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(54) PERMANENT FORMWORK

(57) The invention relates to the field of construction, namely to formwork and is a scalable, modular, periodic, permanent beam-node formwork for casting reinforced concrete, including underwater, and forming flat and volumetric concrete structures, including trusses isolated from corrosive effects of the external environment.

The technical result of the patented formwork is the possibility of using it for the construction of reinforced concrete 3D farms in the tidal zone and underwater in coastal areas of water reservoirs (from 1 to 12 meters deep) by eliminating deformations when filling the formwork with concrete and during operation, as well as by insulating concrete from the corrosive effects of salt water, biological destruction. The shell of the proposed formwork also significantly reduces the adhesion of concrete to ice, which significantly increases the operation life of concrete products in conditions of the sea or freezing water reservoirs.

The proposed technical result is provided by the construction of a permanent formwork, including nodal connecting elements, hollow pipes fixed in the nodal connecting elements, wherein the nodal connecting elements are hollow volumetric bodies with openings (sockets) oriented at angles to each other (hollow pipes are installed in some of them), as well as units with plugged (unused) sockets.

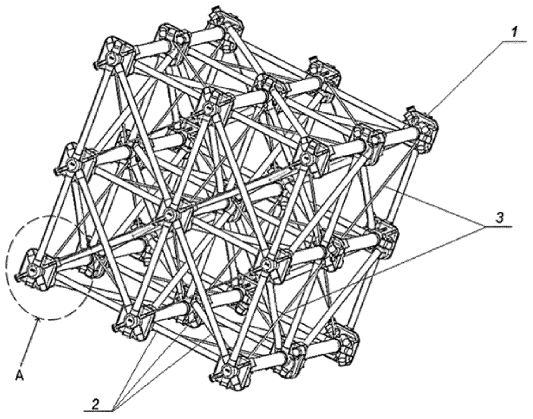

Fig. 1

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Description

[0001] The invention relates to the field of construction, namely to formwork and is a scalable, modular, periodic, permanent beam-node formwork for casting reinforced concrete, including underwater, and forming flat and volumetric concrete structures, including trusses isolated from corrosive effects of the external environment.

[0002] From the state of the art are known removable and permanent formworks for the formation of concrete structures of the "wall" type and various methods of joining such walls to each other (corner, tee, crosspiece), made of steel, plywood, foams, glued-pressed boards, etc.

[0003] For example, known is a block of a permanent formwork, including formwork plates connected to a spatial reinforcing lattice frame made of tubular elements, and the lattice units - in the form of spherical elements connected to the formwork plates, in which sockets with internal threads are formed, and the tubes are provided with tips located along their longitudinal axis with a threaded cantilever protrusion for placement in receptacles of spherical elements (RU 2029840 C1, published 27.02.1995).

[0004] Also known is a permanent decorative formwork, representing a spatially positioned flat elements limiting at least a part of the outer contour of the manufactured object, wherein these flat elements are bonded to each other to form a space between these elements for placing fittings and filling with a fluid-flowing material capable of solidification, wherein these flat elements are made of sheet steel and represent fragments of the external contour of the manufactured object, part of which is made fastenable to fittings to form part of the surface of the manufactured object after solidification of the fluid-flowing material (RU 138426 U1, published 20.03.2014).

[0005] Also known are removable and permanent formworks for forming concrete structures of the "round" or "rectangular" column type. For example, the formwork disclosed in patent RU 2258122 C2, published on 10.08.2005, formed by several flat rectangular shields, each of which has a flat inner side and an outer side provided with transverse ribs formed by C-shaped profiles, which are inextricably connected to the shield by their central sections.

[0006] Also known are removable undismountable formworks for the manufacture of a concrete product of the "flat farm" type, widely used for inter-floor constructions and roof structures. For example, a formwork comprising a form-forming flexible support shell in the form of a closed awning, the base of which is laid on a deck mounted on auxiliary beams, and the upper forming part of the awning is made with a relief surface corresponding to the formed structure and comprising intersecting channels for reinforcement of ribs installed in them to form a honeycomb surface of the structure (RU 2737744 C1, published 02.12.2020).

[0007] All above mentioned types of a formwork are unsuitable for casting concrete underwater due to great difficulties with their installation and dismantling in water, as well as rapid destruction of the formwork material in salt water, moreover, known formworks are not suitable for casting concrete into wet (flooded) formwork and require preliminary removal of water from the casting mold - by using cofferdams, caissons, temporary dams and other expensive methods. Moreover, the known formworks are unsuitable for the formation of a volumetric truss.

[0008] The majority of the known mass formwork systems for products of the "wall" type are not designed to be moved in assembled state and require installation of elements strictly "in situ". Such formwork systems, as a rule, are unsuitable for assembly on the shore, followed by the transfer of a fully finished concrete formwork into the water. The work of assembling the formwork underwater is extremely expensive and dangerous. The vast majority of such formworks cannot be easily removed from a hardened concrete product underwater, and they are left underwater, which causes significant environmental damage.

