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(54) RUDDER ROTATION COMMAND ASSEMBLY

(57) A rudder rotation command assembly (1) for a floating navigation craft comprising a hull (50) and a directional rudder (90) rotatably mounted relative to a structure integral with said hull (50) about a rudder rotation axis (U), wherein said rudder rotation command assembly (1) comprises: a rotary electric motor (10) comprising a stator (11) and a rotor (12) adapted to rotate relative to said stator (11) about a rotor axis (R); a supporting structure (60) comprising a motor fixing portion (62) configured to fix said stator (11) to said supporting structure (60), and a hull fixing opposite portion (61) adapted to fix said supporting structure (60) relative to said structure integral with said hull (50); a rudder connecting device (30) connectible to said rotor (12) and fixable to said directional rudder (90), so as to correlate the rotation of said rotor (12) relative to said stator (11) with the rotation of said directional rudder (90) relative to said supporting structure (60).

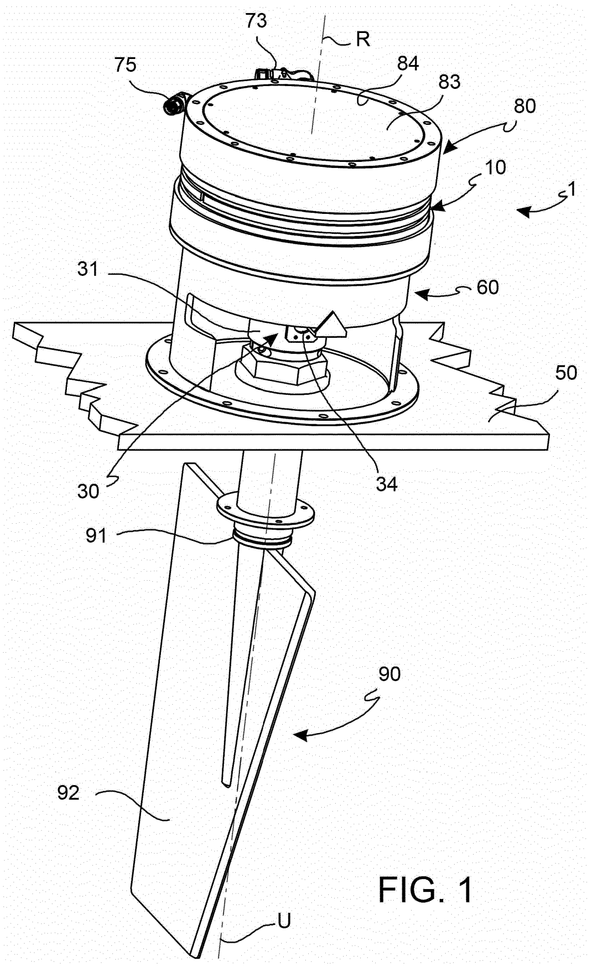

FIG. 1

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Description

Field of the invention

[0001] The present invention relates to a rudder rotation command assembly for a floating navigation craft, e.g., such as a yacht, as well as a steering gear system capable of guaranteeing high maneuverability of said floating navigation craft.

Background art

[0002] The use of a rudder is known in the nautical field to impart a direction of navigation or movement to a floating navigation craft, e.g. such as a boat, a ship, a yacht.

[0003] The rudder comprises a rudder blade and a rudder stock firmly fixed thereto.

[0004] The rudder blade defines two opposite blade directional surfaces and ideally defines a rudder mid-plane interposed between said two opposite blade directional surfaces.

[0005] The rudder stock is an elongated element defining a rudder stock main axis arranged along a main extension direction of the rudder stock, and is rigidly fixed to the rudder blade so that the rudder stock main axis either belongs or is parallel to the rudder mid-plane.

[0006] The rudder stock is rotatably engaged relative to the hull of the floating navigation craft about a rudder rotation axis coincident with the rudder stock main axis.

[0007] The rudder pivot axis is generally placed vertically in use, and the rudder blade is arranged in a submerged position in use.

[0008] The rudder stock protrudes from the rudder blade along the rudder mid-plane defining a free end of the rudder stock, opposite to the blade.

[0009] A rotation of the blade, and hence of the directional surfaces of the blade, is caused by the hydrodynamic action of the water in which it is immersed by applying a torque of rotational forces to the rudder stock about the rudder rotation axis, higher in value than an opposite torque of forces applied to the rudder stock by the blade.

[0010] A hydrodynamic thrust force applied by the water to the blade derives from the angle of incidence of the relative direction of motion of the water relative to the directional surfaces of the rudder blade, which thrust force is transmitted to the hull of the floating navigation craft through the rudder stock, causing a change in the direction of navigation of the craft and/or a translation of the craft.

[0011] The free end of the rudder stock generally enters into the craft through a hole passing through the hull of the craft and is hinged to the hull by means of a rotary coupling, known as a "shroud", comprising a tubular structure which internally covers said hole and which rotatably accommodates said free end of the stock inside in a watertight manner.

[0012] To apply the aforesaid torque of rotational forces about the rudder stock and rotate the rudder about the rudder rotation axis, it is known to associate a rudder rotation command assembly with the rudder stock, in other words, an actuating device for rotating the rudder blade to a desired angular position relative to the centerline of the floating navigation craft.

[0013] Furthermore, a steering device, e.g., a rudder wheel rotatable about its rotation axis, operable by a person driving said craft, is provided in a steering position of the floating navigation craft, so that each angle of rotation of the rudder wheel corresponds to a respective angle of rotation of the rudder blade, and thus the rudder mid-plane, relative to a centerline of the floating navigation craft.

[0014] A centerline is defined as a line running longitudinally from the bow to the stern of the floating navigation craft, in particular the vessel or ship.

[0015] Finally, the steering device is connected to the rudder rotation command assembly so that the rudder rotation command assembly can receive the angular position information to be imposed on the rudder blade relative to the centerline from the steering device.

[0016] Several types of rudder rotation command assemblies are known.

[0017] Rudder rotation command assemblies are known to have a linear actuator which can be hydraulic or electromechanical. In particular, figures 19 and 20 show diagrammatic views taken along a direction parallel to the rudder rotation axes of two rudders, which diagrammatically show an example of this prior art.

[0018] In particular, in the case of a rudder rotation command assembly having a hydraulic linear actuator, such an actuator comprises a hydraulic cylinder having a linear thrust rod having a free end translating between a minimum length position and a maximum length position, and a tiller arm transverse to the rudder axis is fixed on the rudder stock, the free end of which is hinged to the free end of the linear thrust rod. In this manner, a translation of the linear thrust rod imparts a corresponding rotation to the tiller arm and thus to the rudder itself.

[0019] In the case of a rudder rotation command assembly having an electromechanical linear actuator, such an actuator comprises a cylinder having a linear thrust rod having a free end translating between a minimum length position and a maximum length position, wherein the control of said thrust is due to the rotation of a motion reduction gear placed inside the cylinder, which in turn is rotated by an electric motor having a rotation axis axial to the motion reduction gear and the rod.

[0020] In either case, such known rudder rotation command assemblies have some limitations.

[0021] Indeed, independently of the type of hydraulic actuator, it must be actuated by a hydraulic system capable of pressurizing a thrust fluid and conducting it through the actuator. In other words, the hydraulic actuator requires a hydraulic power unit to pressurize the liquid, a pipe system which connects the control unit with the actuator, tanks for the thrust liquid, various electro valves which control the system, a control unit.

[0022] These components reduce usable space in the vessel, which is already limited, as well as requiring high installation times and maintenance costs.

[0023] Therefore, the need is felt to provide a rudder rotation command assembly having a compact shape, substantially self-contained, with a small footprint compared to that of the prior art.

[0024] Furthermore, the need is felt to provide a rudder rotation command assembly capable of avoiding the need to install bulky external equipment on board, such as tanks, fluid pressurization units, pipes, etc., to leave more usable space onboard the vessel.

[0025] Another major disadvantage of a rudder rotation control assembly having a linear actuator and a tiller arm fixed to the rudder stock is that the linear actuator and the tiller arm physically limit the maximum right and left rudder rotation angles relative to a longitudinal centerline of the navigational device, due to the encumbrance of the linear actuator stem and the free end of the rudder stock, which would collide with each other.

[0026] Furthermore, the rotations made at angles greater than 90° would become difficult to manage due to the motion geometries and angles of the forces driving the rotation.

[0027] Furthermore, in the case of rudder rotations at high angles, the linear actuator strokes would have to be very high, leading to larger actuator footprints.

[0028] For these reasons, known steering gear systems, such as those described above, do not normally allow angular rotation of the rudder greater than 35° rightwards and 35° leftwards.

[0029] During navigation, such maximum rightward and leftward rudder angles of rotation are generally sufficient to steer the craft to the desired course and to easily change direction, but insufficient to facilitate mooring maneuvers.

[0030] Therefore, the need is felt to provide a rudder rotation command assembly capable of rotating the rudder by an angle of rotation rightwards and leftwards greater than 35° relative to the centerline, preferably even up to 90°.

[0031] Furthermore, if the navigating craft comprises two rudders, the prior art provides connecting them to each other through a synchronization bar having its opposite ends hinged to respective tiller arms fixed to the rudder stock of the two rudders, to maintain the blades of the two rudders always mutually parallel.

[0032] This synchronization bar, which is interposed between the two rudders, also takes up space onboard the craft.

[0033] Therefore, the need is also felt to provide a rudder rotation command assembly which, if several rudders are present, can move them parallel to each other, avoiding the encumbrance of the synchronization bar.

[0034] The need is also felt for a rudder command assembly which, if several rudders are present, can position the blade of each rudder according to rotation angles which are not necessarily equal to each other, and thus rotate the rudder blades according to different rotation angles, and thus operate the various rudders independently.

Summary of the invention

[0035] It is the object of the present invention to devise and provide a rudder rotation command assembly which allows the aforesaid needs to be satisfied and the drawbacks described above with reference to the prior art to be at least partially overcome.

[0036] In particular, it is a task of the present invention to provide a rudder rotation command assembly capable of rotating the rudder blade beyond 35° rightwards and leftwards relative to the centerline of the floating navigation craft, to cause it to translate, during mooring operations, rightwards or leftwards orthogonal to the centerline, in cooperation with the navigation propellers acting parallel to the centerline, avoiding the need for a stern thruster acting orthogonally to the centerline.

[0037] It is, therefore, an object of the present invention to provide a rudder rotation command assembly capable of causing the translation of the navigation craft during mooring orthogonally to its centerline, acting solely on the rudder angle relative to the centerline and navigation propulsion in a mutually coordinated manner.

[0038] In particular, it is a task of the present invention to provide a rudder rotation command assembly having a compact shape and small footprint.

[0039] It is an object of the present invention to provide a modular rudder rotation command assembly which forms an independent and self-contained module of small footprint and compact encumbrance, and which contains within it all its mechanical components.

[0040] It is another purpose of the present invention to provide a rudder rotation command assembly which is easy and quick to install, avoiding any hydraulic system outside the footprint of the assembly itself.

[0041] It is a further object of the present invention to provide a rudder rotation command assembly which, if the navigating craft comprises two or more rudders, allows each rudder to be operated at mutually different angles relative to the centerline.

[0042] These and further purposes and benefits are achieved by a rudder rotation command assembly, as well as by a steering gear system, according to the independent claims.

[0043] Further objects, solutions, and advantages are present in the embodiments described below and claimed in the dependent claims.

Brief description of the drawings

[0044] The invention will be illustrated below by describing some embodiments by way of non-limiting example, with reference to the accompanying figures, in which:

- figure 1 shows an isometric view of a first embodiment of a rudder rotation command assembly according to the present invention, comprising a cycloidal reduction gear;
- figure 2 shows a section view of the rotation command assembly in figure 1, taken along section plane II comprising the rotor axis and orthogonal to the rudder mid-plane;
- figure 3 shows a side view of figure 1 of the rudder rotation command assembly in a direction orthogonal to the rudder mid-plane;
- figure 4 shows a side view of figure 1 of the rudder rotation command assembly in a direction parallel to the rudder mid-plane;
- figure 5 shows an enlarged detail of the section view in figure 2, in which the plug-in coupling is in a position constrained to the rudder stock;
- figure 6 shows the enlarged detail of figure 5, in which the plug-in coupling is in a position disconnected from the rudder stock;
- figure 7 shows a portion on an enlarged scale of the coupling device in figure 6;
- figure 8 shows a partial perspective view of the coupling in figure 7;
- figure 9 shows an isometric view of the figure 1 rudder rotation command assembly in which a lever bar manually actuatable by an operator is mounted to manually operate the rudder in the disengaged position of the coupling;
- figure 10 shows a side view of the rudder rotation command assembly in figure 9, in a direction orthogonal to the rudder mid-plane;
- figure 11 shows a side view of the rudder rotation command assembly in figure 9, in a direction parallel to the rudder mid-plane;
- figures 12 and 13 show the rudder rotation command assembly in figure 1, having a fixing portion to a structure integral with the hull different from the one in figure 1;
- figures 14 and 15 respectively show a first portion and a second portion of a steering gear system for controlling two rudder rotation command assemblies in figure 1 for two respective rudders mounted on the floating navigation craft;
- figure 16 shows an isometric view of a second embodiment of the rudder rotation command assembly according to the invention, comprising an epicycloidal reduction gear;
- figure 17 shows a side view of the rudder rotation command assembly in figure 16;
- figure 18 shows a section view of the rudder rotation command assembly in figure 17, according to an axial section plane XVIII containing the rotor axis;
- figures 19 and 20 show two angular positions of two rudders according to a known hydraulically actuated technique, in which the rudders cannot be rotated according to a rudder angle greater than 35° rightwards and leftwards of the centerline, due to the mechanical encumbrances of the known drive;
- figure 21 shows two rudder rotation command assemblies according to the invention, which allow rudders to be rotated according to rightward and leftward rotation angles greater than 35°;
- figure 22 shows a diagrammatic cross-sectional view of a further embodiment of the rudder rotation command assembly according to the invention, in which the speed reduction gear is of the cycloidal type and is arranged axially outside of the rotary electric motor, and in which the rudder connection device has been omitted for the sake of convenience of illustration.

