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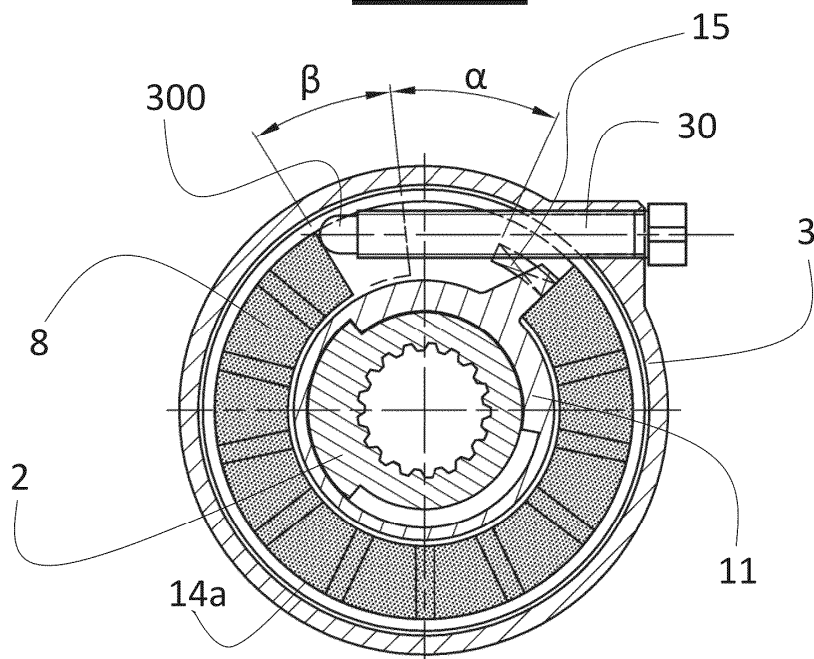
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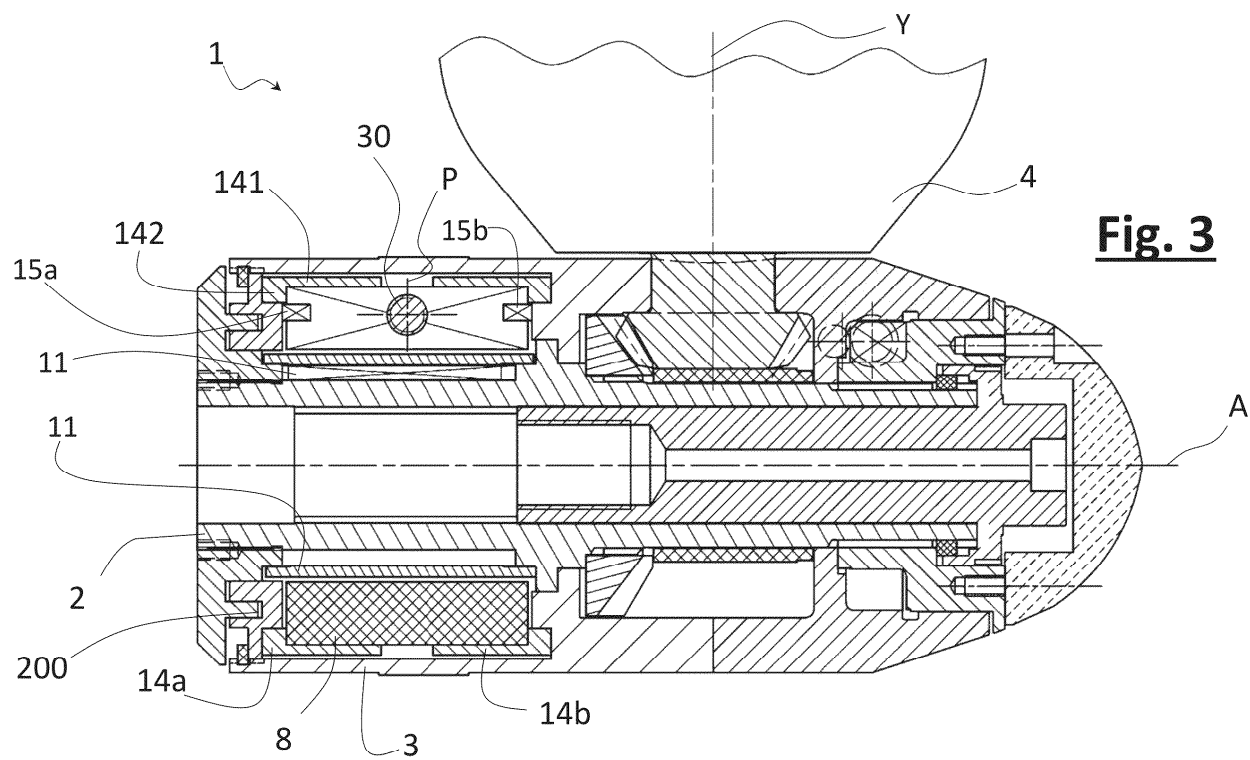
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(54) NAUTICAL PROPELLER

(57) Propeller (1) comprising a cylindrical body (3), a hub (2) able to be coupled to a drive unit and rotatably assembled at least partially in said cylindrical body of the propeller, and at least one blade (4) rotatably pivoted to said cylindrical body of the propeller, said hub (2) being rotatable relative to said cylindrical body of the propeller, or vice versa, for adjusting the fluid dynamic pitch of said at least one blade (4), the propeller further comprising at least one elastic element (8) for adjusting the fluid dy-

namic pitch of said at least one blade and an adjusting device (30) for adjusting at least the preload of said at least one elastic element (8), characterized by comprising at least one housing body (14a, 14b) interposed between said elastic element (8) and said cylindrical body (3), said elastic element (8) being housed in said housing body (14), said housing body (14a, 14b) being rotatable relative to said cylindrical body (3).

Fig. 2C



Description

FIELD OF THE INVENTION

[0001] The present invention concerns to a propeller, preferably for nautical use, and a respective use method, in which the blades can be arranged at the fluid dynamic pitch most suitable to the various propeller operation conditions.

[0002] It is well known that, to achieve ideal conditions with optimal efficiency at every stage of navigation, the arrangement of the propeller blades must adopt and maintain the correct fluid dynamic pitch in each individual stage, that is, adopt and maintain a proper and suitable angle of attack relative to the fluid they encounter. Specifically, the operation of the propellers used in nautical propulsion can be subdivided into three main stages, which follow each other as the navigation speed of the vessel increases. The first stage of the propeller operation, which usually corresponds to the minimum navigation speed, is when the vessel's maneuvers are carried out. The second stage of operation, in which the navigation speed increases from the first stage, is usually used for cruising navigation.

[0003] The third stage of operation, identifiable by a further increase in navigation speed until the maximum rotation speed of the drive unit is reached, is when the vessel is propelled up to the maximum navigation speed.

PRIOR ART

[0004] In conventional fixed-pitch propellers, known in the art, the fluid dynamic pitch of the blades is sized according to the power supplied by the drive unit at the maximum rotation speed of the drive unit on which the propeller is to be installed.

[0005] The so sized propeller will only be able to provide good efficiencies in the first and third stages of operation. De facto, as mentioned above, the pitch of the conventional fixed propeller is sized precisely to achieve the best efficiency in the third stage, that is, with the maximum navigation speed and the maximum propeller rotation speed. Maximum speed can only be achieved with small pitches.

[0006] Even in the maneuvering stage (first phase), a small pitch does not give rise to any drawbacks (it is rather advantageous instead) since no performance in navigational speed is required in this stage, but only readiness to respond to commands given by the maneuverer. On the other hand, a small pitch is very disadvantageous in the second stage of operation, that is to say in cruising navigation, this stage being, as known, of great importance as it is by far the most used. In the second stage, a small fixed pitch will result in low efficiency of the propeller, and the power supplied by the drive unit will not be effectively converted into propulsive thrust.

[0007] In order to ensure high efficiency during cruising navigation (a stage with medium values of rotation

speed), it is essential to arrange the propeller blades with a high fluid dynamic pitch.

[0008] To meet these needs, propellers have been developed in which the relative angle of rotation of the hub relative to the propeller body, and vice versa, can be varied during navigation. This variation is achieved by a dedicated known kinematic system. In particular, it is known to equip a propeller with a specifically shaped elastic element which adjusts the relative rotation of the hub relative to the propeller body, and consequently the propeller pitch, during the operation of the propeller itself, as described, for example, in Patent Application WO2018065800 (hereinafter also referred to as WO'800), in the name of the Applicant.

[0009] Specifically, such a propeller is equipped with a device described in WO'800 (which is also schematically depicted in Figure 1 which refers to the known art) that allows the navigation of a vessel to be made more efficient, particularly during the cruising stage. A propeller of this type allows high navigation speed to be achieved at a medium/low engine rotation speed. From now on, the rotation speed is referred to as "RPM" (number of revolutions per minute).

[0010] The device of WO'800 allows the propeller to absorb and convert, into thrust for the vessel, a significantly higher portion of the power available to the engine compared to the power portion that is absorbed and converted into thrust by using a conventional fixed-pitch propeller at the same RPM.

[0011] Therefore, the device of WO'800 advantageously allows high navigation speeds to be achieved at medium RPMs.

[0012] Referring to Figure 1, which relates to the known art described in Patent Application WO'800, the power portion available to the engine (which the propeller is able to absorb and convert into thrust for the vessel) generates a driving torque which is equal and opposite to the torque countering the rotation of the propeller.

[0013] Said driving torque generates the thrust F₂, which is transmitted to the elastic element 101 housed in the propeller body.

[0014] The device according to the known art provides that an element for adjusting the preload of the elastic element 101, such as a screw 103, is inserted into the propeller body 102.

[0015] By means of such an adjusting element, for example by means of such a screw 103, the user can apply to the elastic element 101 the force F₁ that creates a preload condition in the elastic element.

[0016] As long as the torque countering the rotation of the propeller (which generates the force F₂) is less than or equal to the preload torque applied by the force F₁ to the elastic element, the pitch of the propeller remains fixed at the preset value.

[0017] If acceleration is applied, and thus the torque countering the propeller rotation is increased until it exceeds the preload torque generated by the force F₁, the elastic element 101 begins to be compressed, thus gen-

erating a relative rotation between the hub 104 and the propeller body 102 and, as a result, through a known kinematic system, a change in the pitch of the propeller. Specifically, the propeller pitch begins to decrease allowing the engine to reach the maximum RPM set by the engine manufacturer.

[0018] From a theoretical point of view, the preset propeller pitch remains constant as long as the thrust F2 produced by the torque countering the rotation of the propeller remains less than or equal to the thrust F1.

[0019] However, it has been found that, due to the frictional forces between the elastic element 101 and the propeller body 102, adjusting the preload of the elastic element does not always actually allow an accurate adjustment of the behavior of the elastic element 101.

[0020] In fact, when the elastic element is loaded by means of the screw 103 and the thrust F1 becomes sufficiently high, and thus begins to compress the elastic element 101, a relative motion (and consequently friction) is actually generated between the body of the elastic element 101 and the propeller body, namely the inner surface of the propeller body that forms the seat of the elastic element 101. In particular, friction is generated between the thin plates, which, according to an embodiment, make up the elastic element, and the inner surface of the propeller body. As a result, it follows that the preload, which is generated in the elastic element 101 by the thrust F1, causes a deformation of the elastic element 101 which gradually decreases as the distance from the point of contact with the screw 103 increases. The end of the elastic element that is compressed by the hub (by applying the force F2) is not affected as desired by the preload applied by the screw 103. In other words, in propellers equipped with an elastic element as stated in Patent Application WO'800, frictional forces have indirect effects that can interfere with the proper and desired deformation of the elastic element, since the frictional forces counter the uniform compression of the elastic element during propeller operation.

