular orifices fitting the dimensions of the side wall outer cross-section in the middle of the cup (12). 5
15. A method of manufacture of the modular floating system according to any of claims 1-14 **characterised in that** the elements constituting the containers are made from plastic in the process of casting, preferably pressure casting, or light-section casting, or heavy-section casting, or shell casting, or centrifugal casting, or compound casting, or injection moulding, preferably runnerless injection moulding. 10

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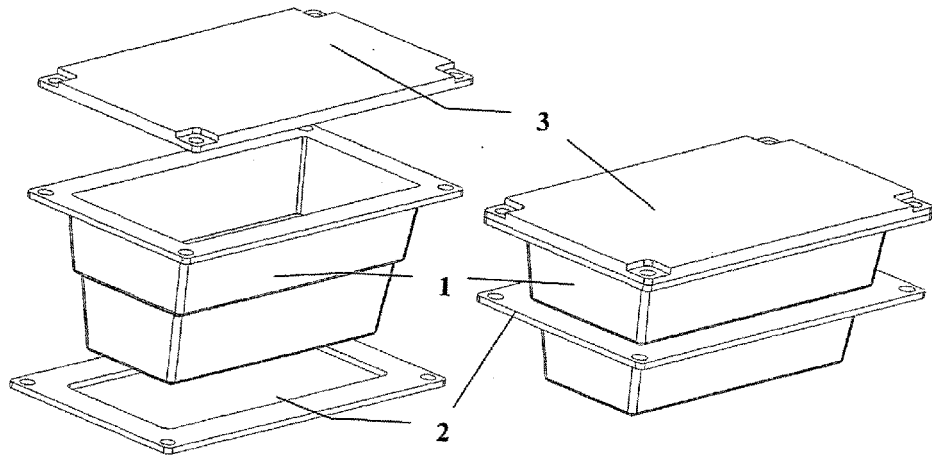