Description of the preferred embodiments

[0045] With reference to the figures, a rudder rotation command assembly according to the invention for a floating navigation craft is indicated by reference numeral 1 as a whole.

[0046] The floating navigation craft comprises a hull and a directional rudder 90 rotatably mounted relative to a structure 50 integral with said hull, about a rudder rotation axis U.

[0047] The rudder rotation command assembly 1 comprises a rotary electric motor 10 comprising a stator 11 and a rotor 12 adapted to rotate relative to said stator 11 about a rotor axis R.

[0048] The rudder rotation command assembly 1 comprises a supporting structure 60 comprising a motor fixing portion 62 configured to fix said stator 11 to said supporting structure 60, and a hull fixing opposite portion 61 designed to fix said supporting structure 60 relative to said structure integral with said hull 50.

[0049] Preferably, the motor fixing portion 62 is at an upper end of said supporting structure 60, and the hull fixing portion 61 is at an opposite lower end of said supporting structure 60.

[0050] With reference to the figures, the upper end of the supporting structure is defined as the one farthest from the rudder, or hull, and the lower end of the supporting structure is defined as the one closest to the rudder, or hull.

[0051] The rudder rotation command assembly 1 further comprises a rudder connecting device 30 arranged to receive a rotary motion from said rotor 12 and fixable to said directional rudder 90, to correlate the rotation of said rotor 12 relative to said stator 11 with the rotation of said directional rudder 90 relative to said supporting structure 60.

[0052] According to an embodiment, said rotor axis R-R is arranged coaxial with, or parallel to, said rudder rotation axis U.

[0053] In other words, both the rotor 12 and the rudder connecting device 30 are adapted to rotate about a common rotation axis, in particular the rotor axis R.

[0054] In other words, the rotor 12 and the rudder connecting device 30 are either adapted or arranged to rotate in line, or aligned with, each other.

[0055] According to an embodiment, the stator 11 is annular in shape and is coaxial with said rotor axis R and has a central stator cavity 13 in which said rotor 12 is rotatably housed, and wherein said rotor 12 is annular in shape and is coaxial with said rotor axis R and has a central rotor cavity 14.

[0056] According to an embodiment, the rudder rotation command assembly 1 comprises a speed reduction gear 40 connected to and interposed axially between said rotor 12 and said rudder connecting device 30.

[0057] According to an embodiment, as shown for example in the figures, said rudder connecting device 30 is axially interposed between said speed reduction gear 40 and said hull fixing portion 61 of said supporting structure 60, preferably avoiding said rudder connecting device 30 from axially crossing said speed reduction gear 40 and/or said rotary electric motor 10.

[0058] According to an embodiment, the speed reduction gear 40 is at least partly housed inside said central rotor cavity 14 and/or said central stator cavity 13.

[0059] The speed reduction gear 40 has a rotational motion input coupled to and coaxial with said rotor 12 and a rotational motion output coupled to and coaxial with said rudder connecting device 30.

[0060] The rotational motion input defines a rotational axis input and the rotational motion output defines a rotational axis output, preferably parallel to the input rotational axis, even more preferably coaxial with the input rotational axis.

[0061] This configuration allows mounting the electric motor 10, the speed reduction gear 40, the rudder connecting device 30, all coaxial to each other, i.e. in line. In this manner, the distribution of the forces exchanged between the mechanical components is optimized during use, mechanical energy losses are reduced, and thus mechanical efficiency is increased, a stable and constant mechanical output torque is obtained on the rudder connecting device 30 in every angular position along the rudder rotation, and high mechanical torque is obtained while considerably reducing the overall dimensions of the rudder rotation command assembly 1.

[0062] According to an embodiment, e.g. shown in figures 1-13, the speed reduction gear 40 is a cycloidal reduction gear.

[0063] Such a cycloidal reduction gear is particularly advantageous in that, with the same reduction ratio, it has a very small footprint along a direction parallel to the rotor axis R.

[0064] According to another embodiment, for example shown in figures 16-18, the speed reduction gear 40 is an epicycloidal reduction gear.

[0065] This second embodiment differs from the first embodiment shown in the figures from 1 to 13 only in that it comprises an epicycloidal reduction gear instead of a cycloidal reduction gear.

[0066] The epicycloidal reduction gear has a larger axial dimension than the cycloidal reduction gear, thus it remains axially more distant from the motor, compared to the first embodiment.

[0067] Therefore, an additional portion 64 of the supporting structure 60 is present, which remains axially interposed between the epicycloidal speed reduction gear 40 and the rotary electric motor 10.

[0068] Such an additional portion 64 is preferably tubular in shape.

[0069] According to an embodiment, the rotary electric motor 10 is a brushless motor.

[0070] In a preferred embodiment, rotary electric motor 10 is a torque motor.

[0071] The technology of a torque motor, in particular of a brushless torque motor, concerns a type of electric motor having a mutually coaxial rotor and a stator both of a generally annular shape, of which the element with a smaller radius of either said rotor or said stator is axially accommodated inside the element with a larger radius of either said rotor or said stator.

[0072] This configuration allows obtaining a rotary electric motor having a very small size along the rotor axis even though it has a larger outer radius.

[0073] Practically, such a motor of this type is generally ring- or disc-shaped. It lends itself well, for example, to being incorporated into the encumbrance of a wheel of an electrically-powered self-propelled vehicle.

[0074] According to an embodiment, the central stator cavity 13 defines a radially inner surface 18 of the stator 11, preferably having a cylindrical shape, coaxial with the rotor axis R, and the rotor 12 defines a radially outer rotor surface, preferably having a cylindrical shape, coaxial with the rotor axis R.

[0075] The radius of the radially inner surface 18 of stator 11 is preferably greater than the radius of the radially outer surface of the rotor to allow rotation of rotor 12 relative to stator 13.

[0076] According to an embodiment, the speed reduction gear 40 is at least partially housed within said central rotor cavity 14.

[0077] This configuration is particularly advantageous because it allows considerably reducing the axial dimensions of the rudder rotation command assembly 1.

[0078] According to an embodiment, said mechanical transmission 40 is at least partially housed within said central stator cavity 13.

[0079] This configuration is also particularly advantageous because it allows reducing the axial dimensions of the rudder rotation command assembly 1.

[0080] According to an embodiment, the rotor 12 comprises permanent magnets installed therein, and the stator 11 comprises a plurality of electrical windings, not shown in the figures, configured to generate a rotating magnetic field adapted to take said rotor 12 into rotation.

[0081] In this manner, the rotor 12 may have a rather reduced radial thickness by providing a central rotor cavity 14 having increased dimensions to accommodate a larger portion of said speed reduction gear 40.

[0082] According to an embodiment, the central rotor cavity 14 defines a radially inner rotor surface of cylindrical shape coaxial with said rotor axis R and thus coaxial with the radially outer rotor surface.

[0083] This simplifies the introduction of said at least a portion of the speed reduction gear 40 into the central rotor cavity 14, during assembly operations.

[0084] According to an embodiment, the rotor defines a radially outer rotor surface having a cylindrical shape coaxial with said rotor axis R.

[0085] Such a radially outer rotor surface may comprise one or more cooling fins 19, preferably circumferentially arranged.

[0086] According to an embodiment, the stator 11 defines two opposite stator base surfaces, orthogonal to the rotor axis R, thus parallel to each other, preferably flat.

[0087] The assembly between the stator 11 and a supporting and containment structure 60, in which it is sufficient to make a cylindrical flaring, is simplified in this manner.

[0088] According to an embodiment, the rotor 12 defines two opposite rotor base surfaces, orthogonal to the rotor axis R, thus parallel to each other, preferably flat.

[0089] The rotary electric motor 10 as described above can be actuated through an electronic controller, or electronic switch, to power and control said electric windings.

[0090] Such an electronic controller is preferably installed in an electrical panel on board the vessel.

[0091] According to an embodiment, the rudder rotation command assembly 1 comprises a temperature sensor adapted to measure the internal temperature of the rotary electric motor 10 during use.

[0092] According to an embodiment, the rudder rotation command assembly 1 comprises an angular encoder 70 configured to detect the angular position of the rotor 12 relative to the stator 11.

[0093] According to an embodiment, the supporting structure 60 is substantially tubularly coaxial with said rudder rotation axis U and defining a tubular structure upper end 64 comprising said motor fixing portion 62, a tubular structure opposite lower end 65 comprising said hull fixing portion 61, a tubular structure side wall 63 which connects the tubular structure upper end 64 and the tubular structure lower end 65 to each other, wherein said rudder connecting device 30 is contained in said supporting structure 60.

[0094] According to an embodiment, said rotary electric motor 10 is arranged to close said structure upper end 64.

[0095] According to an embodiment, the rudder rotation command assembly 1 comprises a container lid 80 associated with said stator 11 on the opposite side relative to said rudder connecting device 30 to close said rotary electric motor 10 at the top.

[0096] According to an embodiment, said container lid 80 comprises a cover body 81 comprising a seat 82 for accommodating said stator 11 at least in part according to a direction parallel to said rotor axis R, of a shape complementary to said radially outer surface 19 of said stator 11.

[0097] According to an embodiment, the rudder rotation command assembly 1 comprises at least one O-ring seal interposed between said seat 82 and said radially outer surface 19 of the stator 11.

[0098] In this manner, a seal is created between the electric motor 10 and the container lid 80 to prevent water and salt mist from entering.

[0099] According to an embodiment, said container lid 80 has a cylindrical shape, or cylindrical symmetry, coaxial with said rotor axis R.

[0100] According to an embodiment, said container lid 80 defines an upper end face 83 on opposite side relative to said motor 10, wherein said upper end face 83 is arranged orthogonal to said rotor axis R, and is preferably a flat surface.

[0101] According to an embodiment, said encoder 70 is mounted within said container lid 80, preferably along the rotor axis R.

[0102] According to an embodiment, the rudder rotation command assembly 1, preferably said container lid 80, comprises a first electrical connector 73 for electrically powering and controlling said electric motor 10, preferably for powering and controlling said stator windings.

[0103] According to an embodiment, the rudder rotation command assembly 1, preferably said container lid 80, comprises a second electrical connector 74 for providing an output of an electrical signal of angular position detected through said encoder 70.

[0104] According to an embodiment, the rudder rotation command assembly 1, preferably the container lid 80, comprises a third electrical connector 75 for outputting an electrical signal of the temperature detected through said temperature sensor.

[0105] According to an embodiment, the upper end face 83 comprises an access window 84 for access from the outside to the inside of the container lid 80, and/or preferably to reach the encoder 70 and/or the temperature sensor.

[0106] According to an embodiment, the container lid 80 comprises a closing element 85 for non-permanently closing said access window 84.

[0107] According to an embodiment, an O-ring gasket 86 interposed between said window 84 and said closing element 85 to achieve a seal between them.

[0108] According to an embodiment, said opening 84 and said closing element 85 are circular in shape with a center on the rotor axis R.

[0109] According to an embodiment, the speed reduction gear 40 has a predetermined reduction ratio value.

[0110] The value of the predetermined reduction ratio is chosen as a function of the torque delivered by the electric motor 10, the geometry of the rudder blade 92, and the maximum speed of the vessel.

[0111] In particular, the torque required to move the rudder is determined by two parameters: rudder blade geometry and vessel speed.

[0112] According to the electric motor used and the nominal torque it can deliver, the most suitable speed reduction gear is chosen to obtain the necessary torque and the best trade-off relative to the rotation speed of the rudder, which must not be too slow.

[0113] Accordingly, the rotational torque to be applied to the rudder connecting device 30 depends on the size of the vessel, such as displacement and length of the vessel, the maximum design speed, and the surface area of the rudder.

[0114] A first example of a rudder rotation command assembly 1 is configured to apply to the rudder connecting device 30, a torque of approximately 4000 Nm nominal, gross of the efficiency of the speed reduction gear. In this case, the brushless electric motor is preferably powered at 24V and the cycloidal reduction gear has a reduction ratio of about 1:50.

[0115] A second example of a rudder rotation command assembly 1 is configured to apply to the rudder connecting device 30, a torque comprised between approximately 4000 Nm and 9000 Nm nominal, gross of the efficiency of the speed reduction gear. In this case, the brushless electric motor is preferably powered at 220V or 380V, and the speed reduction gear is chosen with a higher reduction ratio of about 1:81.