[0021] During the operation of the device of the known art, the thrust force F2 produced by the torque opposing the rotation of the propeller may be very different from the thrust force F1. As a result, the force F2 can be subject to considerable fluctuations depending on the variation in frictional forces. In addition, it is also possible for a portion of an end of the spring to be deformed, while the other end of the spring remains substantially undeformed. Clearly, such a situation causes a spring response different than the one desired.

[0022] What has been discussed also causes the following drawbacks: the thrust force F2 produced by the torque countering the rotation of the propeller cannot reach the desired values (which are high) or reaches them with considerable difficulty. Therefore, it is not possible to precisely adjust the F2 value via the screw 103. As a result, navigation will be subject to irregularities with speed changes that cannot be easily controlled. Also due

to the frictional forces, the range of adjustment of the propeller pitch will not be able to be large because only part of the thin plates of the elastic element cooperates to this variation.

[0023] In addition, insertion and removal (e.g. for maintenance) of the flexible element is difficult due to such frictional forces.

[0024] An object of the present invention is to overcome the drawbacks of the prior art briefly discussed above, that is, to suppress or greatly reduce the negative effect of frictional forces.

[0025] Specifically, object of the present invention is to provide a propeller with high efficiency in the cruising stage and in the stage of maximum RPM by making the best use of the characteristics of the drive unit to which the propeller is coupled. Another object of the present invention is to provide a propeller in which the elastic element can be effectively deformed without any frictional force inside the propeller causing it to deform in an uncontrollable manner.

[0026] Further object of the present invention is to provide a propeller in which the elastic element can be assembled, and possibly disassembled, in a simple manner.

[0027] These and other objects are achieved by a propeller according to one or more of the appended claims.

[0028] In particular, the present invention relates to a propeller and a related operating method according to the independent claims, while preferred aspects are set forth in the dependent claims.

[0029] According to an aspect of the invention, a propeller comprises a cylindrical body, a hub which can be coupled to a drive unit and rotatably assembled at least partially in said cylindrical body of the propeller, and at least one blade rotatably pivoted to said cylindrical body of the propeller. The hub is rotatable relative to the cylindrical body of the propeller, or vice versa, in order to adjust the fluid dynamic pitch of the at least one blade. The propeller further comprises at least one elastic element for adjusting the fluid dynamic pitch of the at least one blade and an adjusting device for modifying at least the preload of the at least one elastic element. The propeller further comprises at least one housing body rotatably interposed between the cylindrical body of the propeller and the elastic element. The elastic element is housed in the housing body.

[0030] Thus, the elastic element counters the relative rotation between the hub and the propeller body, allowing precise adjustment of the fluid dynamic pitch of the at least one blade during propeller use, that is, according to the forces acting on the propeller during use.

[0031] Advantageously, with the propeller according to the present invention, when the resistant torque, i.e., the torque countering the rotation of the propeller, exceeds the resistant torque generated by the elastic element, the deformation of the elastic element itself is possible and will take identical values in the two ends of the elastic

element. Therefore, forces acting at the ends of the elastic element are equal and opposite, so that the behavior of the elastic element can be adjusted with considerable precision by means of the preload adjusting device.

[0032] It should be noted that the adjusting device adjusts "at least" the preload of the elastic element. "At least" means that this device can be used for other adjustments as well. Specifically, in preferred embodiments, the adjusting device is provided with an operating range, that is, a travel. The device can be configured so that in a first part of the travel, the adjusting device pushes the adjusting element, which in turn pushes the hub, thus causing it to rotate relative to the cylindrical body. As discussed, this causes the pitch of the at least one blade to be modified. At this stage, the elastic element substantially is not compressed, it acts as a rigid body, so that at this stage the adjusting device does not affect the preload of the elastic element and causes a modification in the pitch of the propeller.

[0033] Subsequently, the elastic element reaches the cylindrical body or more typically an element rotationally integral with it. Thus, as the action on the adjusting device continues, the thrust acting on the elastic body causes the elastic body to be compressed between the adjusting device and the cylindrical body. Thus, in this stage, no relative rotation occurs between the cylindrical body and the hub, so that the pitch of the at least one blade remains constant and therefore only the preload of the elastic element is changed.

[0034] It should be noted that the elastic element is defined to be interposed between the housing body and the hub, and is housed in the housing body. This implies that the elastic element is arranged between the hub and housing body but it is possible to have additional elements arranged between the hub and the elastic element, such as an intermediate thrust element, which is better discussed later. Instead, the elastic element is housed within the housing body and is therefore in contact with it. It should be noted that the at least one housing body of the elastic element can freely rotate relative to the cylindrical body of the propeller. This innovative freedom of rotation allows frictional forces operating on the elastic element to be distributed and reduced. Moreover, as better discussed later, more than one housing body, such as a pair of housing bodies, may be provided, which are not in contact with the entire outer surface of the elastic element, so as to reduce frictional forces acting thereon.

[0035] More specifically, during the pitch variation, the relative motion (and thus the friction) between the body of the elastic element (e.g., between its thin plates) and the housing body is very limited. Compared with the previous solution discussed in WO'800, therefore, friction is less and is more distributed. With such a device, it is therefore possible to greatly reduce the negative effect of frictional forces.

[0036] Thus, thanks to the present invention, it is possible to achieve precise adjustment of the behavior of the

elastic element and consequently more effective control over the pitch of the blades, which allows optimal pitch and thus optimal performance to be achieved in both the cruising and maximum RPM stages.

[0037] According to an aspect of the propeller according to the present invention, before the start of the deformation of the at least one elastic element, the at least one blade is arranged with at least one first fixed fluid dynamic pitch. Normally, this first pitch will turn out to be greater than the pitch which is desirable during cruising navigation.

[0038] The force at the preloading device acts at a first end of the elastic element, whereas the force provided by the torque applied by the hub acts on the opposite end (called here and in the following "second end") of the elastic element.

[0039] It should be noted that, even in cases where the elastic element is more compressed at the first or second end, for example due to assembling, the behavior of the elastic element can be precisely adjusted.

[0040] Consider, for example, the case of a thin plates spring, in which the thin plates of the elastic element are more compressed, that is, leaned against the preload screw. In such a case, at the first operational stage, the compression of the elastic element begins from the second end, that is, where the hub thrust is applied. Therefore, in that first stage, the housing of the elastic element will not rotate with respect to the cylindrical body of the propeller. Conversely, if the thin plates are leaned against the second end, where the hub thrust is applied, the first thin plates to deform will be those leaned against the preload screw. Thus, in this case, in the first stage, the housing of the elastic element immediately begins to rotate with respect to the cylindrical body of the propeller. In both of the cases described above, therefore, there is an initial stage of deformation affecting only one end of the elastic element.

[0041] However, due to the presence of the at least one housing body and to reduced frictional forces involved, this first stage is only temporary, since once an equilibrium is reached, for example when the thin plates exhibit equal deformation at both ends of the elastic element, compression of the elastic element begins to be simultaneous and identical at its own two ends.

[0042] In this initial temporary stage, in order to achieve a given deformation of the elastic element (which, as seen, occurs in only one end of the elastic element itself), a quite high increase of the torque is required.

[0043] Therefore, in practice, the compression of elastic element begins from only one end (the less compact end) until an equilibrium position is reached.

[0044] It is important to note that while reaching the equilibrium of load between the two ends of the elastic element, the change in propeller pitch occurs during the compression of only one end of the element. Therefore, for the same load change, the deformation and pitch change of the propeller will be small. On the other hand, when the equilibrium between the two ends is reached, at

the same load change, the deformation of the elastic element and the change in the pitch of the propeller will be advantageously high (about twice as high as in the first stage).

[0045] In general, therefore, during the propeller operation, excluding a possible initial transient period, the entire elastic element (i.e., the entire length of the elastic element) advantageously contributes to the pitch variation of the at least one blade.

[0046] Thus, the overall pitch variation can easily be controlled and adjusted by means of the preload adjusting device, through fixed and precise adjustment. In addition, the adjustment range will be very wide. Thus, thanks to the device that is the object of the present invention, the drawbacks of known devices are suppressed.

[0047] It should further be noted that the discussion regarding the "housing body" is intended to apply to each housing body in the present invention. Indeed, as more fully discussed below, in preferred embodiments of the present invention there is a pair of housing bodies, which are arranged opposite to each other relative to a plane perpendicular to the axis of rotation of the hub, and which are typically placed at a distance from each other so that part of the outer surface of the elastic element is not in contact with any housing body.

[0048] According to a possible aspect, each housing body is substantially annular around the elastic element.

[0049] It should be firstly noted that the terminology "substantially annular" will be used here and in the following to refer to an element of little thickness and predominantly extending according to an annular shape, and this does not preclude the housing body from having abutment surfaces or protrusions along its inner or outer surface. In particular, according to a preferred embodiment, the body is substantially "L-shaped", with a thinner portion adapted to be coupled externally to the elastic element, and a thicker portion adapted to be coupled also laterally to the elastic element, so as to allow the at least one housing body to be precisely positioned with respect to the elastic element.

[0050] Additionally, the housing body can be a continuous element but it is not excluded that the annular housing body can be divided into several parts.

[0051] Moreover, an annular body extends essentially annularly but does not necessarily make a complete turn, so it is not excluded that the housing body extends for only part of the substantially annular shape, thus resulting open.

[0052] According to an aspect, the propeller comprises at least one end-stop body for the elastic element, preferably a pair of end-stop bodies, each end-stop body being rotationally integral with the cylindrical body and being arranged so as to define the end-stop position for at least one end of the elastic element, preferably for both ends of the elastic element.

[0053] According to a possible aspect, each housing body is arranged laterally to said preload adjusting device

in at least one plane that comprises the axis of rotation of the hub.

[0054] According to an aspect, the propeller is further equipped with an adjusting device in the form of one or more screws that extend through the cylindrical body, so that from the outside of the propeller it is possible to reach the elastic element (and thus act on the elastic element by coming into direct or indirect contact therewith) for adjusting the preload.

[0055] The expression indirect contact is intended to mean the possible interposition of one or more elements between the preload adjusting device and the elastic element.

[0056] It should be firstly noted that the term "preload" is used to denote an initial deformation the at least one elastic element is subjected to, regardless of the external actions acting thereon. It is also important to note that the preload can also be adjusted to the null value, that is, the adjusting device can be adjusted so that the preload is zero. In detail, the elastic element is preloaded by its deformation and preferably its compression. As is well known, preloading an elastic element shifts the beginning of its operating range, that is, it shifts the beginning of its deformation due to the external forces to which the elastic element is subjected.

[0057] In addition, it should also be noted that the term "resistant torque" is used to refer to the torque, and in general to the forces, that counter the rotation of the propeller during its operation. For example, included in the resistant torque is the resistance given by the fluid to the rotation of the propeller. In addition, it should be noted that the resistant torque may, for example, also comprise the drag of the vessel to which the propeller is coupled.

[0058] As is well known, the resistant torque countering the rotation of the propeller increases as the rotation speed of the propeller increases, and thus increases as the rotation speed of the drive unit to which the propeller is coupled increases, and also increases as the speed at which the vessel is moving forward increases.