Fig. 1

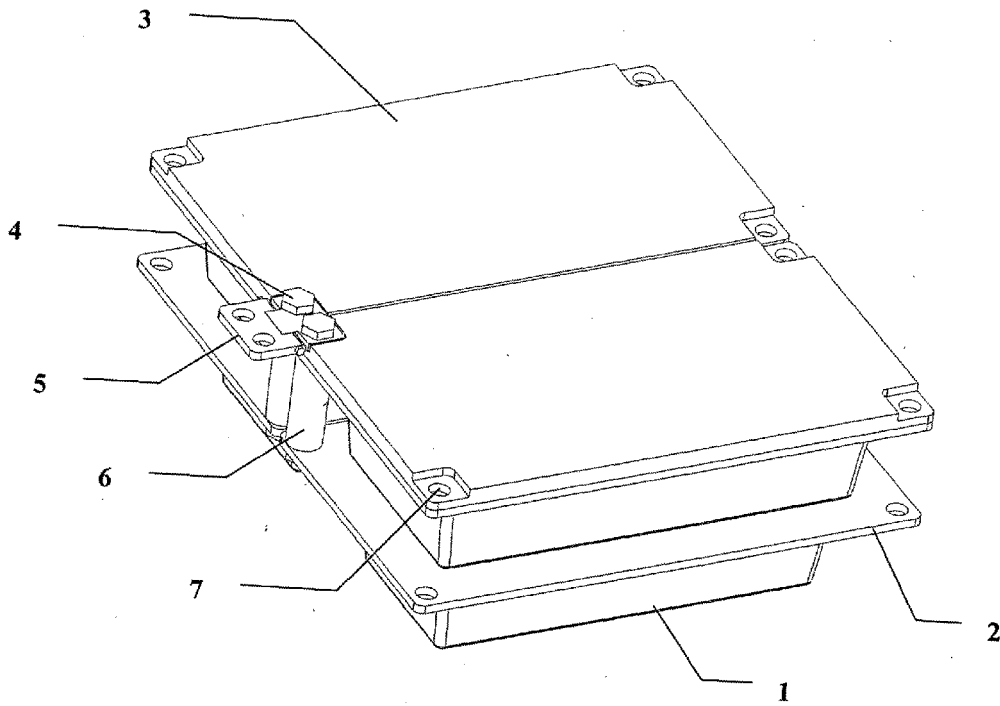


Fig. 2

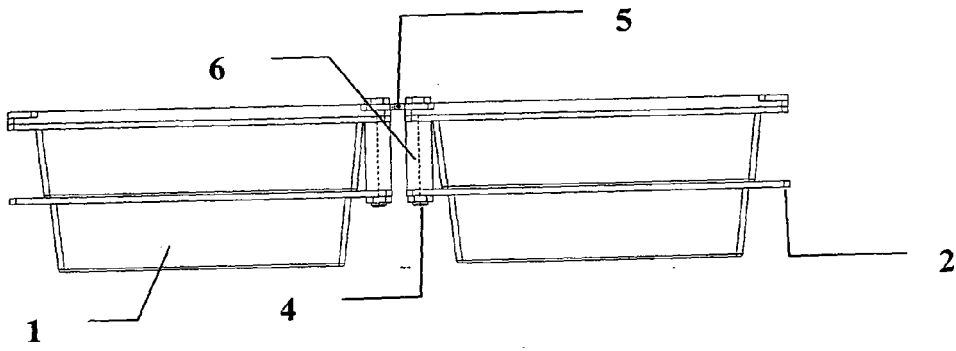


Fig. 3

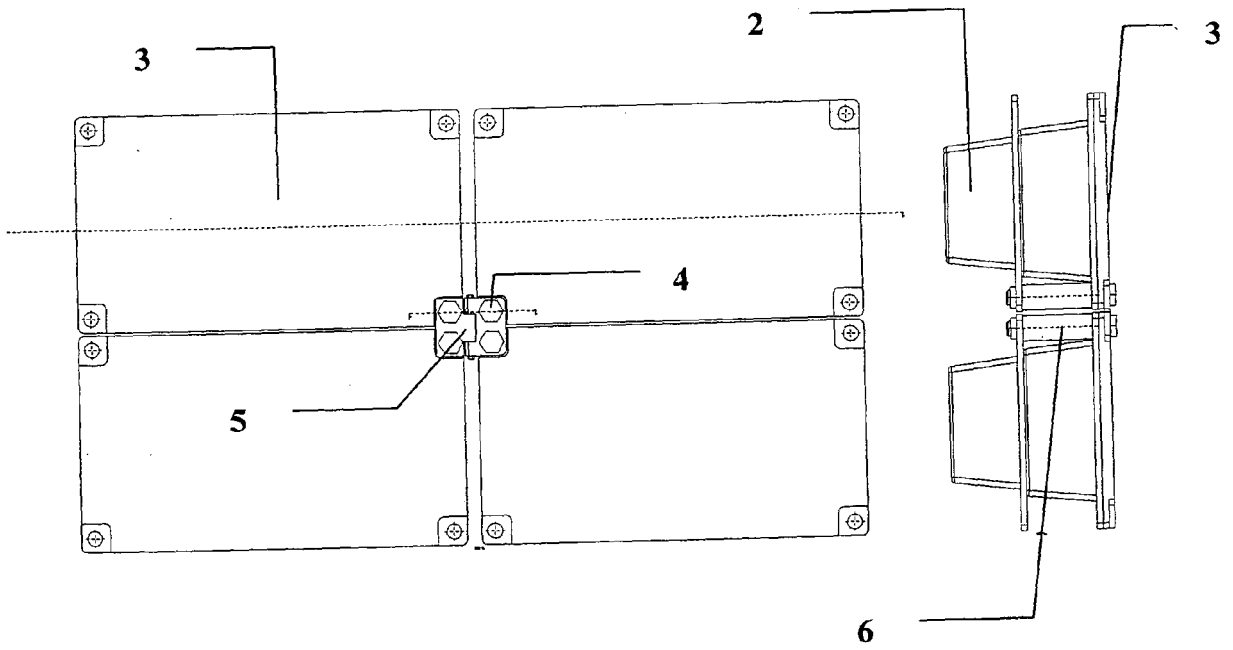


