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(54) **SCREW PROPELLER (VARIANTS) AND THE INVOLUTE OF THE BLADES THEREOF**

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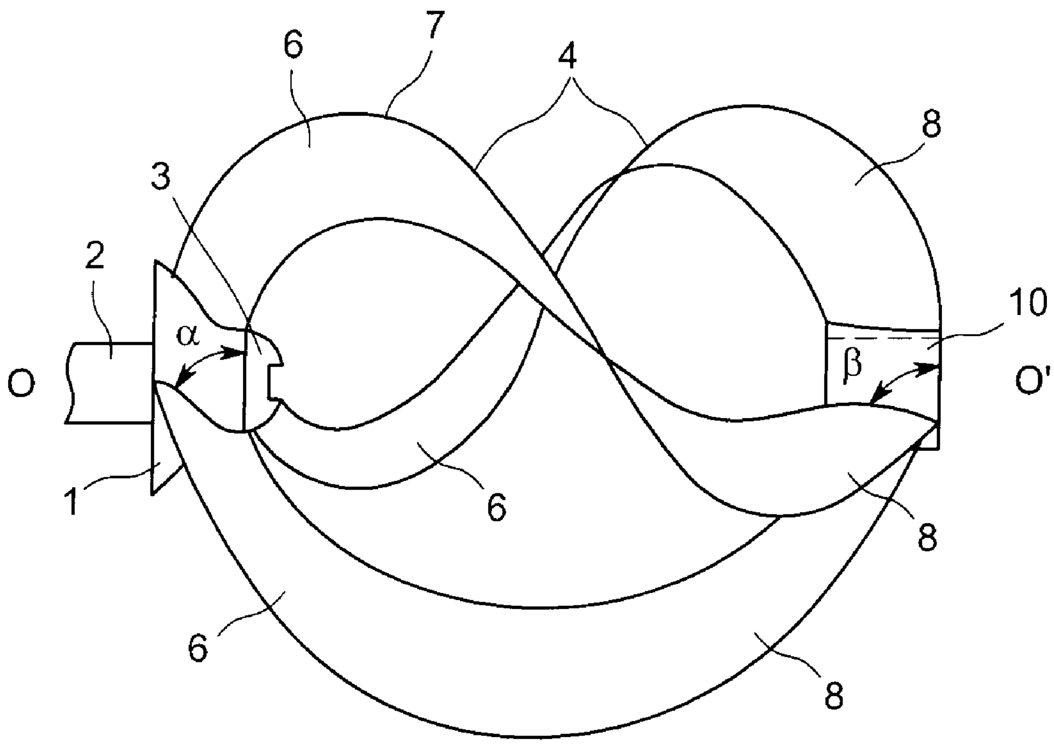
(57) **ABSTRACT**

The invention relates to a screw propeller and its variants for converting mechanical energy in a fluid medium, and can be used in the form of water and air screws for engines and propulsers, making it possible to simplify the production method of propeller blades, to reduce the dimensions and material consumption of propeller blades, and to simultaneously increase a thrust produced thereby without decreasing the strength and efficiency thereof. The inventive propeller comprises at least two scimitar-shaped blades whose basic sections are fixed to the hub of a driven shaft. The basic section of each blade is straight and scimitar in shape, wherein the front edge of the blade is bent backwards in relation to the direction and plane of rotation and gradually transforms into the inverse, scimitar-shaped end section. Moreover, the front edge of the blade is forwardly bent in relation to the direction and plane of rotation. The blades are arranged along the propeller axis and fastened by means of the end sections in such a way that an axially symmetric figure is formed. The involute of all the blades of the propeller is shaped in the form of a single integral flat figure provided with one or more holes (**5**) corresponding to the coupling size of the hub of a driven shaft.