[0059] It should also be noted that, although here and in the following reference will be made to the resistant torque that counters the rotation of the propeller, what is described can obviously be applied with reference to the vessel's forward speed or with reference to power, according to known mathematical relationships.

[0060] Indeed, as is well known, the resistant torque varies approximately depending on the square of the forward speed, whereas the required power varies approximately depending on the third power of the vessel's forward speed.

[0061] According to an aspect of the present invention, the at least one blade is arranged with at least one first fluid dynamic pitch preferably adapted for ahead navigation, as a result of the rotation according to a first direction of rotation of the hub relative to the cylindrical body of the propeller in an angular range, preferably non-zero, of free rotation of the hub relative to the cylindrical body of the propeller.

[0062] It follows that, in the propeller according to the present invention, substantially in the first and second operating stages, i.e., in the maneuvering and cruising stages, the fluid dynamic pitch remains constant on a first value that can be advantageously set during propeller manufacture or easily modified by adjusting (e.g., by mechanical machining of the element) the angle of relative rotation between the hub and the cylindrical body, and more preferably between the hub and at least one intermediate element with which the propeller is equipped.

[0063] Specifically, before the elastic element start to operate and thus before the start of the rotation of the housing body and the resulting deformation of the elastic element housed therein, the propeller according to the invention behaves as a fixed-pitch propeller having a predetermined first fluid dynamic pitch.

[0064] The first fluid dynamic pitch of propeller operation can be determined, by setting at manufacture or later modifying, the amplitude of the angular range of free rotation of the hub relative to the cylindrical body of the propeller.

[0065] Only later, as the rotation speed of the drive unit increases, and thus as the resistant torque countering the propeller rotation increases, the housing body begin to rotate with the resulting rotation of the elastic element housed therein which begins to be deformed, and preferably compressed, to allow pitch modification and adjustment. Preferably, the elastic element allows the fluid dynamic pitch to decrease, thus allowing the drive unit to reach the maximum rotation speed.

[0066] When the resistant torque that counters the rotation of the propeller exceeds the torque generated by the preload of the elastic element, which can be adjusted by means of the adjusting device, the fluid dynamic pitch will be modified and, in particular, it will begin to decrease and the propeller will behave as a variable-pitch propeller allowing, again, high efficiency to be maintained compared to the absorption curve of a fixed-pitch propeller.

[0067] As mentioned above, according to an aspect, during the change of the propeller pitch, a rotation of the housing body relative to the propeller body occurs and preferably takes place simultaneously with the deformation of the elastic element housed therein.

[0068] In addition, according to an aspect, the final pitch achievable by the blades can also be advantageously adjusted by an end-stop abutment or similar means, which allow excessive decrease in fluid dynamic pitch, that is achieved at the maximum rotation speed of the drive unit, to be prevented. The end-stop abutment can be advantageously set at the time of propeller manufacturing or easily modified later.

[0069] Advantageously, the propeller according to the present invention allows the propeller's efficiency to be maximized and the blades to be arranged with an initial fixed fluid dynamic pitch, which can be set and is suitable for performing maneuvers and for cruising navigation, the

propeller subsequently allowing, as the resistant torque countering the propeller's rotation, and thus its rotation speed, increases, the housing body to begin to rotate, thus allowing the resulting deformation of at least one preloaded elastic element housed in the housing body.

[0070] By modifying the preload of the elastic element, the beginning of its operating range can be adjusted, thereby allowing the subsequent modification of the fluid dynamic pitch and in particular the decrease of the pitch, in order for the drive unit to be able to reach high rotation speeds that allow navigation at high/maximum speeds, while still maintaining high efficiency.

[0071] According to the present invention, the preload of the elastic element can be adjusted to set the range of action of the elastic element, i.e., the operating conditions of the propeller and thus of the drive unit, at which the fluid dynamic pitch will be modified as a result of the deformation of the elastic element.

[0072] By modifying the preload of the elastic element, the value of the propeller's resistant torque can be modified and when this is exceeded, the housing body begins to rotate and the elastic element, since it deforms integrally with the rotation of the housing body, will begin to deform, thus allowing the fluid dynamic pitch to be modified. Consequently, the rotation speed of the drive unit at which the fluid dynamic pitch will be modified, as a result of the deformation of the elastic element, can also be set.

[0073] On the other hand, when the hub is rotated in the second direction of rotation, the free rotation between the hub and the propeller body, preferably in a non-zero angular range, results in the arrangement of the at least one blade with a pitch suitable for reverse navigation. Possible embodiments in which the pitch suitable for reverse navigation can be advantageously modified and set by the user are not excluded.

[0074] Advantageously, thanks to the means for adjusting the initial pitch according to the present invention, by virtue also of the presence of the housing body of the elastic element, the efficiency of the propeller in the cruising and maximum RPM stages can be improved.

[0075] Additional characteristics are disclosed in the following description and/or related dependent claims.

[0076] Further characteristics and advantages of the present invention will be more evident from the following description, made by way of example, with reference to the accompanying figures in which:

- Figure 1 shows a cross-sectional view in a plane perpendicular to the axis of the hub of a possible embodiment of the propeller according to the known art;
- Figures 2A, 2B, and 2C are sectional views of a possible embodiment of the propeller according to the present invention in a plane perpendicular to the axis of the hub, in which components are visible in a relative position for pitch adjustment, a position in which the adjusting device is not inserted (Figure

2A), a position in which the adjusting device is partially inserted (Figure 2B) into the cylindrical body of the propeller without varying the preload of the elastic element, and a position (Figure 2C) in which the adjusting device is fully inserted, so as to vary the preload of the elastic element;

- Figure 2D is an enlargement of a detail of Figures 2A, 2B and 2C;
- Figure 3 shows a cross-sectional view, according to a plane passing through the axis of rotation of the hub and perpendicular to the adjusting device, of a possible embodiment of the propeller according to the present invention, where, for simplicity, the section of the end-stop bodies, which should not be present on that plane, is also shown;
- Figures 3A and 3B are two enlargements of details of Figure 3;
- Figure 4 is a view similar to Figures 2A - 2C, showing an embodiment alternative to that of Figures 1 - 3;
- Figure 5 is a longitudinal section view of the embodiment of Figure 4;
- Figure 6 is a longitudinal section view of an alternative embodiment with respect to the one of Figure 5.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0077] A propeller 1 according to the present invention comprises a hollow cylindrical body 3 to which one or more propeller blades 4 (e.g., three blades) are constrained. Despite this, the propeller 1 according to the present invention can be equipped with a number of blades 4 varying depending on construction and use requirements.

[0078] The propeller 1 can be constrained to a drive shaft actuated by a drive unit. It should be noted that, according to different possible embodiments, the propeller can be constrained directly to the drive shaft of the drive unit or it can be constrained according to known means to a hub 2, which in turn is rotationally constrained integrally with the drive shaft, or the hub 2 can be an end of the drive shaft itself. For simplicity, in the following we will refer to the hub 2 as the element of the propeller 1 that is rotated by the drive unit to which the propeller is connected.

[0079] The propeller hub 2 is coaxially coupled to the cylindrical body 3 so as to allow rotary motion to be transmitted from the drive shaft to the cylindrical body 3, as will be better described below. In addition, it should be noted that the cylindrical body 3 may be made in one piece or it may be formed by two or more parts con-

strained together, in a known manner, in order to form the outer cylindrical body of the propeller.

[0080] For example, as shown in Figure 3, the blades 4 of the propeller are pivoted to the propeller body 3 in such a way that they can rotate about their pivot axis Y. In other words, the blades 4 can rotate about an axis Y that is preferably orthogonal to the axis of rotation A of the propeller, which generally coincides with the propeller's forward direction during forward and backward motion.

[0081] It should be firstly noted that, in the following, reference will be made to the axis of rotation A of the propeller about which it rotates, as a result of the drive unit being actuated. Preferably, the axis of rotation A of the propeller coincides with the longitudinal axis of the hub 2, about which the latter rotates.

[0082] The propeller 1 according to the present invention further comprises a kinematic system, which is adapted to convert the rotary motion of the drive shaft, and thus of the hub 2 relative to the propeller body 3, or vice versa, into the rotary motion of each of the one or more blades 4 about their pivot axis Y around which they pivot with respect to the propeller body 3.

[0083] In more detail, the kinematic system causes the rotation of the blades 4 about their pivot axis Y, thus varying the angle of attack with respect to the fluid (and thus the fluid dynamic pitch), when the drive shaft, and therefore the hub 2, rotates relative to the cylindrical body 3 of the propeller by a non-zero angle of rotation, or vice versa.

[0084] Such rotation of each blade 4 about its own axis Y results in the variation of the respective angle of attack and thus of the fluid dynamic pitch of the propeller.

[0085] Consequently, the relative rotation of the drive shaft, or hub 2, relative to the cylindrical body of the propeller 3 results in the rotation of the blades about the axis Y, by an angle that is obviously a function of the relative angle of rotation between hub 2 and cylindrical body of the propeller 3. Preferably, the kinematic system to transmit the rotary motion is of the gear-wheel type, preferably truncated-cone shaped. In more detail, at least one gear wheel is constrained at the root of each blade 4 and at least one toothed pinion is constrained and made rotationally integral with the hub 2.

[0086] Clearly, further embodiments of the at least one kinematic system to convert/transmit the motion can be provided on the condition that the relative rotational motion of the hub 2 with respect to the cylindrical body 3 of the propeller can be converted into the rotational motion of the at least one blade 4 about its pivot axis Y.

[0087] The rotation of the hub 2 provided by the drive unit in a first direction of rotation, preferably clockwise, is usually used for ahead navigation. In contrast, the rotation of the hub 2 given by the drive unit in a second direction of rotation, preferably counterclockwise, is usually used for reverse navigation.

[0088] The propeller further comprises at least one elastic element 8 and at least one housing body 14a, 14b, preferably at least one substantially annular housing

body, for housing this at least one elastic element 8.

[0089] It should be firstly noted that the elastic element 8 described herein is preferably made by means of a foil spring, preferably a foil spring such as those shown in WO2018065800, but other ways of making such elastic elements are not excluded. Typically, therefore, the at least one elastic element 8 for fluid dynamic pitch adjustment comprises at least one spring made by a foil (plate). Such a spring is preferably provided with transverse notches and folded in the shape of a bush. Advantageously, the leaf spring can be folded to form a kind of bush that is housed in at least one housing body 14a, 14b.

[0090] Specifically, the propeller 1 has at least one housing body 14a, 14b, preferably a pair of housing bodies 14a, 14b, arranged around the elastic element 8, which is rotatable about the axis A relative to the cylindrical body 3, and thus typically relative to the hub 2 as well.

[0091] To promote the relative rotation between housing body 14a, 14b and cylindrical body 3, a cavity 16 is preferably arranged between the two elements, which is adapted to reduce the friction between the at least one housing body 14a, 14b and the cylindrical body 3, thus allowing greater freedom of movement for the elastic element. It is also possible to arrange lubricants such as grease and the like within the cavity 16.

[0092] The elastic element 8 can then be compressed and expanded inside the at least one housing body 14a, 14b, and each housing body 14a, 14b can rotate relative to the cylindrical body 3.

[0093] The at least one housing body 14a, 14b is preferably made of metal material, typically bronze. Each housing body 14a, 14b typically has annular shape so that it can be arranged around the elastic element 8.

