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(54) **HYDROFOIL FOR TRANSPORT OVER WATER AND MOVEMENT APPARATUS FOR APPENDAGES OF A HYDROFOIL**

(57) Hydrofoil for transport over water, which comprises a hull (2) extended along a main extension axis (X), at least one appendage (4), mounted on said hull (2), a movement apparatus (5) mechanically connected to the appendage (4) in order to move it and comprising at least one first actuator member (6), actuatable for rotating the appendage (4) around a first rotation axis (Y) substantially parallel to the main extension axis (X); the movement apparatus (5) also comprises a support body (7) rotatably constrained to the hull (2), actuatable to ro-

tate around a second rotation axis (Z) and comprising a first hinge member (8) carrying, rotatably mounted thereon, the appendage (4), a second actuator member (9), actuatable for rotating the support body (7) around the second rotation axis (Z), connection means (10), between the second actuator member (9) and the support body (7) adapted to move the support body (7) around the second rotation axis (Z) following the actuation of the second actuator member (9).

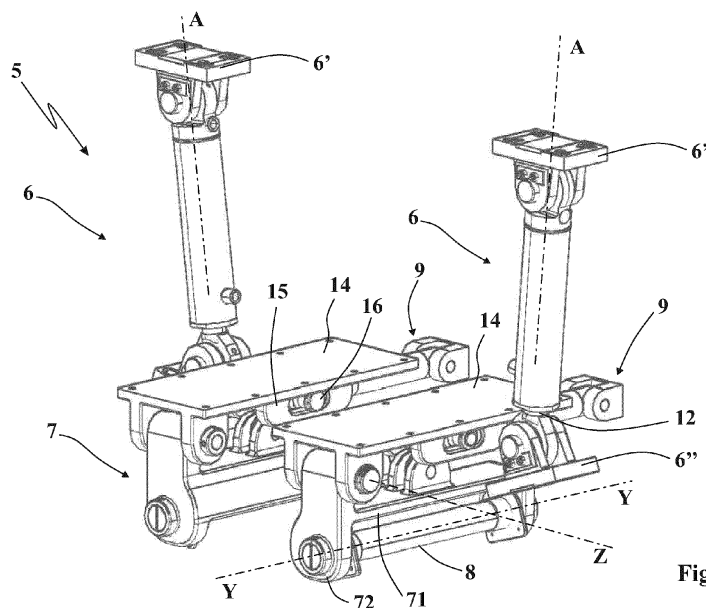


Fig. 3

Description

Field of application

[0001] The present invention regards a hydrofoil for transport over water and an apparatus for moving appendages of a hydrofoil, according to the preamble of the respective independent claims.

[0002] The present hydrofoil and apparatus are intended to be advantageously employed in the nautical field for transporting people over water.

[0003] More in detail, the hydrofoil and the apparatus, object of the present invention, are advantageously employable for the movement of appendages so as to modify the position of the hydrofoil itself.

[0004] The invention is therefore inserted in the context of the nautical industry, both in the scope of production of hydrofoils and accessories thereof and in the scope of use of such hydrofoils.

State of the art

[0005] Known on the market are new boats, also termed "hydrofoils", which are provided with appendages mounted on the hull of the boat and projecting below with respect to such hull for the purpose of being at least partially immersed in water.

[0006] During use, such appendages are capable of interacting with a water flow on which they advance, converting the pressure resulting from the relative speed between that of advancement of the hydrofoil and that of the water flow into a lift force directed upward. In particular, the greater the advancing speed of the hydrofoil on which such appendages are mounted, the greater the resulting lift force applied to the appendages, which lifts the hull from the free surface of the water.

[0007] More in detail, once a predetermined value of advancing speed has been exceeded, the generated lift force exceeds the weight force of the hydrofoil and the hull of the latter is lifted from the free surface of the water up to completely emerging and obtaining a navigation condition termed "foilborne".

[0008] Such foilborne navigation allows numerous advantages. In particular, during foilborne navigation, only the appendages are immersed in water and the hydrofoil navigates with a smaller surface area with respect to a "conventional" navigation, in which also the hull is at least partially immersed in water.

[0009] The aforesaid smaller immersed surface area involves a lower hydrodynamic resistance of the water on the hydrofoil and allows the hydrofoil to reach higher navigation speeds, given the same installed motor power.

[0010] One example of a hydrofoil of known type is described in the document US 3886884. The hydrofoil described herein is provided in a per se conventional manner with a hull intended to advance on the water in a first navigation condition of conventional type, i.e. with

at least one portion of such hull immersed in water.

[0011] The aforesaid hydrofoil of known type also comprises two appendages, intended to be immersed in water in order to allow the hydrofoil to navigate also in a second condition, i.e. in foilborne condition.

[0012] More in detail, the hydrofoil of known type is provided with a bow appendage and with a stern appendage, which are mounted on the hull so as to project below the hull itself in order to be immersed in water and they are spaced from each other along a main extension direction of the hull itself.

[0013] In particular, the bow appendage is rigidly mounted on the rudder blade of the hydrofoil and it is intended to always be immersed.

[0014] Otherwise, the stern appendage is rotatably mounted on the hull in proximity to its stern and is susceptible of being moved with respect to the hull itself. More in detail, the stern appendage is extended transversely to the hull, from port to starboard, and is movable around a rotation axis orthogonal to the main extension axis of the hull itself and substantially horizontal.

[0015] In particular, the aforesaid stern appendage is movable between a lifted position, in which the appendage is substantially side-by-side the hull and the hydrofoil is susceptible of navigating in a conventional manner, and a lowered position, in which the appendage projects below with respect to the hull and the hydrofoil is susceptible of navigating, once the speed threshold value has been exceeded, in foilborne condition. More in detail, in the aforesaid lifted position, the stern appendage of the hydrofoil of known type is horizontal, side-by-side the hull and it completely emerges from the water so as to not interact with the water flow lines and not generate lift.

[0016] In this situation, the hull remains at least partially immersed, allowing the aforesaid navigation of conventional type.

[0017] Otherwise, in the lowered position, the stern appendage is vertical, projects below the bottom wall of the hull and is completely immersed in water so as to interact with the water flow lines and generate lift.

[0018] In order to allow a greater control of the position of the hydrofoil i.e. so as to maintain it substantially always horizontal during the entire navigation, the hydrofoil described in US 3886884 is also provided with movable terminations mounted on the bow and stern appendages.

[0019] More in detail, each bow and stern appendage has substantially flat shape, and is placed horizontal when the appendage is immersed in water. The aforesaid terminations are plates mounted on the appendages at a rear edge thereof, i.e. directed towards the stern, in opposite direction with respect to the advancement direction. In addition, the aforesaid terminations are hinged to the corresponding appendage and are susceptible of being moved in order to vary an incidence profile (i.e. the substantially horizontal profile of the appendage which interacts with the water flow in order to convert the pressure of the water into the aforesaid lift force) of the appendage itself with the water flow lines.

[0020] In particular, the variation of the incidence profile involves a different interaction of the appendage with the water flow and then involves a different lift force developed by the appendage itself.

[0021] The hydrofoil of known type described herein also comprises an apparatus for moving the movable terminations of the appendages.