[0116] According to an embodiment, e.g. shown in figures 2, 5-8, the said rudder connecting device 30 comprises a connecting flange 42 adapted to be connected either directly or indirectly to said rotor 12, and a connecting body 31 fixable to said rudder, said connecting flange 42 and said connecting body 31 being rotatable about the rudder rotation axis U, and comprising a plug-in coupling 33 configured to rotationally constrain/release said connecting body 31 to/from said connecting flange 42, selectively, between a constrained position and a released position.

[0117] The plug-in coupling 33 between said connecting body 31 and said connecting flange 42 is configured to transmit the rotational motion between said connecting flange 42 and said connecting body 31, at said constrained position.

[0118] According to an embodiment, said plug-in coupling 33 comprises at least one protrusion 36 integral with either said connecting flange 42 and said connecting body 31, and at least one complementary recess 46 integral with the other between said connecting flange 42 and said connecting body 31, which are mutually couplable/uncouplable by translation of said connecting body 31 relative to said connecting flange 42 along a direction parallel to the rudder rotation axis U.

[0119] According to an embodiment, e.g. shown in figure 8, the at least one protrusion 36 is a protrusion integral with the connecting body 31, and the at least one recess 46 is a recess integral with said connecting flange 42.

[0120] According to an embodiment, e.g. shown in figure 8, the at least one recess 46 is a radial slot relative to the rudder pivot axis U, and the at least one protrusion 36 is a radial rib relative to the rudder pivot axis U.

[0121] According to an embodiment, e.g. shown in figures 9-11, said connecting body 31 has an engagement seat 34 to removably engage a lever bar 35 which can be manually actuated by an operator to manually rotate said connecting body 31 in said released position.

[0122] According to an embodiment, the connecting body 31 slides axially relative to said connecting flange 42 along the rudder rotation axis U between said constrained position and said released position.

[0123] Thus, in the event of a motor failure, it is possible to decouple the rudder 90 from the motor 10 by moving the connecting body 31 away from the connecting flange 42 to the disengaged position, and then manually operating the lever bar 35 to control the rotation of the rudder 90.

[0124] According to an embodiment, the rudder rotation command assembly 1 comprises at least one directional rudder 90, said directional rudder 90 comprising a rudder blade 92 and a rudder stock 91 fixed along said rudder blade 92, said rudder stock 91 extending along said rudder rotation axis U and having a rudder shaft free end 93 fixed to said rudder connecting device 30.

[0125] According to an embodiment, the rudder connecting device 30 comprises a removable spacer ring 37 coaxial with said rudder rotation axis U, configured to push the connecting body 31 against said connecting flange 42 into said constrained position when said spacer ring 37 is present, as shown in figure 5, and to allow translation away from the connecting body 31 from the connecting flange 42 into said disengaged position when said spacer ring 37 is removed, as shown in figure 6.

[0126] According to an embodiment, the spacer ring 37 is an open ring or is a ring in two separable half-rings, so that said spacer ring 37 can be slipped off according to a direction transverse to the rudder rotation axis U.

[0127] According to another embodiment of the present invention, shown in figure 22, the speed reduction gear 40 is of a cycloidal type and is arranged axially outwardly from the rotary electric motor 10.

[0128] In figure 22, the rudder connecting device was omitted for the sake of convenience of illustration but it is worth noting that the rudder rotation command assembly 1 in figure 22 also comprises the aforesaid rudder connecting device 30 arranged to receive a rotary motion from said rotor 12 and fixable to said directional rudder 90, so as to correlate the rotation of said rotor 12 relative to said stator 11 with the rotation of said directional rudder 90 relative to said supporting structure 60.

[0129] The aforementioned rudder connecting device 30 comprises any of the features of the rudder connecting device described above for the other embodiments.

[0130] The rotary electric motor is, preferably, of an axial flux motor, preferably an axial flux brushless motor.

[0131] According to an aspect of the invention, the aforesaid purposes and advantages are met by a steering gear system 200, e.g. shown in figures 14 and 15, comprising:

- at least one steering station 202, 203 comprising a respective angular position encoder 210, 211 of a respective steering member (not shown in the figures, e.g. a rudder wheel), capable of providing an angular position electrical signal;

- a main electronic control unit 205 connected to said respective angular position encoder 210, 211 of said respective steering member to receive said angular position electrical signal;
- at least one rudder rotation command assembly 1A, 1B as described above, wherein the rotary electric motor 10 is connected to said main electronic control unit 205 so that said main electronic control unit 205 actuates the rotary electric motor 10 so as to orient the rudder 90 associated with said at least one rudder rotation command assembly 1A, 1B, according to a desired angular position as a function of said angular position electric signal.

[0132] According to an embodiment, the rotary electric motor 10 of each of said at least one motor rotation command assembly 1A, 1B, when said motor 10 is a brushless motor, is associated with a respective electronic motor control 207, 208 configured to control said motor 10.

[0133] According to an embodiment, each of said at least one rudder rotation command assembly 1A, 1B, is connected with said main electronic control unit 205, in a feedback mode, wherein the angular encoder 70 of said at least one rotation command assembly 1A, 1B is connected to said main electronic control unit 205, to provide said main electronic control unit 205 with a respective feedback signal dependent on the angular position of the rudder 90.

[0134] According to an embodiment, the at least one rudder rotation command assembly 1A, 1B comprises a right rudder rotation command assembly 1A and a left rudder rotation command assembly 1B.

[0135] According to an embodiment, the steering gear system 200 comprises a redundant electronic control unit 206, equal to said main control unit 205, connected to said rotary electric motor 10 of each of said at least one rudder rotation command assembly 1A, 1B, and to said respective angular position encoder 210, 211 of said at least one steering station 202.

[0136] According to an embodiment, the redundant electronic control unit 206 is configured to operate when the main electronic control unit 205 is faulty.

[0137] According to an embodiment, the at least one steering station 202, 203 is formed by a main steering station 202, preferably arranged on a command deck, or bridge, of the navigating craft, and a secondary steering station 203, preferably arranged on a different deck of the navigating craft, such as on the fly deck.

[0138] According to an embodiment, the main steering station and the secondary driving station are configured to be selectively operable.

[0139] The comparison of figures 19, 20, and 21 illustrates a main technical advantage of the invention over the prior art.

[0140] In particular, figures 19 and 20 show a known steering gear system comprising two rudders 90, the angular position of which is controlled by a single linear hydraulic actuator 95, e.g., a hydraulic cylinder, and such rudders are connected to each other by a transmission bar 96 to transmit the angular position from one to the other of the two rudders.

[0141] In figure 19, the rudders 90 are arranged with their respective rudder mid-plane 94 parallel to the longitudinal centerline M of the navigating craft to steer the navigating craft on a straight course.

[0142] In figure 20, through the linear actuator 95, the two rudders are rotated according to a maximum angle of rotation, wherein the rudder mid-planes 94 form a maximum rotation angle relative to the longitudinal centerline M.

[0143] Such a maximum rotation angle is mechanically limited by the overall dimensions of the linear actuator 95, and the drive bar 96.

[0144] Thus, this maximum angle of rotation, according to the prior art, cannot exceed 35°.

[0145] Instead, figure 21 shows a steering gear system comprising two rudder rotation command assemblies according to the invention.

[0146] As readily apparent, the linear actuator 95 and the transmission bar 96 are completely absent.

[0147] This allows the rudders 90 to be rotated to a maximum angle far greater than is possible using the prior art.

[0148] The possibility of rotating the rudders 90 at angles far greater than 35° allows steering the craft, in cooperation with the propellers, in any direction relative to the longitudinal centerline M of the craft, substantially facilitating transverse maneuvers of the craft during mooring maneuvers.

[0149] Another advantage of the invention is that it allows the angle of rotation of each of the two rudders to be controlled differently from the angle of rotation of the other of the two rudders.

[0150] A person skilled in the art may make changes and adaptations to the embodiments to the device described above or can replace elements with others which are functionally equivalent to satisfy contingent needs without departing from the scope of protection of the appended claims. All the features described above as belonging to one possible embodiment may be implemented independently from the other described embodiments.

[0151] The figures are not in scale.

[0152] All the features described here may be combined in any combination, except for the combinations in which at least some of such features mutually exclude one another.

Claims

1. A rudder rotation command assembly (1) for a float-

ing navigation craft comprising a hull (50) and a directional rudder (90) rotatably mounted with respect to a structure integral with said hull (50) about a rudder rotation axis (U),
wherein said rudder rotation command assembly (1) comprises:

- a rotary electric motor (10) comprising a stator (11) and a rotor (12) configured to rotate with respect to said stator (11) about a rotor axis (R);
- a supporting structure (60) comprising a motor fixing portion (62) configured to fix said stator (11) to said supporting structure (60), and a hull fixing opposite portion (61) adapted to fix said supporting structure (60) with respect to said structure integral with said hull (50);
- a rudder connecting device (30) arranged to receive a rotary motion from said rotor (12) and fixable to said directional rudder (90), so as to correlate the rotation of said rotor (12) with respect to said stator (11) with the rotation of said directional rudder (90) with respect to said supporting structure (60).

2. A rudder rotation command assembly (1), according to claim 1, wherein said rotor axis (R) is arranged coaxially with said rudder rotation axis (U).

3. A rudder rotation command assembly (1), according to claim 1, wherein said stator (11) is annular in shape and is coaxial with said rotor axis (R) and has a central stator cavity (13) in which said rotor (12) is rotatably housed, and wherein said rotor (12) is annular in shape and coaxial with said rotor axis (R) and has a central rotor cavity (14).

4. A rudder rotation command assembly (1) according to claim 1, comprising a speed reduction gear (40) connected to and interposed between said rotor (12) and said rudder connecting device (30).

5. A rudder rotation command assembly (1) according to claims 3 and 4, wherein said speed reduction gear (40) is at least partly housed inside said central rotor cavity (14) and/or said central stator cavity (13).

6. A rudder rotation command assembly (1), according to claim 4, wherein said speed reduction gear (40) is a cycloidal reduction gear.

7. A rudder rotation command assembly (1), according to claim 1, wherein said rotary electric motor (10) is a brushless motor.

8. A rudder rotation command assembly (1), according to claim 1, wherein the rotary electric motor (10) is a torque motor.

9. A rudder rotation command assembly (1), according to claim 1, wherein the supporting structure (60) is substantially tubular in shape and coaxial with said rudder rotation axis (U) and defining a tubular structure upper end (64) comprising said motor fixing portion (62), an opposite tubular structure lower end (65) comprising said hull fixing portion (61), a tubular structure side wall (63) connecting the tubular structure upper end (64) and the tubular structure lower end (65), wherein said rudder connecting device (30) is contained in said supporting structure (60).

10. A rudder rotation command assembly (1), according to claim 9, wherein said rotary electric motor (10) is arranged in order to close said structure upper end (64).

11. A rudder rotation command assembly (1), according to claim 1, comprising a container lid (80) associated with said stator (11) on the opposite side with respect to said rudder connecting device (30) to close said rotary electric motor at the top (10).

12. A rudder rotation command assembly (1), according to claim 1, wherein said rudder connecting device (30) comprises a connecting flange (42) adapted to be connected either directly or indirectly to said rotor (12) and a connecting body (31) fixable to said rudder, said connecting flange (42) and said connecting body (31) being rotatable about the rudder rotation axis (U), and comprising a plug-in coupling (33) configured to constrain/release in rotation said connecting body (31) to/from said connecting flange (42), selectively, between a constrained position and a released position.

13. A rudder rotation command assembly (1), according to claim 12, wherein said connecting body (31) has an engagement seat (34) to removably engage a lever bar (35) which can be manually actuated by an operator to manually rotate said connecting body (31) in said released position.

14. A rudder rotation command assembly (1), according to claim 12, wherein said connecting body (31) can slide axially with respect to said connecting flange (42) along the rudder rotation axis (U) between said constrained position and said released position.

15. A rudder rotation command assembly (1), according to at least one preceding claim, comprising at least one directional rudder (90), said directional rudder (90) comprising a rudder blade (92) and a rudder stock (91) fixed along said rudder blade (92), said rudder stock (91) extending along said rudder rotation axis (U) and having a rudder stock free end (93) fixed to said rudder connecting device (30).

16. A steering gear system (200) for a floating navigation craft, comprising:

- at least one steering station (202, 203) comprising a respective angular position encoder (210, 211) of a respective steering member, capable of providing an angular position electrical signal,
- a main electronic control unit (205) connected to said respective angular position encoder (210, 211) of a respective steering member to receive said angular position electrical signal;
- at least one rudder rotation command assembly (1A, 1B) according to at least one preceding claim, wherein the rotary electric motor (10) is connected to said main electronic control unit (205) so that said main electronic control unit (205) actuates the rotary electric motor (10) in order to orient the rudder (90) associated with said at least one rudder rotation command assembly (1A, 1B), according to a desired angular position as a function of said angular position electric signal.