[0094] As discussed, in preferred embodiments, there is at least one pair of housing bodies 14a, 14b arranged opposite each other, typically symmetrically, relative to a plane P, which is perpendicular to the axis of rotation A. The housing bodies, therefore, are arranged laterally with respect to such a plane P (which in Figure 3 is visible as a straight line), and are preferably also arranged laterally with respect to the preload adjusting device 30, better discussed later. In other words, the housing bodies are arranged at a distance 17 (measured in a direction parallel to the axis A, i.e., an axial direction with respect to the axis of rotation A) such that the contact between the housing bodies 14a, 14b and the preload adjusting device 30 is prevented, thus allowing the housing bodies 14a, 14b to rotate without running into the adjusting device 30.

[0095] The at least one housing body 14a, 14b typically has a thinner portion 141 arranged, in use, outside the elastic element 8 or radially to the axis A, and a thicker portion 142 partially arranged laterally to the section of the elastic element 8, so as to abut against the elastic element 8. Therefore, the housing bodies 14a, 14b preferably have an "L" shape.

[0096] The propeller 1 further comprises end-stop

bodies 15a, 15b for the elastic element 8. The end-stop bodies 15a, 15b define the maximum angular position for each end of the elastic element 8. Preferably, the same end-stop body 15a, 15b defines the maximum angular position of each end of the elastic element 8. Therefore, each end-stop body has a first end adapted to contact the first end of the elastic element, as shown in Figure 2A, and a second end adapted to contact the second end of the elastic element, as shown in Figures 2B and 2C.

[0097] This allows the elastic element to be assembled within the at least one housing body 14a, 14b, and also allows proper operation of the adjusting device 30, better discussed later. In particular, the end-stop body allows the first end of the elastic element to face the seat of the adjusting device 30 even when the adjusting device 30 is removed from (or not yet inserted into) the propeller 1. As described, the propeller 1 comprises an adjusting device 30 to adjust at least the preload of the elastic element 8, preferably in the form of one or more screws.

[0098] Therefore, a screw that functions as an adjusting device 30 preferably comprises at least one shank 30b and one tightening head 30a that can reach a position of contact with at least one abutment portion of the seat 31 of the cylindrical body of the propeller in which it is installed.

[0099] According to a possible embodiment, such as the one shown in Figure 2, the adjusting device 30 comprises a terminal portion 300 (or tip) adapted to contact the elastic element 8, preferably an end 8a of said elastic element.

[0100] According to possible embodiments, the terminal portion 300, or tip, has a tapered, or conical, or spherical shape, or a combination of one or more of the above.

[0101] In general, the terminal portion 300 of the preload adjusting device 30 is movable (integrally with), and in particular can rotate together, with respect to the body of the preload adjusting element, for example the screw shank 30b or preload adjusting rod 30.

[0102] The terminal portion 300 or tip can be made in one piece with the body of the preload adjusting element, such as the screw shank or preload adjusting rod, or it can be constrained so as to be integral with the body of the preload adjusting element, such as the screw shank.

[0103] Possible embodiments in which the terminal portion 300 of the adjusting device 30 can rotate relative to the body thereof, such as relative to the screw shank 30b or the preload adjusting rod 30 to which the terminal portion is constrained, are not excluded.

[0104] Advantageously, the terminal portion 300 allows the preload to be applied to the elastic element smoothly and without applying stresses, particularly as a result of rotation about the axis X of the adjusting device 30.

[0105] In other words, thanks to the surface tapered, or conical or spherical, and in general having a small diameter, undesirable torques, that undesirably deform the elastic element in a plane perpendicular to the extent of

the propeller axis and that can be generated as a result of the rotation about the axis X of the adjusting device 30, can be prevented, allowing instead the effective deformation of the elastic element in the direction of its main longitudinal extent.

[0106] The terminal portion 300 or the entire adjusting device 30 is made of high-hardness material. Preferably, the adjusting device 30 is shaped so as to define a single operating position for the user, such as by means of a full screwing of an adjusting device within its seat, or otherwise by means of reaching a predefined end stop for the insertion of the adjusting device 30 into the cylindrical body 3.

[0107] It should be noted that the term "screw" is used herein to refer to any item provided with at least one threaded shank having a predetermined length. The screw, and in general any other element, may further be equipped with at least one portion, or head, that can reach at least one position of contact with at least one abutment portion of the seat within which the screw is installed.

[0108] It should be noticed that the propeller according to the present invention may comprise a plurality of threaded elements having lengths different from each other. By doing so, the different elements of the adjusting device 30 can each define a specific preload of the elastic element, or use a locking grub screw in an intermediate position.

[0109] Several adjusting devices 30, or screws, of different lengths, which are interchangeable with each other, can thus be available to the user, in order to adjust the preload of the elastic element as desired.

[0110] In general, propellers with non-interchangeable adjustable screws or with multiple screws having different lengths are, for example, described in US 10,336,421 and US 9,533,745 B2, in the name of the Applicant.

[0111] As discussed, the adjusting device 30 adjusts "at least" the preload and, preferably, adjusts (alternately) the pitch of at least one blade 4 and the preload of the elastic element.

[0112] Specifically, in preferred embodiments, for a first part of its travel, the adjusting device 30 adjusts the pitch of at least one blade 4, and for a second part of its travel the adjusting device 30 adjusts the preload of the elastic element 8.

[0113] According to a preferred aspect, when the adjusting device 30 is not inserted or otherwise is not acting on the elastic element 8, the elastic element 8 is indeed at its maximum extension within the propeller 1, that is, within the at least one housing body 14a, 14b. In such a position, the hub 2 (or the thrust element 11 integral with the hub 2, better described below) is at an angular distance α from its own end stop of rotation relative to the cylindrical body of the propeller, typically defined by, or otherwise placed at, the end-stop body 15a, 15b.

[0114] For a first part of the insertion travel of the adjusting device 30 into the cylindrical body 3, therefore, the adjusting device pushes the elastic element 8, which

in turn pushes the hub, thus causing it to rotate relative to the cylindrical body 3. As discussed, such relative rotation causes a change in the pitch of the at least one blade 4 of the propeller 1. This stage lasts until the hub 2 has completed a rotation equal to α . In that stage, the elastic element is not compressed (or at any rate is only minimally compressed), so that it acts essentially as a rigid body. At that stage, therefore, the adjusting device allows the pitch of the at least one blade to be varied by rotating the hub 2 by means of the elastic body 8 without varying the preload of the elastic element 8. Subsequently, typically due to the elastic element reaching an element of the cylindrical body 3, for example a surface of an end-stop body 15a, 15b (as for example shown in Figure 2B), the elastic element is no longer able to rotate the hub 2 in the direction toward which it is pushed by the adjusting device 30.

[0115] Therefore, further inserting the adjusting element 30 into the cylindrical body causes the elastic element 8 to be compressed, without rotating the hub 2 and the cylindrical body 3 relative to each other. This compression, shown as angle β in the figures, causes a change in the preload of the elastic element 8, without changing the pitch of the at least one blade 4.

[0116] Therefore, when the adjusting device 30, in a first part of its travel, acts on an end of the elastic element 8, the adjusting device 30 causes the first end 8a of the elastic element 8 to be angularly displaced by an angle α . At that stage, however, the other end of the elastic element also moves by substantially the same angle α , in a manner integral with the hub. In the second part of its travel, the adjusting device causes an additional angular movement of the first end 8a of the elastic element 8 by an angle β . Since the other end of the elastic element 8 is now integral with cylindrical body 3 (typically through contact between the elastic element 8 and an end-stop body 15a, 15b), the hub 2 can no longer rotate relative to the cylindrical body 3. Accordingly, in this second part of the travel, the elastic element 8 is compressed by an angle β . In other words, in a first part of its own travel, the adjusting device causes an angular translation of the elastic element by an angle α , and in a second part of its own travel, the adjusting device 30 compresses the elastic element 8 by an angle β .

[0117] However, this doesn't exclude embodiments in which the first part of the travel of the adjusting device 30 is not present. In these embodiments, therefore, the translation angle α of the elastic element 8 is absent, so that the insertion of the adjusting device 30 causes only a compression (by an angle β) of the elastic element 8.

[0118] The cylindrical body 3 has a seat 3a for the adjusting device 30.

[0119] Such seat 3a can have different shapes. For example, as in the embodiments of Figures 1 - 3, the seat 3a may protrude with respect to the rest of the cylindrical body 3. Thus, the cylindrical body 3 has a substantially circular shape, in a section in a plane perpendicular to the

axis of rotation of the propeller, except for the protrusion formed by the seat 3a. This solution is easy to implement but may have drawbacks to the appearance of the propeller.

[0120] In possible embodiments, therefore, such as the one in Figures 4 and 5, and in the one of Figure 6, the seat 3a is arranged inside the cylindrical body 3, so that it does not protrude with respect to the rest of the cylindrical body 3, that is, so that it does not protrude relative to the circular geometry thereof. It should be noted that in Figure 5 the seat 3a has two holes. A first through-hole 31a is for the adjusting device 30. A second hole 32a, typically blind, is to allow a safety grub screw to be inserted, such as described e.g. in US9533745B2. The safety grub screw, among other functions, prevents accidental unscrewing of the adjusting element while the propeller is in use. This safety grub screw is not exclusively for the present embodiment but can also be used in the other embodiments, such as the one of Figures 1 - 3.

[0121] In embodiments in which the seat 3a is inside the cylindrical body 3, the seat 3a can have the same function of the end-stop bodies 15a, 15b, which can then be omitted.

[0122] As e.g. shown in Figure 6 (wherein the upper portion of the section, at the seat 3a, is shown on a different plane with respect to the one of Figure 5), the seat 3a is provided with protrusion 315a, 315b, that are placed laterally with respect to the screw, and they act as end-stop bodies.

[0123] According to a possible aspect of the present invention, the propeller may comprise at least one intermediate thrust element 11 interposed between the hub 2 and the propeller body 3, in particular arranged between the hub 2 and the housing body 14a, 14b. The intermediate thrust element 11 is provided with a first and a second surface 12, 13 of contact with the hub 2, which are spaced from each other and define a cavity, i.e., an angular range of movement of the hub relative to the intermediate thrust element 11. This cavity causes the formation of a space of relative free rotation of the hub 2 with respect to the cylindrical body 3, which allows a modification in the fluid dynamic pitch of the blades 4, as a result of the relative idle rotation of these two components 2 and 3 without the intervention of the at least one elastic element 8.

[0124] The intermediate thrust element 11 is interposed between the hub 2 of the propeller and the cylindrical body 3 thereof, in particular between the hub 2 and the housing body 14a, 14b. According to a possible embodiment, the intermediate thrust element 11 is preferably made in the form of a ring, or at least a portion of a ring, preferably made of metal.

[0125] According to a possible aspect, the connection between the elements constituting the propeller, in particular in the area where the at least one housing body 14a, 14b is located, is configured to prevent lubricant leakage from the propeller 1. In particular, there are elements having portions complementary to each other, so as to form a labyrinth path (denoted schematically in the fig-

ures by the numerical reference 200), for the containment of lubricating fluids/oils, in order to reduce the effects of the frictional forces generated by the relative rotation between the various elements that make up the propeller.