[0022] More in detail, the apparatus of known type comprises at least one linear actuator mechanically connected to each movable termination and actuatable for being moved between a retracted configuration, in which it moves the movable termination into a configuration coplanar with the appendage, and an extended configuration, in which it moves the movable termination into a configuration that is tilted with respect to the corresponding appendage so as to increase or decrease the lift force imparted to the hull. As anticipated above, each movable termination is connected to the corresponding appendage by means of a hinge which allows the movement thereof between the coplanar configuration and the tilted configuration by rotating around a substantially horizontal rotation axis.

[0023] The hydrofoil of known type described in brief up to now and the apparatus provided in such hydrofoil have in practice demonstrated that they do not lack drawbacks.

[0024] The main drawback of the aforesaid hydrofoil of known type lies in the fact that the movable terminations of the appendages allow a limited configuration variation, in particular only around a single rotation axis and limited to a limited portion of the appendages.

[0025] In this situation, the appendages of the hydrofoil of known type allow a limited capacity adapted to the various progression situations of the hydrofoil and consequently they have in practice demonstrated that they are incapable of handling sudden turn requests or adverse water conditions.

[0026] A further drawback of the hydrofoil and of the apparatus of known type described above lies in the fact that the hinge of the movement apparatus of the movable terminations of the appendages is directly applied on the wings of the appendages themselves.

[0027] In this situation, the hinge of the apparatus must be provided with limited size and weight, in order to avoid negatively affecting the aerodynamic and fluid-dynamic performances of the appendage.

[0028] As is known, limited size and weight translate into poor mechanical strength and reliability, often resulting in breakage and/or malfunctions of mechanical type and consequently poor reliability of the hydrofoil of known type.

[0029] In order to at least partially overcome the drawbacks of the above-described prior art, a hydrofoil is also known, for example described in the document DE 102014105883, which provides for an apparatus for moving the entire appendages.

[0030] More in detail, the appendages are mechanically mounted on the hull, externally and laterally with

respect to the latter, and they are movable between a lifted configuration, in which they are laterally side-by-side the hull and they do not intercept the water, and a lowered configuration, in which they are arranged below the hull, to intercept the water in order to generate a lift force and lift the hull from the free surface of the water itself.

[0031] The movement apparatus comprises an articulated quadrilateral placed to connect between a corresponding appendage and the hull of the hydrofoil.

[0032] More in detail, the articulated quadrilateral is mechanically fixed on one side to a slidable carriage, which is actuatable by a linear actuator mounted on the hull, and on the other side is connected to the appendage to be moved.

[0033] In operation, by actuating the linear actuator, the carriage consequently moves the articulated quadrilateral, which moves the appendages between the aforesaid lowered and lifted configurations.

[0034] Also the latter hydrofoil and its apparatus have in practice demonstrated that they do not lack drawbacks.

[0035] The main drawback lies in the fact that the appendages are only movable in the two aforesaid lowered and lifted configurations, actually limiting the adaptive capacity to the various progression situations of the hydrofoil, and consequently they have in practice demonstrated that they are incapable of handling sudden turn requests or adverse water conditions.

[0036] A further drawback of the hydrofoil and of the apparatus of known type described in brief above lies in the fact that the carriage and the articulated quadrilateral of the movement apparatus are quite bulky and extremely unaesthetic.

[0037] A further drawback lies in the fact that the appendages, moved into the lifted configuration, remain externally projecting with respect to the hull, resulting bulky and negatively affecting the aerodynamic and fluid-dynamic capacities of the hydrofoil of known type.

Presentation of the invention

[0038] In this situation, the problem underlying the present invention is therefore that of overcoming the drawbacks manifested by the hydrofoils of known type, by providing a hydrofoil for transport over water and an apparatus for moving appendages of a hydrofoil which allow easily moving the appendages in order to maintain the hydrofoil itself in the desired position in any operating condition.

[0039] A further object of the present invention is to provide a hydrofoil for transport over water and an apparatus for moving appendages of a hydrofoil which is easy to use.

[0040] A further object of the present invention is to provide a hydrofoil for transport over water and an apparatus for moving appendages of a hydrofoil which ensures high movement performances of the appendages, in order to adapt them to the navigation requirements.

[0041] A further object of the present invention is to provide a hydrofoil for transport over water and an apparatus for moving appendages of a hydrofoil that is entirely efficient and reliable in operation.

Brief description of the drawings

[0042] The technical characteristics of the invention, according to the aforesaid objects, can be clearly seen in the contents of the below-reported claims and the advantages thereof will be more evident in the following detailed description, made with reference to the enclosed drawings, which represent a merely exemplifying and non-limiting embodiment of the invention, in which:

- Fig. 1 shows a perspective view of a hydrofoil, object of the present invention, in which the hydrofoil is represented with the appendages placed in a lifted position in order to execute a conventional navigation, i.e. with the hull intended to be at least partially immersed in water;
- Fig. 2 shows a further perspective view of a hydrofoil, object of the present invention, in which the hydrofoil is represented with the appendages placed in a lowered position in order to execute a foilborne navigation;
- Fig. 3 shows a perspective view of a movement apparatus, also object of the present invention, with several parts of the hydrofoil removed in order to better illustrate other parts;
- Fig. 4 shows a further perspective view of the movement apparatus, object of the present invention, with some parts removed in order to better illustrate other parts;
- Fig. 5 shows an exploded perspective view of the movement apparatus, object of the present invention, with some parts removed in order to better illustrate other parts.

Detailed description of the preferred embodiment

[0043] With reference to the enclosed drawings, reference number 1 overall indicates a hydrofoil, according to the present invention.

[0044] The hydrofoil 1 according to the invention, during use, is advantageously intended to float on a body of water, preferably with a substantially horizontal position, such position intended to be controlled by means of a movement apparatus, also object of the present invention.

[0045] In particular, in the following present description, with the term "position" it is intended the spatial position of the hydrofoil 1 and more in detail the tilt of a lying plane of such hydrofoil 1 with respect to an ideal plane, preferably horizontal, as described more in detail hereinbelow.

[0046] Advantageously, the present control method is

aimed to maintain the position of the hydrofoil 1 substantially horizontal during navigation of the hydrofoil 1 itself on the body of water, regardless of the surface conditions of the free surface of the water.

[0047] The hydrofoil comprises a hull 2 extended along a main extension axis X between a bow end 21 and a stern end 22.

[0048] In the following present description, reference will always be made to a hydrofoil 1 provided with only one hull 2; nevertheless, an alternative embodiment of the hydrofoil 1 is also intended as possible in which the hydrofoil 1 is provided with two or more hulls 2, without departing from the protective scope of the present patent. Advantageously, the main extension axis X defines an advancement direction of the hydrofoil 1 itself along a navigation course thereof.

[0049] Preferably, in a manner per se known to the man skilled in the art, the hydrofoil 1 comprises at least one helm, mechanically mounted on the hull 2 and movable into a plurality of positions, each defining a corresponding turn angle α with respect to the main extension axis X.

[0050] In particular, with the term "helm" it must be intended hereinbelow a turn request member, preferably mounted at a driving zone of the hydrofoil 1, e.g. a driving cabin of the hydrofoil 1, and manipulatable by a pilot so as to drive a turning of the hydrofoil 1 with respect to the advancement direction.