[0009] To form a structure of the desired size and shape, as a rule, it is necessary to use an assortment of elements of various sizes and shapes, which complicates the manufacture and logistics and the use of such formworks, especially in the case of permanent systems.

[0010] One of the technical problems solved by the proposed invention is to create a formwork system that allows to provide a concrete product with optimal wave and corrosion resistance .

[0011] The solution to this task creation of a 3D truss, which is an optimal construction (base) in terms of strength/material consumption and strength/cost ratios for underwater parts of most hydraulic structures. An open 3D truss also provides minimal resistance to waves and does not lead to erosion of the bottom soil.

[0012] Another problem is that in case of necessity to manufacture a monolithic product (without a cold seam) of high height, continuous batch casting technologies are used, when the next layer of concrete is poured after the previous one just begins to set. However, continuous batch casting is impossible under water and one must cast the entire product at once. Most of the known formwork systems are designed for casting a column of fresh concrete with a height of no more than 3 meters. When casting a higher column, undesired deformations of the formwork occur (and therefore of the concrete product), for example, a surface with overlays.

[0013] The proposed technical solution provides the possibility of a sealed connection (or several connections), incl. at lower points of the cast cavity to the concrete pump, by means of a concrete pipeline, which allows for pressure casting of concrete "from below upwards " at a distance of up to 80 meters from the coast line, with minimal human participation.

[0014] The technical result of the patented formwork is the possibility of using it for the construction of rein-

forced concrete 3D trusses in the tidal zone and underwater in coastal areas of water reservoirs (from 1 to 12 meters deep) by eliminating deformations when filling the formwork with concrete and during operation, as well as by insulating concrete from the corrosive effects of salt water, biological destruction. The shell of the proposed formwork also significantly reduces the adhesion of concrete to ice, which significantly increases the operation life of concrete products in conditions of the sea or freezing water reservoirs.

[0015] The proposed technical result is provided by the construction of a permanent formwork, including nodal connecting elements and pipes, wherein the nodal connecting elements are made in the form of hollow volumetric bodies with sockets oriented at angles to each other, some of which are plugged, and pipes are installed in others.

[0016] In one embodiment of the invention, the formwork includes external shafts made of metal or composite bars installed in the sockets of the nodal connecting elements at an angle to the sockets with pipes.

[0017] In an embodiment of the invention, at least one socket of the nodal connecting element is made with the possibility to be connected to a concrete pump for filling the formwork with concrete.

[0018] In an embodiment of the invention, the formwork includes reusable removable frames fixed on nodal connecting elements.

[0019] In an embodiment of the invention, the nodal connecting elements are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

[0020] In an embodiment of the invention, as pipes are used water or gas or sewer tubes.

[0021] In an embodiment of the invention, the pipes are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

[0022] In an embodiment of the invention, the pipes are fixed in the sockets of a nodal connecting element by welding or tube-locking, or gluing, or a spigot and socket connection, or fixing by screws, anchors, or rivets.

[0023] In an embodiment of the invention, at least one pipe is made with a window in its wall.

[0024] In an embodiment of the invention, the sockets of the nodal connecting elements are arranged coaxially with the possibility of a through placement of pipes.

[0025] In an embodiment of the invention, the sockets of the nodal connecting elements are arranged coaxially with the possibility of a through placement of shafts.

[0026] The construction of the described formwork allows to create an open 3D concrete truss by forming a cavity for filling with concrete, including hollow pipes and hollow nodal connecting elements, which in the final product perform the function of a shell protecting the concrete truss from interaction with the environment (water, ice, pollution, etc.), thereby preventing the destruction of the structure. Initially (from the factory), all openings in the NCE (sockets) are plugged and openings are drilled only in those sockets where pipes, rods are inserted, or where a concrete pump is connected to. Unused openings (sockets) in the NCE remain plugged in order to preserve the tightness of the mold.

[0027] Further, the invention is explained by references to the figures, which show the following.

Fig. 1 -general view of a permanent formwork.
Fig. 2 - general view of a nodal connecting element.
Fig. 3 - formwork unit, type A from FIG. 1.
Fig. 4 - example 1 of the embodiment of the invention (construction of rail slips (wedge winch boatlifts) or roller ramps).
Fig. 5 - example 2 of the embodiment of the invention (formwork for the manufacture of reinforced concrete keel blocks for sailing yachts, mooring boats or speedboats).
Fig. 6 - example 3 of the embodiment of the invention (formwork for the construction of surface crossings, bathing platforms, sea terraces and other low-load (pedestrian, recreational) areas above water).

3D-model No. 1- proposed formwork in general view.
3D-model No. 2 - example 1 of the embodiment of the invention.
3D-model No. 3 - example 2 of the embodiment of the invention.

[0028] The proposed permanent formwork is designed for creation of an underwater reinforced concrete 3D truss for structures in coastal water areas. The structure, ready to be filled with concrete, includes polymer nodal connecting elements (NCE) 1, hollow polymer pipes 2 (FIG. 1, 3D-model 1). Hollow pipes are made of polyethylene or PVC or polypropylene or metal (stainless or galvanized steel or aluminum) or fiberglass, and are usually widely available water or gas or fecal pipes.