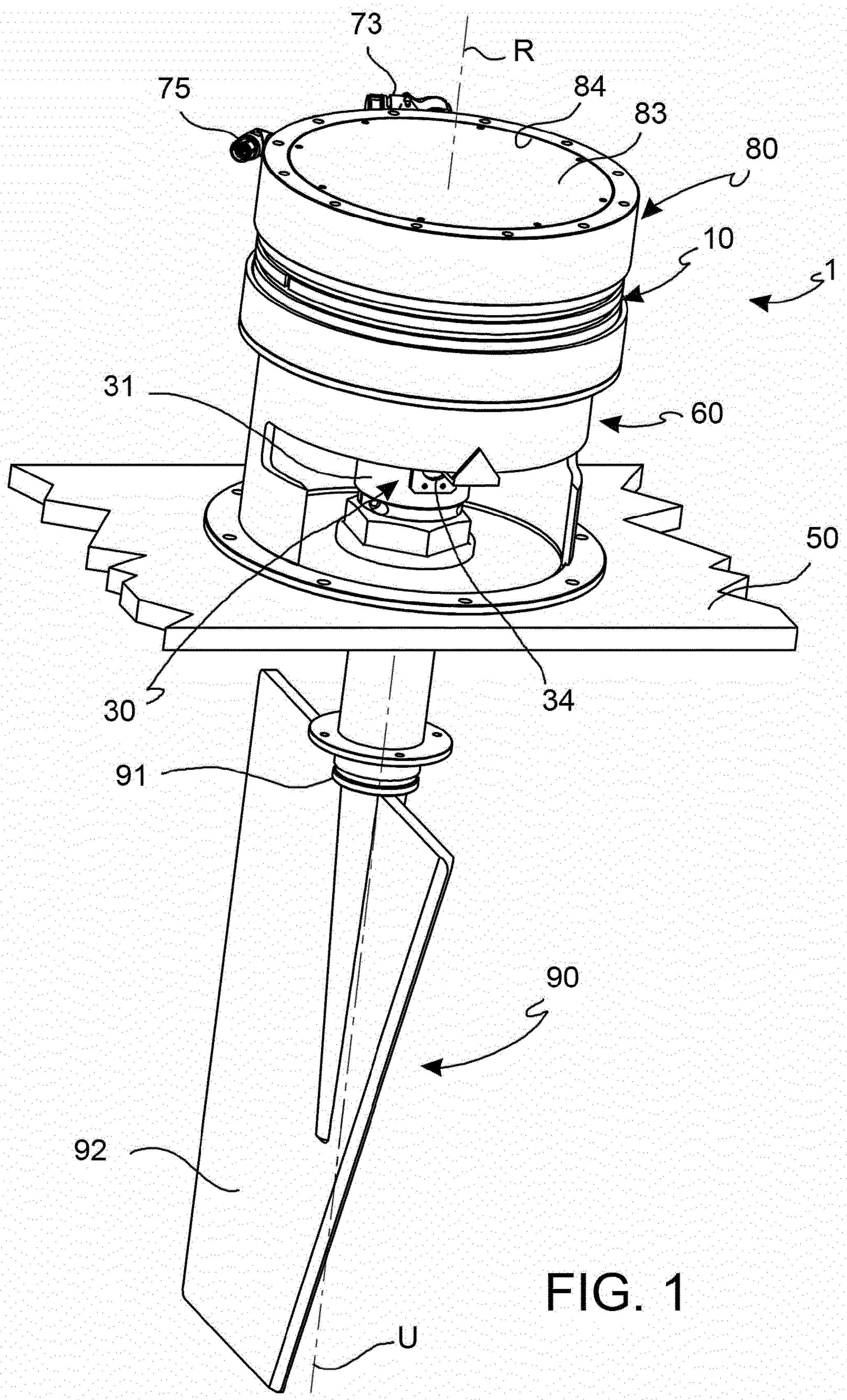

FIG. 1

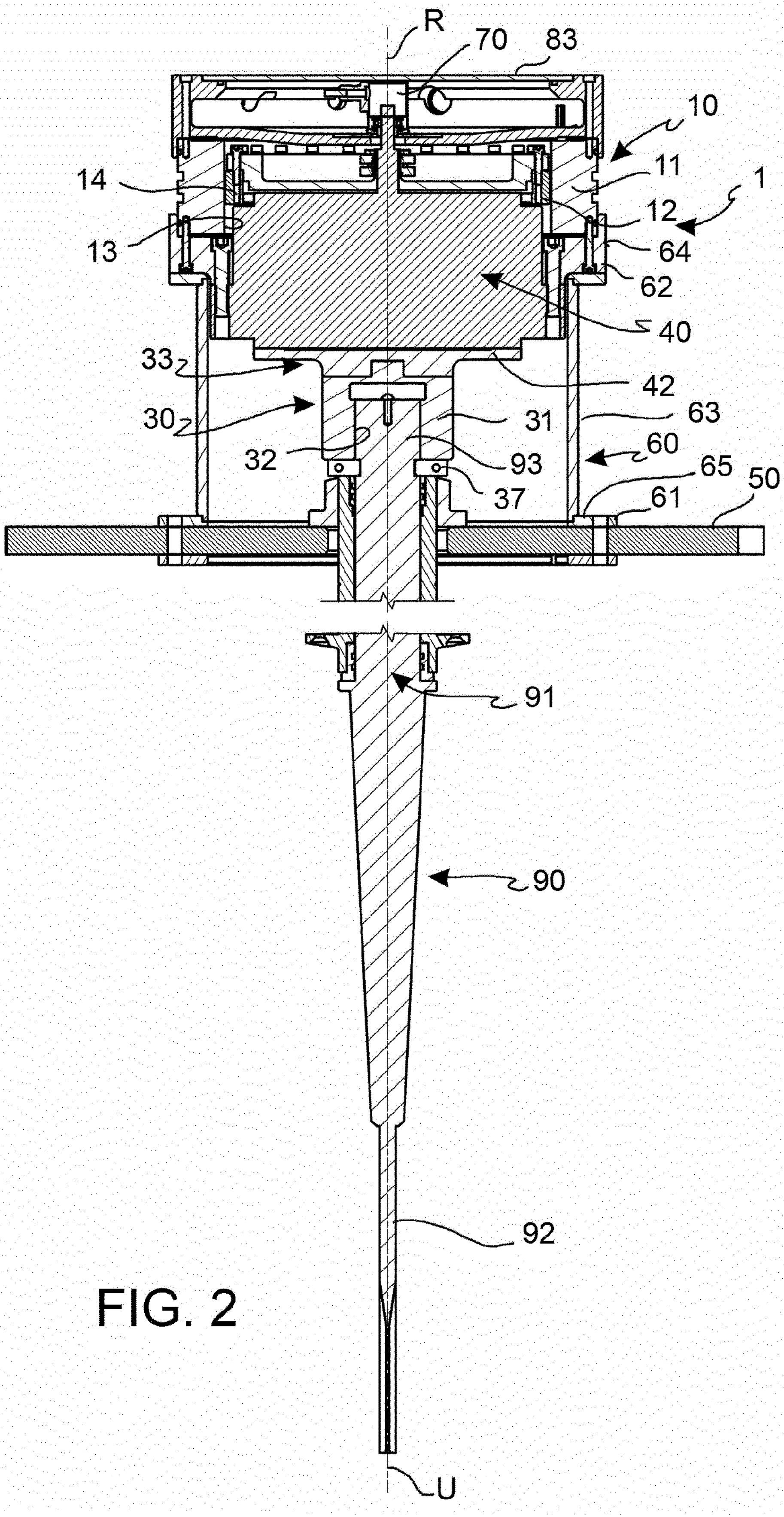
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FIG. 2