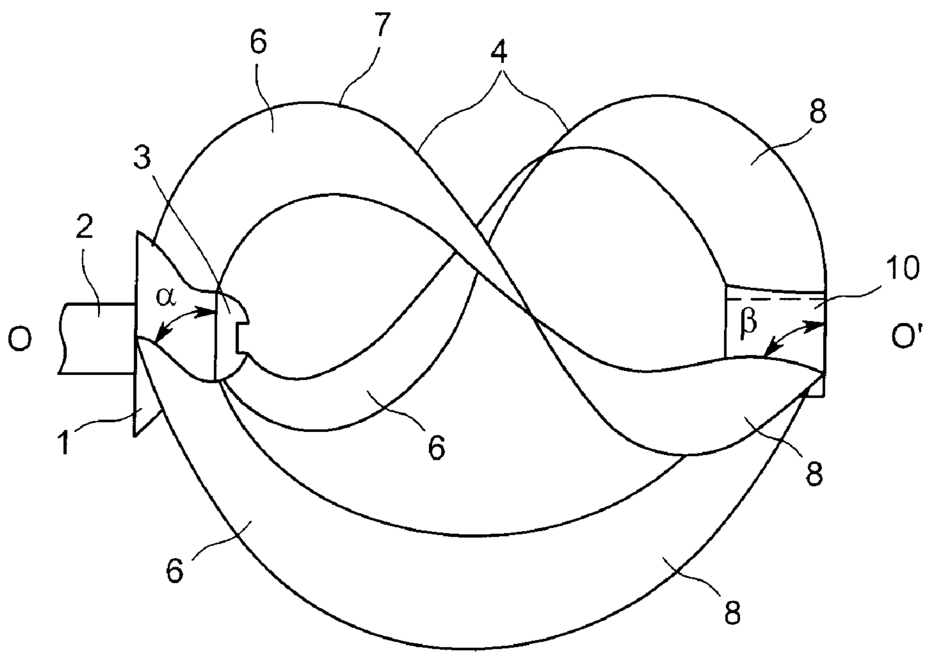


FIG. 1

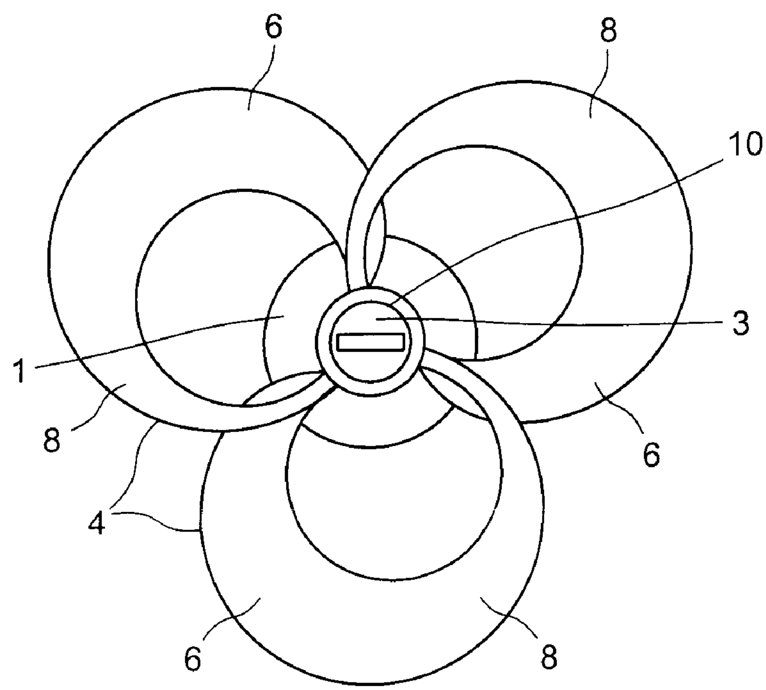


FIG. 2

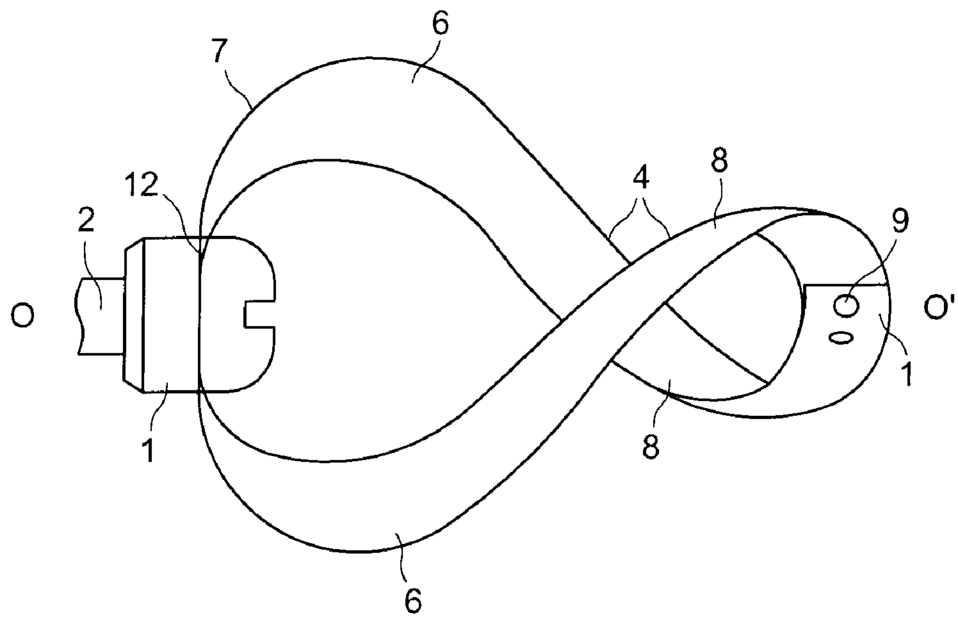


FIG. 3

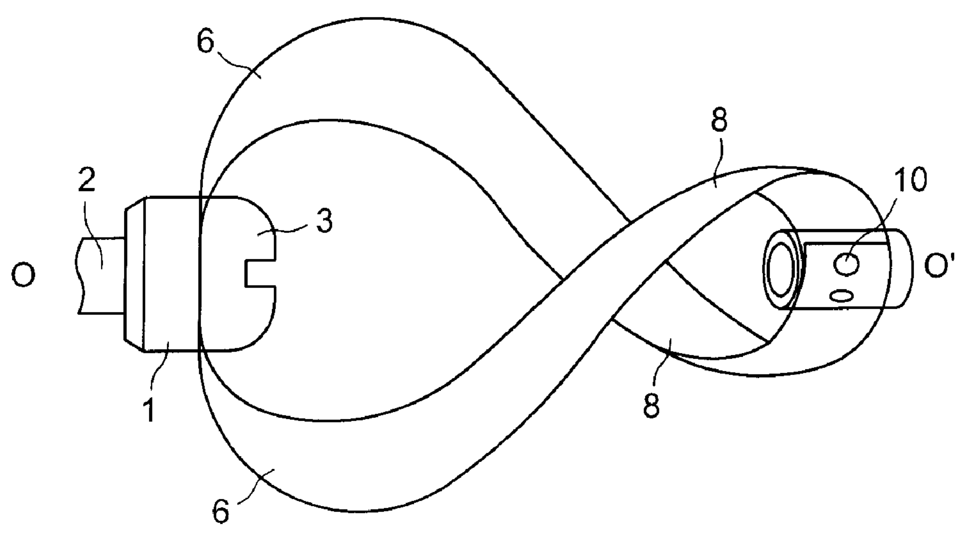


FIG. 4

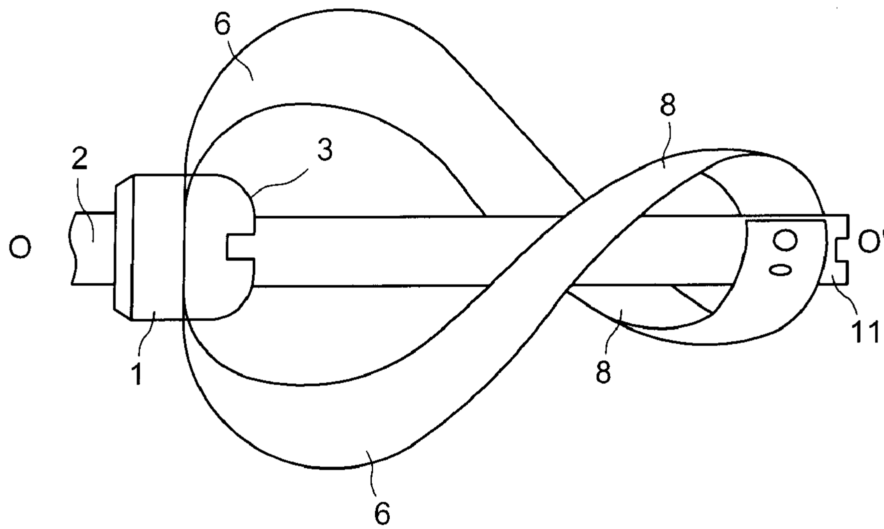


FIG. 5

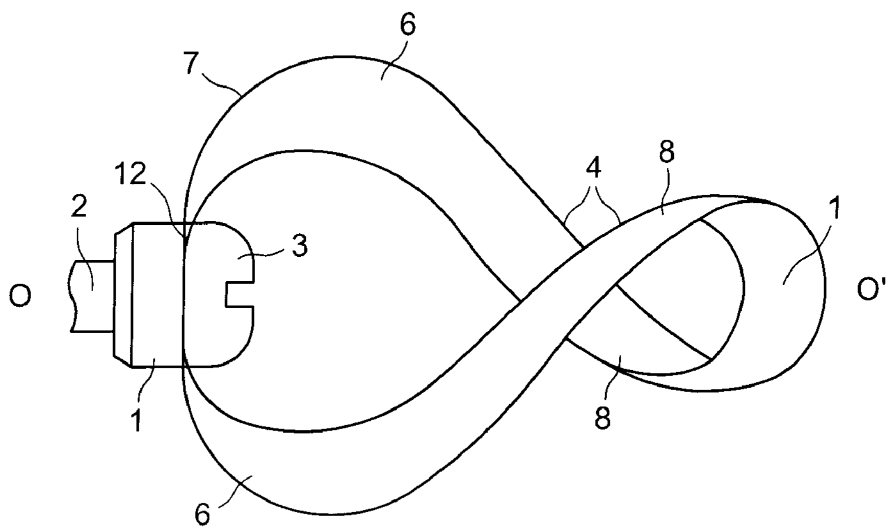


FIG. 6

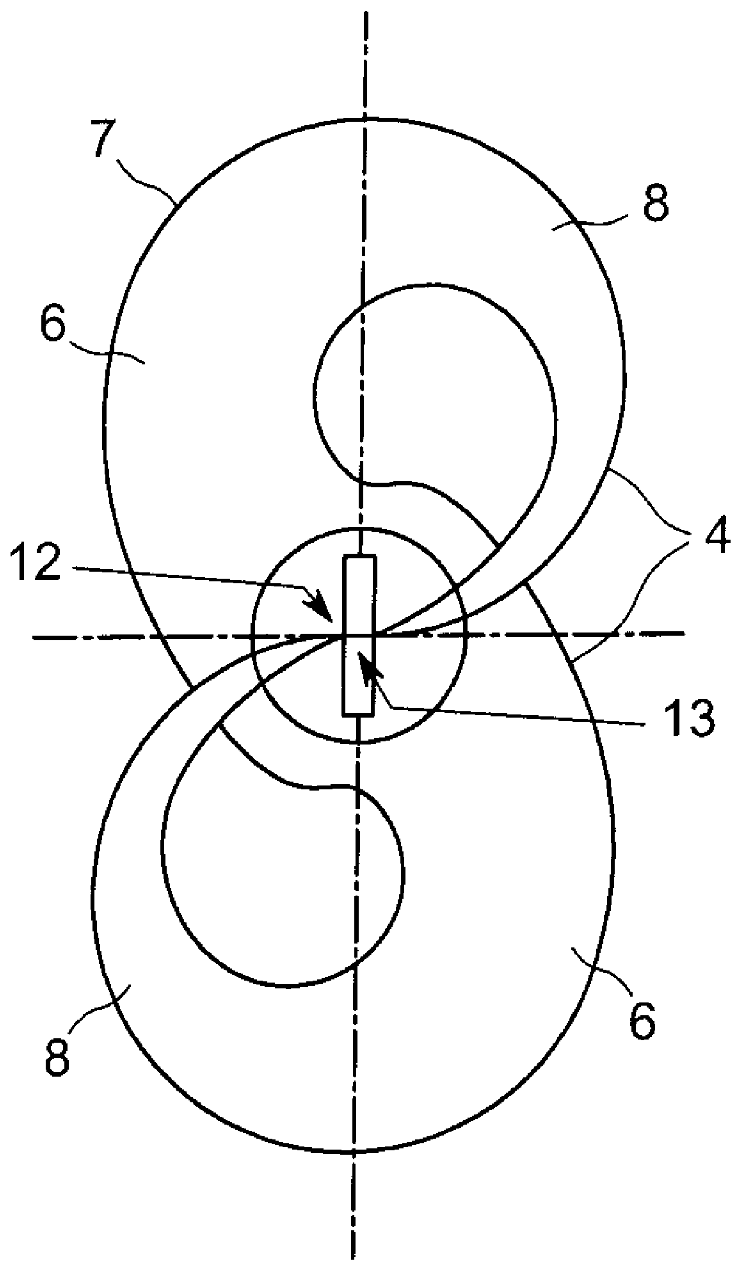


FIG. 7

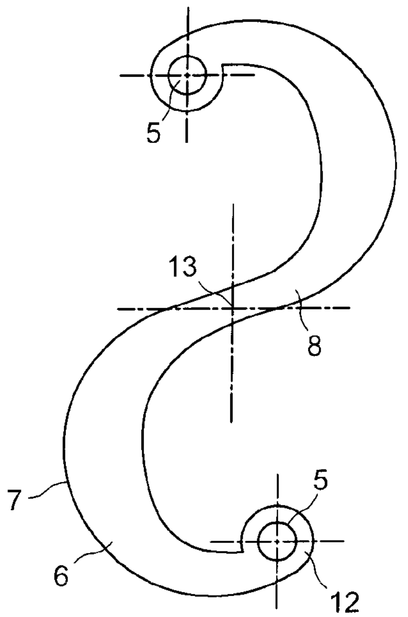


FIG. 8

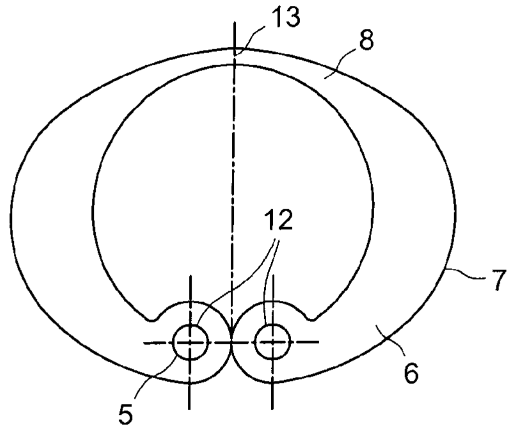


FIG. 9

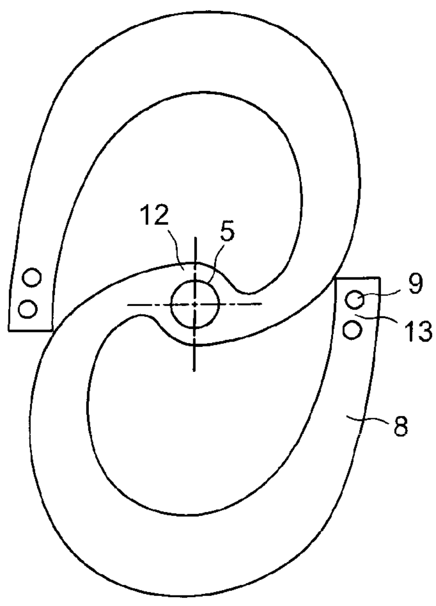


FIG. 10

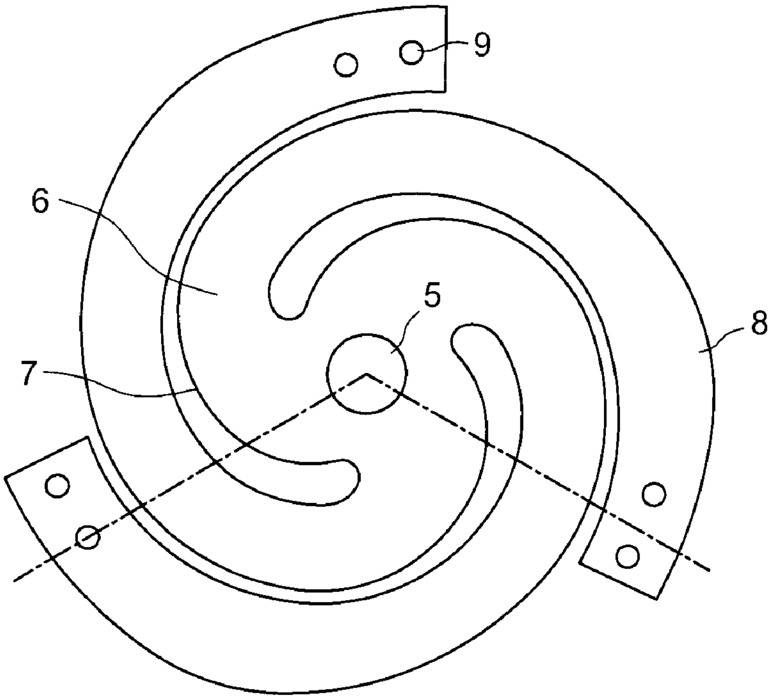


FIG. 11

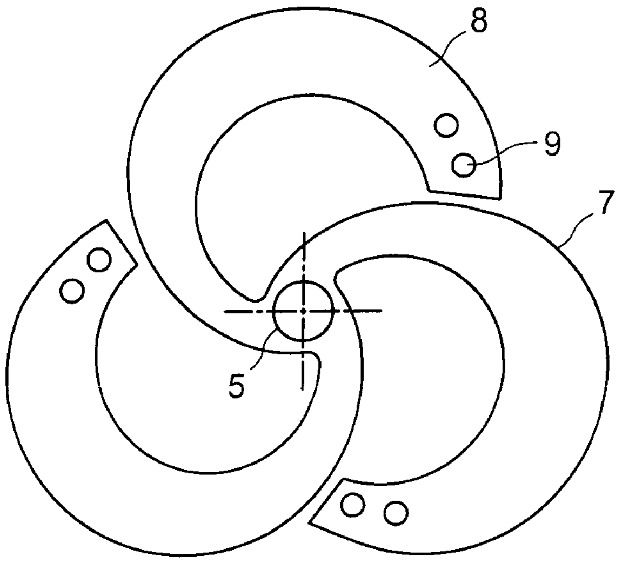


FIG. 12

SCREW PROPELLER (VARIANTS) AND THE INVOLUTE OF THE BLADES THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of the priority filing date in PCT/RU2007/000121 referenced in WIPO Publication WO 2007/111532. The earliest priority date claimed is Mar. 28, 2006.

FEDERALLY SPONSORED RESEARCH

[0002] Not Applicable

SEQUENCE LISTING OR PROGRAM

[0003] Not Applicable

STATEMENT REGARDING COPYRIGHTED MATERIAL