[0029] Also, in embodiments of the invention the formwork may include shafts 3 made of metal or composite materials (bars), the shafts are not filled with concrete and play the role of external reinforcement, the diameter of the shafts in the range of 12-40 mm allows to withstand a tensile force of up to 150 tons, with a weight of 200-900 g per linear meter, providing the finished 3D truss with spatial rigidity.

[0030] The structure is beam-angular, all pipes 2 and straight shafts 3 in the structure begin and end at the nodal connecting elements 1. However, console pipes can be used that go beyond the dimensions of the 3D truss, and L-shaped shafts that start with a straight end in the fitting, and a bent one fixed at any point on the pipe.

[0031] The nodal connecting element is a hollow volumetric body with sockets 4 oriented at different angles to each other (30°, 60°, 45°, 90°), and also opposite from different sides of the element (coaxially) with openings providing through passage of the pipe through the openings in the sockets. In the part of the openings of the nodal connecting element 3 pipes of various diameters (50-500mm) are installed at different angles, forming a

3D truss cell, and part of the sockets is plugged. The nodal connecting elements are made of polyethylene or PVC or polypropylene or metal (stainless or galvanized steel or aluminum) or fiberglass.

[0032] In the openings of the sockets 5 of a smaller diameter (12-40 mm) are installed shafts, wherein the sockets can be made coaxially, with the possibility of through passage of shafts through them. Unused openings of the sockets 5 are also plugged.

[0033] Therein, initially the nodal connecting elements are made with plugged sockets 4 and 5, and some of them, for installing pipes 2 and shafts 3 in them, are drilled by installers during assembly in various combinations, depending on the position of the fitting in the structure or the desired mechanical load on the structure, to ensure complete retention of concrete in the formwork, without leakage through unused openings.

[0034] The pipes 2 can be fixed in the openings of the sockets 4 of the nodal connecting element by welding or tube-locking and/or gluing and/or a spigot and socket connection and/or fixing by screws, anchors, rivets or by means of through passage of the pipe through the nodal connecting element with a window in the pipe wall or without a window.

[0035] For filling the flooded formwork with concrete through the lower point, by displacing water with concrete "from below upwards ", the nodal connecting elements are made with a socket 6, to which a concrete pump is connected by means of a concrete pipeline. For this purpose, any nodal connecting element in the lower (bottom) part of the formwork is used.

[0036] Nodal connecting elements may have fixing units for external removable (reusable) reinforcement of the formwork structure in order to prevent deformation or destruction of the structure at the time of filling with fresh (liquid) concrete. The specified reinforcement (for example, wooden frames) is disassembled and reused on another structure, after setting the concrete and gaining a minimum calculated strength.

[0037] The nodal connecting elements may have the same design, which can be used for all units of the structure. In another embodiment of the invention, different nodal connecting elements can be used for different formwork units, for example, one set for the middle layers of the structure and another set for the bottom (= upper) layer of the structure. Therein, each set can include from 1 to 4 nodal connecting elements.

[0038] The proposed formwork is scalable, the basic distance between adjacent nodal elements of the structure can be selected by the user arbitrarily and in a wide range due to the possibility of open-ended installation of pipes in nodal elements. The selection of the length of the basic pipe(s) automatically sets the length of all other pipes. Therein, changing the cell size of the structure does not require an additional range of specialized formwork elements (as in most known prior art), but influences only the cutting of the pipes.

[0039] For assembling a plurality of different structures, only few models of nodal connecting elements (or one) will be required, which will be repeated many times in the units of the structure. Therein, the nodal connecting element, as a rule, has an excessive number of ports (sockets) for connecting pipes and shafts, which allows it to be used in truss units with a different required set of pipes (angle, face, side surface, etc.).

[0040] The formwork structure is periodic, the angles between the pipes 2 in several adjacent nodal connecting elements (usually six or eight elements) set the shape of an elementary volumetric cell of the structure, which will be repeated many times in different directions. Therein, all (or part of) adjacent cells will be equally sized, and the other part will be proportionally sized (each subsequent cell is proportionally larger or smaller than the previous one).

[0041] For filling the formwork is used reinforced concrete with fiber additives and/or concrete that fills the formwork with placed therein earlier reinforcement grids or reinforcing elements.

[0042] Further are provided examples of the implementation of the invention.

Example 1 - construction of rail slips (wedge winch boatlifts) or roller ramps.

[0043] The structure consists of two half-trusses, one above the other. The lower half-truss (FIG. 4, 3D model No. 2) is an inclined (18°) trapezoid that sets the slope of the entire ramp. If the slope of the ramp is not required (the bottom relief has a slope), it is possible to completely abandon the lower half-truss (or replace it with bored piles).

[0044] The main advantages of slips and ramps built using the proposed technology are the following. Imperceptibility of the structure by bottom sediments, saving concrete, durability. The possibility of assembling the structure at a distance from the shore and at depths of up to 4.5 meters. The structures are adapted to tides with an amplitude of up to 150 cm. The working depth difference (reachable for trolley) is up to 3 meters. The possibility to assemble wide (3 frames) slips for ships with a hull length of more than 9.5 meters. The possibility of a blocked assembly of several slips or ramps in order to save the surface of the water area and increase the ice resistance of the structure.

