

## Submersible

The invention relates to a submersible having a hull, which comprises a bottom hull in the area of its underside, wherein a flow channel is accommodated at least sectionally in the hull or wherein a flow channel is assigned to the hull, wherein the flow channel comprises a flow outlet in the area of the stern, wherein the flow channel is disposed, at least sectionally, inside a flow channel mount, in particular a bulge, protruding from the bottom hull, wherein a water acceleration device, in particular a propeller, which can be driven directly or indirectly by a motor via a drive shaft, is disposed in the flow channel, and wherein the axis of rotation of the drive shaft forms a virtual thrust axis.

Submersibles according to the invention are, for instance, swimming and diving aids. They can be used to pull a user, wherein the submersible is capable of switching between surface travel and submerged travel. In particular, the submersible can be designed to switch between surface travel and submerged travel solely by shifting weight.

A submersible according to the invention may, for instance, be such that it has a support surface on its topside, on which support surface a user can rest part of the user's body.

For instance, the submersible may comprise a handle each on the starboard side and on the port side, which handle a user can hold on to during travel. In particular, the handle may also be equipped with operating elements that can be used to control the functions of the submersible.

In particular, the submersible may be set up such that a user can rest part of their upper body in the stern section during travel.

For instance, one or more control elements may be used to vary the speed of an electric motor used to drive the propeller in the flow channel. Preferably, submersibles in the context of the invention can be such that they are driven at a speed of less than 4000rpm, particularly preferably at a speed of less than 3000rpm at the drive shaft, to be able to achieve a suitable drive power for both surface and underwater travel.

Preferably, in submersibles according to the invention, the handles can be disposed in the front part of the watercraft, in particular in the bow area of the submersible.

- 5 Furthermore, a submersible according to the invention may comprise a display, which is disposed in the user's field of vision and which is designed to display functions and/or operating states of the submersible.

10 DE 10 2013 100 544 A1 describes a swimming and diving aid, in which a flow channel is incorporated in the hull. A propeller is disposed in the flow channel, which propeller is driven by an electric motor via a drive shaft. The electric motor is powered by rechargeable batteries, which are also located in the hull.

15 Another submersible that can be used as a swimming and diving aid is known from US 2015/0217847 A1. A drive unit comprising a flow channel is attached to the bottom hull of the submersible. In the floating position of the watercraft at rest, i.e. not in driving mode, the axis of rotation of the drive shaft, which drives the propeller in the flow channel, is oriented horizontally. This creates a horizontally oriented thrust plane. During surface travel, the hull-side dynamic pressure acting on the bottom hull  
20 generates a righting moment that causes the submersible to lean. This increases the water resistance.

The invention addresses the problem of providing a submersible of the type mentioned at the beginning, which is designed to be flow-optimized both for surface travel and for  
25 submerged travel.

This problem is solved by the features of claim 1. Accordingly, provision is made for downwards directed sliding surfaces, which end above the thrust axis in the stern area of the vehicle, to bilaterally adjoin the flow channel mount, in particular to the bulge at  
30 the bottom hull, such that a bow tip section of the hull is formed, which, starting from the bow tip in the direction of the vehicle stern, extends along a length of at most 10%, preferably at most 5%, particularly preferably at most 2.5%, of the vehicle length measured from the bow tip to the stern end, and for the virtual thrust axis to be inclined downwards from the bow towards the stern and for it to intersect the bow tip section.

As a result of the thrust axis being set at an angle to the rear and downwards, a water jet is generated, which is directed diagonally downwards during surface travel. This results in a thrust component that acts vertically downwards. This thrust component aims to righten the submersible at the stern section. However, this is counteracted by the frontal flow of the submersible (and possibly the weight of the part of the user's upper body that rests on the submersible at the stern section), which tries to raise the hull at the bow. As a result, the water position of the submersible is stabilized and the flow resistance is kept low. The sliding surfaces provided according to the invention are used to enable the watercraft to slide on the water surface. Accordingly, the sliding surfaces can be used to transfer the submersible from displacement travel to sliding travel. This reduces the incident-flow surface facing the water, such that during surface travel significantly higher speeds can be achieved compared to conventional submersibles.

Furthermore, the inclined thrust axis simplifies the transition to submerged travel or a descent, as the aforementioned vertical thrust force component then supports the descent behavior after the bow is tilted downwards. During submerged travel, the user can tilt the submersible to stabilize it in its underwater position and then take up the desired direction of travel. During submerged travel, the sliding surfaces have little or no effect on the driving characteristics, so that this driving mode is also optimized.

According to a preferred variant of the invention, provision may be made for the sliding surfaces at the stern to end in end sections in the area of the flow outlet of the flow channel. This creates generously dimensioned and therefore effective sliding surfaces.

To guarantee stable sliding travel, according to a variant of the invention provision is made for the central longitudinal plane to intersect the boundary rim of the flow outlet at an upper boundary point, for a boundary line intersecting the bow tip and the upper boundary point to be provided, for the boundary line to lie in a horizontal plane, wherein two vectors spanning the horizontal plane are disposed such that the first vector extends in the direction of the boundary line and the second vector extends perpendicular thereto between the port and starboard sides in parallel to the thrust plane, and for the stern ends of the sliding surfaces to intersect the horizontal plane,

or for the stern ends of the sliding surfaces to be disposed at a maximum distance from the horizontal plane and below the horizontal plane by the dimension  $M = 0.2 \cdot X$ , preferably  $M = 0.1 \cdot X$ , wherein  $X$  is the maximum clear opening dimension of the flow outlet.

5

To guarantee sufficient propulsion during surface travel, in particular during sliding travel, according to one variant of the invention provision is made for the flow outlet of the flow channel to protrude in the direction of the underside of the bottom hull at least as far as the thrust axis beyond the stern ends of the end sections of the sliding surfaces, for preferably at least 75%, more preferably at least 90%, particularly preferably the whole of the cross-sectional area of the flow outlet to protrude beyond the stern ends of the end sections of the sliding surfaces.