[0051] In accordance with the preferred embodiment, the hydrofoil 1 comprises propulsor means adapted to move a water flow along a thrust direction, so as to allow the advancing of the hydrofoil on the water along a direction substantially coinciding with the main extension axis X. Such propulsor means for example comprise a motor mounted on the hull 2 and a propeller mechanically engaged with the motor and projecting below the hull 2 in order to intercept the water and generate a propulsion force. The propulsor means are per se known to the man skilled in the art and therefore are not illustrated in detail and will not be described hereinbelow.

[0052] The hydrofoil 1 also comprises at least one appendage 4, and preferably at least two appendages 4, rotatably mounted on the hull 2 and projecting below with respect to the hull 2 itself.

[0053] In particular, such appendages 4 are during use intended to be at least partially immersed in water in order to generate a lift force and lift the hull 2 from the free surface of the water, allowing the hydrofoil 1 to navigate in foilborne condition.

[0054] With the term "lift", a lifting force must be intended in the present text, which is substantially directed upward, resulting from the fluid-dynamic forces that the water imparts on the aforesaid appendages 4.

[0055] In accordance with the preferred embodiment illustrated in the enclosed figures, the hull 2 is advantageously provided with a median plane M, comprising the aforesaid main extension axis X and defining a port half-hull 2' and a starboard half-hull 2". Advantageously, with

the hydrofoil 1 at rest, the median plane M is a substantially vertical plane which defines the aforesaid two half-hulls 2', 2" that are preferably mirrored and congruent with respect to each other.

[0056] Advantageously, the aforesaid at least two appendages 4 comprise at least one port appendage 4' mounted on the port half-hull 2' and susceptible of generating a first lift force and at least one starboard appendage 4" mounted on the starboard half-hull 2" and susceptible of generating a second lift force.

[0057] In accordance with the preferred but non-limiting embodiment of the present invention, illustrated in the enclosed figures, the hydrofoil 1 comprises four appendages 4 mechanically connected to the hull 2, and in particular comprises two port appendages 4' connected to the port half-hull 2' and spaced from each other parallel to the main extension axis X, and two starboard appendages 4" connected to the starboard half-hull 2" and spaced from each other parallel to the main extension axis X and substantially opposite the port appendages 2' with respect to the median plane M.

[0058] In order to maintain the desired position of the hydrofoil 1, the at least one appendage 4 is movable in order to handle the different navigation conditions, for example due to a turn request by a pilot by means of the aforesaid helm, or due to a variation of the free surface of the water and/or of the water currents.

[0059] For such purpose, the hydrofoil 1 according to the invention comprises a movement apparatus 5 mechanically connected to the at least one appendage 4 in order to move it with respect to the hull 2 and comprising at least one first actuator member 6, which is extended between a first end 6' mechanically fixed to the hull 2 and a second end 6" mechanically fixed to the appendage 4, and is actuatable to rotate such appendage 4 around a first rotation axis Y substantially parallel to the aforesaid main extension axis X of the hull 2.

[0060] Advantageously, the first actuator member 6 is provided, at the first end 6' and at the second end 6", with corresponding hinge joints which each define a rotatable coupling with three degrees of freedom. For example, each hinge joint comprises at least one spherical joint.

[0061] According to the idea underlying the present invention, the movement apparatus 5 also comprises a support body 7 rotatably constrained to the hull 2, actuatable to rotate around a second rotation axis Z substantially orthogonal to the first rotation axis Y and in particular substantially orthogonal to the median plane M. The support body 7 comprises a first hinge member 8 carrying, rotatably mounted thereon, the aforesaid appendage 4 and configured for allowing the rotation of the appendage 4 around the first rotation axis Y.

[0062] The movement apparatus 5 also comprises, according to the invention, a second actuator member 9, which is extended between a third end 9' mechanically fixed to the hull 2 and a fourth end 9" mechanically connected to the support body 7 and is actuatable to rotate

the support body 7 around the second rotation axis Z.

[0063] Advantageously, the second actuator member 9 is provided, at the third end 9' and at the fourth end 9", at least with corresponding rotatable couplings having rotation axis substantially parallel to the second rotation axis Z.

[0064] In addition, according to the aforesaid idea underlying the present invention, the movement apparatus 5 comprises connection means 10, which are placed as a mechanical connection between the fourth end 9" of the second actuator member 9 and the support body 7 and are adapted to move the support body 7 around the second rotation axis Z following the actuation of the second actuator member 9.

[0065] In this manner, the hydrofoil 1 allows quickly and simply moving each appendage 4 around two separate rotation Y, Z axes, substantially orthogonal to each other, by means of the activation of two corresponding actuator members 6, 9 in a synchronized and independent manner with respect to each other.

[0066] The hydrofoil 1 for transport over water according to the invention therefore allows easily moving the appendages 4, advantageously independently with respect to each other, in order to maintain the hydrofoil 1 itself in the desired position in any operating condition.

[0067] In accordance with a preferred embodiment of the present hydrofoil 1, illustrated in the enclosed figures 1 and 2, each appendage 4 comprises at least one first wing 41 that is substantially plate-like and mainly extended along a first lying plane.

[0068] More in detail, the aforesaid first wing 41 is shaped in a manner such to allow generating lift force, for example it is shaped with a NACA profile.

[0069] Preferably, the hydrofoil 1 according to the invention comprises a different movement apparatus 5 mechanically fixed to the hull 2 for each appendage 4.

[0070] More in detail, in accordance with the preferred embodiment illustrated in the enclosed figures, the hydrofoil 1 comprises four separate movement apparatuses 5, in particular two port movement apparatuses 5' fixed on the port half-hull 2' in order to move the two corresponding port appendages 4' and two starboard movement apparatuses 5" fixed on the starboard half-hull 2" in order to move the two corresponding starboard appendages 4".

[0071] Preferably, the first hinge member 8 carrying, rotatably mounted thereon, the aforesaid appendage 4 is configured for allowing the rotation of the appendage 4 around the first rotation axis Y in order to carry the first wing 41 of the corresponding appendage 4 with tilt angle with respect to a substantially horizontal plane (i.e. substantially with respect to the free surface of the water) preferably comprised between -10° and 10° . The value of the tilt angle depends on the particular profile of the first wing 41, in particular it depends on the type of NACA profile used, on the dimensions of the first wing 41. During use, in addition, the value of the maximum tilt angle advantageously depends on the maximum progression

speed of the hydrofoil 1.

[0072] More precisely, the movement apparatus 5 is adapted to move each appendage 4 around the first rotation axis Y, in a plurality of positions with increasing lift between a position of minimum lift and a position of maximum lift.

[0073] Advantageously, the different positions with different lift are varied based on the different advancement speeds, in particular as the advancement speed increases, the positions of the appendages 4 is varied from a position of higher lift towards a position of lower lift, in order to maintain the position substantially constant during the entire movement of the hydrofoil 1.

[0074] In particular, in the position of minimum lift, the first wing 41 is placed with its first lying plane substantially parallel to the main extension axis X of the hull 2, and during use it is substantially parallel to the flow lines of the water in which the first wing 41 is immersed, so as to develop the least lift force possible.

[0075] In operation, the lift force is maintained substantially constant since such force is adapted to lift the boat in order to maintain its position constant. The variation of tilt angle serves for adapting the lift force to the advancing speed in order to maintain the desired position at a certain pre-established advancement speed. For example, at maximum speed, tilt angle is negative in order to reduce the lift force and maintain a desired appendage portion 4 immersed. In other words, the hydrofoil according to the invention controls the balancing between hydrodynamic resistance (proportional to the advancement speed) and lift force exerted by the appendages 4, in order to maintain the desired position and speed.

