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(54) Title: ADJUSTABLE PITCH PROPELLER

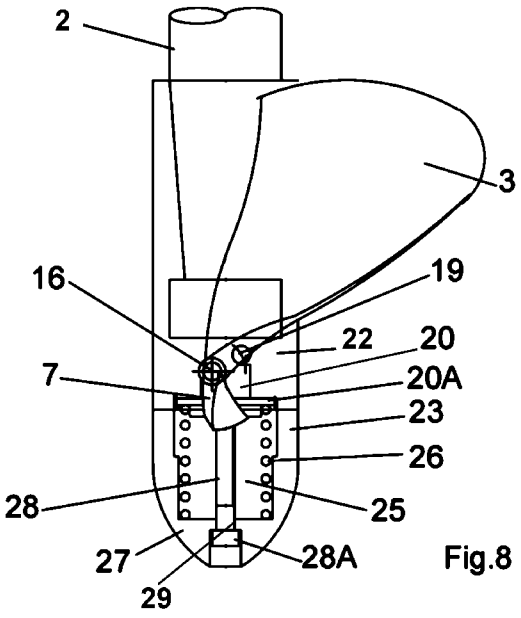

Fig.8

(57) Abstract: The propeller has a hub (22, 23) rotatably carried on a drive shaft (2) with blades (3) projecting radially from the hub. Each of the blades includes a fixed-pitch portion which is fixed relative to the hub and a pitch-change flap (7) which is pivotable about a pitch-change axis extending along a trailing edge of each blade. At the root of each blade the flap has a pivot pin (16) which is inserted into the hub where the pin carries a pitch-change arm. The arms carry pitch-change pins (19) which are inserted into an axially movable control head (20). The control head may act against an adjustable compression spring (26) to provide automatic self-adapting pitch control. The control head may also be operated remotely by a cable, rod or hydraulic fluid passing through the propeller drive shaft.

[Continued on next page]

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ADJUSTABLE PITCH PROPELLER

TECHNICAL FIELD OF THE INVENTION

This invention relates to an adjustable pitch propeller, and particularly a propeller for use on marine or other watercraft wherein the pitch of the blades can passively adapt to or be controlled remotely to take account of different operating conditions.

BACKGROUND

Controllable pitch propellers are known, as are self-pitch-adjusting propellers - see **US 5 366 343** to Muller (expired) for example. On a known adjustable pitch propeller the propeller blades are mounted in bearings on a propeller hub such that the blades can each rotate about a radial axis. The pitch angle of the blades is changed by a mechanism which is contained within the hub. The hub is therefore enlarged relative to a fixed pitch propeller to accommodate the blade axles, bearings and control mechanism, and the drive shaft upon which the hub is mounted has to be substantially larger to contain the pitch-change

control mechanism. This reduces the effective working area of the blade and increases frictional drag, resulting in reduced propeller performance and efficiency.

Adjustable pitch propellers have advantages and disadvantages over a fixed pitch propeller. On the one hand the propeller pitch can be changed or fine-tuned to suit the vessel operating conditions. For example, the pitch can be reduced or feathered when the vessel is heavily loaded and increased when the vessel is light. On the other hand, an adjustable pitch propeller is much more expensive than a fixed pitch propeller, is not so strong, and, as already stated, in its optimum pitch setting is less efficient than a fixed pitch propeller designed for equivalent operating conditions.

GB 550 484 discloses an adjustable pitch propeller in which each of the blades includes a fixed-pitch portion which is fixed relative to the hub and a pitch-change flap which is pivotable about a pitch-change axis extending along a trailing edge of each blade; and the hub is provided with a pitch-change mechanism arranged to adjust the angle of the flaps about their respective pitch-change axes.

By changing the angle of the flaps on the propeller blades, the overall pitch of the blade, and therefore the propeller pitch itself, is changed. This behaves in a similar way to a technique used by propeller designers called cupping, where the pitch of an existing propeller can be changed significantly by cupping the trailing

edges of the propeller blades. A small amount of cupping can cause large increases in the propellers pitch.

The present invention seeks to provide a new and inventive form of adjustable pitch propeller in which the hub can be reduced in size with less shaft-line complexity and increased efficiency.

SUMMARY OF THE INVENTION

According to one aspect the present invention provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm engaged with a control head which is movable axially of the drive shaft.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap supported by a pivot pin which is inserted into the hub.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm engaged with a

control head which is movable against spring loading.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm engaged with a control head which is movable against a compression spring which is located in a chamber in the hub.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm engaged with a control head which is movable against spring loading, and includes means to vary the spring load applied to the control head.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap with a pitch-change arm engaged with a control head which is movable by a rod, cable or hydraulic fluid.