A variant of the invention can be characterized in that the end sections of the sliding surfaces each merge into a sliding surface front section in the direction of the bow, in that the sliding surface front sections each form a transition section at their ends facing away from the end section, which transition section extends in the direction of the bow, and in that the transition sections of the front sections each extend laterally of the inlet opening of the flow channel. This results in an efficient and space-saving design. Preferably, the area of the flow channel that forms the inlet opening into the flow channel protrudes at least sectionally beyond the transition sections in the direction of the underside, preferably at least 50%, more preferably at least 75%, particularly preferably at least 85% of the cross-sectional area of the inlet opening protrudes downwards beyond the transition sections. This guarantees that the flow channel is always supplied with a sufficient amount of water in every driving situation.

According to one variant of the invention, provision may be made for the sliding surfaces to extend from the stern end of the sliding surfaces at least along 30%, preferably at least along 40%, particularly preferably at least along 50%, of the vehicle length, laterally next to the flow channel and above the thrust plane in the direction of the bow. This creates sufficiently large sliding surfaces on the submersible in a space-saving manner.

A submersible according to the invention can be such that at least one rechargeable battery for supplying the motor with electricity is accommodated in the vehicle hull, and that the volume occupied by the rechargeable battery is disposed for the most part, preferably completely, above the thrust axis. This makes for a space-saving design and at the same time a good weight trim of the submersible both above and below water.

Preferably, provision may also be made for two rechargeable batteries to be accommodated in the vehicle hull, which rechargeable batteries are disposed on both sides of the thrust axis, and for the volume occupied by both rechargeable batteries to be disposed for the most part, preferably completely, above the thrust axis. This means that one of the rechargeable batteries is located on the starboard side and the other on the port side. This further improves the weight trim in favor of driving stability. Preferably, the rechargeable batteries are disposed symmetrically to the central longitudinal plane of the submersible.

A preferred variant of the invention can be such that the thrust axis lies in a thrust plane, wherein two vectors spanning the thrust plane are disposed such that the first vector extends horizontally from the port side to the starboard side in the direction of the thrust axis and the second vector extends horizontally perpendicular thereto in the floating position and in the rest position of the submersible, wherein a central longitudinal plane perpendicular to the thrust plane and incorporating the thrust axis is provided, and that the sliding surfaces intersect the thrust plane in the area of the vehicle hull, the thrust axis, wherein preferably provision is made for the sliding surfaces to intersect the thrust plane in an area, which is disposed at a distance of 25% of the vehicle length from the bow end and/or the stern end, respectively. This results in a good moment equilibrium during surface travel of the submersible.

Preferably, provision may be made for the sliding surfaces to intersect the thrust plane in an area that is spaced apart from the stern end by at least 20% and at most 60% of the maximum vehicle length, preferably by at least 20% and at most 50% of the maximum vehicle length, further preferably by at least 20% and at most 40% of the maximum vehicle length. By shifting the cutting areas towards the center of the vehicle, a particularly maneuverable design of the submersible is created. Particularly good

driving characteristics for compactly built submersibles are achieved in particular if provision is made for the sliding surfaces to intersect the thrust plane in an area that is spaced apart from the stern end by at least 25% and at most 40% of the maximum vehicle length.

5

One conceivable variant of the invention is such that each sliding surface comprises a mean virtual sliding surface plane and/or a plane surface, wherein the mean virtual sliding surface plane is arranged such that equal proportions of the surface parts of the sliding surface extend above and below this mean virtual sliding surface plane, and that the plane surface or the mean virtual sliding surface plane forms a sliding angle open towards the stern with the thrust plane. Such a design makes for good sliding behavior and stable surface sliding travel. If the watercraft is doing submerged travel, the sliding surfaces lose their buoyant effect due to their inclination, or at least this buoyant effect is greatly reduced. This makes for stable submerged travel.

15

Preferably, provision is made for the sliding angle to be selected in the range from 2° to 20°, preferably in the range from 4° to 15°, particularly preferably in the range from 10° to 14°. It is then possible to switch dynamically between sliding travel and submerged travel. In particular, an angle range from 4° to 15° results in a good compromise between good sliding properties and a good flow to the watercraft during submerged travel. An angle range from 10° to 14° is designed optimized for sliding travel.

20

A preferred variant of the invention can be such that the projections of the boundary line and the plane surface of the sliding surface or the mean virtual sliding surface plane into the central longitudinal plane are at a boundary angle in the range from 3° to 14° to each other, wherein this boundary angle opens towards the bow. The thrust force component, which acts downwards as a result of the thrust axis being adjusted in accordance with the invention, is increased by the angular assignment of the sliding surface to the boundary line of sliding travel. This means that this fast-driving mode can also be sufficiently stabilized. In displacement travel, on the other hand, the inclined position of the thrust axis is smaller, such that a low water resistance acts in favor of energy-efficient operation. These properties are particularly advantageous if provision is made for the limiting angle to be selected in the range from 5° to 12°, particularly preferably from 5° to 10°.

25

30

According to an embodiment of the invention, each sliding surface may comprise a mean virtual sliding surface plane or a plane surface, wherein the mean virtual sliding surface plane is arranged such that equal proportions of the surface parts of the sliding surface extend above and below this mean virtual sliding surface plane, and a reference transverse line of the planar surface or of the mean virtual sliding surface plane, which extends in the direction from the central longitudinal plane towards the assigned starboard or port side of the submersible and which extends through the center of gravity of the planar surface or of the mean virtual sliding surface plane, may form an angle of inclination with the central longitudinal plane, which angle of inclination opens towards the assigned starboard or port side. The mean virtual sliding surface planes or the plane surfaces of the sliding surfaces can preferably be disposed in a V-shape relative to each other. Such a geometry is particularly advantageous for fast cornering, both above and below water. It is also possible that this angle is selected to be equal to  $0^\circ$ . The mean virtual sliding surface planes or the plane surfaces of the sliding surfaces may be aligned with or in parallel to each other.