[0076] In this manner, the movement apparatus 5 according to the invention allows, by varying the position of the appendages 4, to maintain substantially constant the wet (i.e. immersed) portion of the appendages 4 in order to have a control over the forces, both hydrodynamic resistance and lift, which contribute to maintaining the position equilibrium of the hydrofoil 1.

[0077] Advantageously, in the position of maximum lift, the first wing 41 of the corresponding appendage 4 is placed with the first lying plane tilted by a maximum tilt angle with respect to the main extension axis X of the hull 2, and during use it is tilted with respect to the flow lines of the water in which the first wing 41 is immersed, by an angle such to develop the greatest possible lift force.

[0078] In operation, in the position of maximum lift, the first wing 41 exerts the maximum lift force, in particular it is advantageously provided at the minimum advancement speed of the hydrofoil 1, allowing a transition from a navigation in normal configuration, in which the hull 2 is at least partly immersed, to a configuration of foilborne navigation, in which the hull 2 is lifted from the water and in which the hydro-dynamic resistance forces decrease and therefore also the lift force of the appendages 4 must decrease in order to maintain constant the position of the hydrofoil 1.

[0079] Each position of the appendages 4, comprised between the aforesaid positions of minimum lift and of maximum lift, corresponds with a different tilt angle of the first lying plane with respect to the main extension axis X comprised between -10° degrees (corresponding to the position of minimum lift) and a maximum tilt angle value, and in particular about 10° , increasing tilt angles corresponding with increasing lift forces.

[0080] In accordance with the preferred embodiment illustrated in the enclosed figure 2, each appendage 4 also comprises a second wing 42, substantially plate-like and extended starting from the first wing 41 along a second lying plane tilted with respect to the first lying plane of the first wing 41. In other words, the first and the second wing 41, 42 of each appendage 4 are placed mechanically constrained to each other to form a substantially "C" shaped profile and joined together by an elbow 43, placed as a junction between the first and the second wing 41, 42, acting as a connector between the first and the second lying plane. Such appendages 4 are known, in the technical jargon of the field, with the name "T-foils".

[0081] Preferably, each appendage 4 comprises at least one support leg 40 placed as a mechanical connection between the elbow 43 and the hull 2. More in detail, each support leg 40 is extended between a first end, fixed to the elbow 43, and a second end, rotatably mounted on the hull 2.

[0082] Advantageously, in order to move each appendage 4 towards a direction with higher lift, the movement apparatus 5 is adapted to move the corresponding support leg 40 to rotate its first end around the second rotation axis Z, in particular towards the bow end 21 of the hydrofoil 1.

[0083] Likewise, in order to move each appendage 4 towards a direction with lower lift, the movement apparatus 5 is adapted to move the corresponding support leg 40 to rotate first end thereof around the second rotation axis Z, in particular towards the stern end 22 of the hydrofoil 1.

[0084] Advantageously, the first actuator member 6 comprises a first linear actuator provided with a first piston 12 movable along a first direction A, and the second actuator member 9 comprises a second linear actuator provided with a second piston 13 movable along a second direction B substantially transverse with respect to the first direction A of the first linear actuator and in particular substantially transverse with respect to the second rotation axis Z.

[0085] Advantageously, the first linear actuator is connected to the first end 6' and to the second end 6" of the first actuator member 6 by means of the aforesaid corresponding hinge joints.

[0086] In particular, each hinge joint comprises a pin parallel to the first rotation axis Y, and on which a ball joint is mounted that is fixed to the first linear actuator (and only partially visible in the enclosed figures).

[0087] Preferably, the second linear actuator is connected to the third end 9' of the second actuator member

9 by means of the corresponding aforesaid rotatable coupling. Preferably, the first linear actuator of the first actuator member 6 is a hydraulic or pneumatic piston. Analogously, the second linear actuator of the second actuator member 9 is also a hydraulic or pneumatic piston.

[0088] The movement apparatus 5 also preferably comprises supply means (not illustrated in the enclosed figures) placed in air communication with the first and the second linear actuator of the first and second actuator members 6, 9 in order to push the corresponding first and second pistons 12, 13 along the respective first and second directions A, B.

[0089] For example, the supply means can comprise a compressor, in the event in which the first and second members 6, 9 comprise two corresponding pneumatic pistons, or they can comprise a pump for pushing an oil, in the event in which the first and second members 6, 9 comprise two corresponding hydraulic pistons.

[0090] Of course, the supply means can be of any type, mechanical or electrical, of type per se known to the man skilled in the art, without departing from the protective scope of the present patent.

[0091] In accordance with a further embodiment not illustrated in the enclosed figures, the connection means 10 comprise a substantially direct mechanical connection between the fourth end 9" of the second actuator member 9 and the support body 7.

[0092] In accordance with the preferred embodiment illustrated in the enclosed figures, the connection means 10 of the movement apparatus 5 comprise a connecting rod 11 placed to connect between the fourth end 9" of the second actuator member 9 and the support body 7, shaped for converting a rectilinear motion of the second linear actuator into a rotary motion of the support body 7 around the second rotation axis Z. Advantageously, the second piston 13 of the second actuator member 9 comprises at least one first pin 16 provided at the fourth end 9" extended projectingly transverse with respect to the second direction B and rotatably engaged with the connecting rod 11 (in particular defining the corresponding rotatable coupling of the fourth end 9") in order to allow the relative rotation of the connecting rod 11 with respect to said second actuator member 9. In particular, the aforesaid first pin 16 is parallel to the second rotation axis Z.

[0093] Preferably, the connecting rod 11 is advantageously provided with a first through hole traversed by the pin 16 and a second through hole that is spaced with respect to the first through hole and mechanically associated with the support body 7, as described in detail hereinbelow.

[0094] More in detail, the fourth end 9" of the second actuator member 9 is shaped as a fork and comprises two shoulders provided with two corresponding third through holes transversely aligned with respect to the second direction B, and between such holes the fork 11 is interposed with the first through hole also aligned with the third through holes of the fourth end 9" of the second

actuator member 9.

[0095] Advantageously, the first through hole of the connecting rod 11 and the third through holes of the fourth end 9" of the second actuator member 9 are all engaged by the first pin 16.

[0096] Advantageously, the first pin 16 projects laterally with respect to the shoulders of the fourth end 9" with two corresponding opposite sliding portions 16'.

[0097] The connection means 10 of the movement apparatus 5 comprise at least one anchorage bracket 14 mechanically fixed to the hull 2 and provided with at least one guide shoulder 15 provided with a guide slot 17 extended parallel to the second direction B slidably engaged by the first pin 16 of the second actuator member 9 in order to allow the translation of the connecting rod 11 during the movement of the second piston 13 of the second actuator member 9.

[0098] In accordance with the preferred embodiment, the anchorage bracket 14 comprises two guide shoulders 15, extended parallel to each other and spaced parallel to the second direction B. Each of the two guide shoulders 15 is provided with a corresponding guide slot 17. The two guide slots 17 are opposite each other and engaged by a corresponding sliding portion 16' of the first pin 16.