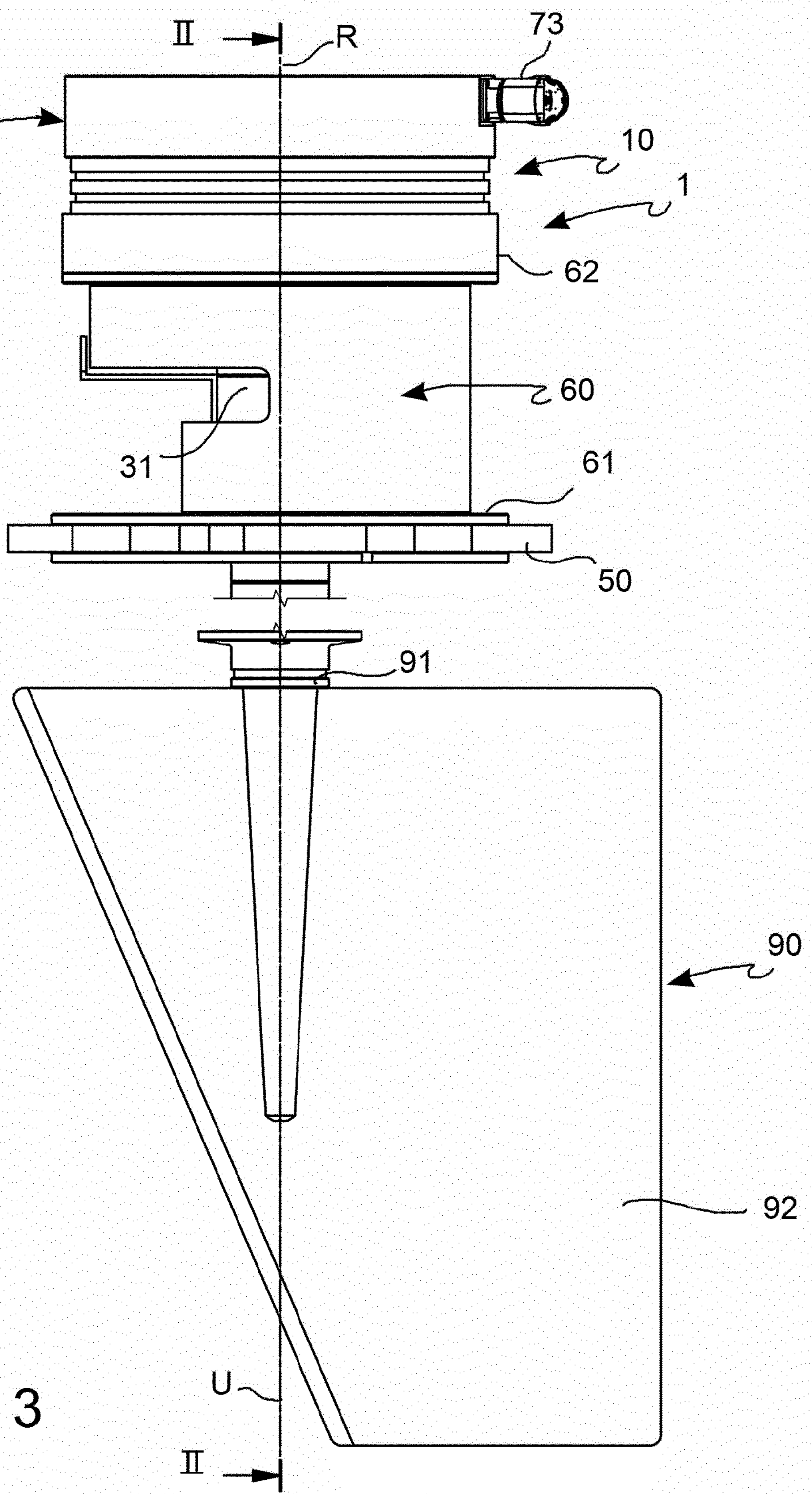

FIG. 3

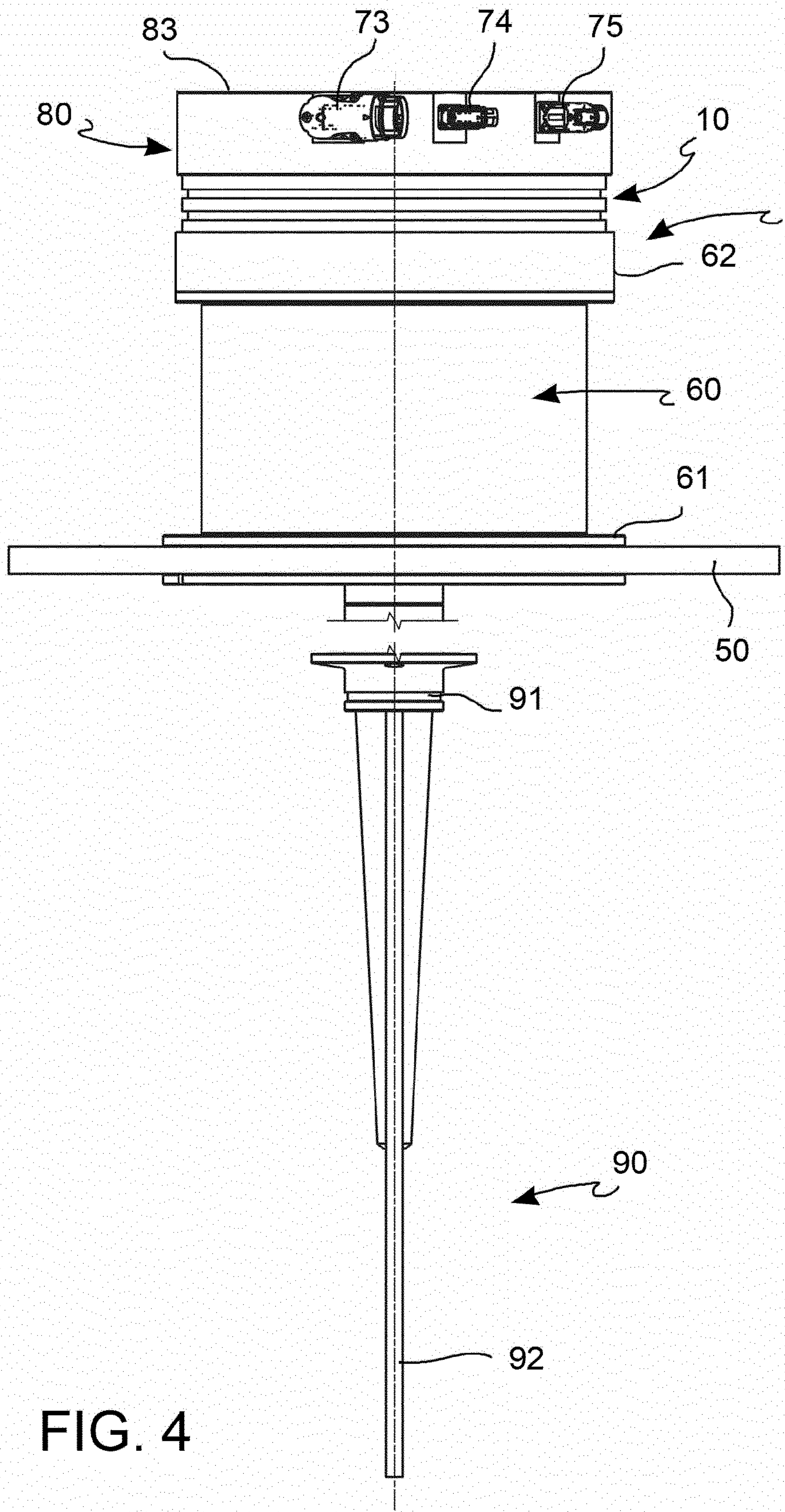

FIG. 4

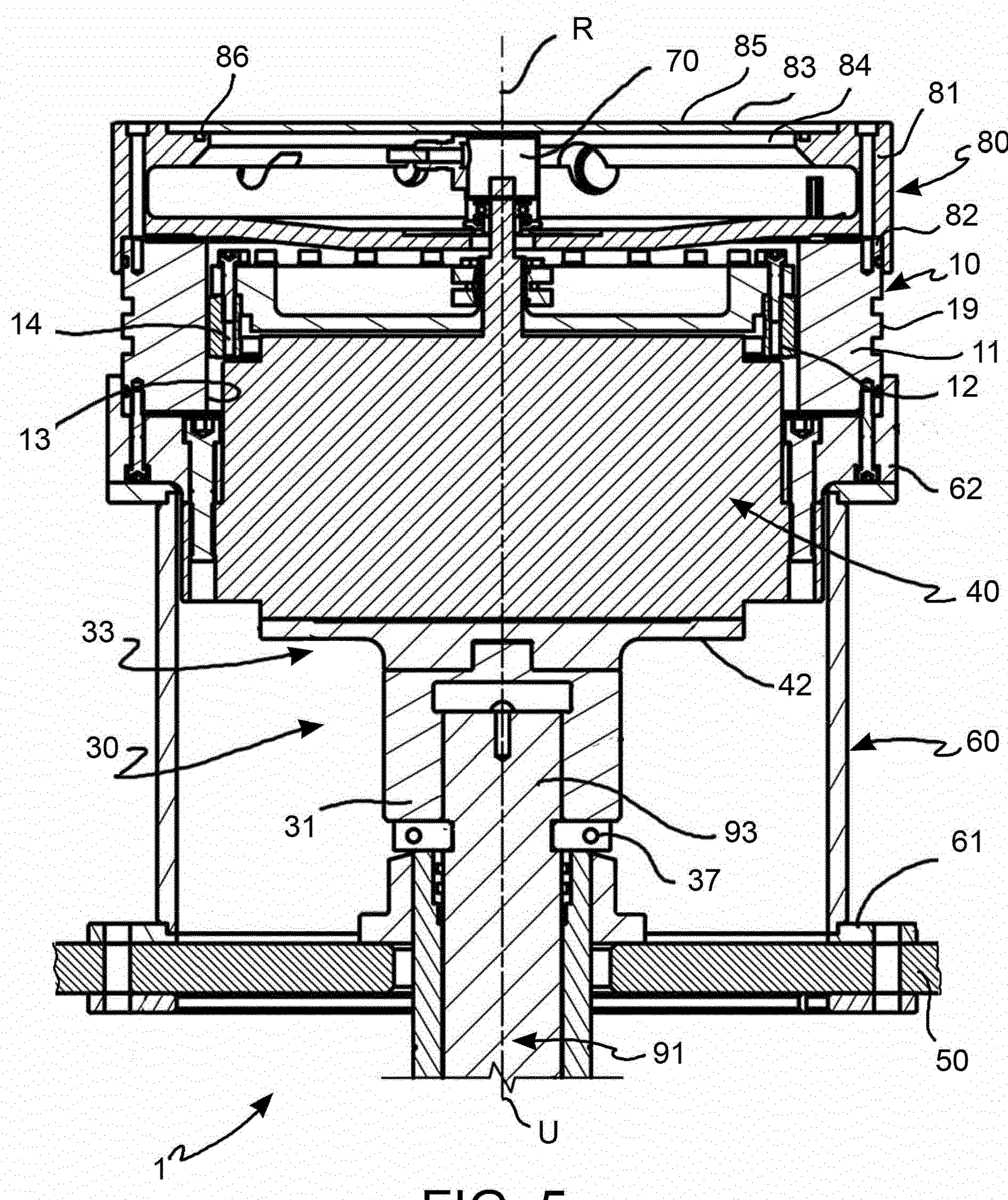
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FIG. 5

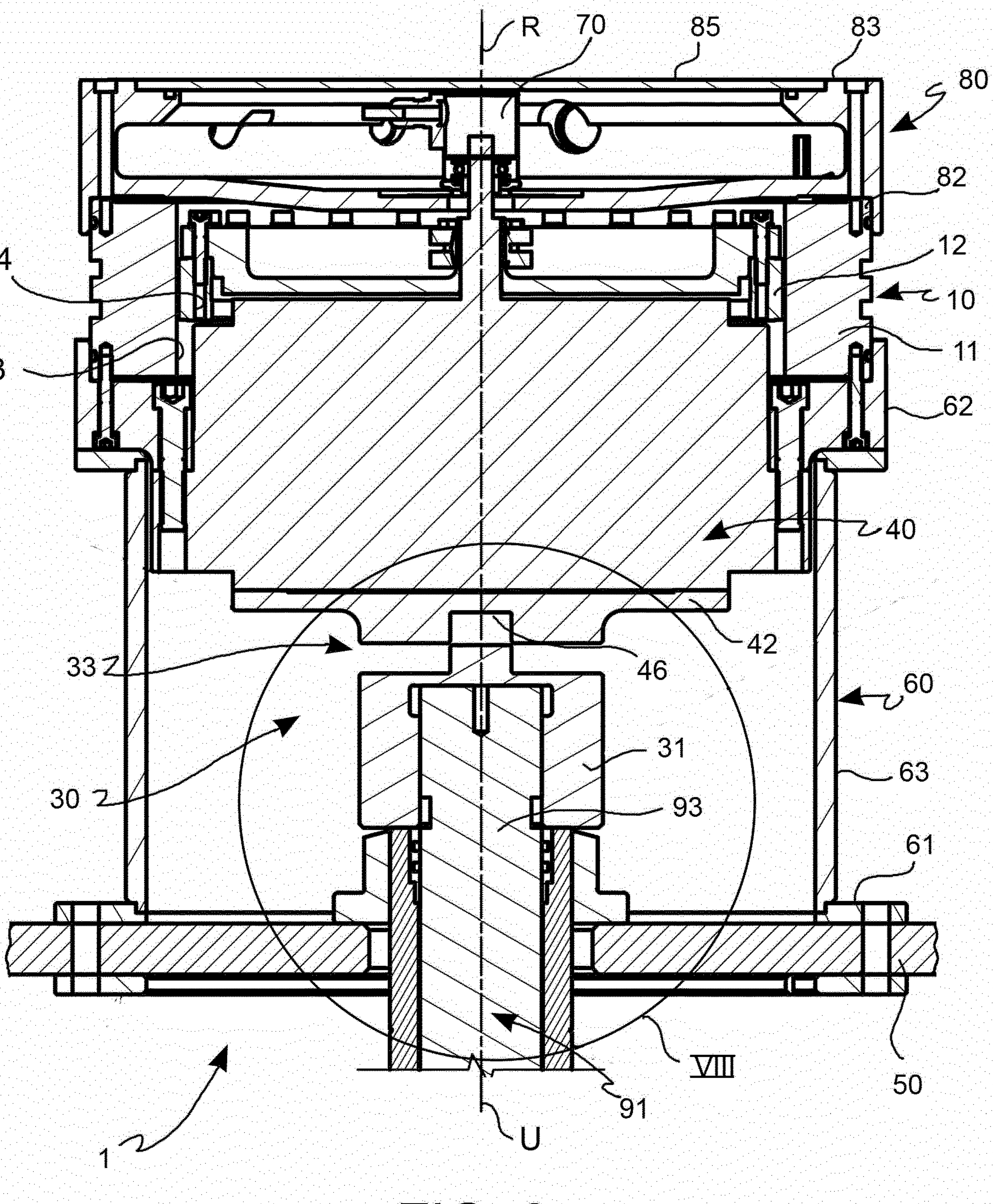
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FIG. 6