Fig. 4

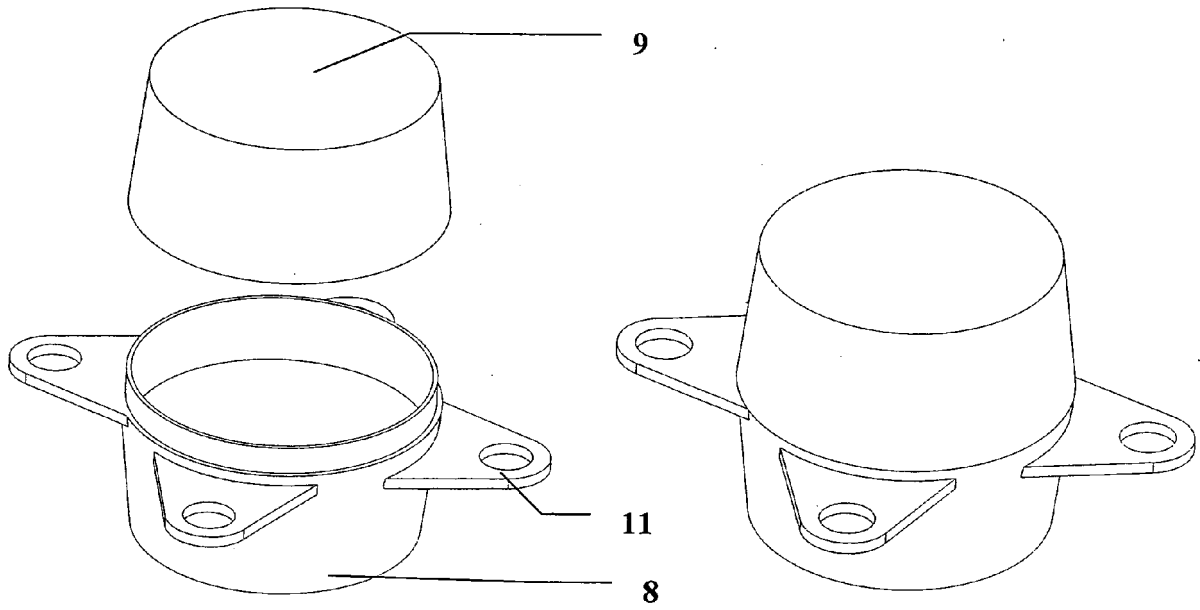


Fig. 5

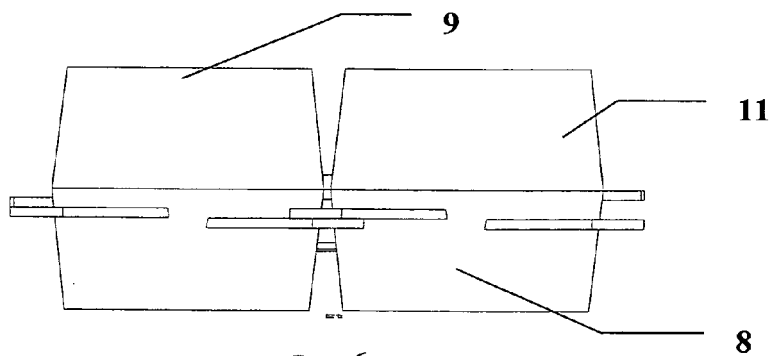


Fig. 6