The invention also provides an adjustable pitch propeller which includes a drive shaft, a hub and a plurality of blades each having a pitch-change flap and an outer end of each blade carries a tip plate which rotatably supports the outer end of the flap.

BRIEF DESCRIPTION OF THE DRAWINGS

The following description and the accompanying drawings referred

to therein are included by way of non-limiting example in order to illustrate how the invention may be put into practice. In the drawings:

Figure 1 is an end view of an adjustable pitch propeller;

Figure 2 is a section II-II through a blade of the propeller;

Figure 3 is an edge view of the propeller blade as viewed from the tip of the blade;

Figure 4 is an edge view of the propeller blade as viewed from the root of the blade;

Figure 5 is a detail of the root of the blade showing the blade flap as viewed from one end of the propeller;

Figure 6 is a transverse sectional view of the propeller hub;

Figure 7 is another sectional view of the propeller hub as assembled;

Figure 8 is a sectional view of the propeller shown at rest in a high pitch condition;

Figure 9 is another sectional view of the propeller in a

heavily-loaded low pitch condition;

Figure 10 is a sectional detail of one of the blades in a modified form of the propeller;

Figure 11 is a transverse sectional view of the propeller hub in the modification of Fig. 10;

Figure 12 is a transverse section through one of the blades in a second modified form of the propeller;

Figure 13 is a transverse section through one of the blades in a third modified form of the propeller;

Figure 14 is a plan view of one of the blades in a fourth modified form of the propeller;

Figure 15 is a general view of one of the blades in a fifth modified form of the propeller;

Figure 16 is a transverse section through the blade of Fig. 15; and

Figure 17 is a transverse section through one of the blades in a sixth modified form of the propeller.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring firstly to **Fig. 1**, the adjustable pitch propeller has a hollow hub 1 which is rotatably carried on a drive shaft 2 (**Fig. 8**) and blades 3 (five in this example) which project radially from the hub. Each of the blades 3 has a main fixed-pitch portion 4 which is fixedly mounted on the hub 1 with a curved leading edge 5 and a straight trailing edge 6. The trailing edge of each blade is provided with a strip-like pitch-change flap 7 extending from the blade tip 12 to the root 13 adjacent to the hub 1. Referring to the sectional view of **Fig. 2**, the blades 3 have an upstream suction surface 8 and a downstream pressure surface 9. Each flap 7 is pivotal about a pitch-change axis 14 extending along the trailing edge of the respective blade so that the flap may move continuously through a range of positions, three of which are depicted in the drawing by way of example. In transverse cross-section the flaps 7 have a convex suction surface 10 and a concave pressure surface 11. The pressure surfaces 11 have a greater curvature than the suction surfaces 10. In addition, the suction surfaces 10 are narrower than the pressure surfaces 11, the two surfaces 10 and 11 being connected by an inclined trailing edge 12 which makes an acute angle with the pressure surface 11.

As shown in **Fig.s 1 and 3**, the outer end of each flap 7 is supported and pivotably mounted at the tip of the respective blade 3 by a blade tip plate 15. The blade tip plates may also act to reduce tip lift losses and tip vortice generation. Again, for the purposes of illustration, only two of the range of possible angular

positions of the flap 7 are shown.

Referring now to **Fig.s 4 to 7**, the inner end of each of the flaps 7, at the root of each blade, is provided with a pivot pin 16 which is journalled in a socket 17 in the hollow hub 1. Inside the hub the pivot pin 16 carries a radially projecting arm 18 which, in turn, carries a pitch control pin 19 spaced from the pivot axis 14 of the flap 7. The pitch control pins 19 of the blades are rotatably received in a pitch control head 20, **Fig. 7**, which is mounted within the hub 1 for axial movement such that movement of the control head axially of the drive shaft 2 causes all of the flaps to pivot simultaneously about their pitch-change axes 14.

In one embodiment which is shown in **Fig.s 8 and 9** the pitch of the propeller may be controlled automatically to adapt to different operating conditions. In this embodiment the pitch-change flaps 7 are journalled in a cylindrical hub component 22 which is bolted to a hub nut 23 using threaded axial holes 24 (**Fig.s 6 and 7**). The hub nut 23 contains a cylindrical chamber 25 which contains a compression spring 26 acting between the end wall 27 of the chamber 25 and a flange 20A on the pitch control head 20. An adjustment rod 28 which is screw-threaded into the pitch control head 20 extends through the chamber 25, passing through a stepped hole 29 in the end wall 27, ending in a stop head 28A. By rotating the stop head 28A to screw the adjustment rod 28 in and out of the control head 20 the propeller pitch can be finely adjusted to give correct engine revolutions when the vessel is loaded or lightly loaded, and in the case of a high speed vessel, to

help the vessel to plane.