BACKGROUND

[0005] The invention relates to a screw propeller ("screws") and its variants for converting mechanical energy in a fluid medium, such as liquid or gas, and can be used in the form of water and air screws for engines and propulsers of ships, airborne devices (dirigibles), windmills, household fans and other household appliances, toys and other items.

[0006] Already known in the art is a fluid medium engine impeller comprising an elastic ribbon blade with a one-sided Mobius surface, attached to radial bars perpendicular to the drive shaft [USSR Certificate of Authorship No. 1305430, IPC FO3D 1/06, publ. 09.30.85]. However, such device is characterized by design complexity, inefficiency or high cost of energy (COE), and noise due to the presence of radial bars that do not participate in generating useful aerodynamic forces.

[0007] Currently, multiblade screws with cantilever fitted scimitar-shaped blades are considered the most efficient. Unattached ends of the blades are bent backwards relative to the direction and plane of rotation [USSR Certificate of Authorship No. 1711664, IPC B64C 11/00, publ. 10.24.86]. However, such screws are characterized by insufficient reliability and by manufacturing complexity, which is due to the one-sided cantilever attachment of scimitar-shaped blades, with large elongation and curvature, significant noise during operation, low COE per unit of blade area, and a large mass (as well as the overall dimensions of the structure).

[0008] The technical result the proposed invention is aimed to achieve is to simplify the propeller blades manufacturing process, reduce the dimensions and hence metal content of the blades while at the same time increasing their thrust without reducing their strength of effectiveness.

SUMMARY

[0009] The invention relates to a screw propeller and its variants for converting mechanical energy in a fluid medium, and can be used in the form of water and air screws for engines and propulsers, making it possible to simplify the production method of propeller blades, to reduce the dimensions and material consumption of propeller blades, and to simultaneously increase a thrust produced thereby without decreasing the strength and efficiency thereof. The inventive propeller comprises at least two scimitar-shaped blades whose basic sections are fixed to the hub of a driven shaft. The basic section of each blade is straight and scimitar in shape, wherein the front edge of the blade is bent backwards in relation to the direction and plane of rotation and gradually transforms into the inverse, scimitar-shaped end section. Moreover, the front edge of the blade is forwardly bent in relation to the direction and plane of rotation. The blades are arranged along the propeller axis and fastened by means of the end sections in such a way that an axially symmetric figure is formed. The involute of all the blades of the propeller is shaped in the form of a single integral flat figure provided with one or more holes (**5**) corresponding to the coupling size of the hub of a driven shaft.