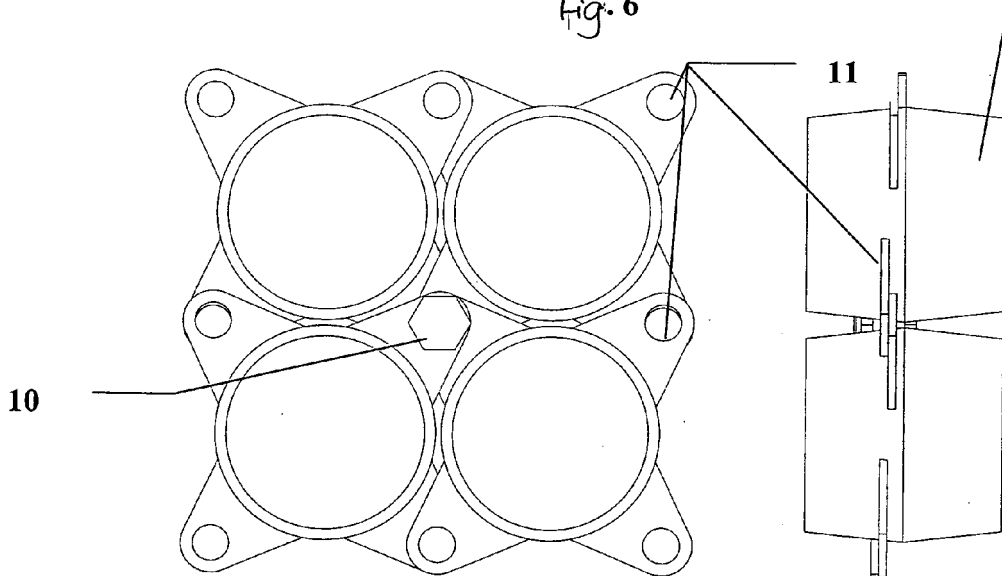


Fig. 7

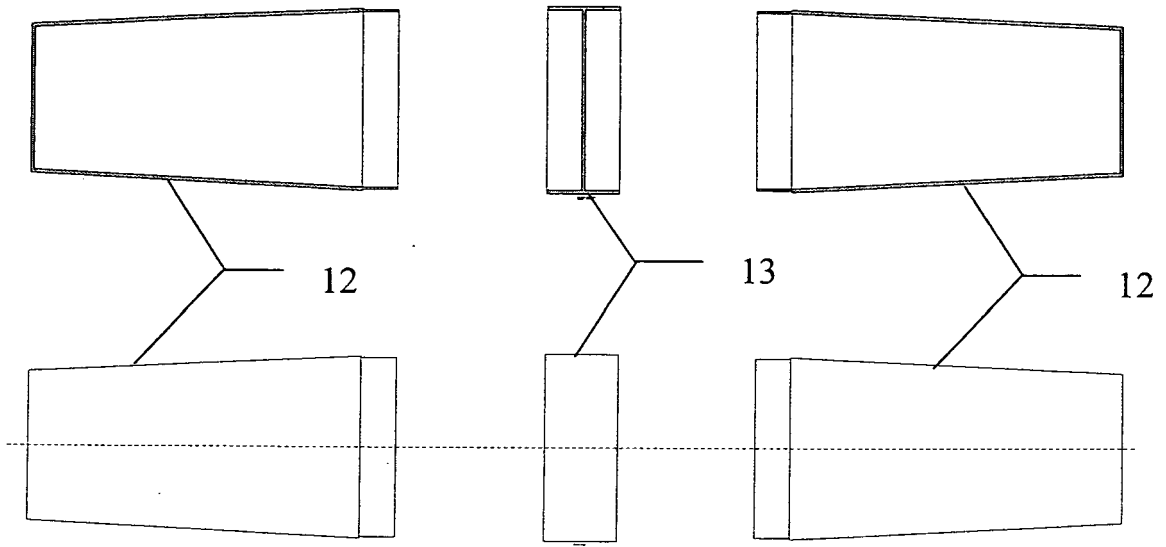


Fig. 8

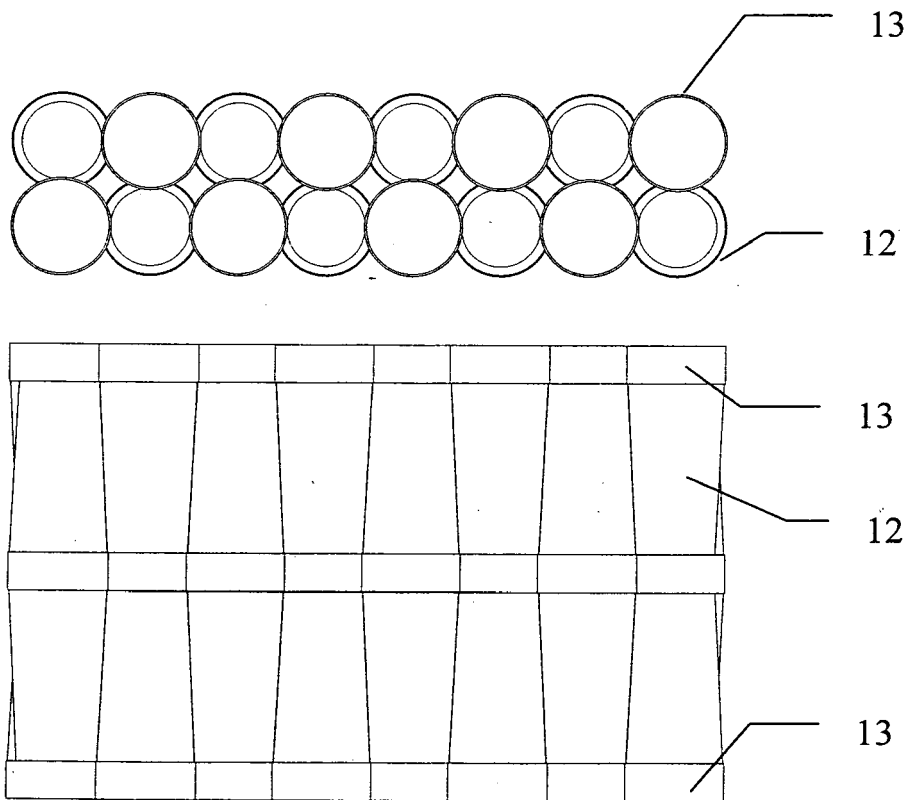


Fig. 9