When the propeller is at rest with no loading, as shown in **Fig. 8**, the trailing edge flaps 7 are held in the high pitch position by the adjustable spring 26 contained in the hub nut 23. When blade pressure is high the trailing edge flaps rotate against the action of the spring 26 to lower the propeller pitch, as shown in **Fig. 9**. When blade pressure reduces again the trailing edge flaps rotate to increase the propeller pitch. For instance, when a vessel is accelerating from a start position the propeller shaft speed is low, the torque is high, and the pressure on the blades is high. The high pressure on the blades passively adjusts the angle of the trailing edge flaps and this reduces the effective propeller pitch. The lower pitch allows the engine speed to increase and therefore to produce more power which in turn increases the acceleration of the vessel. Conversely when the shaft speed and vessel speed is high, the torque and the blade pressure is less and this adjusts the flaps to increase the propeller pitch.

Instead of, or in addition to, the automatic self-adapting pitch-change mechanism described above, the pitch can be controlled from ahead or from astern by a cable, rod or hydraulic fluid passing through the propeller drive shaft. In **Fig.s 10 and 11** the propeller pitch can also be controlled remotely by a rod 30 inserted co-axially through the propeller drive shaft. The rod is secured to a pitch control head 20B which in this embodiment comprises a grooved collar formed by a spacer 31 clamped between end plates 32 and 33. The pitch control pins 19 are

located in the peripheral groove 34 formed between the end plates 32 and 33 so that as the pitch control head is moved axially by the push rod 30 the angle of the pitch control flaps 7 changes between the two positions shown in **Fig. 9**.

Although the sectional shape of the blades 3 and flaps 7 is preferably as described above in relation to **Fig. 2** they could have other profiles as shown in **Fig.s 12 and 13**. The flaps 7 could also be curved along the length of the blade, or the flaps could be formed of interconnected segments 7a-7c, **Fig. 14**, to accommodate a non-straight trailing edge of the blade. In **Fig.s 15 and 16** the outer end of the flap 7 is supported by the blade tip 40 and the inner end by a C-foil wedge feature 41 at the root of the blade. **Fig. 17** shows a further modification in which an elastomer filler 46 is interposed between the flap 7 and the trailing edge of the blade 3 in the region of the pivot. The elastomer acts as a spring which assists the flap 7 to return towards its rest position, and also reduces the risk of cavitation by eliminating a potential void in this region.

In the embodiments described above the effective propeller shape remains the same as an optimised and efficient fixed pitched propeller but with the provision of fine pitch adjustment. The hub assembly can be reduced in size compared to a conventional controllable pitch propeller so that the propeller has less hydrodynamic drag and can be more efficient which will improve performance and save fuel.

Whilst the above description places emphasis on the areas which are believed to be new and addresses specific problems which have been identified, it is intended that the features disclosed herein may be used in any combination which is capable of providing a new and useful advance in the art.

CLAIMS

1. An adjustable pitch propeller which includes:
- a drive shaft (2) rotatable about an axis;
- a hub (1) rotatably carried on the drive shaft; and
- a plurality of blades (3) projecting radially from the hub;
in which each of the blades includes a fixed-pitch portion which is fixed relative to the hub and a pitch-change flap (7) which is pivotable about a pitch-change axis (14) extending along a trailing edge of each blade; and the hub is provided with a pitch-change mechanism arranged to adjust the angle of the flaps about their respective pitch-change axes, in which each pitch-change flap is supported by a pivot pin (16) which is inserted into the hub, and the pivot pin carries a pitch-change arm (18) inside the hub,
characterised in that the pitch-change arm (18) is engaged with a pitch control head (20) which is movable axially of the drive shaft.

2. An adjustable pitch propeller according to Claim 1 in which the pitch control head is movable against spring loading.

3. An adjustable pitch propeller according to Claim 2 in which the spring loading is provided by a compression spring which is located in a chamber in the hub.

4. An adjustable pitch propeller according to Claim 3 in which the compression spring acts between the pitch control head and an end wall of the chamber.

5. An adjustable pitch propeller according to Claim 2 in which a screw-threaded adjuster is engaged with the control head to vary the spring load applied to the control head.

6. An adjustable pitch propeller according to any of Claim 1 in which the control head is movable remotely by a rod, cable or hydraulic fluid passing inside the drive shaft.