[0126] The labyrinth path 200 is preferably formed by means of two elements 201, 202, for example two elements having annular extent and placed to cover the elastic element 8. A first element 201 is constrained (e.g. by a threaded grub screw or a toothing and an elastic ring) to the propeller body 3, and the second element 202 is constrained (e.g. by a threaded grub screw) to the hub 2.

[0127] In general, these elements 201, 202 are provided with substantially complementary coupling portions 203, 204, 205. These portions are defined as substantially complementary because the portions of a first element are shaped to create seats for the complementary portions of the other element, so as to allow the elements to be interlocked and create a tortuous, or labyrinth-like, path to effectively retain the lubricant.

[0128] Such "interlocking" is actually a coupling with clearance, since the substantially complementary portions 203, 204, 205 are configured in such a way that, in use condition, clearances, i.e., gaps, of limited size are formed between them, so as to allow the sliding coupling of the respective elements while effectively retaining the lubricant. It is indeed the presence of such clearances or spaces that form the labyrinth path 200 for the lubricant.

[0129] As e.g. shown in figure 6, in possible embodiments it is possible to provide a similar labyrinth path 250a, in order to retain the lubricant, at the coupling between the elements of the propeller, in particular between the hub and the propeller body, even in the front portion of the propeller, i.e. forward to the blades 4 (considering a forward motion of the propeller), usually at the tip 400 of the propeller.

[0130] Advantageously, the presence of a labyrinth-like, or tortuous, path allows the lubricating fluid to be better contained at the elastic element and the housing body 14a, 14b so as to ensure proper lubrication and reduce frictional forces.

[0131] A possible method of using the propeller according to the present invention will be described hereinafter.

[0132] The blade 4 is typically arranged with at least one first fluid dynamic pitch, which is fixed according to a preferred embodiment. The adjusting device 30 is operated so as to apply a preload to the elastic element, which may possibly null, i.e. of zero value. In particular, the adjusting device can be only partially inserted, so that the elastic element is translated integrally with the hub relative to the cylindrical body 3 of the propeller.

[0133] In other words, when the insertion of the adjusting device 30 causes the first end 8a of the elastic element to move less than a threshold, that is to say the angle α shown in the figures, the elastic element is not preloaded. When the insertion of the adjusting device causes the first end 8a of the elastic element 8 to move

more than a threshold, i.e., the angle α shown in the figures, the elastic element is preloaded.

[0134] This preload allows the elastic element 8 to be deformed only when the resistant torque countering the rotation of the propeller exceeds the torque provided by the preload of the elastic element 8 housed in the housing body 14a, 14b.

[0135] Before the deformation of the elastic element 8, or more generally when no relative rotation occurs between the hub 2 and the cylindrical body 3, the propeller 1 according to the present invention acts as a fixed-pitch propeller. The first fixed fluid dynamic pitch of the blades 4 is therefore preferably chosen to be the most suitable fluid dynamic pitch for ahead navigation and, in particular, in the first and second stages of propeller use, i.e., in the maneuvering stage and the cruising stage. As the rotation speed of the drive unit increases, the first fluid dynamic pitch of the blades 4 is not immediately modified, and in particular, due to the presence of the elastic element 8, it does not decrease immediately. Actually, the preload of the elastic element 8 causes the first fluid dynamic pitch to remain constant until the resistant torque countering the rotation of the propeller exceeds the torque generated by the preloaded elastic element, and of the respective housing body 14a, 14b where this elastic element is housed.

[0136] Only then, when the resistant torque is greater than the torque generated by the preloaded elastic element, the elastic element 8 can be deformed (and, as a result, the housing body 14a, 14b can rotate) and thus can modify the fluid dynamic pitch, preferably causing it to gradually decrease, so that the drive unit can reach its maximum rotation speed and allow navigation at high speeds in the third stage of the propeller use.

[0137] The relative rotation of the hub 2 with respect to the cylindrical body 3 allows the fluid dynamic pitch of the blades 4 to be modified via the kinematic system that converts the rotational motion of the propeller.

[0138] Advantageously, the preload of the elastic element 8 can be adjusted by the user of the propeller to determine when, and thus under what operating conditions of the propeller and the drive unit, the elastic element starts its operation and thus the housing body 14a, 14b starts to rotate simultaneously with the deformation of this elastic element 8 housed therein, which is deformed to allow the fluid dynamic pitch of the blades to be modified.

[0139] In other words, the method of using the propeller allows the first fluid dynamic pitch to be set, possibly even by successive modifications (successive approximations), and then by gradual changes, preferably through known means (for example described in the Application WO2018065800), and/or the preload of the elastic element 8 to be set, preferably through the adjusting device 30. This way, the user can gradually approach the optimum propeller operation, in terms of first fluid dynamic pitch chosen and in terms of start of rotation of the housing body and start of deformation of the elastic

element held therein for pitch modification, best suited to his or her needs.

[0140] In particular, the presence of the at least one housing body 14a, 14b significantly reduces the friction acting on the elastic element 8, thus allowing a fine adjustment of the preload to be made thereon and allowing it, at least at full operating conditions, to be compressed along its full extent in response to a compression operated by the hub 2 (or by thrust element 11), so that the initial adjustment of the preload 8 actually leads to the desired behavior for the elastic element 8 itself. Therefore, the navigation will be smooth with easily commanded and controlled speed. Therefore, according to a preferred aspect of the invention, if a high preload is applied on the elastic element 8, the starting pitch of the propeller will have a small value. In contrast, if the preload is small, or even of zero value, the starting pitch is high. It is equally easy to deduce that when the engine thrust ceases, the at least one elastic element 8 automatically returns to its initial position, hence the at least one blade 4 is returned to its starting pitch position. The above shows how a further advantageous use of the propeller according to the invention can be obtained when the propeller is used on vessels also equipped with sail propulsion. Indeed, for this type of vessel, a high starting pitch can be set close to 90°, that is, close to the feathered position. When the engine thrust ceases, the elastic element 8 pushes the at least one blade 4 to the feathered position (or to a position very close to the feathered position) fully automatically and quickly, without the need to lock the rotation of the propeller shaft and without the need for the boat to be moving forward at a speed of at least 5-6 knots.

Claims

1. Propeller (1) comprising a cylindrical body (3), a hub (2) couplable to a drive unit and rotatably assembled at least partially in said cylindrical body of the propeller, and at least one blade (4) rotatably pivoted to said cylindrical body of the propeller, said hub (2) being rotatable relative to said cylindrical body of the propeller, or vice versa, for adjusting the fluid dynamic pitch of said at least one blade (4), the propeller further comprising at least one elastic element (8) for adjusting the fluid dynamic pitch of said at least one blade (4) and an adjusting device (30) for adjusting at least the preload of said at least one elastic element (8), **characterized by** comprising at least one housing body (14a, 14b) interposed between said elastic element (8) and said cylindrical body (3), said elastic element (8) being housed in said at least one housing body (14a, 14b), said housing body (14a, 14b) being rotatable relative to said cylindrical body (3).
2. Propeller according to claim 1, comprising a pair of housing bodies (14a, 14b) arranged opposite each

other relative to a plane perpendicular to the axis of rotation of the hub.

3. Propeller according to claim 1 or 2, wherein each housing body (14a, 14b) has a substantially annular shape around the elastic element. 5
4. Propeller according to one of the preceding claims, configured so that said adjusting device (30) is provided with a travel, so that in a first portion of said travel, said adjusting device pushes said elastic element, which in turn pushes said hub to rotate relative to said cylindrical body so as to vary the fluid dynamic pitch of said at least one blade (4), and in a second portion of said travel said adjusting device continues to push against said elastic element, the relative rotation between said hub and said cylindrical body being prevented, so as to compress said elastic element between said adjusting device and said cylindrical body (3), so as to cause the preload of said elastic element to be increased. 10 15 20
5. Propeller according to one or more of the preceding claims, wherein said cylindrical body (3) comprises a seat (3a) for said adjusting device, which protrudes inward from the rest of the cylindrical body (3). 25
6. Propeller according to one of the preceding claims, comprising at least one end-stop body (15a, 15b) for the elastic element (8), preferably a pair of end-stop bodies (15a, 15b), each end-stop body being rotationally integral with the cylindrical body (3) and being arranged to define the end-stop position for the end of the elastic element opposite the preload modifying device (30). 30 35
7. Propeller according to any one of the preceding claims, wherein said adjusting device (30) is in the form of one or more screws extending through said cylindrical body (3) of the propeller. 40
8. Propeller according to one or more of the preceding claims, wherein each housing body (14a, 14b) is arranged laterally to said adjusting device (30), on at least one plane comprising the axis of rotation of the hub. 45
9. Propeller according to one or more of the preceding claims, comprising a cavity (16) between the at least one cylindrical body of the propeller (3) and the at least one housing body (14a, 14b). 50
10. Propeller according to any one of the preceding claims, comprising an intermediate thrust element (11) interposed between said hub (2) and said housing body (14a, 14b) and configured so that a relative rotation between said hub (2) and said cylindrical body (3) causes said intermediate element (11) to 55

compress the elastic element (8), which is preferably provided with a cavity defining an angular range of free rotation of said hub (2) relative to said cylindrical body (3) of the propeller.

11. Propeller according to one or more of the preceding claims, comprising, at least at said elastic element (8) and/or at the coupling between hub and propeller body at the front portion of the propeller, elements (201, 202) having complementary portions (203, 204, 205), so as to form a labyrinth path (200; 250) for containing lubricants.
12. Method of using a propeller (1) according to any one of the preceding claims, rotationally coupled to a drive unit, wherein a preload of said elastic element is equal to or greater than zero and is provided by said preload modifying device (30), wherein when the thrust (F2) of the hub (2) exceeds the preload (F1) of the adjusting element (30), a compression of the elastic element (8) within said at least one housing body (14a, 14b) takes place, thus causing a relative rotation between said hub (2) and said cylindrical body (3), which in turn causes the pitch of said blade (4) to be changed.