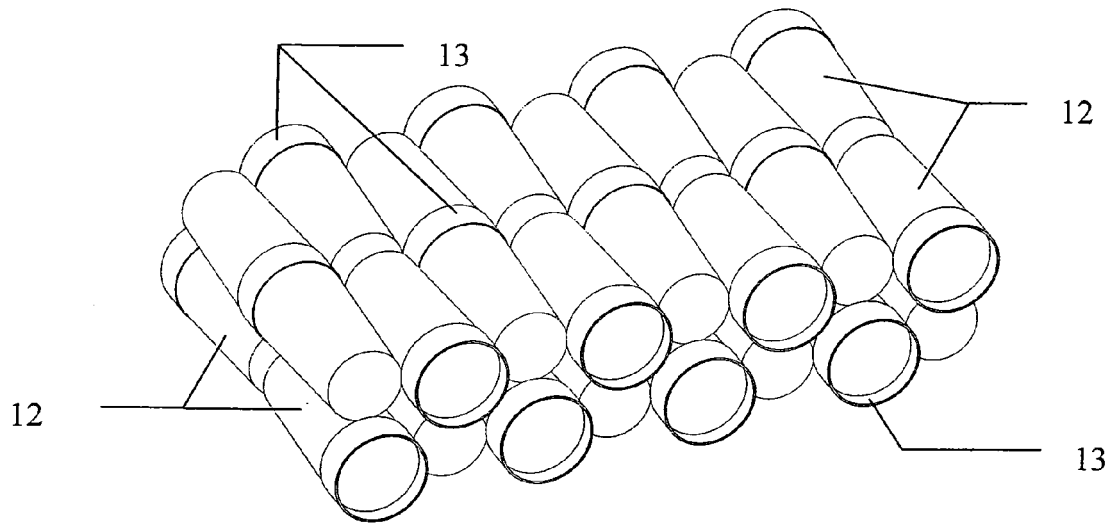


Fig. 10

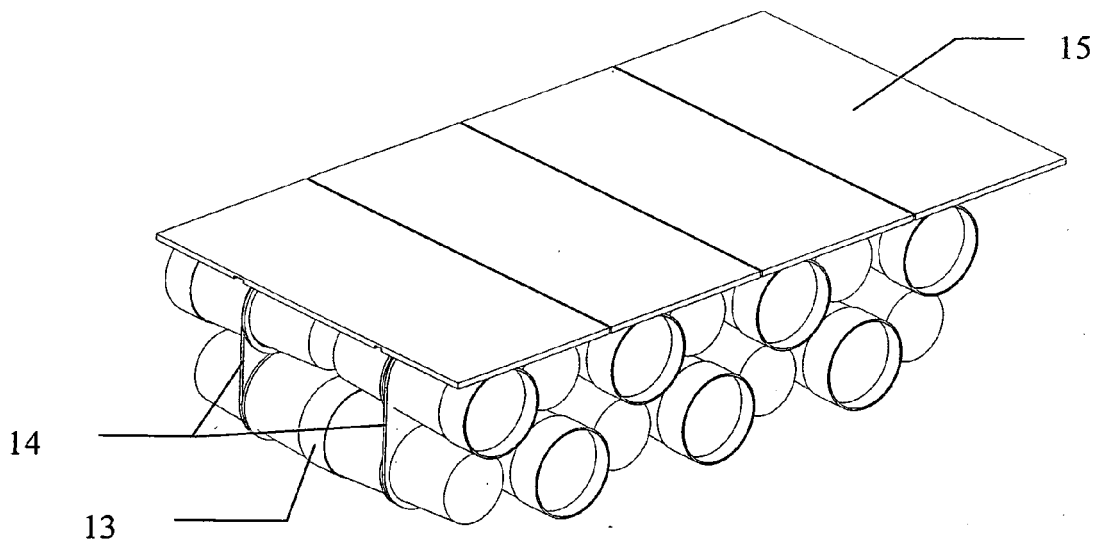


Fig. 11

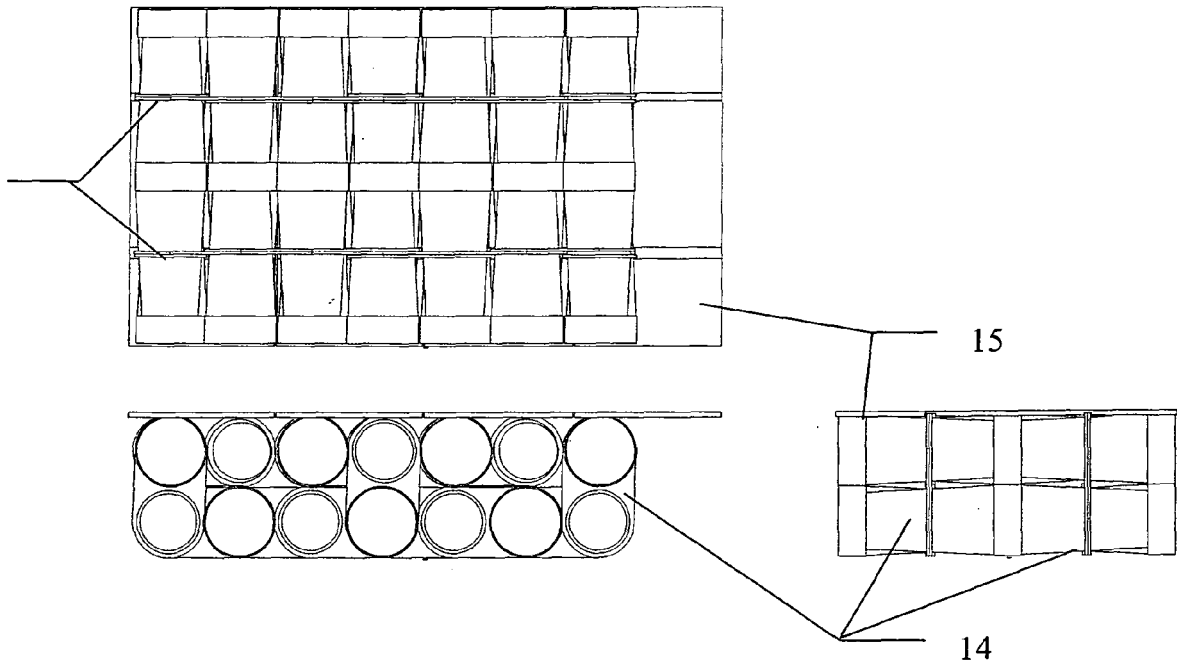