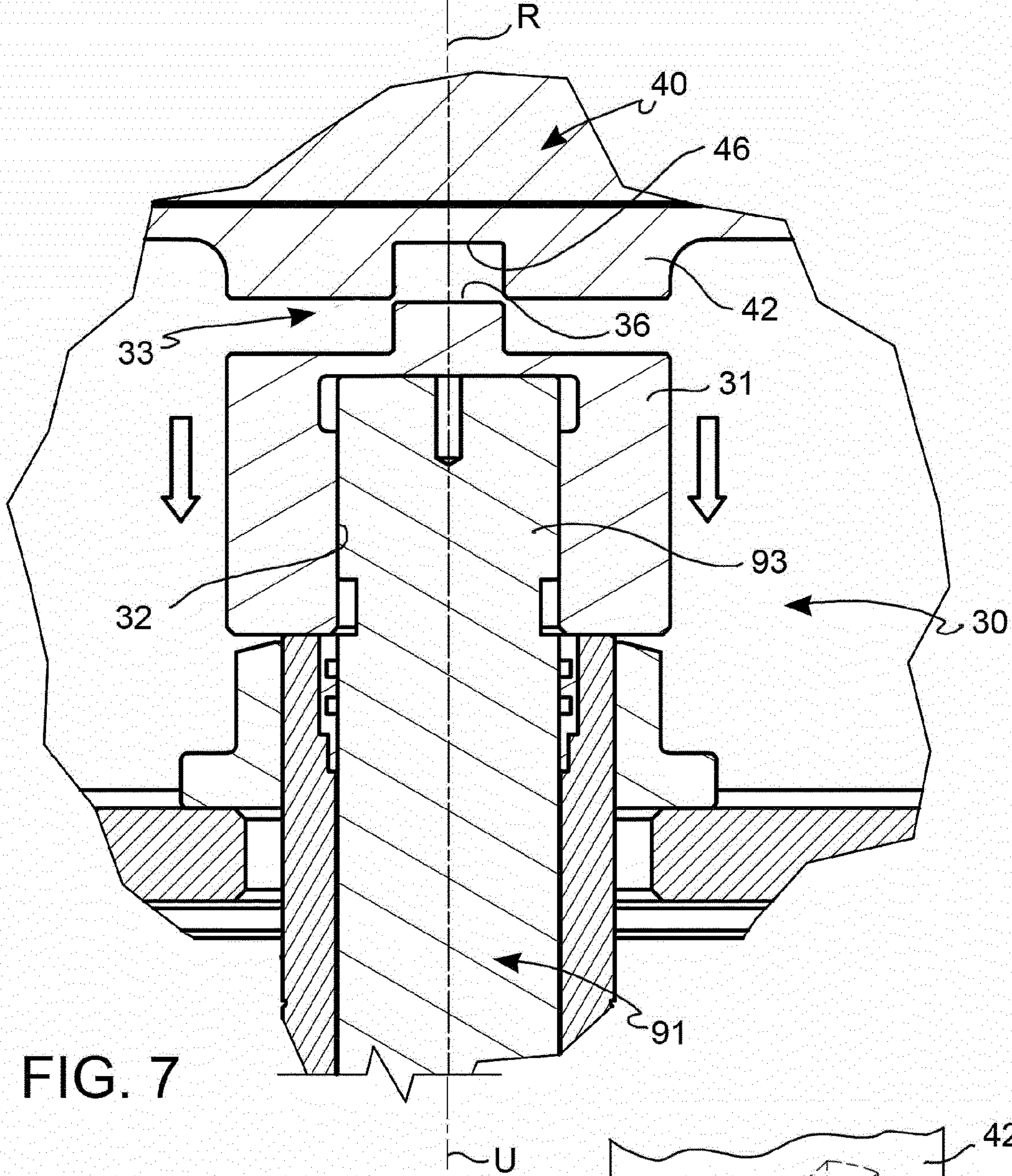

FIG. 7

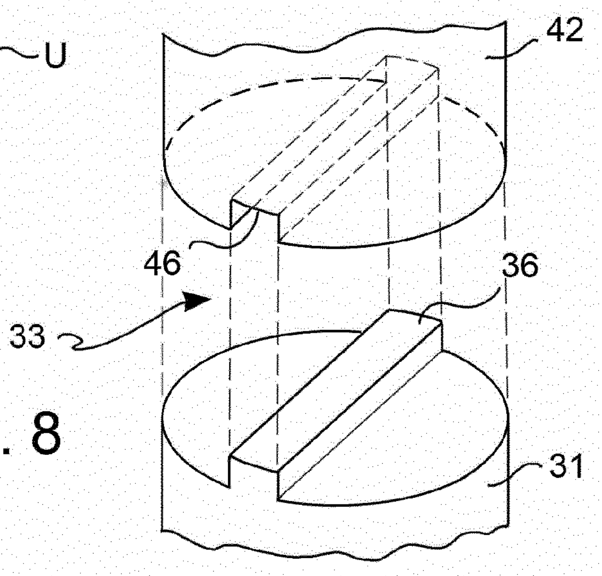

FIG. 8

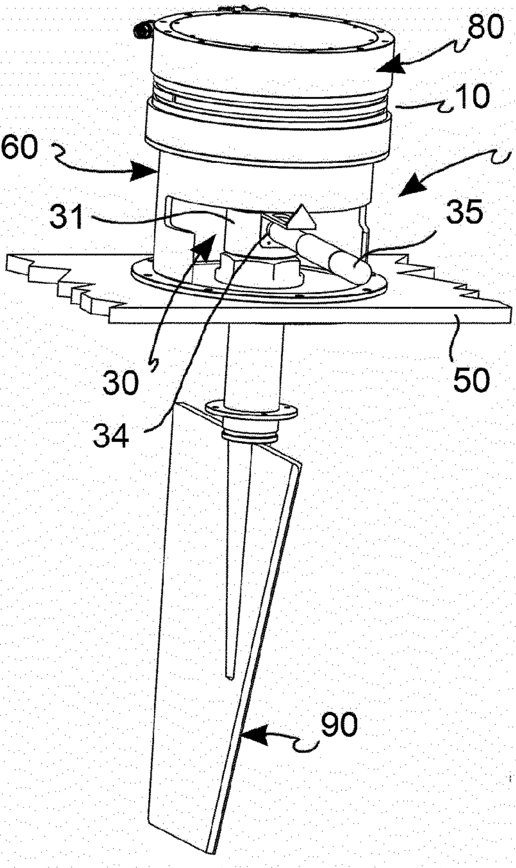

FIG. 9

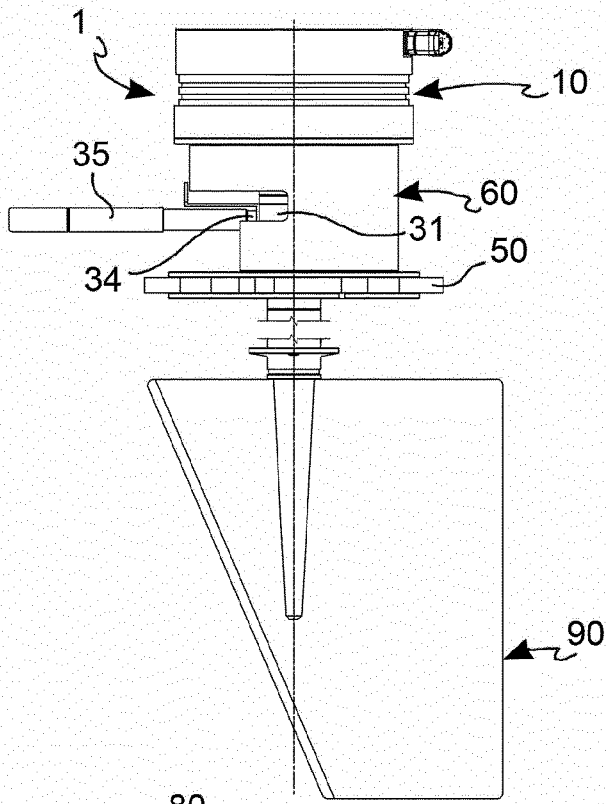

FIG. 10

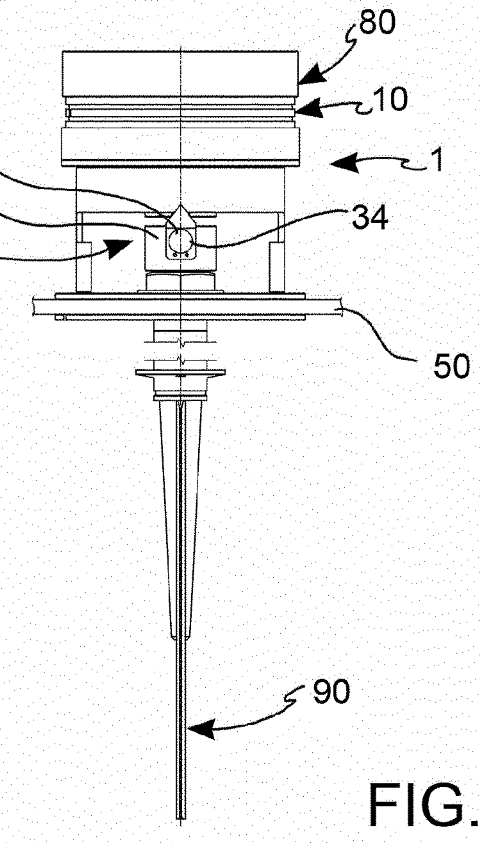

FIG. 11

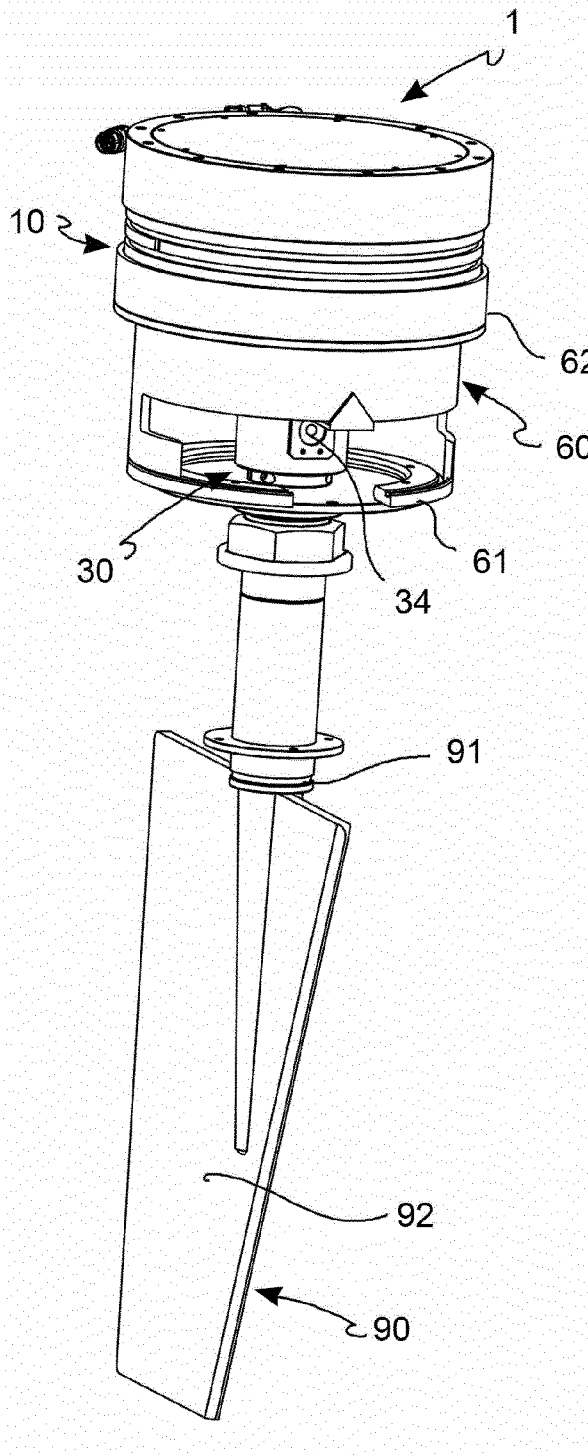

FIG. 12

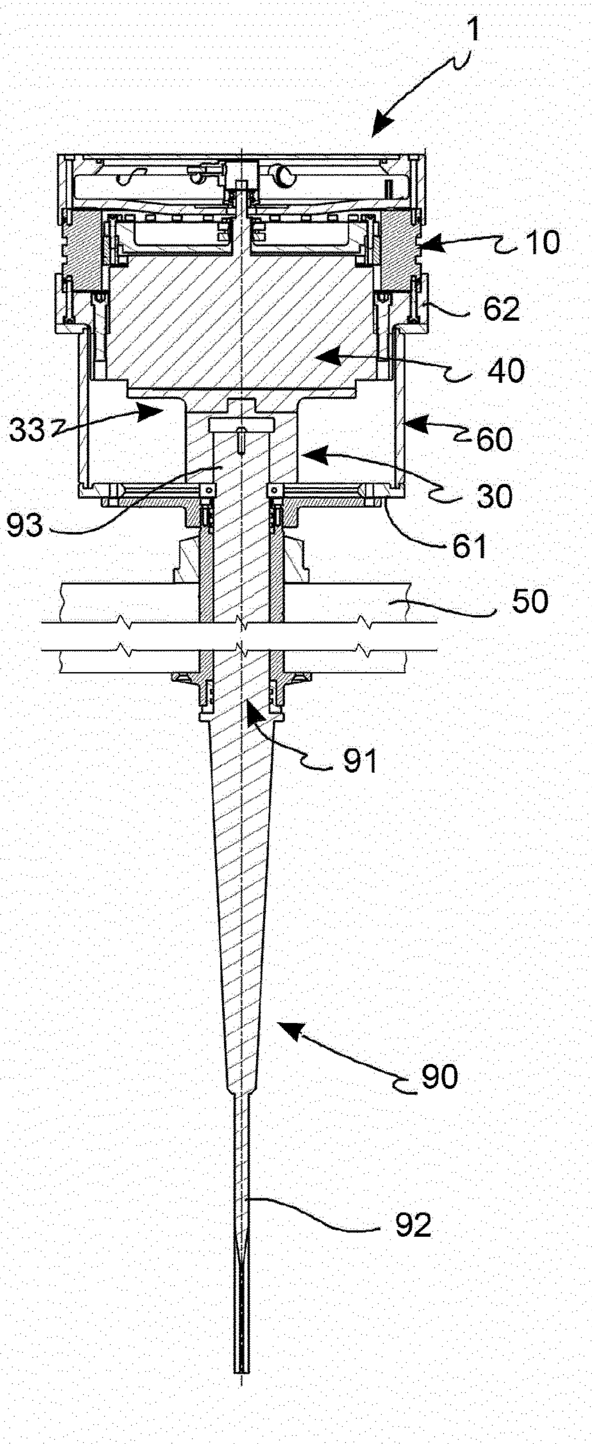

FIG. 13

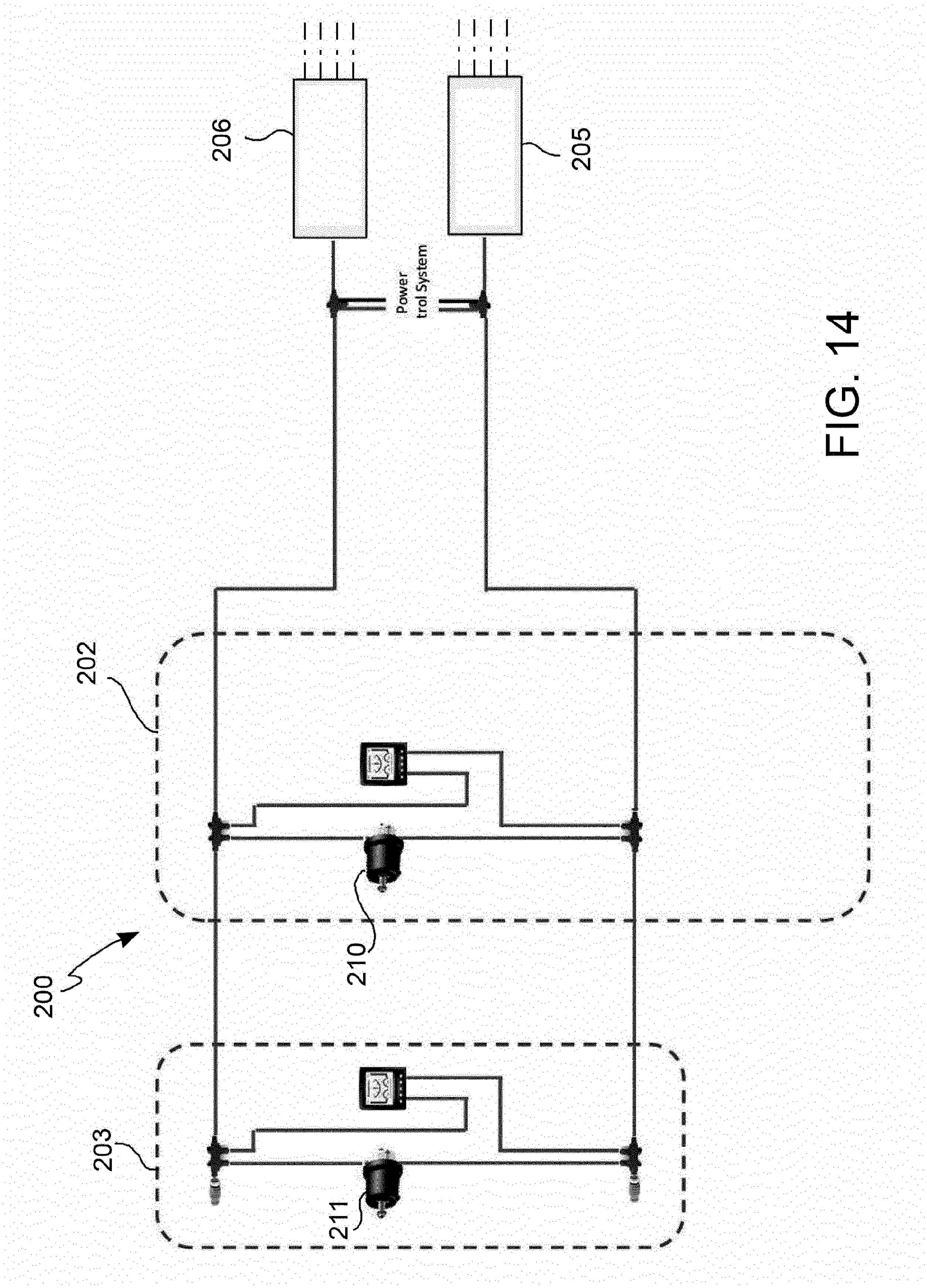

FIG. 14

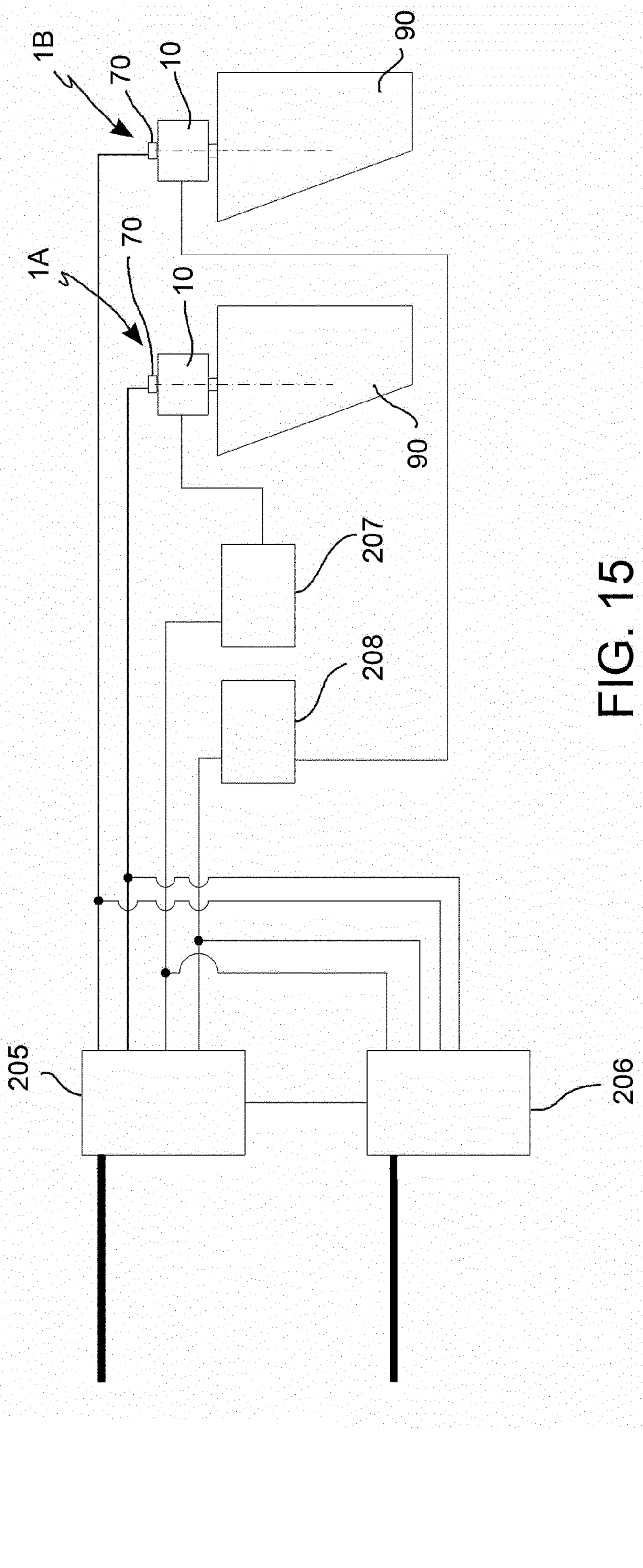

FIG. 15

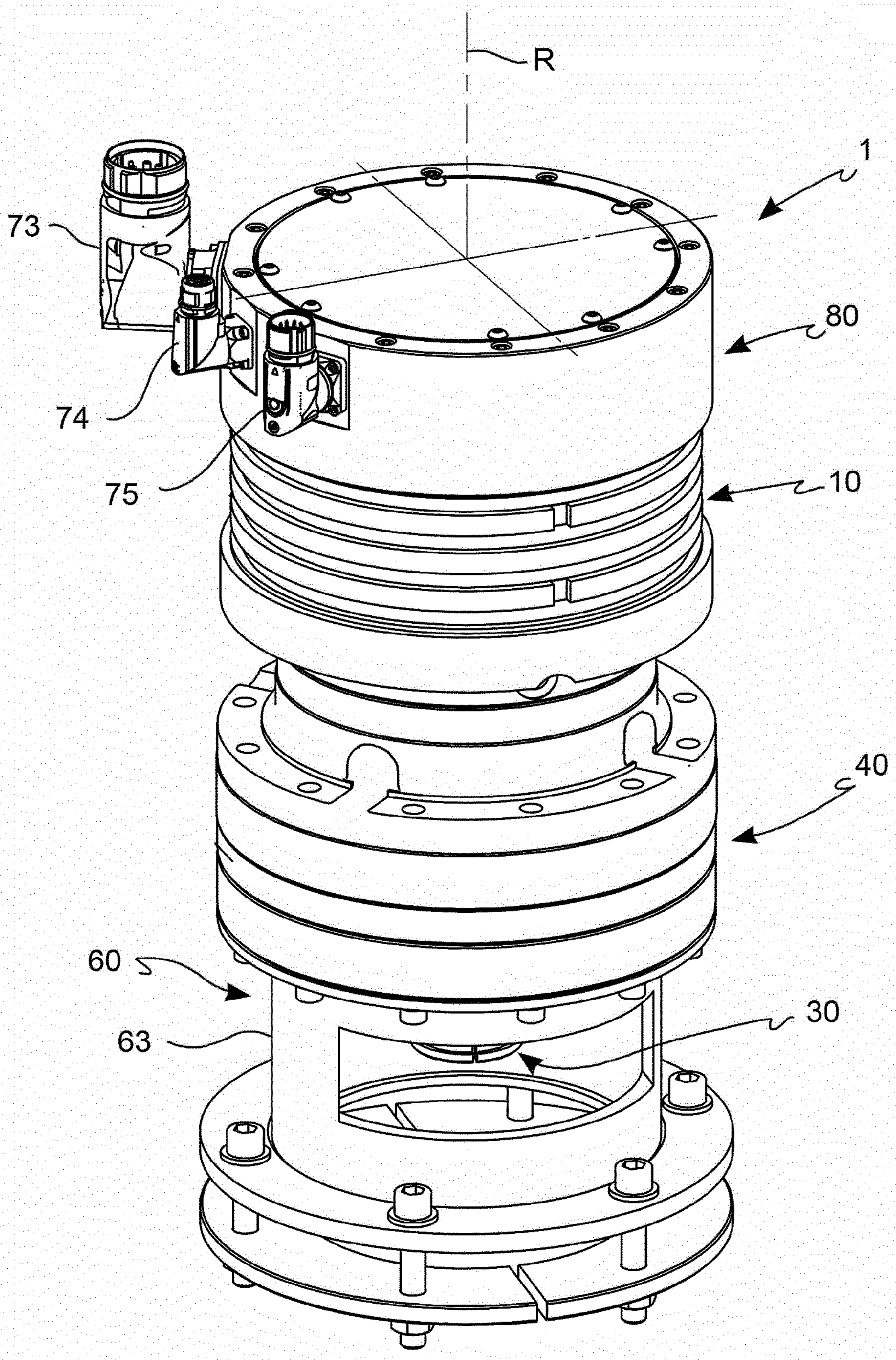

FIG. 16

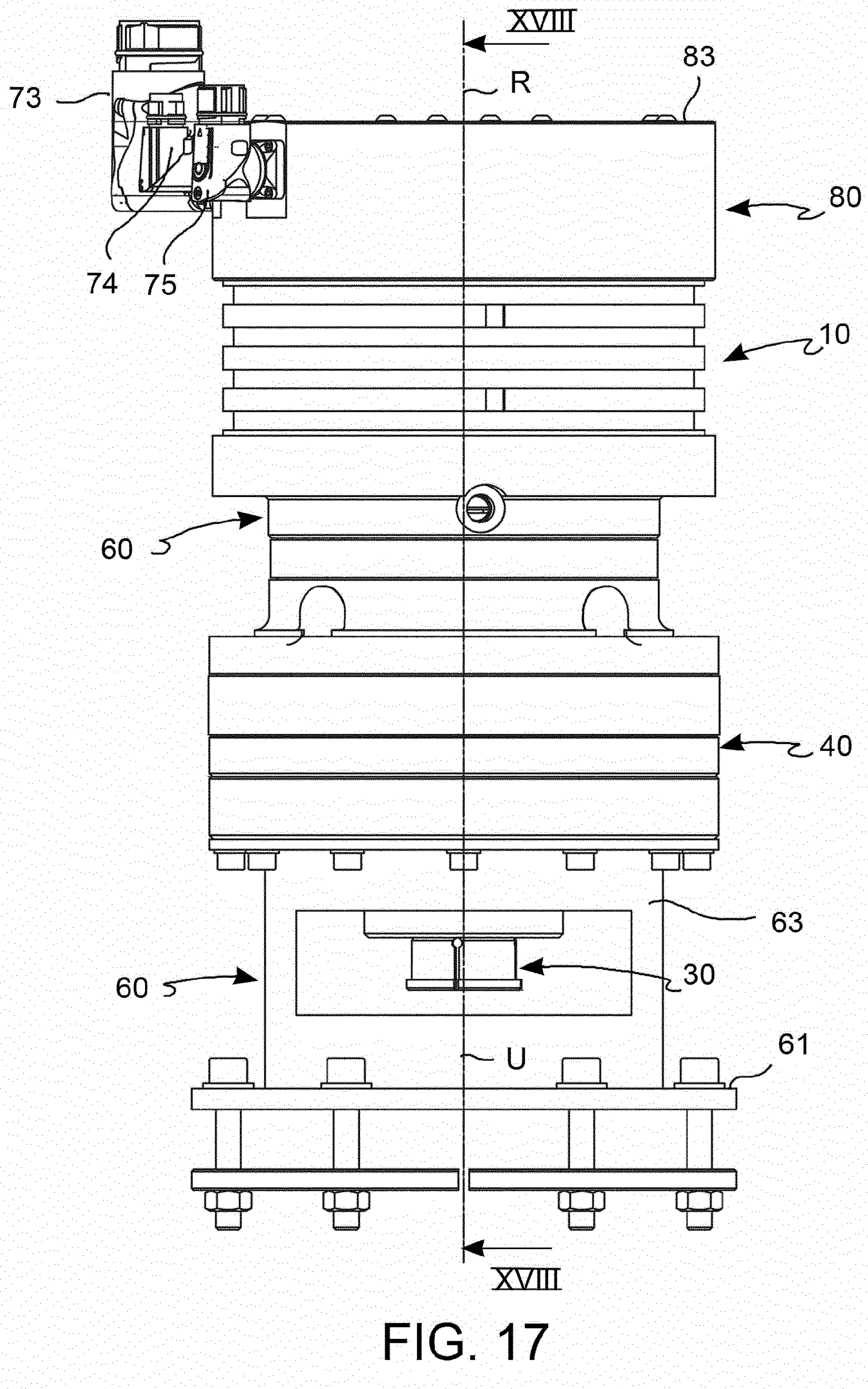

FIG. 17

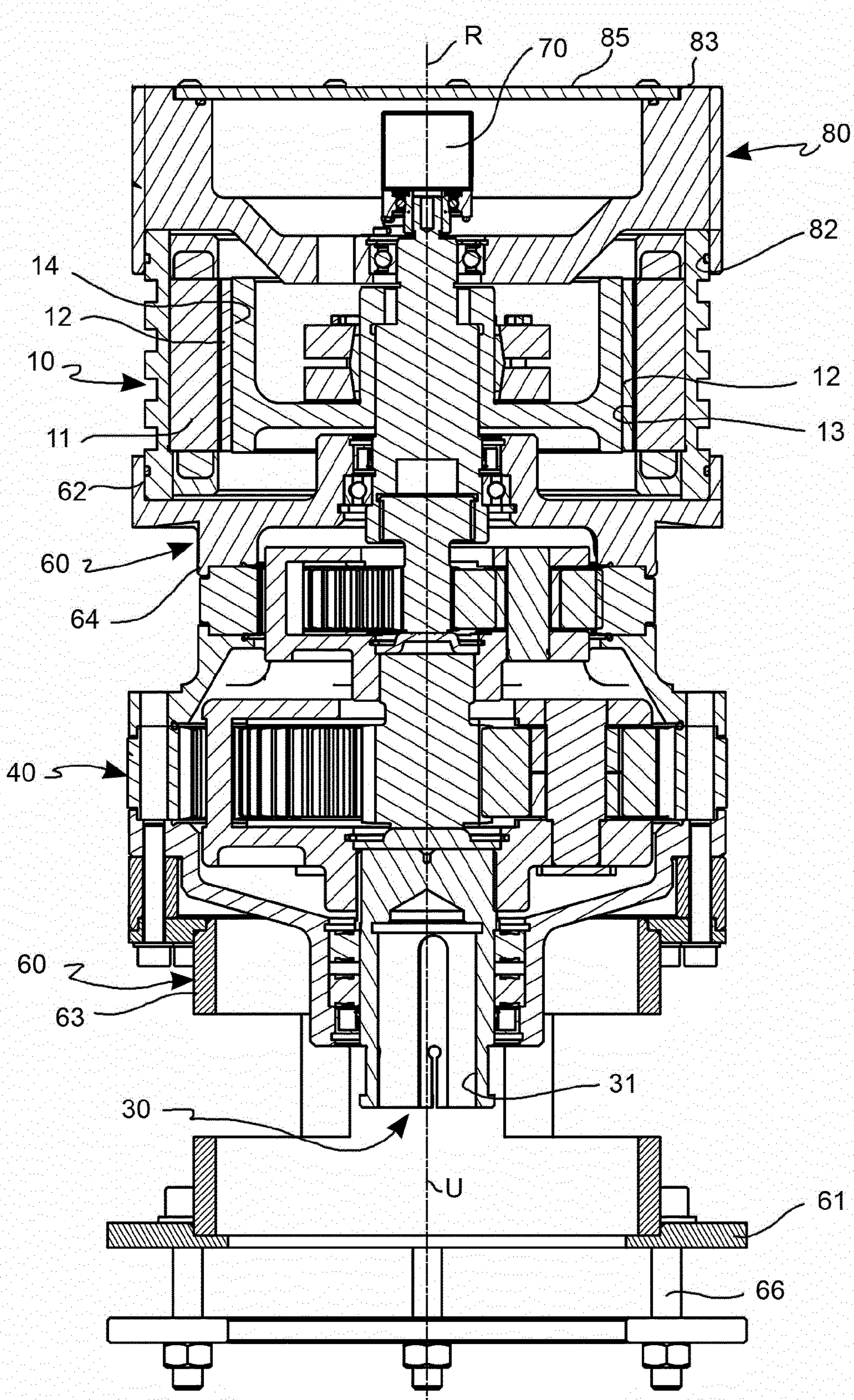