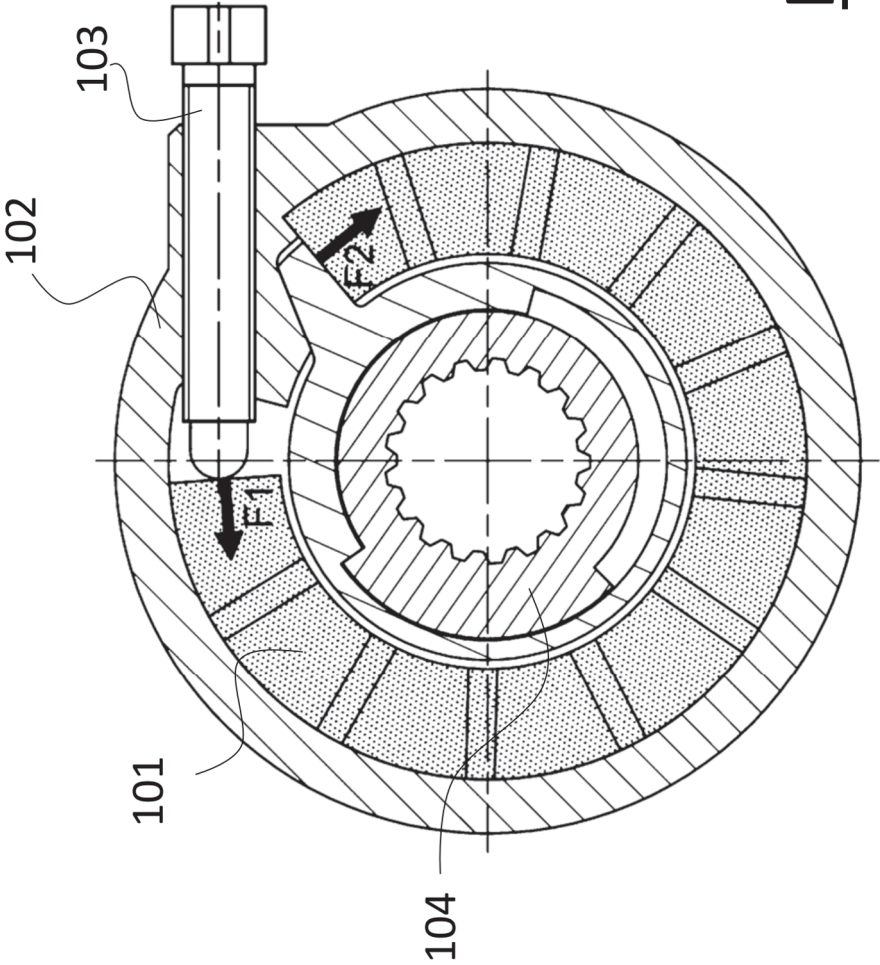


Fig. 1

Fig. 2B

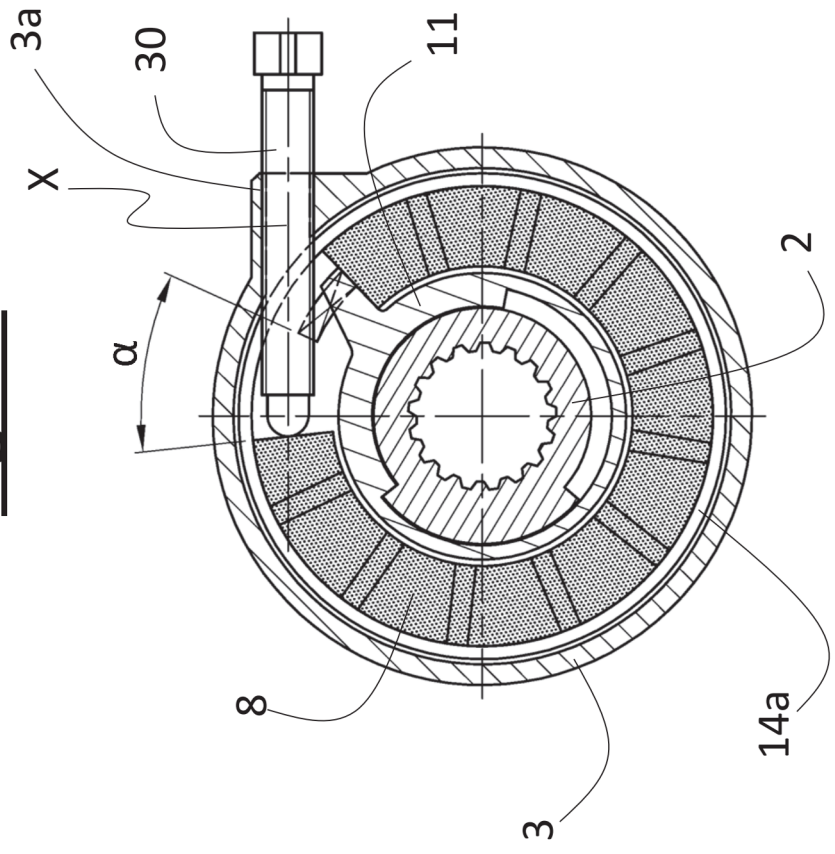


Fig. 2A

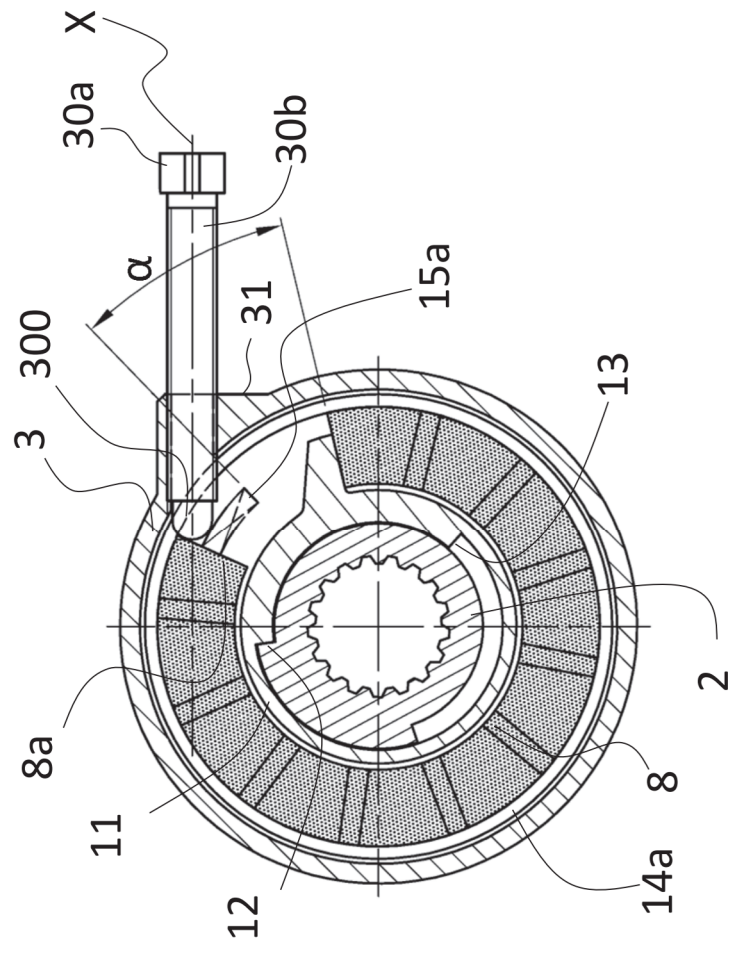
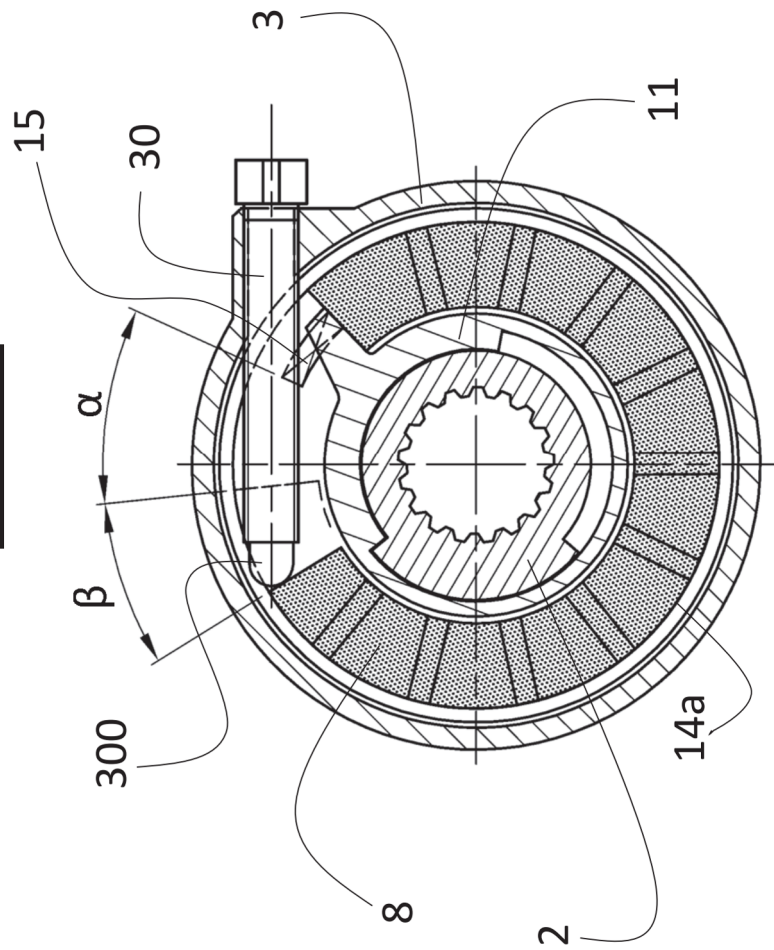