FIGURES

[0010] The essence of the invention is explained in FIGS. **1-12**.

[0011] FIG. **1**—shows a three-blade propeller

[0012] FIG. **2**—shows the axial view of a three-blade propeller.

[0013] FIGS. **3-6**—show two-blade propellers with various types of joining blade ends.

[0014] FIG. **7**—shows the axial view of a two-blade propeller.

[0015] FIGS. **8-12**—show examples of plane developments of propeller blades for both propeller variants

DESCRIPTION

[0016] The technical result the proposed invention is aimed to achieve is to simplify the propeller blades manufacturing process, reduce the dimensions and hence metal content of the blades while at the same time increasing their thrust without reducing their strength of effectiveness. The technical result is achieved by the fact that in a propeller (variant 1) with scimitar-shaped blades whose start sections are attached to the drive shaft hub, the new feature is that the propeller has at least two blades. The start section of each blade is straight, scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation. The start section blends gradually into the reverse scimitar-shaped end section wherein the blade's leading edge is bent forward relative to the direction and plane of rotation. The blades are located along the propeller axis and their end sections are attached to each other, forming an axially symmetrical figure.

[0017] In a propeller (variant 2) comprising scimitar-shaped blades with their start sections attached to the drive shaft hub, the new feature is that the propeller has three or more blades. The start section of each blade is straight, scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation. The start section blends gradually into the reverse scimitar-shaped end section wherein the blade's leading edge is bent forward relative to the direction and plane of rotation. The blades are located along the propeller axis and their end sections are attached to each other, forming an axially symmetrical figure, while the start and end sections of each blade are attached at specified angles of incidence. The end sections of the blades are connected to each other by means of an annular bushing. For an engine, the angle of incidence of the start section of each blade is larger than the angle of incidence of the end section of the respective blade. For a propulsor, the angle of incidence of the start section of each blade is smaller than the angle of incidence of the end section of the respective blade. The sum total of trajectories of the blades' outer edges forms a swept area, mainly oval in shape and elongated along the propeller axis.

[0018] In a propeller (variant 3) comprising scimitar-shaped blades with their start sections attached to the drive shaft hub, the new feature is that the propeller has two blades. The start section of each blade is straight, scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation. The start section blends gradually into the reverse scimitar-shaped end section, wherein the blade's leading edge is bent forward relative to the direction and plane of rotation. The blades are located along the propeller axis, and their end sections are attached to each other, forming an axially symmetrical figure. The end sections of the blades are connected to a single piece, with gradual blending between the surfaces of both blades so that both blades form a single one-sided surface with a single bend. At the attachment points, the surfaces of the start and end sections of each blade are turned 90 degrees relative to each other The propeller axis and the end section surfaces of both blades are located in the same plane. The sum total of trajectories of the blades' outer edges forms a swept area, mainly of oval revolutionary shape, elongated along the propeller axis. The end sections of the blades are connected directly to each other, or the end sections of the blades are connected to each other by means of an annular bushing or a drive shaft.

[0019] The improved propeller blades is characterized in that the sum total of propeller blades is a single one-piece plane figure consisting of at least two spiral-shaped elements forming a symmetrical figure with one or more holes with coupling dimensions for the propeller drive shaft hub. The spiral-shaped elements have axial holes with coupling dimensions for the propeller drive shaft hub. At their open ends, the spiral-shaped elements have holes with coupling dimensions for the propeller drive shaft hub. The present improvement comprising two spiral-shaped elements is a double-focus spiral, symmetrical relative to the line perpendicular to the tangent to the plane figure edge in ds middle section, with holes at the open ends having coupling dimensions for the propeller drive shaft hub.

[0020] BEST VARIANT. The proposed propeller for fluid medium engines and propulsors includes the hub **1** with the drive shaft **2**, the mounting screw **3** and the scimitar-shaped blades **4**. The hub **1** or blades **4** are installed on the shaft **2** by means of the axial hole **5**, ensuring a straight scimitar shape at the start section **6** of the blades **4** and the angle of incidence α. The straight scimitar shape is characterized by the fact that the leading edge **7** of the blade **4** is bent backward relative to the direction and plane of rotation and corresponds to the traditional manufacturing of scimitar-shaped blades. The start section **6** of the straight scimitar shape blends gradually into the end section **8** of the reverse scimitar shape, i.e., ensuring that the that the lead edge **7** of the blade **4** is bent forward relative to the direction and plane of rotation (FIGS. **1** and **2**). The blades **4** are rigidly joined to each other at their end sections **8** using any known method, ensuring the angle of incidence β of the end sections of the blades, which is not equal to the angle of incidence α of the start sections of the blades. The method for joining is based on manufacturing capabilities (threaded joints using holes **9** at the ends of blades **4**; welding; riveting: using accessory annular bushing **10**).