Fig. 12

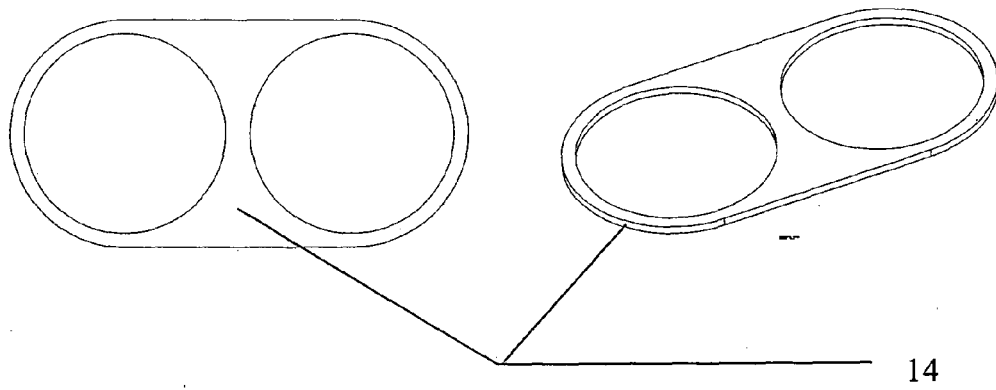


Fig. 13

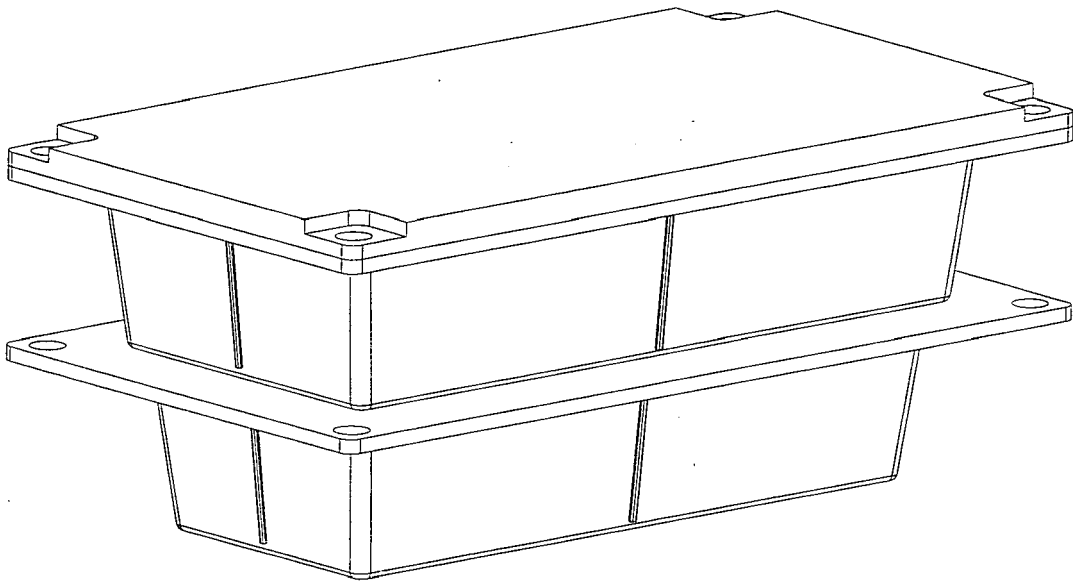


Fig. 14

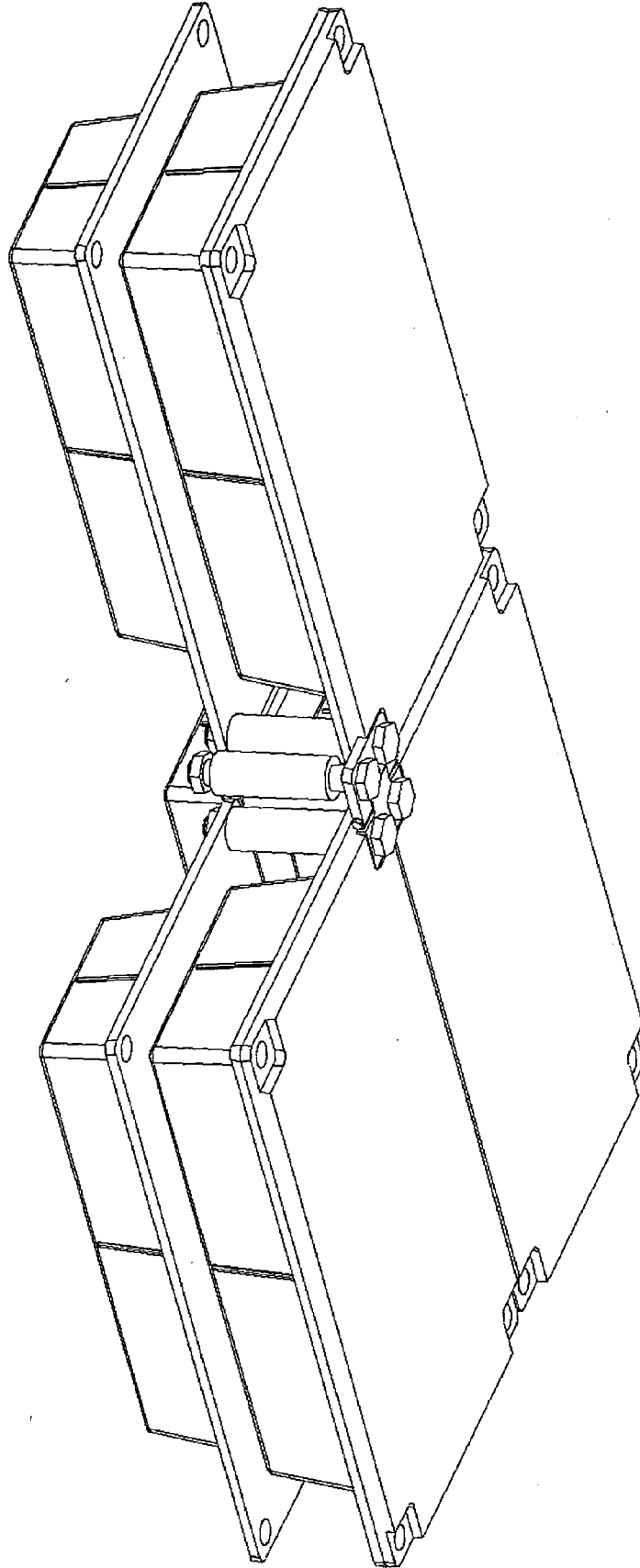