[0099] In this manner, during the movement of the second actuator member 9 and in particular during the movement of the second piston 13 along the second direction B, the pin 16 slides along the guide shoulders 15 with the sliding portions 16' slidably inserted in the corresponding guide slots 17.

[0100] Advantageously, the connecting rod 11 of the connection means 10 comprises a second pin 18 extended projectingly transverse with respect to the second direction B, parallel to the first pin 16 and rotatably engaged with an eyelet 19 of the support body 7 in order to impart a rotation to the support body 7 around the second rotation axis Z following the translation of the first pin 16 of the second actuator member 9 along the guide slot 17.

[0101] Preferably, the second pin 18 laterally projects from the connecting rod 11 with two portions, each engaged with a corresponding eyelet 19 made in two corresponding walls 19' provided on the support body 7.

[0102] In accordance with the preferred embodiment illustrated in the enclosed figures, the support body 7 comprises a main plate 71 provided with an upper face 710 directed towards the hull 2 and a lower face 711 directed in the opposite direction with respect to the upper face 710.

[0103] Advantageously, moreover, the support body 7 comprises at least two lateral sides 72 projectingly extended from the lower face 711 substantially parallel and spaced from each other.

[0104] Preferably, the first hinge member 8 is interposed and rotatably mounted between the lateral sides 72.

[0105] In this manner, the support leg 40 of the corresponding appendage 4 is mechanically constrained to first hinge member 8 provided on the support body 7 of

the movement apparatus 5 according to the invention, such that the appendage 4 can be rotated around the first rotation axis Y due to the aforesaid hinge member 8 and around the second rotation axis Z since the entire support body 7 is rotatably mounted on the hull 7 around the same second rotation axis Z.

[0106] More in detail, the support body 7 comprises a second hinge member 20 mechanically fixed to the upper face 710 of the main plate 71 and rotatably connected to the hull 2 in order to allow the rotation of the support body 7 around the second rotation axis Z. Also forming the object of the present invention is a movement apparatus for appendages of a hydrofoil, of the type described up to now and regarding which the same reference numbers will be maintained for the sake of descriptive simplicity.

[0107] In the present description, all the characteristics described with reference to the movement apparatus 5 of the hydrofoil 1 must be intended as referable without variations also to only the movement apparatus 5, object of the present invention.

[0108] The movement apparatus 5 for appendages 4 of a hydrofoil 1, object of the invention, comprises at least one first actuator member 6, which is extended between a first end 6' intended to be mechanically fixed to a hull 2 of the hydrofoil 1 and a second end 6" intended to be mechanically fixed to an appendage 4 projecting below the hull 2 and is actuatable to rotate the appendage 4 around a first rotation axis Y substantially parallel to the main extension axis X.

[0109] According to the idea underlying the present invention, the movement apparatus 5 also comprises a support body 7 intended to be rotatably constrained to the hull 2, actuatable to rotate around a second rotation axis Z substantially orthogonal to the first rotation axis Y and comprising a first hinge member 8 intended to carry, rotatably mounted thereon, the appendage 4 and configured for allowing the rotation of the appendage 4 around the first rotation axis Y.

[0110] The apparatus 5 also comprises a second actuator member 9, which is extended between a third end 9' intended to be mechanically fixed to the hull 2 and a fourth end 9" mechanically connected to the support body 7 and is actuatable to rotate the support body 7 around the second rotation axis Z.

[0111] In addition, the apparatus comprises connection means 10, which are placed as a mechanical connection between the fourth end 9" of the second actuator member 9 and the support body 7 and are adapted to move the support body 7 around the second rotation axis Z following the actuation of the second actuator member 9. Advantageously, the first actuator member 6 comprises a first linear actuator provided with a first piston 12 movable along a first direction A and the second actuator member 9 comprises a second linear actuator provided with a second piston 13 movable along a second direction B substantially transverse with respect to the first direction A.

[0112] The hydrofoil and the movement apparatus thus

conceived therefore attain the pre-established objects.

Claims

1. Hydrofoil for transport over water, said hydrofoil comprising:

- a hull (2) extended along a main extension axis (X) between a bow end (21) and a stern end (22);
- at least one appendage (4), rotatably mounted on said hull (2) and projecting below with respect to said hull (2);
- a movement apparatus (5) mechanically connected to said at least one appendage (4) in order to move it with respect to said hull (2) and comprising at least one first actuator member (6), which is extended between a first end (6') mechanically fixed to said hull (2) and a second end (6") mechanically fixed to said appendage (4) and is actuatable to rotate said appendage (4) around a first rotation axis (Y) substantially parallel to said main extension axis (X);

said hydrofoil being **characterized in that** said movement apparatus (5) also comprises:

- a support body (7) rotatably constrained to said hull (2), actuatable to rotate around a second rotation axis (Z) substantially orthogonal to said first rotation axis (Y) and comprising a first hinge member (8) carrying, rotatably mounted thereon, said appendage (4) and configured for allowing the rotation of said appendage (4) around said first rotation axis (Y);
- a second actuator member (9), which is extended between a third end (9') mechanically fixed to said hull (2) and a fourth end (9") mechanically connected to said support body (7) and is actuatable for rotating said support body (7) around said second rotation axis (Z);
- connection means (10), which are placed as a mechanical connection between the fourth end (9") of said second actuator member (9) and said support body (7) and are adapted to move said support body (7) around said second rotation axis (Z) following the actuation of said second actuator member (9).

2. Hydrofoil according to claim 1, **characterized in that** said first actuator member (6) comprises a first linear actuator provided with a first piston (12) movable along a first direction (A) and said second actuator member (9) comprises a second linear actuator provided with a second piston (13) movable along a second direction (B) substantially transverse with respect to said first direction (A).