A watercraft used as a swimming and diving aid must have a compact design. To be able to arrange the sliding surfaces on the bottom hull in such a watercraft in a space-saving manner, provision may be made according to the invention for the maximum width of the submersible, measured perpendicular to the thrust axis from port side to starboard side, to have the dimension  $Y$ , for the flow channel mount, in particular the bulge, to be delimited by two side walls, which are interconnected by means of a connecting section in the area of the underside of the flow channel mount, for the sliding surfaces to adjoin the side walls on the underside of the bottom hull on both sides, wherein the sliding surfaces extend transverse to the side walls in the direction of the assigned port or starboard side, respectively, and for the distance dimension bridging the sliding surface between the side walls and the assigned starboard or port side not to fall below the dimension  $Z=0.08*Y$ , preferably  $Z=0.1*Y$ , particularly preferably  $Z=0.15*Y$ , along the entire length of the flow channel mount.

In the case of swimming and diving aids according to the invention, the total maximum vehicle length can be in the range from 0.8m to 1.5m, preferably in the range from 0.9m to 1.25m.

The maximum width of swimming and diving aids according to the invention may, for instance, be in the range from 0.35m to 1.0m, preferably in the range from 0.4m to 0.9m and 0.9m, particularly preferably in the range from 0.4m to 0.85m.

5

A variant of the invention can be such that the thrust axis and the boundary line intersect in the bow area, wherein the intersection point preferably is at a maximum distance of  $0.16 \times$  the maximum overall length of the submersible, preferably at a maximum distance of  $0.2 \times$  the maximum overall length of the submersible from the bow tip. The intersection point should preferably be located inside the hull.

10

The formation of a directed jet, which in particular does not expose the user of the vehicle to the jet or does not expose the user too strongly, is facilitated by the boundary rim delimiting the flow outlet forming a jet outlet surface, through which the water jet generated in the flow channel emerges, wherein the jet outlet surface intersects the boundary line at an angle greater than  $84^\circ$ .

15

The invention is explained in greater detail below based on an exemplary embodiment shown in the drawings. In the figures,

20

Figure 1 shows a perspective view of a submersible in the form of a swimming and diving aid from behind and diagonally above,

Figure 2 shows a perspective view of the submersible shown in Figure 1 from the front and diagonally below,

25

Figure 3 shows a side view of the submersible from the left,

Figure 4 shows another perspective view of the submersible of Figures 1 to 3 from behind and diagonally below,

30

Figure 5a shows a schematic detailed representation along the section marked V-V in Figure 5,

Figure 5 shows the submersible according to the representation of Figure 3, but in a schematized full sectional view,

5 Figure 6 shows the submersible of Figures 1 to 5 viewed from behind and in a floating position when stationary, and

Figure 7 shows the watercraft shown in Figures 1 to 6 from the front.

10 Figures 1 and 2 show a submersible designed as a swimming and diving aid. The submersible has a hull 10.

For instance, as Figure 1 shows, the hull 10 may comprise an upper shell 20. The upper shell 20 may be integrally made or multi-part.

15 A bow tip 21 is formed in the bow area 22 of the submersible. The bow tip 21 forms the front end of the submersible. For instance, the bow tip 21 may be formed by the upper shell 22. However, it is also conceivable that the bow tip 21 is formed by the bottom hull 30. The bottom hull 30 may, for instance, be formed by a lower shell that is connected to the upper shell 20. The lower shell can be designed to be integrally  
20 made or multi-part.

A handle 24 is attached to the upper shell 20 on both the starboard and port sides. At least one control element 25 can be attached to one or both handles 24. The control element(s) 25 can be used to control the functions of the submersible. As can be seen  
25 from the illustrations, the handles 24 are preferably attached in the bow area 22 of the submersible.

A display 23 is disposed centrally, preferably in the area between the two handles 24, in the area of the upper shell 20. Information about the operating status of the  
30 submersible can be shown on the display 23 and read by a user.

The handles 24 are adjoined by arm rests 26 in the direction towards the stern 27 of the watercraft. The armrests 26 extend on the port or starboard side.

Figure 1 also shows that a charging connection 28 may be provided in the area of the upper shell 20. A cover cap covers the charging connection 28. It can be removed to expose the electrical contacts of the charging connection 28. The submersible can be connected to a power supply via the charging connection 28 to charge at least one rechargeable battery 60, which is housed in the hull 10 of the submersible.

Figs. 1 and 2 show that, adjacent to the bow tip 21, the upper shell 20 can be spherical, in particular biconvex. This results in a streamlined shape that is optimized for underwater travel.

The bottom hull 30 can be designed such that it comprises a rounded area 31 adjacent to the bow tip 21, which can be spherical, in particular biconvex. Such a design is flow-optimized for both surface travel and underwater travel.

As Figures 1 and 5 show, there may be a bulge 32 in the rounded area 31, which bulge delimits a space disposed in the hull 10. A component of the submersible can be accommodated therein. For instance, an electric motor 61 and/or a control unit 63, which is installed in the hull 10 in the bow area 22, may be accommodated in the area of the bulge 32 in the hull 10, as shown in Figure 5. In this way, a compact design is supported.

Figures 2 and 4 illustrate that the bottom hull 30 comprises sliding surfaces 37, preferably immediately adjacent to the rounded area 31. The sliding surfaces 37 preferably extend on the port and starboard sides.

The sliding surfaces 37 can preferably be routed up to the stern 27 of the submersible, where they then form end sections 37.3.

The sliding surfaces 37 can be designed as surfaces formed in the three-dimensional space. The sliding surfaces 37 can also be designed as plane surfaces or have at least one such plane surface.