Fig. 15

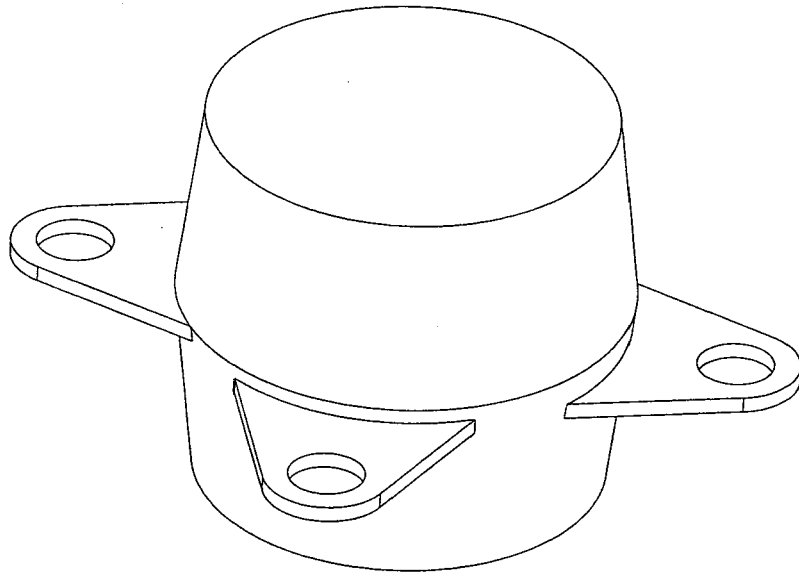


Fig. 16

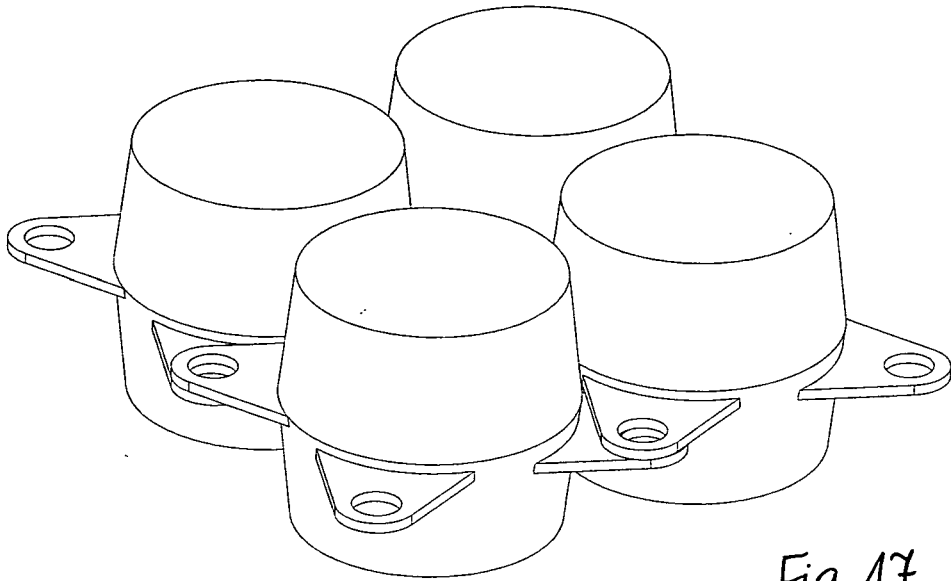


Fig. 17