3. Hydrofoil according to claim 2, **characterized in that** the connection means (10) of said movement apparatus (5) comprise a connecting rod (11) placed to connect between the fourth end (9") of said second actuator member (9) and said support body (7), shaped for converting a rectilinear motion of the second linear actuator into a rotary motion of said support body (7) around said second rotation axis (Z). 5
4. Hydrofoil according to claim 3, **characterized in that** the second piston (13) of said second actuator member (9) comprises at least one first pin (16) provided at the fourth end (9"), extended projectingly transverse with respect to said second direction (B) and rotatably engaged with said connecting rod (11) in order to allow the relative rotation of said connecting rod (11) with respect to said second actuator member (9). 10 15
5. Hydrofoil according to claim 4, **characterized in that** the connection means (10) of said movement apparatus (5) comprise at least one anchorage bracket (14) mechanically fixed to said hull (2) and provided with at least one guide shoulder (15) provided with a guide slot (17) extended parallel to said second direction (B), slidably engaged by the first pin (16) of said second actuator member in order to allow the translation of said connecting rod (11) during the movement of the second piston (13) of said second actuator member (9). 20 25 30
6. Hydrofoil according to claim 5, **characterized in that** the connecting rod (11) of said connection means (10) comprises a second pin (18) extended projectingly transverse with respect to said second direction (B), parallel to said first pin (16) and rotatably engaged with an eyelet (19) of said support body (7) in order to impart a rotation to said support body (7) around said second rotation axis (Z) following the translation of the first pin (16) of said second actuator member (9) along said guide slot (17). 35 40
7. Hydrofoil according to claim 6, **characterized in that** said support body (7) comprises: 45
- a main plate (71) provided with an upper face (710) directed towards said hull (2) and a lower face (711) directed in the opposite direction with respect to the upper face (710);
 - at least two lateral sides (72) projectingly extended from the lower face (711), substantially parallel and spaced from each other;
- said first hinge member (8) being interposed and rotatably mounted between said lateral sides (72). 50 55
8. Hydrofoil according to claim 7, **characterized in that** said support body (7) comprises a second hinge member (20) mechanically fixed to the upper face (710) of said main plate (71) and rotatably connected to said hull (2) in order to allow the rotation of said support body (7) around said second rotation axis (Z).
9. Apparatus for moving appendages of a hydrofoil, said apparatus comprising:
- at least one first actuator member (6), which is extended between a first end (6') intended to be mechanically fixed to a hull (2) of said hydrofoil (1) and a second end (6") intended to be mechanically fixed to an appendage (4) projecting below said hull (2) and is actuable for rotating said appendage (4) around a first rotation axis (Y) substantially parallel to said main extension axis (X);
- said apparatus being **characterized in that** it also comprises:
- a support body (7) intended to be rotatably constrained to said hull (2), actuable to rotate around a second rotation axis (Z) substantially orthogonal to said first rotation axis (Y) and comprising a first hinge member (8) intended to carry, rotatably mounted thereon, said appendage (4) and configured for allowing the rotation of said appendage (4) around said first rotation axis (Y);
 - a second actuator member (9), which is extended between a third end (9') intended to be mechanically fixed to said hull (2) and a fourth end (9") mechanically connected to said support body (7), and is actuable for rotating said support body (7) around said second rotation axis (Z);
 - connection means (10), which are placed as a mechanical connection between the fourth end (9") of said second actuator member (9) and said support body (7) and are adapted to move said support body (7) around said second rotation axis (Z) following the actuation of said second actuator member (9).
10. Movement apparatus according to claim 9, **characterized in that** said first actuator member (6) comprises a first linear actuator provided with a first piston (12) movable along a first direction (A) and said second actuator member (9) comprises a second linear actuator provided with a second piston (13) movable along a second direction (B) substantially transverse with respect to said first direction (A).