Figures 1 and 4 illustrate that the sliding surfaces 37 extend on both sides of a flow channel mount 38. The flow channel mount 38 protrudes from the bottom of the bottom

hull 30. In this case, the flow channel mount 38 may comprise two side walls 38.1 spaced apart from each other, which are directly or indirectly connected to the sliding surfaces 37, for instance via, preferably concave, rounded transitions 38.3 on the port and starboard sides.

5

The two side walls 38.1 can be interconnected via a connecting section 38.2, wherein the connecting section 38.2 is preferably convex.

10 Preferably, the spherically curved rounded area 32 merges into the sliding surfaces 37, wherein the bow tip 21 is disposed above the sliding surfaces 37. During surface travel of the submersible, the water is then directed under the sliding surfaces 37 to achieve an optimized flow to these areas. In addition, annoying water spray is avoided or prevented.

15 The flow channel mount 38 forms or encloses a partial area of the hull 10, inside which a flow channel 39.2 is accommodated. The flow channel 39.2 forms a flow inlet, approximately in the central area of the submersible. The flow channel 39.2 forms a flow outlet 39 in the area of the stern 27.

20 The flow channel 39.2 can be formed and/or delimited at least sectionally by a one-piece or multi-part hollow body, wherein provision may be made for the hollow body to be held at least sectionally in the flow channel mount 38.

25 Figures 1 and 5 illustrate that the flow outlet 39 is delimited by a, preferably circumferential, boundary rim 39.1.

30 A guide element 33 is disposed in the area of the flow inlet. The guide element 33 can be formed, preferably integrally, with the lower shell forming the bottom hull 30. However, it is also conceivable that the guide element 33 is formed as a separate component, which is connected to the bottom hull 30. The guide element 33 can be designed such that it forms an underside edge 33.1 of a wall 33.3. The edge 33.1 and thus also the wall 33.3 extend in the direction from the bow to the stern 27.

Preferably, the wall 33.3 of the guide element 33 divides the area of the inlet opening into the flow channel 39.2 into two sub-areas. This forms two, preferably separated from each other, feed areas 34.1 and 34.2. The first feed area 34.1 extends on the port side and the second feed area 34.2 on the starboard side.

5

However, the wall 33.3 does not necessarily completely separate the two feed areas 34.1 and 34.2 from each other. In fact, provision may also be made for overflow areas to be formed between the two feed areas 34.1 and 34.2.

10 Furthermore, the guide element 33, preferably adjoining the edge 33.1, may be connected to the connecting section 38.2 of the flow channel mount 38.

As the drawings show, the guide element 33 can be coupled to a connection point 33.4 on the inflow-side edge of the flow channel mount 38. Subsequent to the connection  
15 point 33.4, the guide element forms a fastening section 33.5. This fastening section 33.5 is used to attach, for instance integrally mold, the guide element 33 to the inside of the connecting section 38.2 facing the flow channel 39.2.

Preferably, provision is made for the wall 33.3 to form a fastening section 33.4, which  
20 extends into the flow channel 39.2, such that the wall 33.3 is also connected to the connecting section 38.2 on the inside of the connecting section 38.2 in the direction towards the stern 27 by means of a correspondingly designed fastening section 33.5, as shown in particular in Figure 5.

25 Preferably, the flow channel mount 38 is made integrally with the guide element 33.

The guide element 33 extends in the direction of the stern 27, past the edge of the connecting section 38.2 facing the inlet opening and into the flow channel 39.2 in the area of the connection point 33.4. In this way, the guide element 33 delimits two feed  
30 areas 34.1, 34.2 from each other downstream of this connection point 33.4 in the flow channel 39.2.

Figure 5 also illustrates that preferably the projection of the connection point 33.4 perpendicular to the axis of rotation D of the drive shaft 62 into the thrust plane FE of

the submersible results in a projected connection point 33.4', and that the guide element 33 extends beyond this projected connection point 33.4' into the flow channel 39.2.

- 5 As the drawings show, the guide element 33 extends past a drive shaft 62 in the direction of the topside O of the submersible and perpendicular to the axis of rotation D of the drive shaft 63 into the flow channel 39.2. Opposite from the connection point 33.4, the guide element 33 is directly or indirectly coupled to the flow channel mount 38 or a component defining the flow channel 39.2 by means of a coupling section 33.6.

10

Preferably, the guide element 33 in the flow channel 39.2 comprises a feed-through 33.7 downstream of the inlet opening. A sheathing tube 64, which holds the drive shaft 62, is guided through this feed-through 33.7 into the flow channel 39.2. Preferably, the sheathing tube 64 is sealed against the feed-through 33.7.

15

As Figure 5a shows, the area of the guide element 33 that forms the feed-through is thickened in cross-section and bulges laterally, preferably in a convexly curved manner. Guide element sections 33.9 of the guide element 33 are preferably connected to the area forming the feed-through 33.7 on opposite ends of the boundary surfaces 33.8. As the drawings show, the guide element sections 33.9 may extend in  
20 opposite directions towards the inner wall of the flow channel 39.2. There, the guide element sections can be connected to the flow channel or another component, e.g. the flow channel mount.

- 25 The guide element sections 33.9 are preferably wing-shaped.

Figure 5a illustrates that the guide element 33 can be divided in the area of the feed-through 33.7. The dividing plane 33.10 may extend through the feed-through 33.7, which simplifies the assembly of the sheathing tube 64.

30

The guide element 33 can preferably be designed such that it is guided into the rounded area 31 at the bow end, as illustrated in Figures 4 and 5 via a transition 33.2.

Further, the wall 33.3 may taper towards the front, i.e. towards the bow, while decreasing in height.

The wall 33.3 forms water guide surfaces on both ends, which extend from the bow area 22 towards the stern 27 and which guide the flowing water towards the assigned feed area 34.1 or 34.2.