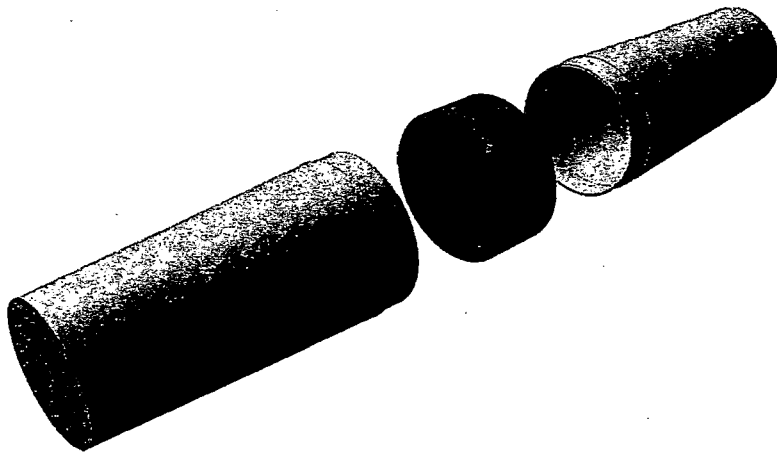


Fig. 18

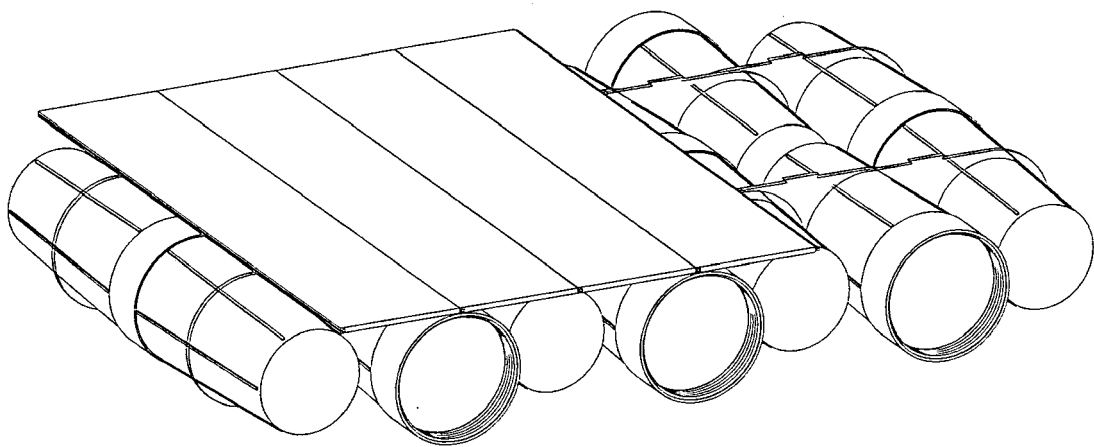


Fig. 19



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