Fig. 2C



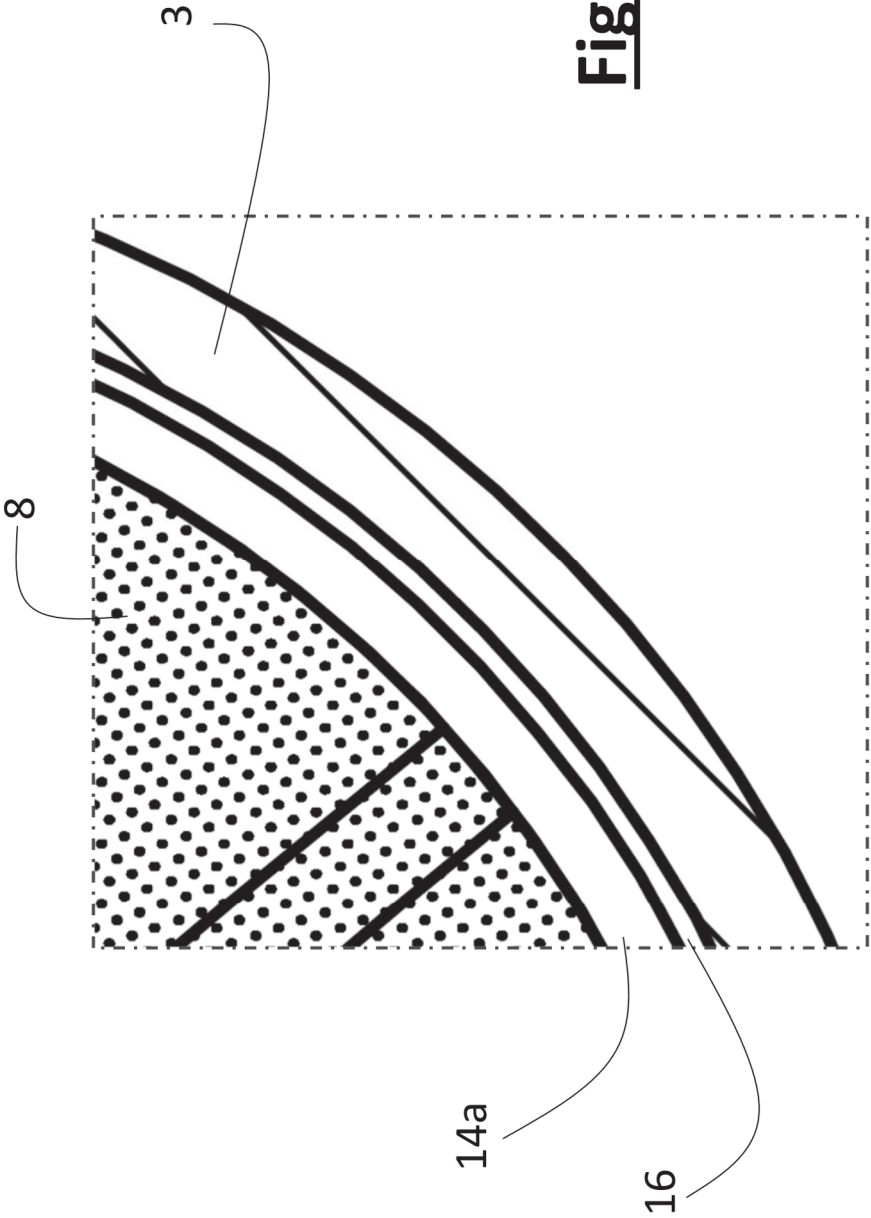
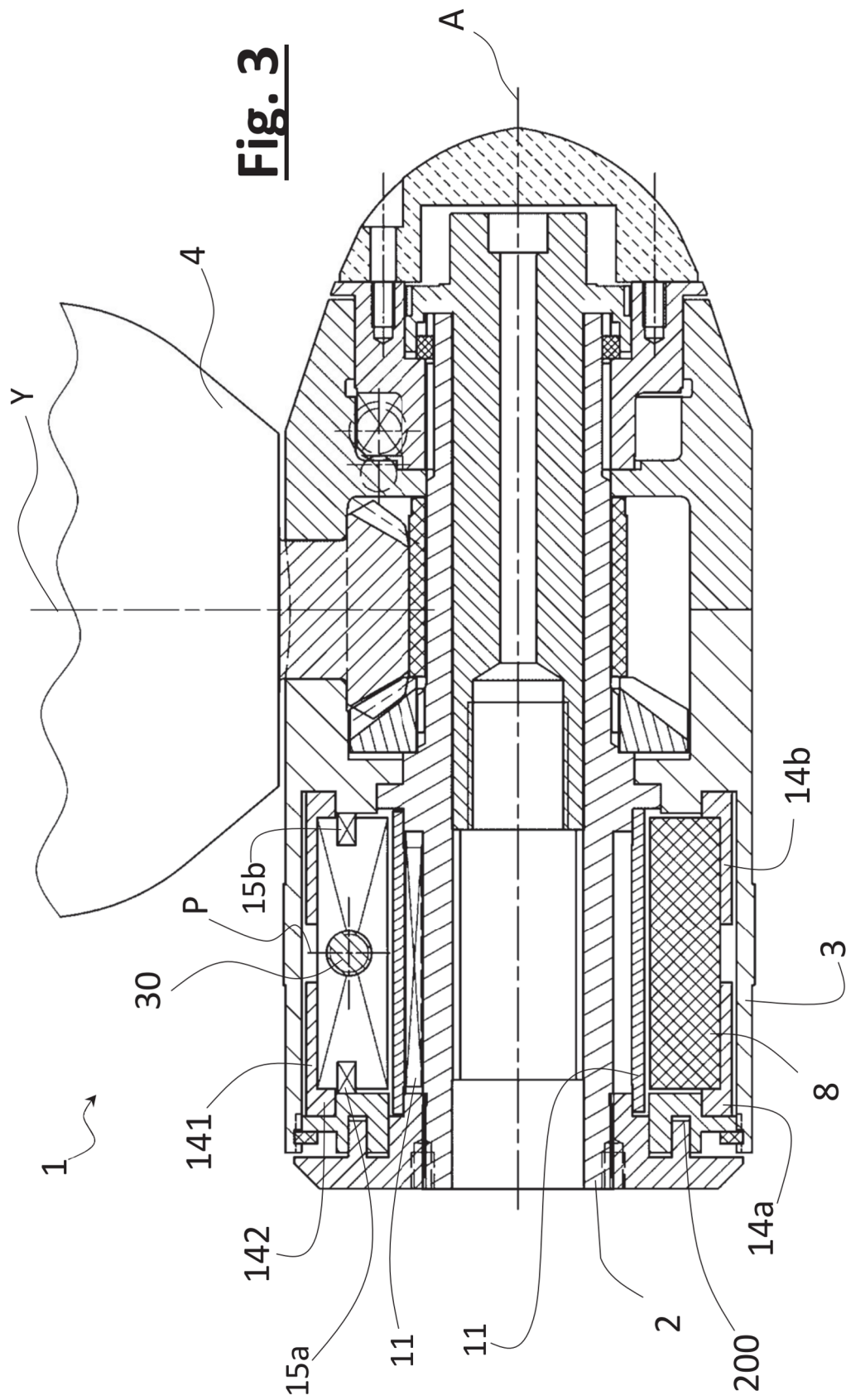