Figure 5 illustrates that a motor 61, preferably an electric motor, is disposed in the interior of the hull 10, which motor drives a propeller 36 by means of a drive shaft 62. Preferably, the drive shaft 62 is guided inside a hollow tube 62.1, such that the rotating drive shaft 62 has little or no influence on the water flow guided in the feed area 34.1, 34.2.

The propeller 36 is connected to the drive shaft 62 for co-rotation and disposed in the flow channel 39.2. This is illustrated in Figure 5. A centering unit 35, preferably in the form of a centering star, is held in the flow channel 39.2 upstream of the propeller 36.

The centering unit 35 may comprise a hub 35.1. Centering blades 35.2 are connected to the hub 35.1. The centering blades 35.2 can preferably be connected to the inner wall of the flow channel 39.2 at the ends facing away from the hub 35.1, preferably be integrally connected thereto.

The drive shaft 62 is guided through a mount of the hub 35.1 of the centering unit 35 and preferably held centered in the flow channel 39.2.

Preferably, at least three centering blades 35.2 can be used, which are disposed offset from one another in the circumferential direction of the drive shaft 62, preferably spaced equidistantly.

Particularly preferably, provision may be made for the wall 33.3 of the guide element 33 to be connected, preferably integrally connected, to the centering unit 35 at least sectionally. For instance, provision may be made for the wall 33 to be connected to the hub 35.1 and/or to at least one of the centering blades 35.2. Preferably, the wall 33.3 is integrally connected to the centering unit 35. This reduces the amount of parts

required and improves production accuracy. This also results in improved flow behavior in the flow channel 39.2, as the design can then be more compact.

A flow stator 40 can preferably be disposed downstream of the propeller 36 in the flow channel 39.2. Preferably, the flow stator 40 is disposed in the area of the stern end of the flow channel 39.2. The flow stator 40 has a plurality of stator blades 41, which preferably extend radially to a thrust axis 53, which coincides with the axis of rotation D of the drive shaft 62.

The arrangement of the stator blades 41 can be clearly gathered from Figures 4 and 6. As these drawings illustrate, a stator tip 42 can be used to interconnect the stator blades 41 in the center of the flow channel 39.2.

The propeller 36 generates a rotating water jet in the flow channel 39.2. The flow stator 40 is used to reduce the rotation in the water jet or, ideally, to direct it without swirling. This results in an improved thrust power.

As Figures 4 and 6 illustrate, the axis of rotation D of the drive shaft 62 forms a thrust axis 53. The thrust axis 53 lies in a thrust plane FE, wherein two vectors spanning the thrust plane FE are disposed such that the first vector extends in the direction of the thrust axis 53 and the second vector extends perpendicular thereto, horizontally between the port and starboard sides in the floating position and in the rest position of the submersible, i.e. perpendicular to the image plane in Figure 5. A central longitudinal plane ME perpendicular to the thrust plane FE and accommodating the thrust axis 53 extends between the port and starboard sides, as shown in Figure 6 (i.e. in the image plane in Figure 5). The central longitudinal plane ME can be disposed such that it intersects the boundary rim 39.1 of the flow outlet 39 at an upper boundary point P as shown in the drawings.

Provision may be made for a boundary line 52 intersecting the bow tip 21 and the upper boundary point P to form an angle  $\gamma$  with the thrust plane FE, preferably in the range between  $2^\circ$  and  $7^\circ$ .

Preferably, the boundary line 52 lies in a horizontal plane HE, wherein two vectors spanning the horizontal plane HE are disposed such that the first vector extends in the direction of the boundary line 52 and the second vector extends perpendicular thereto between the port and starboard sides in parallel to the thrust plane FE, as illustrated in Figure 5. The stern ends of the sliding surfaces 37 intersect the horizontal plane HE and pierce it from bottom to top in the direction from bow to stern, as shown in Fig. 5.

Figure 5 further illustrates that the stern ends of the sliding surfaces 37 may end above the flow outlet 39. Consequently, the entire flow outlet 39 is disposed completely below the horizontal plane HE and/or below the stern ends of the sliding surfaces 37.

However, it is also conceivable that the stern ends of the sliding surfaces 37 end below the horizontal plane HE. For instance, the stern ends of the sliding surfaces 37 may be spaced apart from the horizontal plane HE by a maximum dimension  $M = 0.2 \cdot X$ , preferably  $M = 0.1 \cdot X$ , and end below the horizontal plane HE, wherein  $X$  is the maximum clear opening dimension of the flow outlet 39. In this exemplary embodiment, the maximum clear opening dimension  $X$  is the diameter of the circular flow outlet 39 (see Figure 6).

Figure 5 further illustrates that the boundary rim 39.1, which delimits the flow outlet 39, forms a surface at the stern, this surface is inclined at an angle  $\mu$  to the horizontal plane 52. This angle  $\mu$  is preferably selected in the range greater than  $84^\circ$  and further preferably in the range from  $84^\circ$  to less than  $110^\circ$ , particularly preferably in the range from greater than  $90^\circ$  to less than  $110^\circ$ .

If the angle  $\mu$  is selected to be greater than  $90^\circ$ , the flow direction slopes downwards towards the rear such that the water jet does not or no longer strongly hit the part of the user lying in the water behind the stern of the watercraft.

As Figure 5 further illustrates, at least one, preferably two, rechargeable batteries 60 may be accommodated inside the hull 10. If two rechargeable batteries 60 are used, these can be positioned on either side of the central longitudinal plane ME. Preferably, the two rechargeable batteries 60 are disposed symmetrically to the central longitudinal plane ME.

Preferably, the rechargeable batteries 60 can be disposed completely above the thrust plane FE.

- 5 Preferably, the volume of the rechargeable batteries 60 can extend for the most part above the horizontal plane HE.