FIG. 18

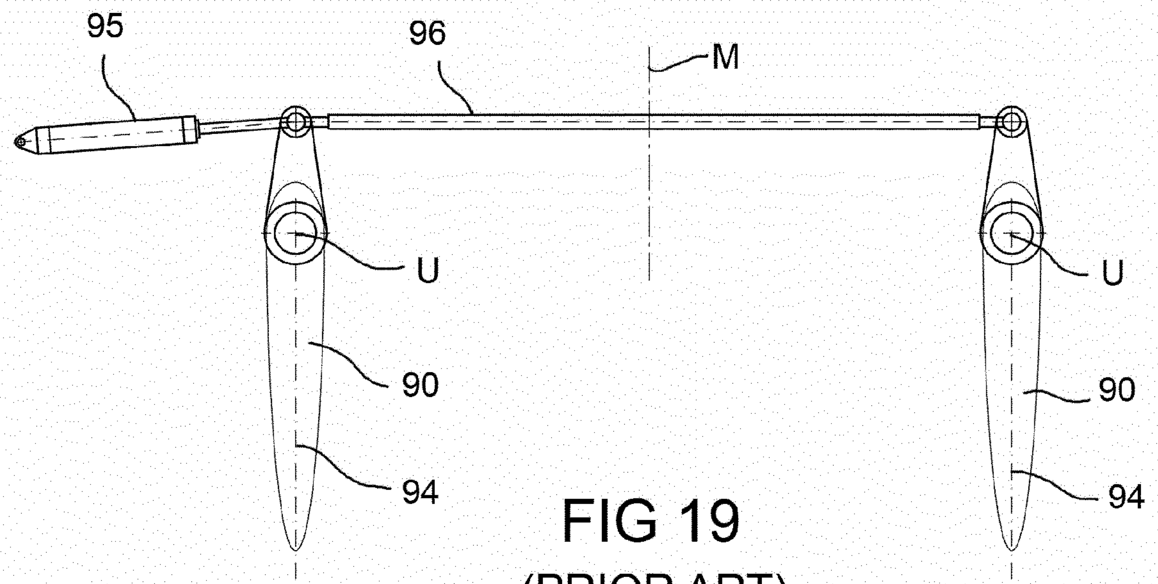

FIG 19
(PRIOR ART)

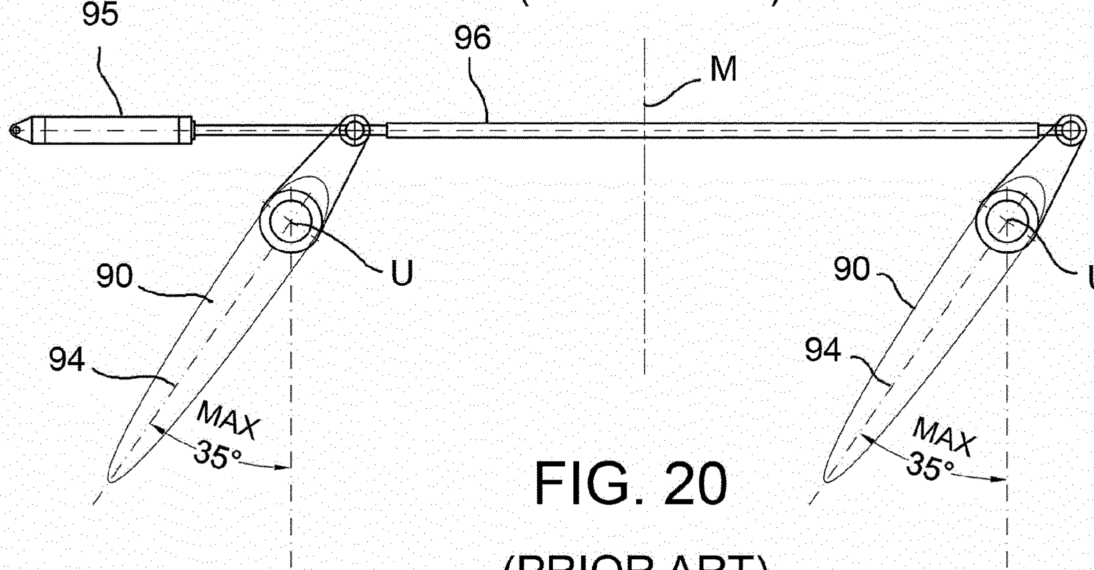

FIG. 20
(PRIOR ART)

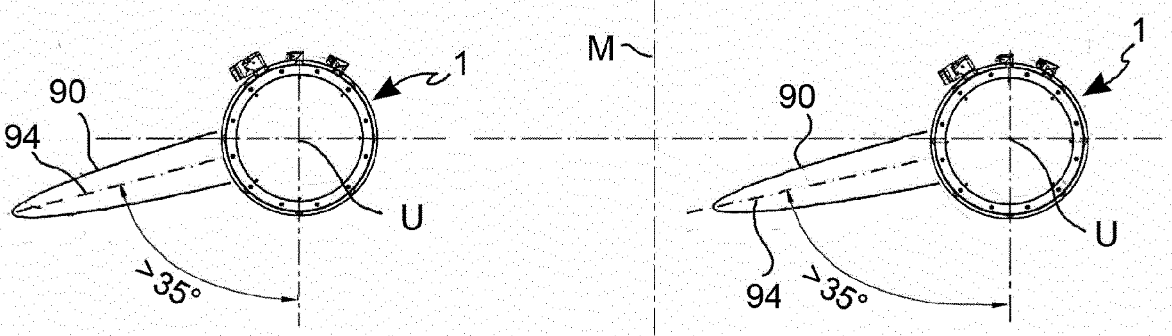

FIG. 21

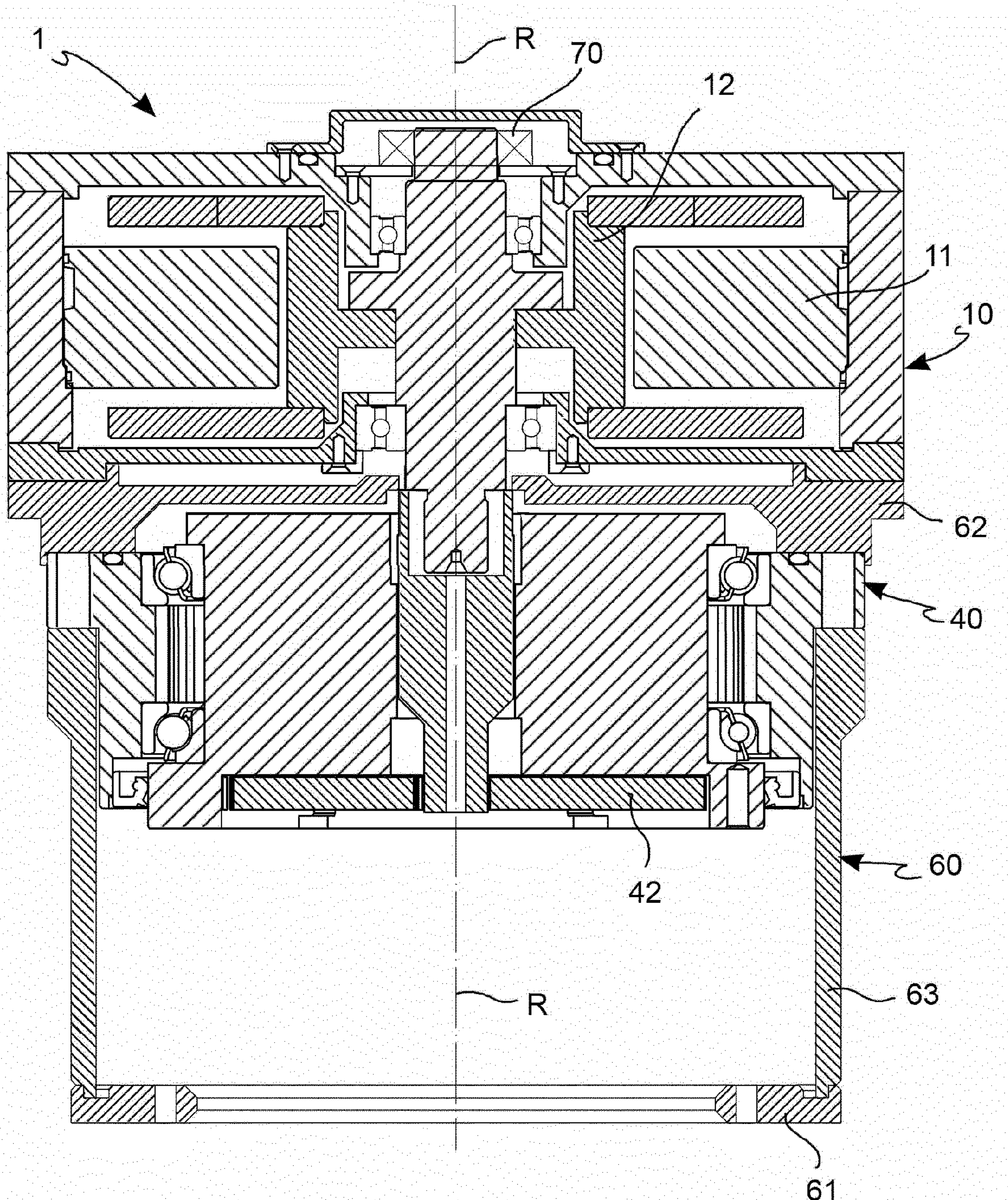

FIG. 22

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 4000

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2017/130100 A1 (CMC MARINE S R L [IT]) 3 August 2017 (2017-08-03) * page 6, line 2 - page 10, line 26; claims; figures *	1-16	INV. B63H25/38 B63H25/24
X	WO 2019/021094 A1 (CMC MARINE S R L [IT]) 31 January 2019 (2019-01-31) * page 3, line 1 - page 7, line 7; claims; figures 1-6 * * page 19, lines 24,25 *	1-12,15	
X	EP 1 384 661 A1 (ALSTOM [FR]) 28 January 2004 (2004-01-28) * paragraphs [0001] - [0016]; claims 1-7; figure 1 *	1-16	
X	ES 2 374 778 A1 (VICUS DESARROLLOS TECNOLOGICOS S L [ES]) 22 February 2012 (2012-02-22) * claims; figures *	1-16	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 March 2022	Knoflacher, Nikolaus

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 20 4000

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15-03-2022

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