[0045] The fitting system is designed for ramp lifting/launching of watercrafts, without a trolley - on rollers. Designed for jet skis, motorboats or dinghies.

[0046] At the top point of the structure, at the stem level, is mounted a manual or electric winch with a pulling force of not less than 50% of the weight of the watercraft, for comfortable lifting of the watercraft onto the ramp and its fixation.

[0047] The working (inter-roller) width of the ramp is set during installation, in accordance with watercrafts intended to be used.

[0048] The ramp is mounted on reliable (including

stepped) bases, subject to the angle of inclination of the ramp.

[0049] The structure does not have horizontal transverse or diagonal beams in the upper tier of fittings, which ensures compatibility with PWC V-hulls and boats.

[0050] Each fitting has two U-shaped attachment points for a thick-walled "roller" pipe with a diameter of 65 mm with the possibility of axial rotation. A concrete pipe flange is provided in each fitting.

[0051] On the roller pipe can be mounted in pairs soft plastic rollers with a diameter of 150-200 mm (not less than 3 pairs per fitting in the upper tier of the ramp). The rollers must have a "floating" angle of ascent adapted to the lines of the boat's hull.

[0052] The external reinforcement is carried out by means of L-shaped edged shafts, it allows adjusting the length of the shafts "in place", and as a "hinge" attachment point, using an opening in any place of the pipe beam anchoring the curved end of the shaft. Therein, the straight (shortened) end is fixed in a standard socket on the fitting. This ensures the functionality of the shafts (the presence of sufficient leverage and compliance with the direction of load perception) at their low cost and complete versatility.

[0053] The system is assembled from polypropylene pipes with an outer diameter of 400 mm and 100 mm, as well as polypropylene NCE.

Example 2 - formwork for the manufacture of reinforced concrete keel blocks for sailing yachts, dinghies or boats (FIG. 5, 3D model No. 3).

[0054] The monofitting used in the system is suitable for the manufacture of support (BUNK) keel blocks, with a soft adjustable stop (fender), and locking (SLING) keel blocks, as well as "Swedish" (hook) extensions (for vessels supported on the keel).

[0055] Depending on the chosen design, the supporting column has an inclination from the vertical of 15° in the direction "to" or "from" the hull of the vessel.

[0056] For catamarans and pontoons, possible are designs with a tilt of the keel block legs along the hulls.

[0057] Support keel blocks, as a rule, have a screw jack or a rubber (including pneumatic) cushion for even distribution of the load between the support points.

[0058] For motorboats and catamarans popular are long rubberized guides.

[0059] The fitting has an excessive number of interconnections, which allows manufacturing both rectangular keel blocks and "oval" ones (with a different distance between each pair of opposing legs).

[0060] The formwork can be with or without undercarriage (central) supports.

[0061] Each fitting has a built-in concrete pipe flange.

[0062] The system is assembled from metal or composite thick-walled pipes with a diameter of 50 mm (stainless steel for marine water areas; galvanized steel for freshwater areas), metal NCE and composite shafts with a diameter of 30 mm.

[0063] Example 3 - formwork for the construction of surface crossings, bathing platforms, sea terraces and other low-load (pedestrian, recreational) areas above the water (FIG. 5). The maximum depth of the water reservoir at the location of the structure - up to 200 cm. The water reservoir can be both fresh and marine, but it must not freeze in winter and experience ice breaks.

[0064] The system consists of 2 series of fittings - extreme (180 degree coverage) and middle (360 degree coverage). The bottom versions of the fittings have additional horizontal ports with a diameter of 160 mm for concreting. The surface version has a platform for screwing internal screw piles and a welded passage with a diameter of 160 for poles and built-in furniture.

[0065] The system is assembled from HDPE or PVC pipes with an outer diameter of 500 mm and 160 mm, metal or composite thick-walled pipes with a diameter of 51 mm (only stainless steel for marine water areas; also allowed is galvanization for freshwater), composite or PVC nodal connecting elements and stainless steel bars with a diameter of 12 mm or composite bars with a diameter of 40 mm. As a deck, it is possible to use hardwood, composite and stainless lattice decking.

Claims

1. Permanent formwork, including nodal connecting elements and pipes, wherein the nodal connecting elements are made in the form of hollow volumetric bodies with sockets oriented at angles to each other, some of which are plugged, and pipes are installed in others sockets.

2. Permanent formwork according to claim 1, **characterized in that** it includes external shafts of metal or composite bar, installed in the sockets of nodal connecting elements at an angle to the sockets with pipes.

3. Permanent formwork according to claim 1, **characterized in that** at least one socket of the nodal connecting element is made connectable to a concrete pump for filling the formwork with concrete.

4. Permanent formwork according to claim 1, **characterized in that** it includes reusable removable frames fixed on nodal connecting elements.