These measures achieve a good weight distribution in a watercraft according to the invention, which results in a stable floating position.

10

The rechargeable battery or batteries 60 may comprise a tubular section in the form of a sheathing tube 64, inside which a plurality of rechargeable battery cells are disposed. At its longitudinal ends, covers 65, 66 seal the pipe section in a watertight manner. Preferably, electronics for monitoring and/or controlling the rechargeable battery cells  
15 are housed inside the sealed area of the tube section.

As Figure 5 shows, a flooding chamber 70 can be formed inside the hull 10. The flooding chamber 70 is connected to the surrounding area via water passage openings. At least one water inlet opening 71 may be present in the bow area and at least one  
20 water outlet opening 72 may be present in the stern section of the submersible. The water inlet opening 71 and/or the water outlet opening 72 may penetrate the hull shell, e.g. is/are formed by the lower and/or upper shell of the submersible.

When the submersible is placed on the water, the flooding chamber 70 is filled with the  
25 surrounding water via the water passage openings. During water travel, in particular during submerged travel, a water flow from the water inlet opening 71 to the water outlet opening 72 occurs in the flooding chamber 70, such that continuous cooling of the electrical components, in particular of the rechargeable batteries 60, is performed in the flooding chamber 70. In addition, the flooding chamber 70 offers the option of  
30 taking in water as a variable mass component by (partially) filling it with water or emptying it. If the flooding chamber 70 is filled or partially filled, it simplifies the transition from surface travel to underwater travel. When the submersible is lifted out of the water, the flooding chamber is emptied via the water passage openings. Preferably, an additional water passage opening can also be provided on the starboard

side 11 and/or on the port side 12, via which additional water passage opening the water can be emptied from the flooding chamber 70 when the submersible is lifted out of the water.

5 Figure 5 also illustrates that, for instance, a control unit 63 may be disposed in the hull 10, by means of which all or at least some of the functions of the submersible can be electrically controlled. The control unit 63 can be assigned to the motor 61 and connected electrically and/or mechanically thereto.

10 According to one design variant, the control unit 63 may be disposed in the flooding chamber 70 in addition to or as an alternative to the rechargeable battery/batteries 60.

Figure 5 also shows, for instance, that most of the motor's 61 volume can be disposed below the horizontal plane HE to optimize the weight distribution.

15

According to one design variant, the electric motor 61 may be disposed in the flooding chamber 70 in addition to or as an alternative to the rechargeable battery/batteries 60 and in addition to or as an alternative to the control unit 63.

20 Figures 2 and 7 show that the sliding surfaces 37 are present on both ends of the flow channel mount 38 on the bottom hull 30 and are arranged facing downwards. The sliding surfaces 37 may be formed at least sectionally by plane surfaces, by surfaces shaped in a three-dimensional space or by a combination of a three-dimensionally shaped surface and at least one plane surface. In this exemplary embodiment, the  
25 sliding surfaces 37 are formed in part, preferably for the most part, by plane surfaces.

As Figure 2 shows, center sections 37.2 adjoin the end sections 37.3 of the sliding surfaces 37 in the direction of the bow. The center sections 37.2 also extend on the port side and starboard side, respectively, laterally next to the flow channel mount 38.

30 Facing away from the end sections 37.3, the center sections 37.2 each merge into a sliding surface front section 37.1. The sliding surface front section 37.1 is routed past the inlet opening of the flow channel mount 38 and preferably extends into the bow area 22. The sliding surface front sections 37.1 are preferably used to continuously

transition the sliding surfaces 37 directly or indirectly into the rounding area 31 in the bow area 22.

5 The drawings show that the sliding surfaces 37 form a sliding plane 51. The sliding plane 51 can be formed by the sliding surfaces 37 themselves if these are designed as plane surfaces or for the most part as plane surfaces.

10 If the sliding surfaces 37 are not designed as plane surfaces or are not completely designed as plane surfaces, the sliding plane 51 is formed by a mean virtual sliding surface plane, wherein this mean virtual sliding surface plane is arranged such that equal proportions of the surface parts of the sliding surface 37 extend above and below this mean virtual sliding surface plane.

15 The drawings illustrate that a reference longitudinal line of the plane surface or of the mean virtual sliding surface plane extending in the direction from the bow to the stern 27 or the mean virtual planar surface plane, which extends through the center of gravity of the planar surface or the mean virtual planar surface plane, forms a sliding angle  $\beta$  with the thrust plane FE. In this exemplary embodiment, the sliding angle  $\beta$  can be selected in the range from  $2^\circ$  to  $20^\circ$ , preferably in the range from  $4^\circ$  to  $15^\circ$ , particularly  
20 preferably in the range from  $8^\circ$  to  $14^\circ$ , especially preferably in the range from  $11^\circ$  to  $14^\circ$ .

Figure 6 illustrates that the plane surface of the sliding surfaces 37 or the mean virtual sliding surface plane is set at an angle of inclination  $\alpha=0^\circ$  to the thrust plane FE.  
25 However, this angle of inclination may also be  $\alpha > 0^\circ$ , wherein the angle of inclination  $\alpha$  preferably opens towards the starboard or port side.

Finally, Figure 5 also illustrates that an angle  $\delta$  is formed between the sliding plane 51 and the horizontal plane 52, which angle opens towards the bow end. This angle  $\delta$  is  
30 preferably selected in the range from  $3^\circ$  to  $14^\circ$ , preferably from  $5^\circ$  to  $12^\circ$ , particularly preferably from  $5^\circ$  to  $10^\circ$ .

Figure 5a illustrates that the centering unit 35 can be disposed in the central longitudinal plane ME and can preferably be designed symmetrically to the central longitudinal plane ME.