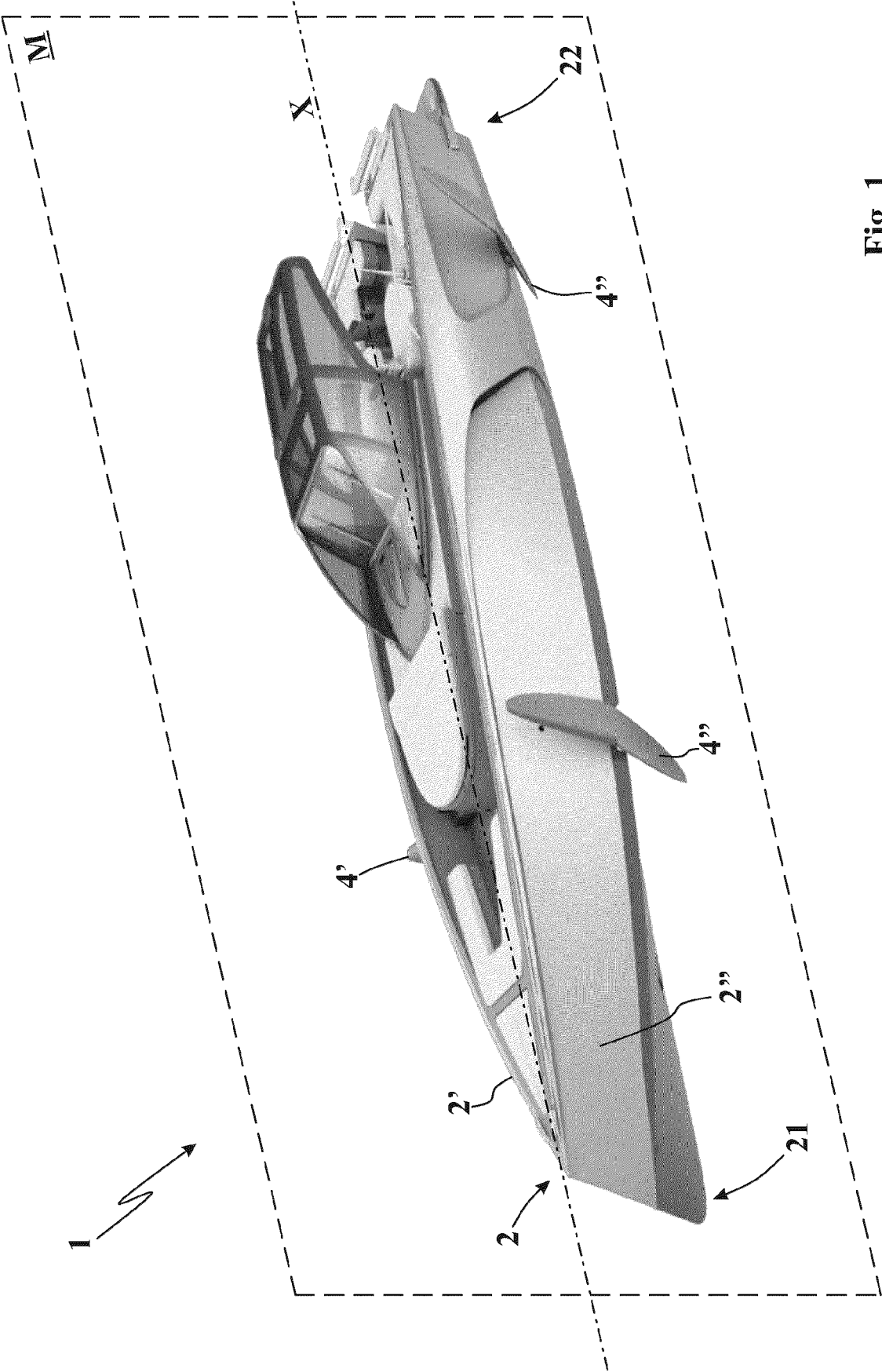


Fig. 1

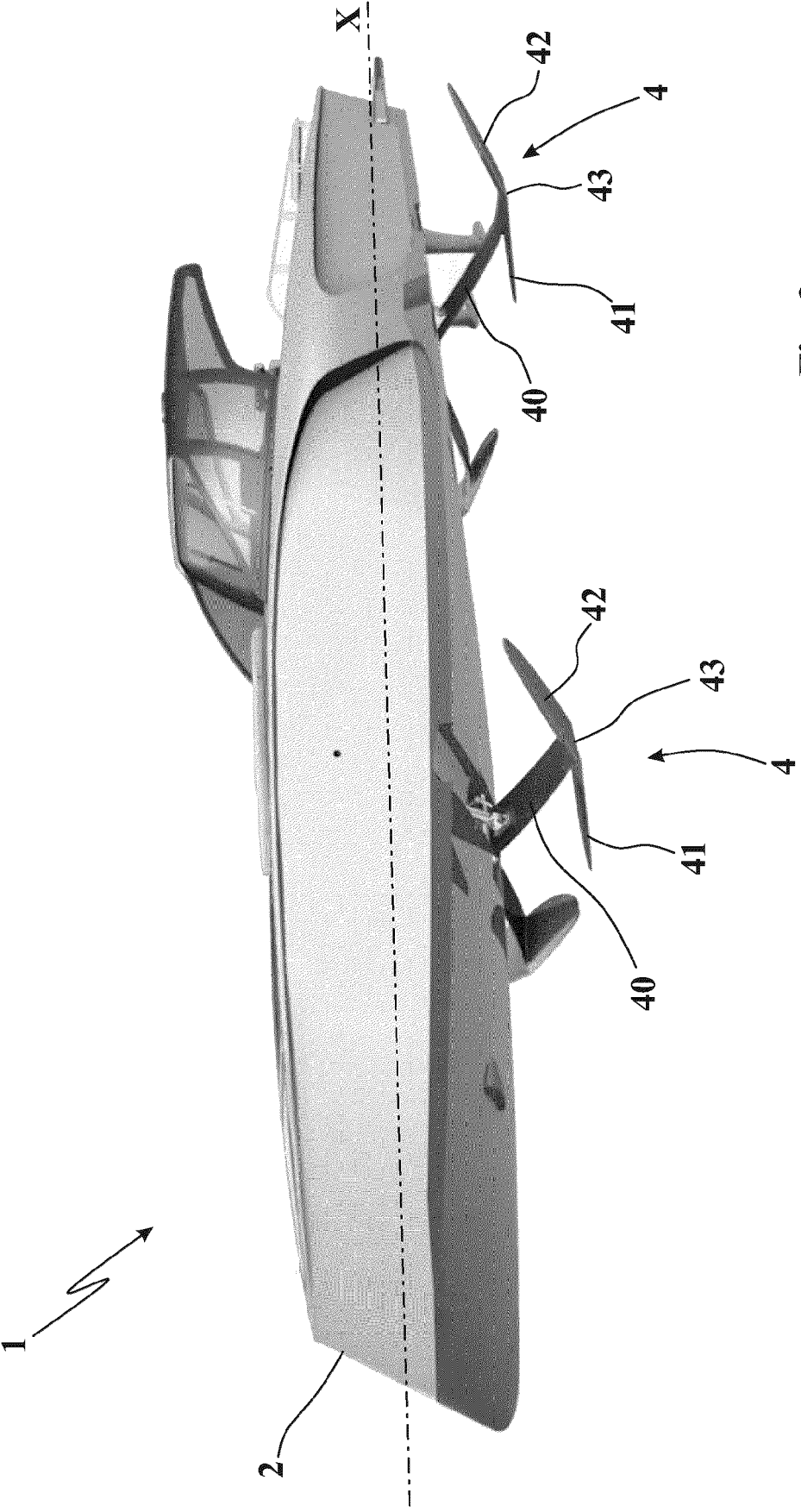


Fig. 2

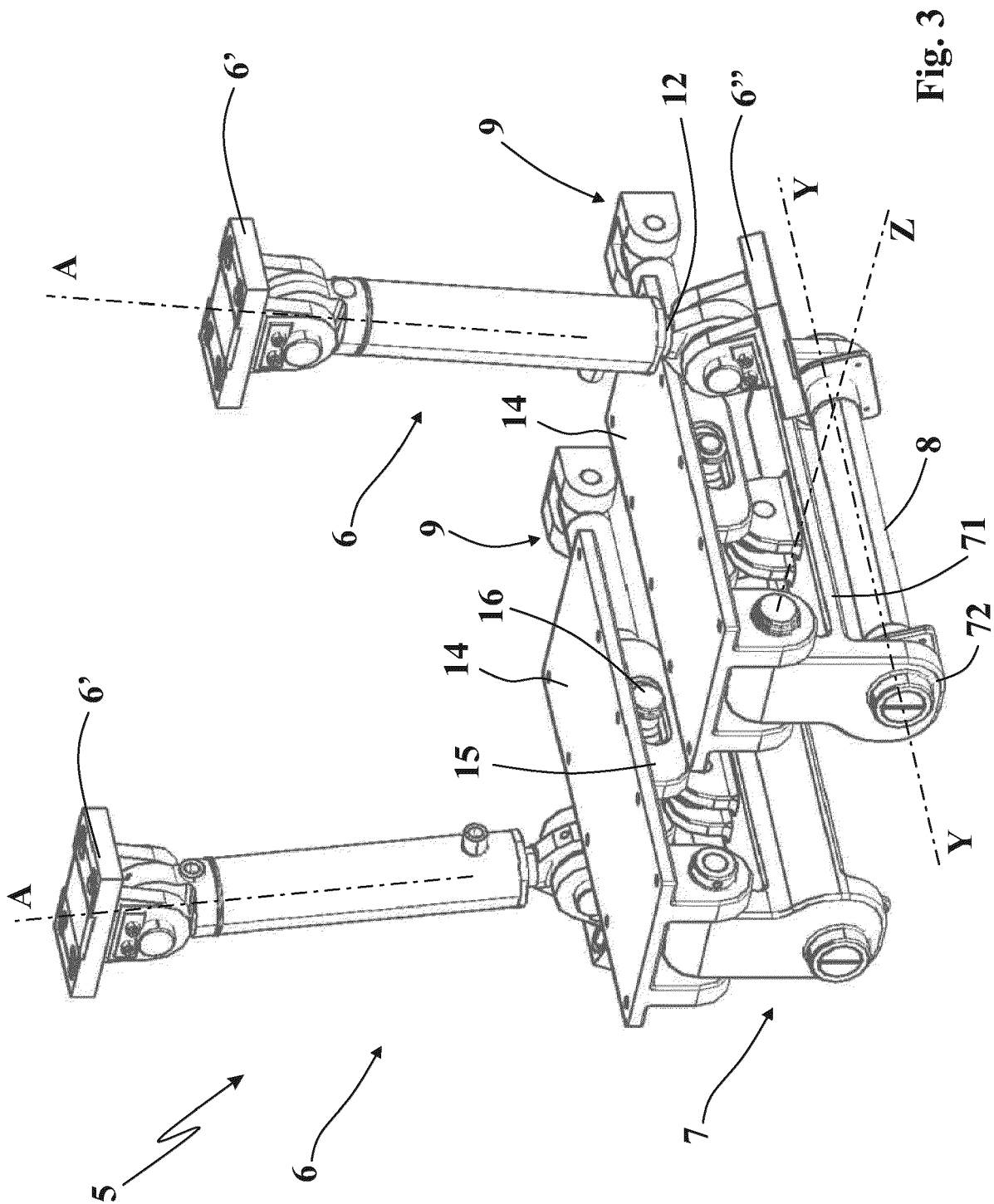


Fig. 3

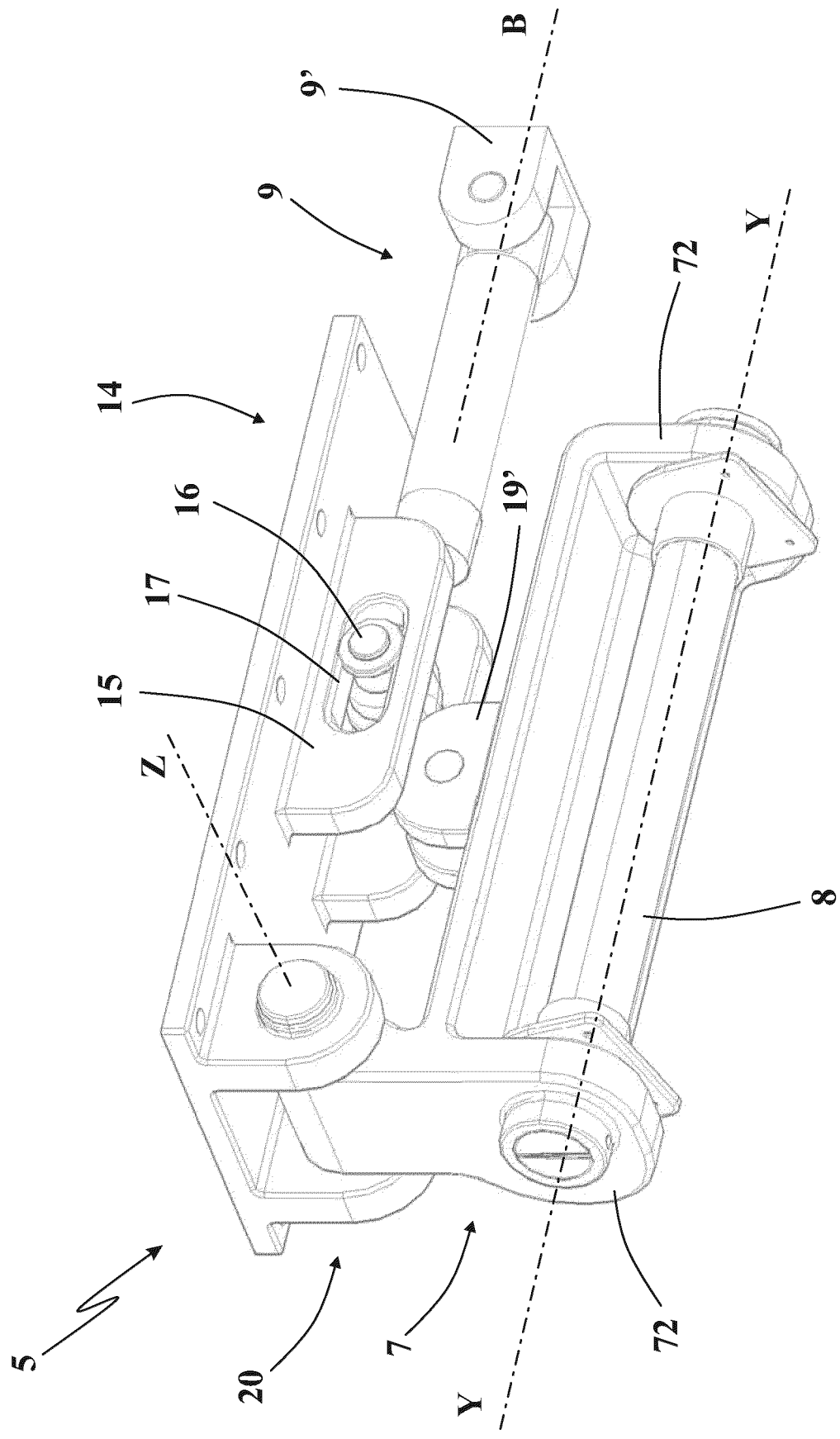


Fig. 4

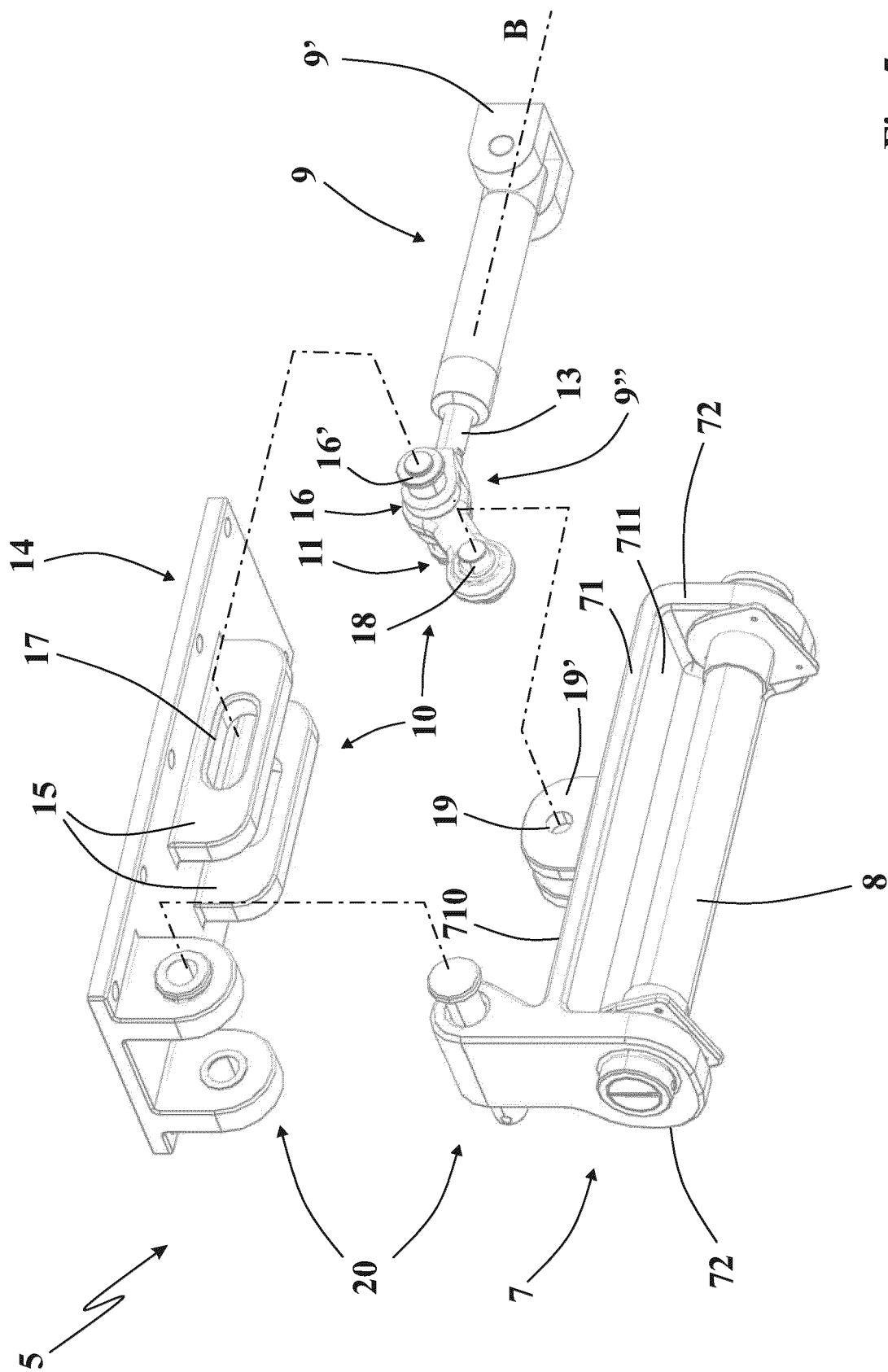


Fig. 5



EUROPEAN SEARCH REPORT

 Application Number
 EP 21 16 6227

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			TECHNICAL FIELDS SEARCHED (IPC)
			B63B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 9 August 2021	Examiner Balzer, Ralf
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The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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