5. Permanent formwork according to claim 1, **characterized in that** the nodal connecting elements are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

6. Permanent formwork according to claim 1, **characterized in that** as pipes are used water or gas or sewer tubes.

7. Permanent formwork according to claim 1, **characterized in that** the pipes are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

8. Permanent formwork according to claim 1, **characterized in that** the pipes are fixed in the sockets of the nodal connecting element by welding or tube-locking, or gluing, or a spigot and socket connection, or fixing by screws, anchors, or rivets.

9. Permanent formwork according to claim 8, **characterized in that** at least one pipe is made with a window in its wall.

10. Permanent formwork according to claim 1, **characterized in that** the sockets of the nodal connecting elements are located coaxially with the possibility of through placement of pipes.

11. Permanent formwork according to claim 2, **characterized in that** the nozzles of the nodal connecting elements are located coaxially with the possibility of through placement of shafts.

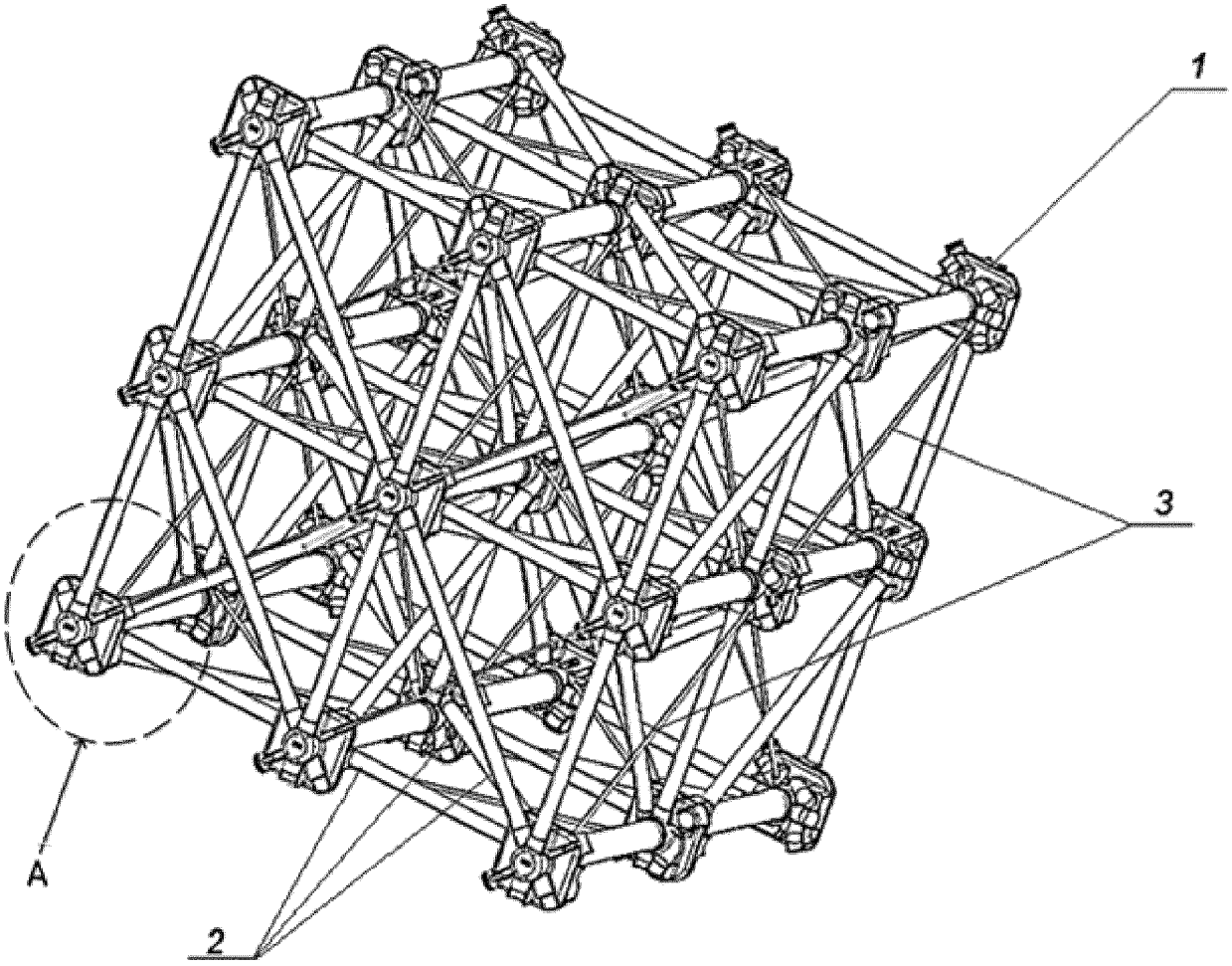

Fig. 1

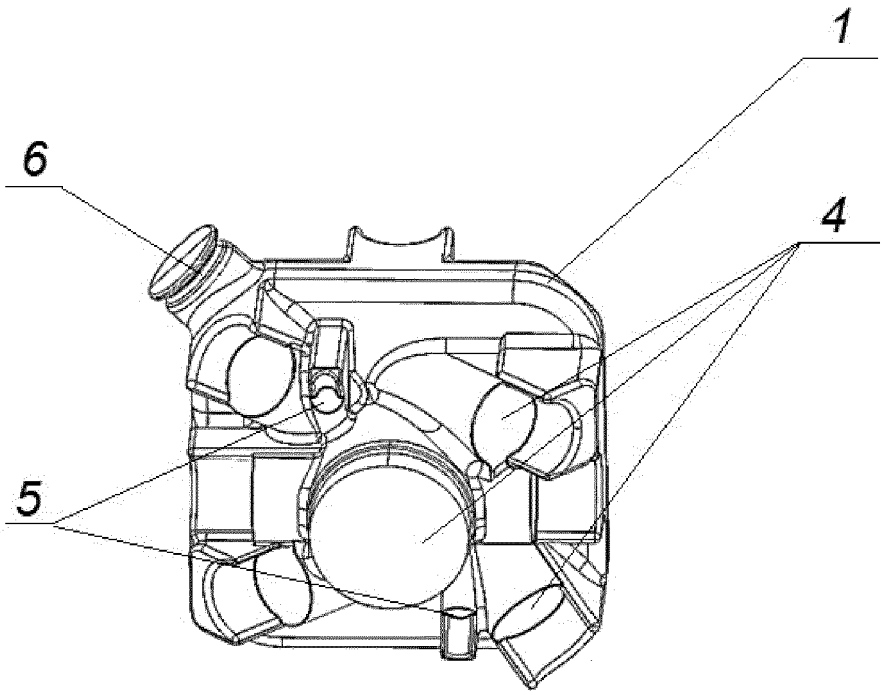

Fig. 2

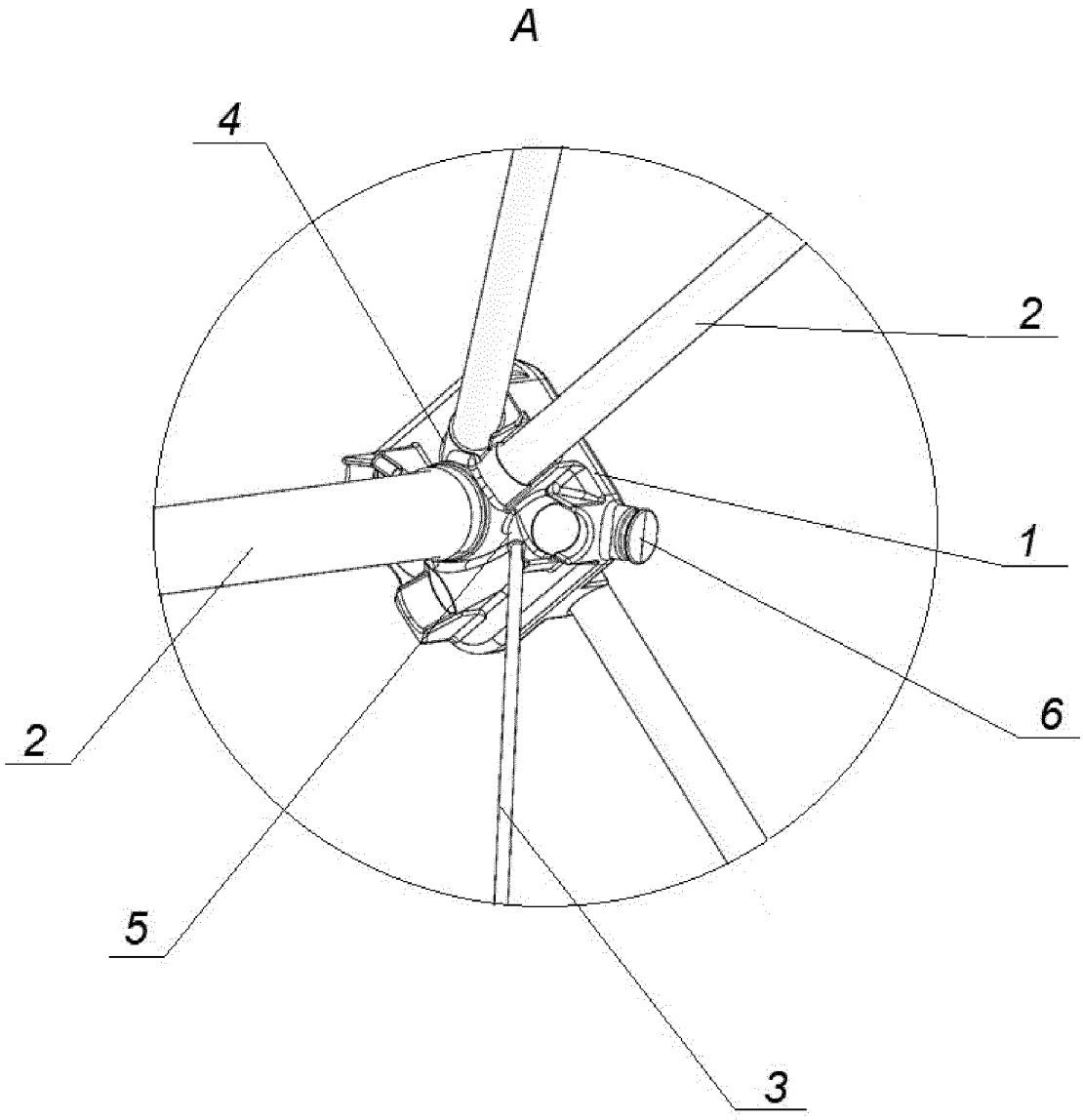

Fig. 3

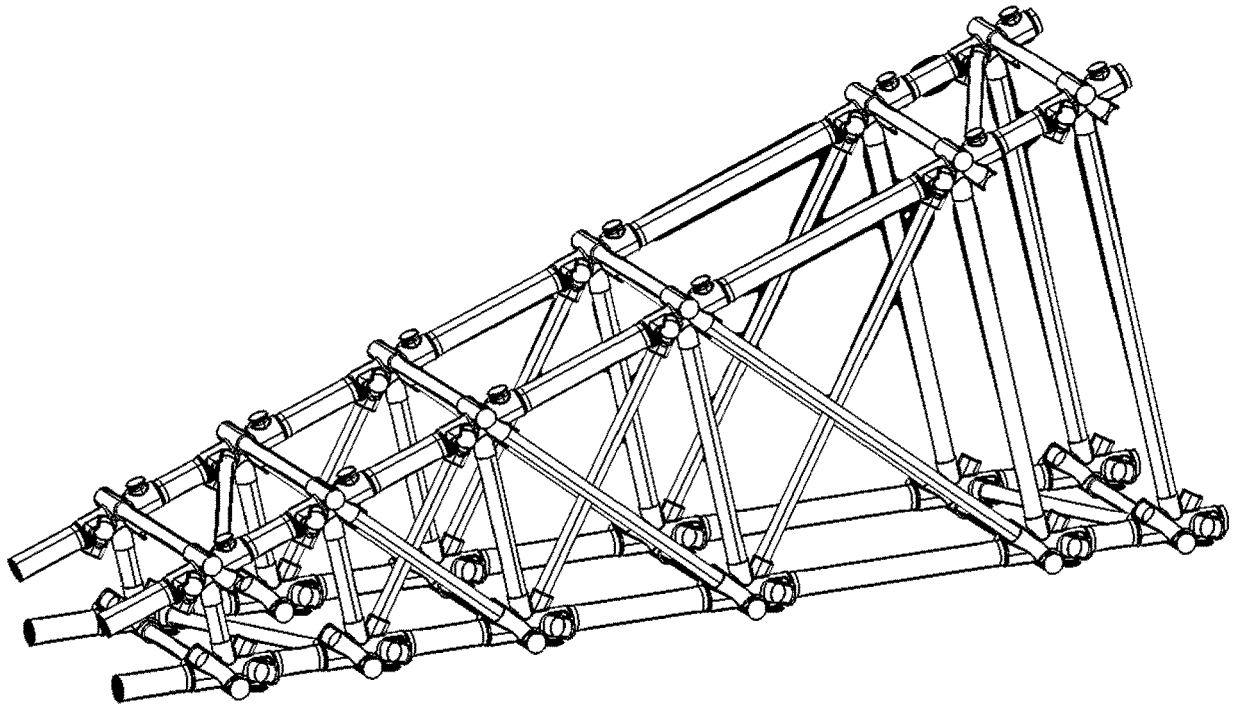

Fig. 4

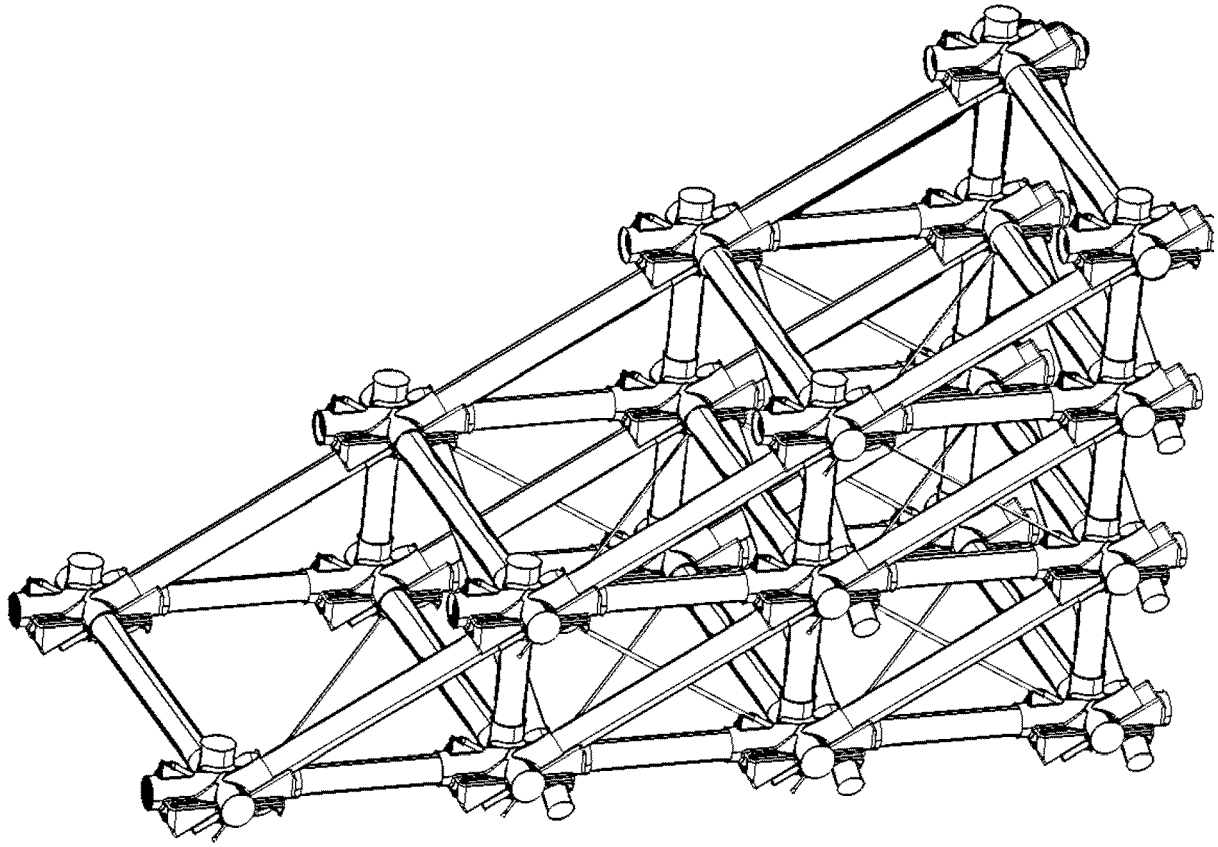

Fig. 5

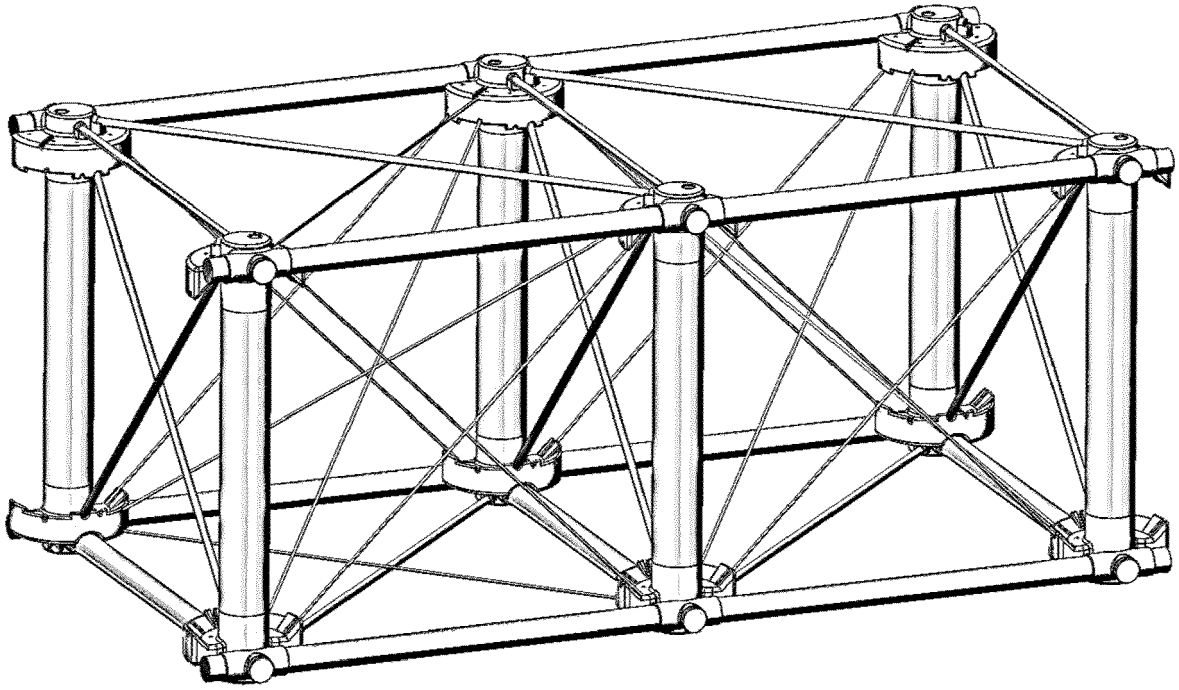

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 24 16 8634

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 067 915 A2 (WESERWIND GMBH [DE]) 10 June 2009 (2009-06-10) * paragraph [0015] - paragraph [0034]; figures *	1-11	INV. E04B2/86 E02B17/00
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TECHNICAL FIELDS SEARCHED (IPC)

E04B
E02C
E02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 September 2024	López-García, G

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 16 8634

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20-09-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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