- 5 The centering unit 35 preferably has at least two centering blades 35.2, which keep the area of the feed-through (hub 35.1) at a distance from the inner wall of the flow channel 39.2. Preferably, at least one of the centering blades 35.2 is disposed in alignment with the guide element 33 in the direction of the axis of rotation D of the drive shaft 62. The guide element 33 can be connected directly or separately to the centering  
10 blade 35.2 via a narrow gap area.

Figure 1 illustrates that the width of the guide element 33 extending perpendicular to the central transverse plane ME increases, preferably continuously, in the direction from the stern to the bow. The guide element 33 may at its bow end facing away from  
15 the stern 27 merge into a rounded area 31 of the bottom hull 30 curved towards the underside U, wherein the rounded area 31 is disposed in the bow area 22 and preferably extends from the guide element 33 to the bow tip 21.

As shown in Figure 5, the submersible advantageously has a flooding chamber 70 in  
20 the hull 10 in addition to the flow channel 39, which flooding chamber is connected to the environment via one or more inlet openings 71 and one or more outlet openings 72. Preferably, at least one inlet opening 71 is disposed in the area of an upper shell 20 of the submersible, which is directed towards the topside O and is formed integrally or multi-part.

25

In the submersible shown in the drawings, the axis of rotation D of the drive shaft 62 forms a virtual thrust axis 53, wherein the sliding surfaces 37 directed downwards adjoin the flow channel mount 38, in particular the bulge 39.3, on both sides of the bottom hull 30. Figure 5 illustrates that a bow tip section B1-B3 of the hull (10) is  
30 formed, which bow tip section, starting from the bow tip 21 in the direction of the vehicle stern, extends along a length of 10%, preferably 5%, particularly preferably 2.5%, of the vehicle length L measured from the bow tip 21 to the stern end. In so doing, the virtual thrust axis 53, which is inclined downwards in the direction from the bow to the stern, intersects the bow tip section B1-B3.

Figures 3 and 5 illustrate that the sliding surfaces 37 preferably extend, starting from the stern end of the sliding surfaces 37, at least along 30%, preferably at least along 40%, particularly preferably at least along 50%, of the vehicle length L laterally next to the flow channel 39.2 and in particular preferably above the thrust plane FE in the direction of the bow (22).

In particular, the sliding surfaces 37 may intersect the thrust plane FE.

Figures 3 and 6 show that the virtual thrust axis 53 lies in a thrust plane FE, wherein two vectors spanning the thrust plane FE are disposed such that the first vector extends in the direction of the thrust axis 53 and the second vector extends perpendicular thereto horizontally from the port side to the starboard side 11, 12 in the floating position and in the rest position of the submersible (perpendicular to the image plane in Figure 5). Furthermore, a central longitudinal plane ME is provided that is perpendicular to the thrust plane FE and incorporates the thrust axis 53. As Fig. 5 shows, the sliding surfaces 37 may intersect the thrust plane FE in the area of the vehicle hull, wherein preferably the sliding surfaces 37 intersect the thrust plane FE in an area that is spaced apart from the bow end and/or the stern end by 25% of the vehicle length L, respectively.

Preferably, as Fig. 5 shows, the sliding surfaces 37 intersect the thrust plane FE in an area that is spaced apart from the stern end by 25%.

## Claims

1. A submersible having a hull (10), which comprises a bottom hull (30) in the area of its underside, wherein a flow channel (39.2) is accommodated at least sectionally in the hull (10), or wherein a flow channel (39.2) is assigned to the hull (10), wherein the flow channel (39.2) comprises a flow outlet (39) in the area of the stern, wherein the flow channel (39.2) is disposed at least sectionally inside a flow channel mount (38), in particular a bulge (39.3), protruding from the bottom hull (30), wherein a water acceleration device, in particular a propeller (36), which can be driven directly or indirectly by a motor (61) via a drive shaft (62), is disposed in the flow channel (39.2), wherein the axis of rotation (D) of the drive shaft (62) forms a virtual thrust axis (53), wherein downwards directed sliding surfaces (37), which end above the thrust axis (53) in the stern area of the vehicle, bilaterally adjoin the flow channel mount (38), in particular the bulge (39.3), at the bottom hull (30), wherein a bow tip section (B1-B3) of the hull (10) is formed, which, starting from the bow tip (21) in the direction of the vehicle stern, extends along a length of 10%, preferably 5%, particularly preferably 2.5%, of the vehicle length (L) measured from the bow tip to the stern end, and wherein the virtual thrust axis (53), which is inclined downwards in the direction from the bow to the stern, intersects the bow tip section (B1-B3).
2. The submersible according to claim 1, characterized in that the sliding surfaces (37) at the stern (27) end in end sections (37.3) in the area of the flow outlet (39) of the flow channel (39.2).
3. The submersible according to claim 1 or 2, characterized in that the flow outlet (39) of the flow channel (39.2) protrudes in the direction of the underside of the bottom hull (30) at least as far as the thrust axis (53) beyond the stern ends of the end sections (37.3) of the sliding surfaces (37), in that preferably at least 75%, more preferably at least 90%, particularly preferably the whole of the cross-sectional area of the flow outlet protrudes beyond the stern ends of the end sections (37.3) of the sliding surfaces (37).
4. The submersible according to any of claims 1 to 3, characterized in that in that the end sections (37.3) of the sliding surfaces (37) each merge into a sliding surface front section (37.2) in the direction of the bow, in that the sliding surface front sections

(37.2) each form a transition section (37.1) at their ends facing away from the end section (37.3), which transition section extends in the direction of the bow, in that the transition sections (37.1) of the front sections (37.2) each extend laterally of the inlet opening of the flow channel (39.2), and in that preferably the area of the flow channel (39.2) that forms the inlet opening into the flow channel (39.2) protrudes at least sectionally beyond the transition sections (37.1) in the direction of the underside, in that preferably at least 50%, more preferably at least 75%, particularly preferably at least 85% of the cross-sectional area of the inlet opening protrude downwards beyond the transition sections (37.1).