Fig. 2D



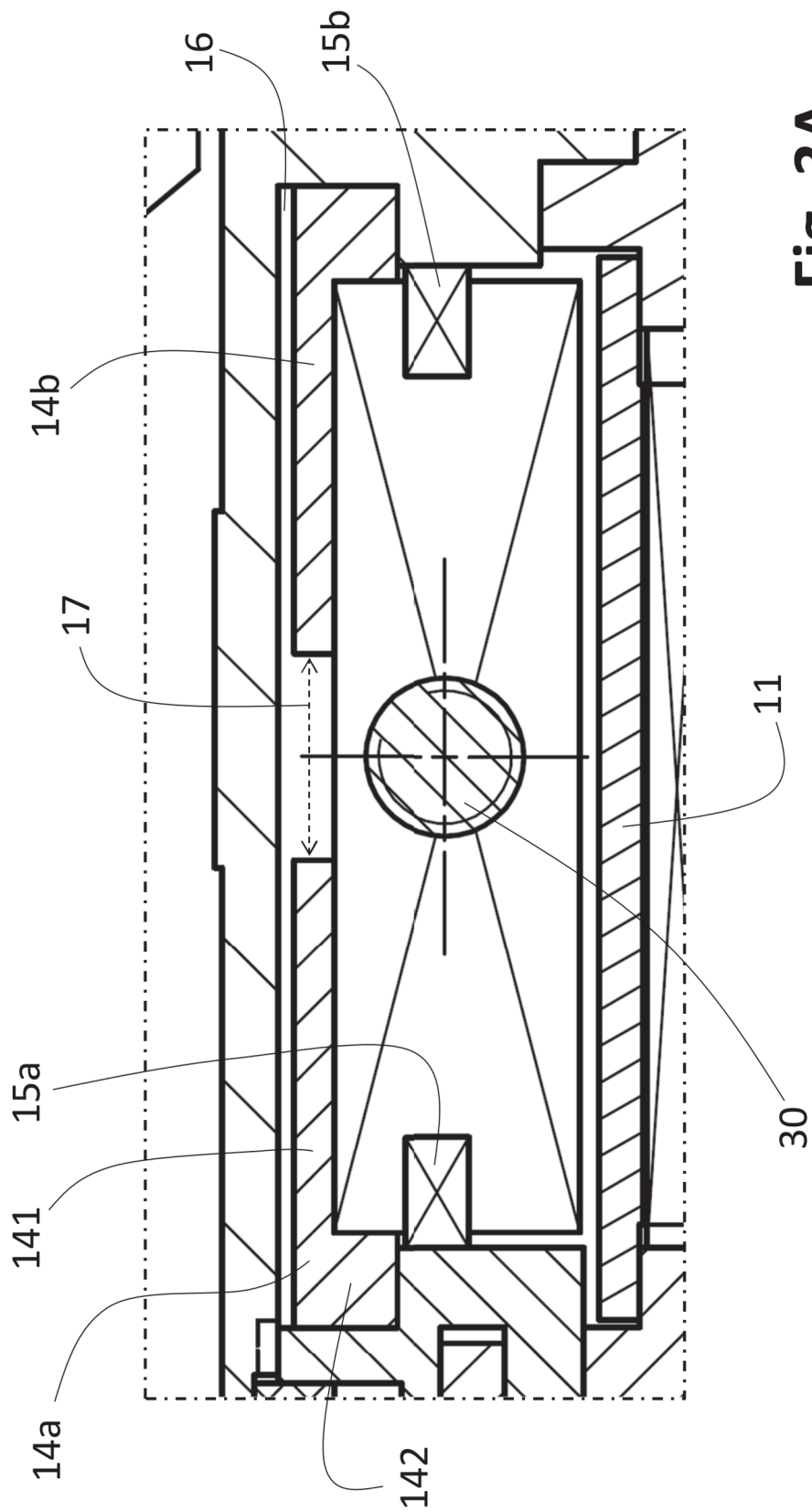


Fig. 3A

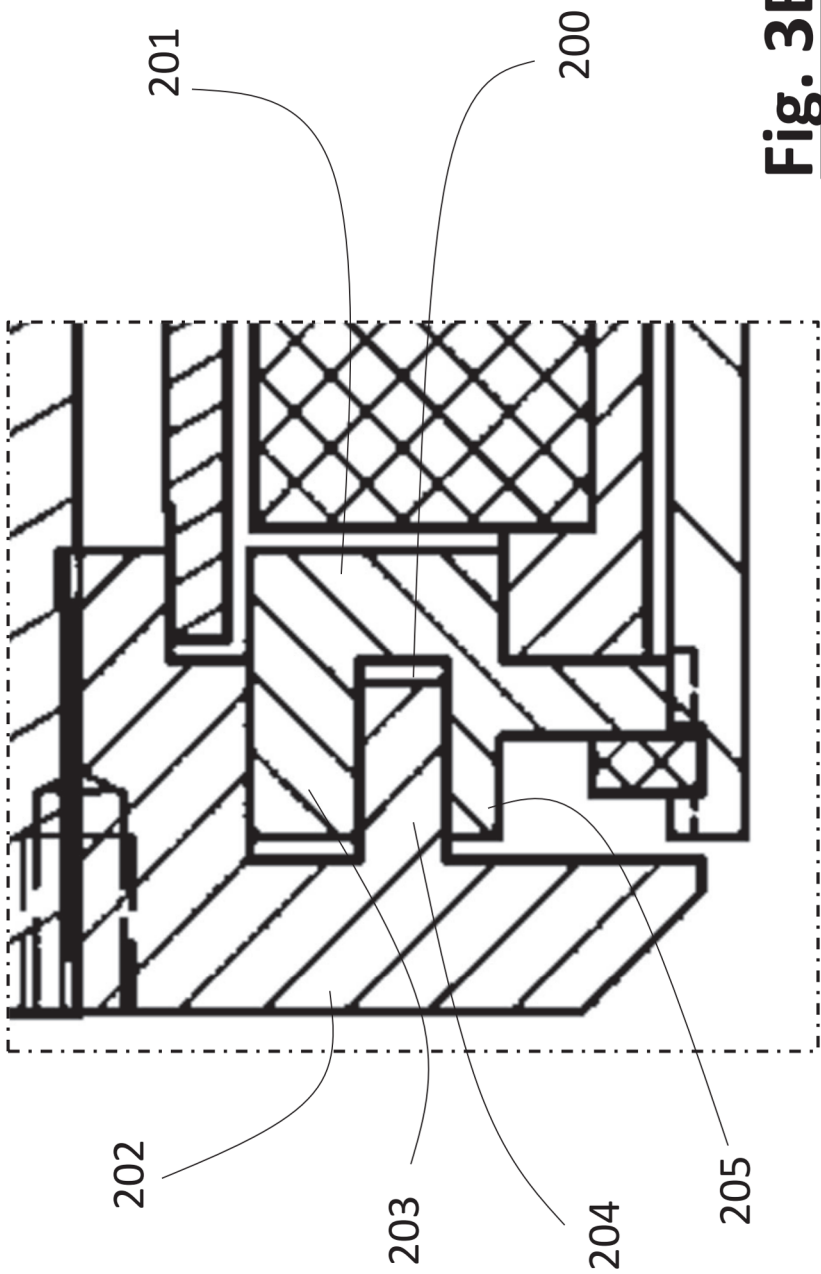


Fig. 3B

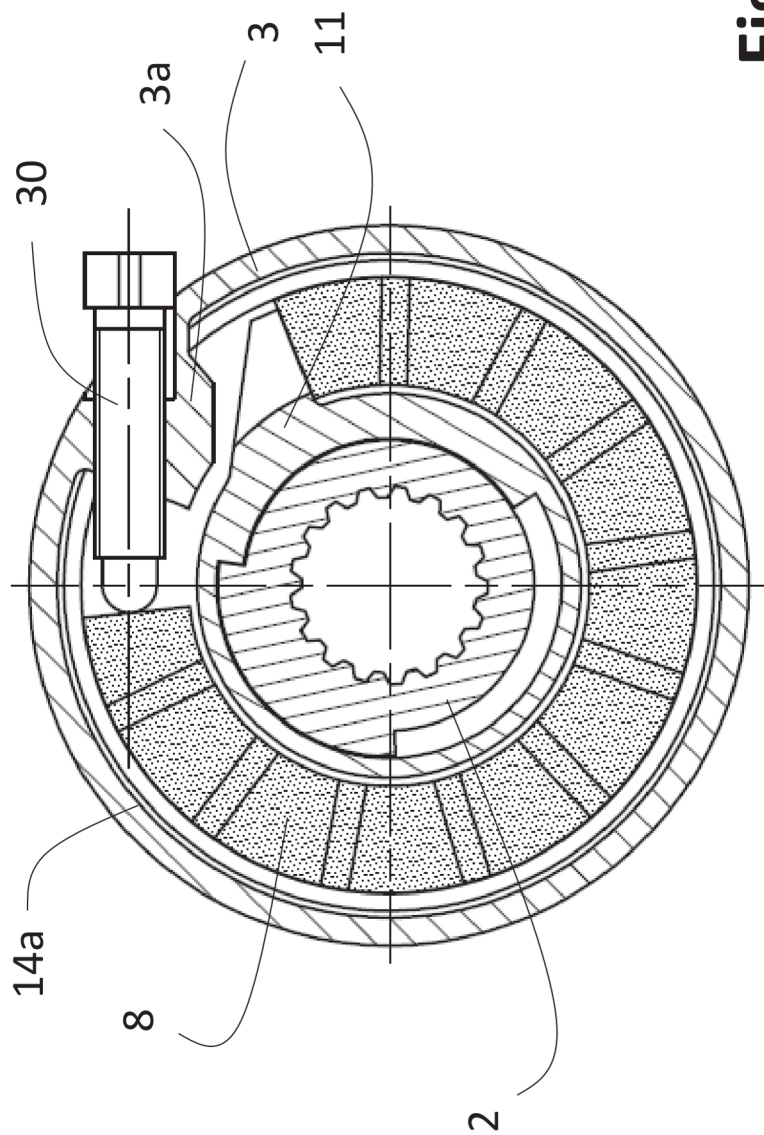


Fig. 4

Fig. 5

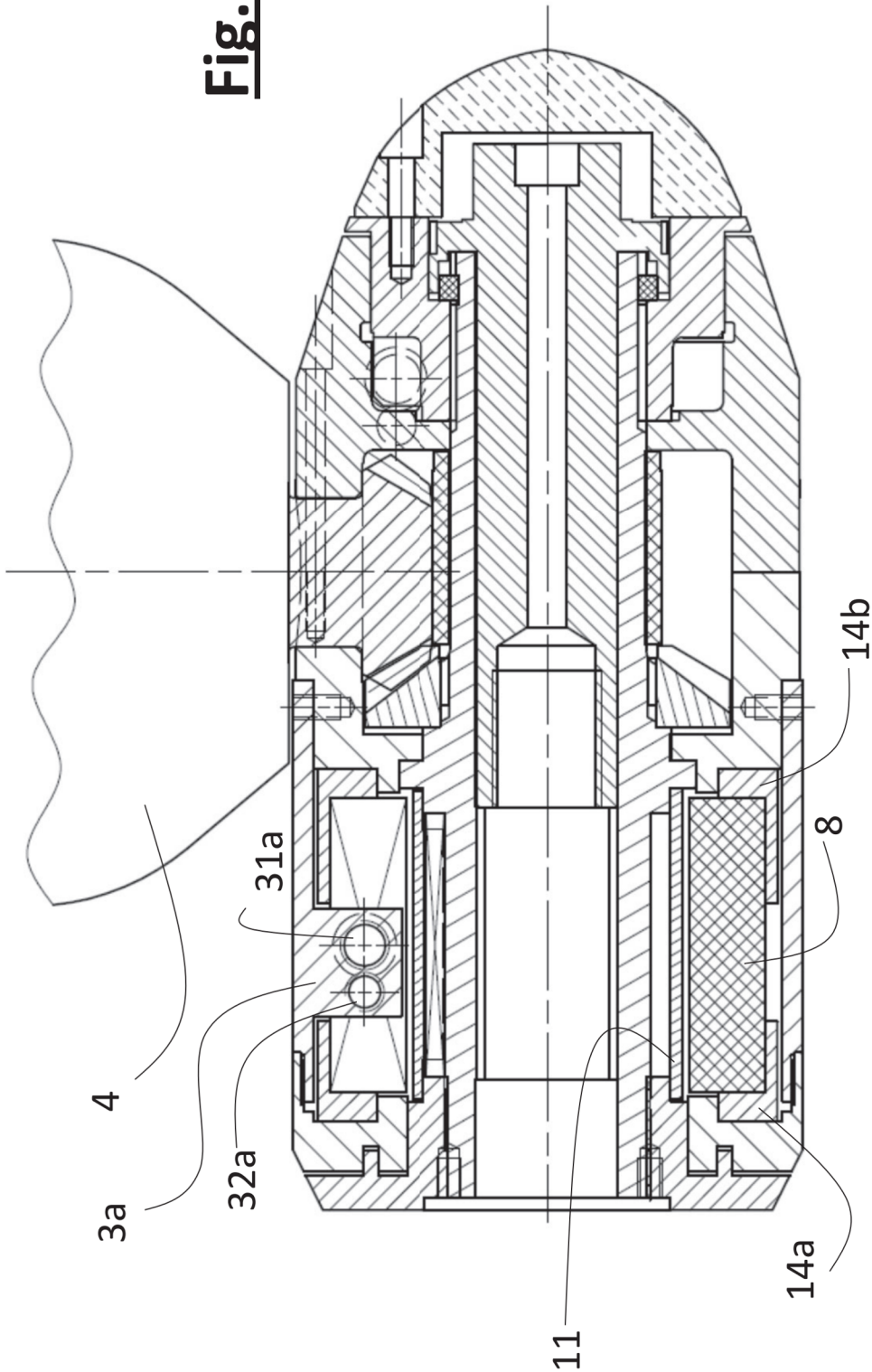
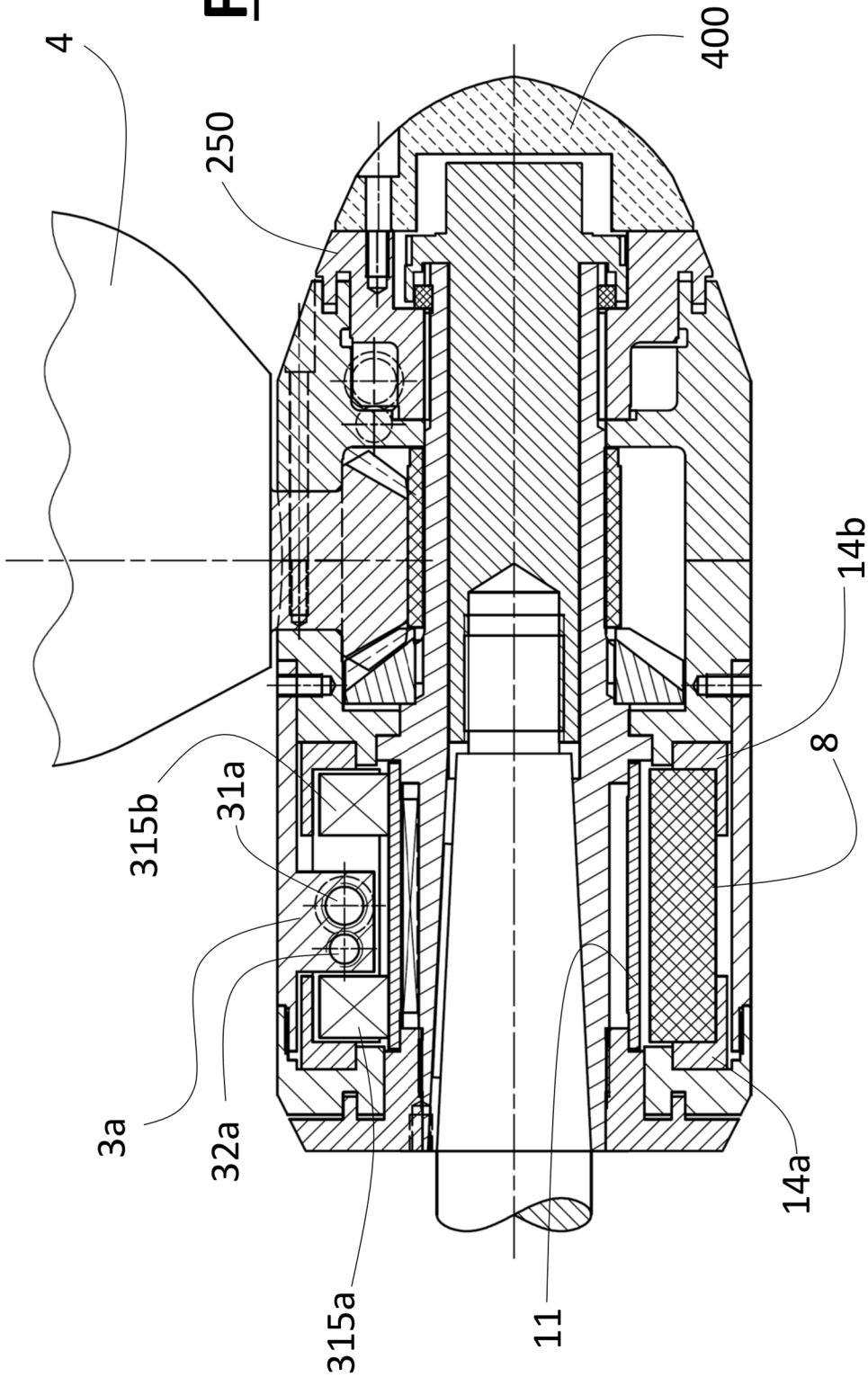


Fig. 6





EUROPEAN SEARCH REPORT

Application Number

EP 25 20 7979

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2012/007971 A1 (MAX PROP S R L [IT]; BIANCHI MASSIMILIAN [IT]) 19 January 2012 (2012-01-19) * page 14, line 29 - page 15, line 4; figures 1, 4 *	1-12	INV. B63H3/00
A,D	WO 2018/065800 A1 (BIANCHI MASSIMILIANO [IT]) 12 April 2018 (2018-04-12) * figures *	1-12	
A	US 4 929 153 A (SPEER STEPHEN R [US]) 29 May 1990 (1990-05-29) * column 11, line 53 - line 56 * * column 14, line 20 - line 25 * * figures 3, 4 *	1-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		7 March 2026	Schmitter, Thierry
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T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 25 20 7979

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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07-03-2026

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