[0021] In a two-blade propeller, the start sections **6** of the blades **4** are installed on the hub **1**, using holes **5** and secured with a screw **3**. At the point of attachment to the hub, the surfaces **12** of the blades **4** are perpendicular to the propeller axis. At the point of attachment to each other, the surfaces **13** of the blades **4** are turned 90 degrees relative to the surfaces **12**, are in the same plane with the propeller axis, and are rigidly attached to each other, forming an axially symmetric figure. For instance, the surfaces **13** of the blades **4** are superimposed and joined using spot welding (FIGS. **3**, **7**). The joining of the end sections **8** of the blades **4** provides a rigid and strong structure, even when using thin steel sheet metal, plastics or composites. The shape of the blades **4**, with gradual blending of their surfaces, gradually changes the angle of incidence and the drag of the incoming flow of fluid medium from maximum to minimum at the ends of the blades **4**. Such redistribution of flow provides higher COE over a wide range of speeds compared to known devices performing the same function. When assembling a two-blade propeller, the end sections **8** of the blades **4** can be attached using annular bushing **10** or a shaft extension **11** along the propeller axis, which makes mounting of the blades **4** on hub **1** easier.

[0022] The size of the fasteners does not change the aerodynamics of the blades (FIGS. **4**, **5**). When the end sections **8** of both blades **4** of the claimed propeller are fastened directly, the blades form a Mobius surface. Accordingly, both blades **4** of the propeller can be made by a single bend of one plane spiral-shaped part with holes at its ends for fastening the part on the hub **1**, forming two blades **4** (FIG. **6**).

[0023] The improved plane in FIGS. **8** and **9** serves as an illustration of the design of such a blade **4**. The plane figure in FIG. **8** consists of two spiral-shaped elements that form an axially symmetrical figure with holes **5** at the open ends of the spiral-shaped elements with coupling dimension for the hub **1** of the drive shaft **2** of the propeller. FIG. **9** shows an improved plane of a two-blade propeller comprised of two spiral-shaped elements in the shape of a double-focus spiral symmetrical relative to the line perpendicular to the tangent of the plane figure edge in its middle section, with holes **5** at the open ends of the spiral-shaped elements with coupling dimensions for the hub **1** of the drive shaft **2** of the propeller.

[0024] A similar propeller design can be achieved from a plane part that has the improvement shown in FIG. **10**. The improvement comprises two spiral-shaped elements that form an axially symmetrical figure with axial holes **5** with coupling dimensions for the hub **1** of the drive shaft **2** of the propeller, while holes **9** at the figure end are for attaching the end sections of the blades **4** to each other. The spiral-shaped surface of the blade **4** ensures: blades shape with a gradual change of the angle of incidence; structural strength of the blades; reduction of the overall dimensions and mass of the propeller with a simultaneous, substantial increase of the COE, and ensuring practically noiseless operation; the swept area diameter is decreased.

[0025] In a three-blade propeller (FIG. **1**), the end sections of the blades **4** are also joined coaxially near the propeller axis by means of an annular bushing **10**, which, on the one hand, makes it easier to access the hub **1** fastening means (FIG. **2**), while on the other hand, not changing the aerodynamics of the blades **4**; it also makes it possible to fasten the end sections **8** of the blades **4** at a certain angle of incidence, the choice of which conforms to standard practice.

[0026] A three-blade propeller, taking into account the type of energy conversion, for instance, from blades **4** to shaft **2** as in a windmill, or when transmitting rotation to blades **4**, can have the angle of incidence $\alpha>\beta$ or $\beta>\alpha$, where α is the angle of incidence of the start section **6** of the blade, and β is the angle of incidence of the end section **8** of blade **4**.

[0027] The propeller works as follows: when the drive shall **2** and hub **1** rotate, the straight scimitar-shaped sections **6** of the blades **4** (which have a smaller angle of incidence then reverse scimitar-shaped sections **8** to ($\alpha<\beta$)) begin interacting with the fluid medium. This results in a gradual acceleration of the ambient fluid medium, which builds up with maximum speed, and exits at the ends of the blades **4**. The sum total of trajectories of the outer edges of the blades **4** forms a mainly oval figure, elongated along the propeller axis. The longer the propeller elongation along the axis, the more gradual the medium accelerates with the propeller. Because the blades **4** are attached at both ends—the start sections **6** to the hub **1** and the end sections **8** to each other—the resulting structure is fairly light and rigid despite the large elongation along the axis of rotation O-O'. The elongation ensures a low distributed pressure gradient in the fluid medium and hence a low level of noise, cavitation and turbulence, which substantially increases the COE and positively affects the technical efficiency of the proposed device. Propellers can be made using any known manufacturing method, e.g., casting or forging. Manufacturing-wise, it is easy to bend a three-blade propeller from plane thin sheet material, e.g., steel (FIGS. **11**, **12**), in the shape of a part that is a single one-piece plane figure comprising spiral-shaped elements forming an axially symmetrical figure with one axial hole **5** with coupling dimension for the propeller drive shaft hub, and mounting holes **9**. As generating spirals, one can use the Archimedes' spiral, hyperbolic and logarithmic spirals, involutes, cycloids and other suitable curves chosen depending on the specific purpose of the proposed device.