10

5. The submersible according to any of claims 1 to 4, characterized in that the sliding surfaces (37) extend from the stern end of the sliding surfaces (37) at least along 30%, preferably at least along 40%, particularly preferably at least along 50%, of the vehicle length (L) laterally next to the flow channel (39.2) and preferably above the thrust plane (FE) in the direction of the bow (22).

15

6. The submersible according to any of claims 1 to 5, characterized in that the maximum width of the submersible, measured perpendicular to the thrust axis (53), from port side to starboard side (11, 12) has the dimension Y, in that the flow channel mount (38), in particular the bulge (39.3), is delimited by two side walls (38.1), which are interconnected by means of a connecting section (38.2) in the area of the underside of the flow channel mount (38), in that the sliding surfaces (37) adjoin the side walls (38.1) on the underside of the bottom hull (30) on both sides, wherein the sliding surfaces (37) extend transverse to the side walls (38.1) in the direction of the assigned port or starboard side (11, 12), respectively, and in that the distance dimension bridging the sliding surface (37) between the side walls (38.1) and the assigned starboard or port side (11, 12) does not fall below the dimension  $Z=0.08*Y$ , preferably  $Z=0.1*Y$ , particularly preferably  $Z=0.15*Y$ , along the entire length of the flow channel mount (38).

20

25

7. The submersible according to any of claims 1 to 6, characterized in that at least one rechargeable battery (60) for supplying the motor with electricity is accommodated in the vehicle hull, in that the volume occupied by the rechargeable battery (60) is disposed for the most part, preferably completely, above the thrust axis (53).

30

8. The submersible according to claim 7, characterized in that two rechargeable batteries (60) are accommodated in the vehicle hull, which rechargeable batteries are disposed on both sides of the thrust axis (53), and in that the volume occupied by both rechargeable batteries (60) is disposed for the most part, preferably completely, above the thrust axis (53).

9. The submersible according to any of claims 1 to 8, characterized in that the thrust axis (53) lies in a thrust plane (FE), wherein two vectors spanning the thrust plane (FE) are disposed such that the first vector extends in the direction of the thrust axis (53) and the second vector extends perpendicular thereto horizontally from the port side to the starboard side (11, 12) in the floating position and in the rest position of the submersible, wherein a central longitudinal plane (ME) perpendicular to the thrust plane (FE) and incorporating the thrust axis (53) is provided, and in that the sliding surfaces (37) intersect the thrust plane (FE) in the area of the vehicle hull, wherein preferably provision is made for the sliding surfaces (37) to intersect the thrust plane (FE) in an area that is spaced from the stern end by at least 20% and at most 60% of the maximum vehicle length, preferably by at least 20% and at most 50% of the maximum vehicle length, further preferably by at least 20% and at most 40% of the maximum vehicle length, particularly preferably by at least 25% and at most 40% of the maximum vehicle length.

10. The submersible according to any of claims 1 to 9, characterized in that each sliding surface (37) comprises a mean virtual sliding surface plane and/or a plane surface, wherein the mean virtual sliding surface plane is arranged such that equal proportions of the surface parts of the sliding surface (37) extend above and below this mean virtual sliding surface plane, and in that the plane surface or the mean virtual sliding surface plane forms a sliding angle ( $\beta$ ) with the thrust plane (FE).

11. The submersible according to claim 10, characterized in that the slide angle ( $\beta$ ) is selected in the range from 2° to 20°, preferably in the range from 4° to 15°, particularly preferably in the range from 8 to 14°, particularly preferably in the range from 11° to 14°.

12. The submersible according to any of claims 1 to 11, characterized in that the central longitudinal plane (ME) intersects the boundary rim (39.1) of the flow outlet (39) at an upper boundary point (P), in that a boundary line (52) intersecting the bow tip (21) and the upper boundary point (P) is provided, in that the boundary line (52) lies in a horizontal plane (HE), wherein two vectors spanning the horizontal plane (HE) are disposed such that the first vector extends in the direction of the boundary line (52) and the second vector extends perpendicular thereto between the port and starboard sides (11, 12) in parallel to the thrust plane (FE), and that the stern ends of the sliding surfaces (37) intersect the horizontal plane (HE),  
or in that the stern ends of the sliding surfaces (37) are spaced apart from the horizontal plane (HE) by a maximum dimension  $M = 0.2 \cdot X$ , preferably  $M = 0.1 \cdot X$ , and are disposed below the horizontal plane (HE), wherein X is the maximum clear opening dimension of the flow outlet (39).
13. The submersible according to any of claims 1 to 12, characterized in that the sliding surfaces (37) and the horizontal plane (HE) diverge in the direction from the stern to the bow.
14. The submersible according to any of the preceding claims, characterized in that the projections of the boundary line (52) and the plane surface of the sliding surface (37) or the mean virtual sliding surface plane into the central longitudinal plane (ME) are at a boundary angle ( $\delta$ ) in the range from  $3^\circ$  to  $14^\circ$ , preferably from  $5^\circ$  to  $12^\circ$ , particularly preferably from  $5^\circ$  to  $10^\circ$  to each other.
15. The submersible according to any of claims 1 to 14, characterized in that the thrust axis (53) and the boundary line (52) intersect in the bow area (22), wherein the intersection point is preferably at a maximum distance of  $0.16 \cdot$  the maximum overall length of the submersible (L), preferably at a maximum distance of  $0.2 \cdot$  the maximum overall length of the submersible (L) from the bow tip (21).
16. The submersible according to any of claims 1 to 15, characterized in that the boundary rim (39.1) delimiting the flow outlet (39) forms a jet outlet surface, through which the water jet generated in the flow channel (39.2) emerges, wherein the jet outlet

surface intersects the boundary line (52) at an angle ( $\mu$ ), preferably in the range of greater than  $84^\circ$ .