INDUSTRIAL PRACTICABILITY

[0028] The above information has been confirmed by full-scale tests of prototypes of household fans based on plane improvements (FIGS. **9**, **10**, **11**) that provided a narrowly focused air jet with low noise levels up to 6000 RPM and with low production cost affordable for any private shop and hence for factories that manufacture low-noise screws for submarines, windmills, aircraft, etc.

The invention claimed is:

1. A propeller comprising scimitar-shaped blades, the start sections of which are attached to the drive shaft hub, distinctive in that the start section of each blade is straight scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation, and blends gradually into the reverse scimitar-shaped end section wherein the blade's leading edge is bent forward relative to the direction and plane of rotation, the blade is twisted along the propeller axis, providing gradual change of the angle of incidence along the entire blade, and attached at its end section to the propeller axis, wherein the start and end sections of the blade are attached at different angle of incidences.

2. A propeller per claim **1**, distinctive in that the plane improvement of the blade surface is of spiral shape.

3. A propeller comprising scimitar-shaped blades, the start sections of which are attached to the drive shaft hub, distinctive in that the propeller has three and more blades, the start section of each blade is straight scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation, and blends gradually into the reverse scimitar-shaped end section wherein the blade's leading edge is bent forward relative to the direction and plane of rotation, the blades are twisted along the propeller axis, providing gradual change of the angle of incidence along the entire blade, and attached at its end section to the propeller axis, wherein the start and end sections of the blade are attached at different angle of incidences.

4. A propeller per claim **3**, distinctive in that the end sections of the blades are connected to each other by means of an annular bushing.

5. A propeller per claim **3**, distinctive in that for an engine, the angle of incidence of the start section of each blade is larger than the angle of incidence of the end section of the respective blade.

6. A propeller per claim **3**, distinctive in that for a propulsor, the angle of incidence of the start section of each blade is smaller than the angle of incidence of the end section of the respective blade.

7. A propeller per claim **3**, distinctive in that the plane development of the blade surface is of spiral shape.

8. A propeller per claim **3**, distinctive in that the sum total of trajectories of the blades' outer edges forms a swept area, mainly of oval shape, elongated along the propeller axis.

9. A propeller comprising scimitar-shaped blades, the start sections of which are attached to the drive shaft hub, distinctive in that the propeller has two blades, the start section of each blade is straight scimitar-shaped wherein the blade's leading edge is bent backward relative to the direction and plane of rotation, and blends gradually into the reverse scimitar-shaped end section wherein the blade leading edge is bent forward relative to the direction and plane of rotation, the blades are twisted along the propeller axis, providing gradual change of the angle of incidence along the entire blade, and attached by their end sections forming and axially symmetrical figure, wherein the start and end sections of each blade are attached at different angles of incidences and joined into a single one-sided Mobius surface with a single bend, wherein at the attachment points the surfaces of the start and end section of each blade are turned 90 degrees relative to each other, while the propeller axis and the end section surfaces of both blades are located in the same plane.

10. A propeller per claim **9**, distinctive in that the plane development of the blade surface is of spiral shape.

11. A propeller per claim **9**, distinctive in that the sum total of trajectories of the blades' outer edges forms a swept area, mainly of oval revolutionary shape, elongated along the propeller axis.

12. A propeller per claim **9**, distinctive in that the end sections of the blades are connected directly to each other.

13. A propeller per claim **9**, distinctive in that the end sections of the blades are connected to each other by means of an annular bushing or a drive shaft.

14. An improvement of propeller blades, characterized in that the improvement of the entire sum total of propeller blades is a single one-piece plane figure comprised of spiral-shaped elements forming a symmetrical figure with one or more holes for the coupling dimension of the propeller drive shaft hub.

15. An improvement per claim **14**, distinctive in that the spiral-shaped elements form an axially symmetrical figure with an axial hole for the coupling dimension of the propeller drive shaft hub.

16. An improvement per claim **14**, distinctive in that it is composed of three individual spiral-shaped elements.

17. An improvement per claim **14**, distinctive in that it is composed of two individual spiral-shaped elements.

18. An improvement per claim **14**, distinctive in that the improvement of a two-blade propeller is a single one-piece plane figure comprised of two spiral-shaped elements forming an axially symmetrical figure with an axial hole for the coupling dimension of the propeller drive shaft hub.

19. An improvement per claim **14**, distinctive in that the improvement of a two-blade propeller is a single one-piece plane figure comprised of two spiral-shaped elements forming an axially symmetrical figure with holes at open ends of the spiral-shaped elements for the coupling dimension of the propeller drive shaft hub.

20. An improvement per claim **14**, distinctive in that the improvement of a two-blade propeller is a single one-piece plane figure comprised of two spiral-shaped elements in the shape of a double-focused spiral, symmetrical relative to the line perpendicular to the tangent to the plane figure edge in its middle section, with holes at the open ends of the spiral-shaped elements for the coupling dimension of the propeller drive shaft hub.

* * * * *