7. An adjustable pitch propeller according to Claim 1 in which an outer end of each blade carries a tip plate which rotatably supports the outer end of the pitch-change flap.

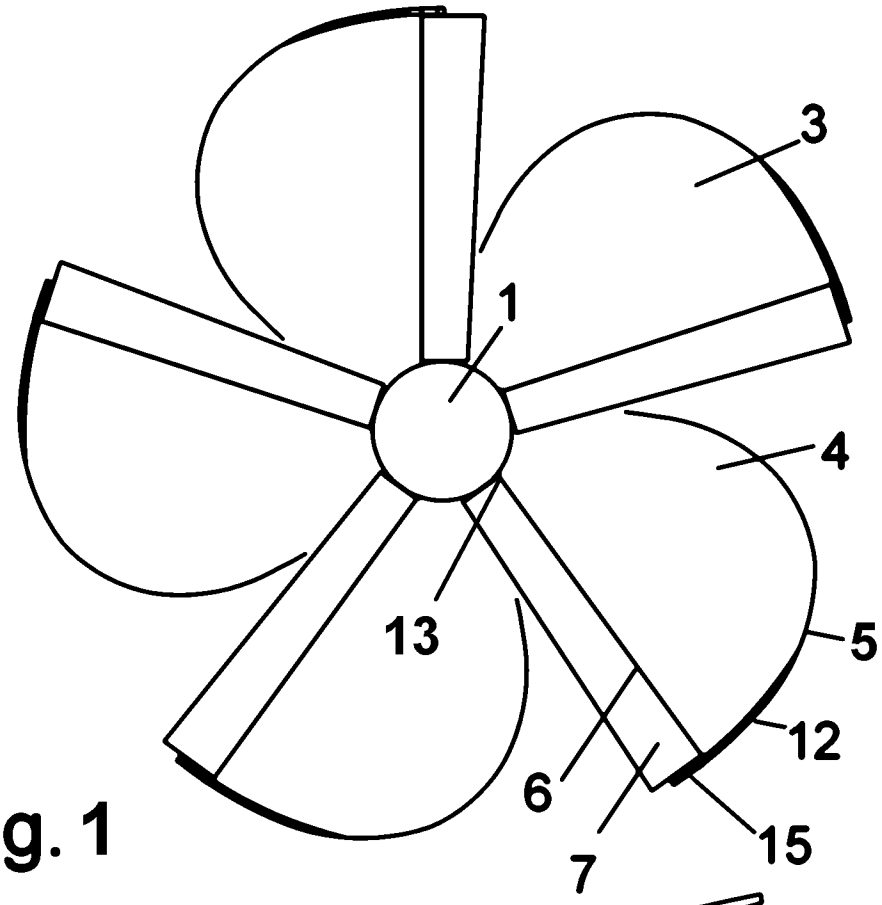

Fig. 1

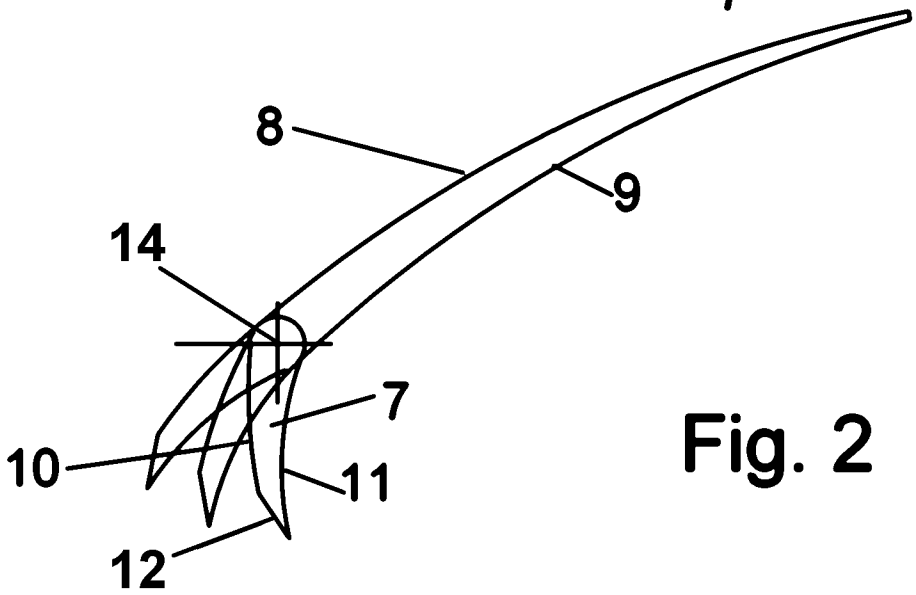

Fig. 2

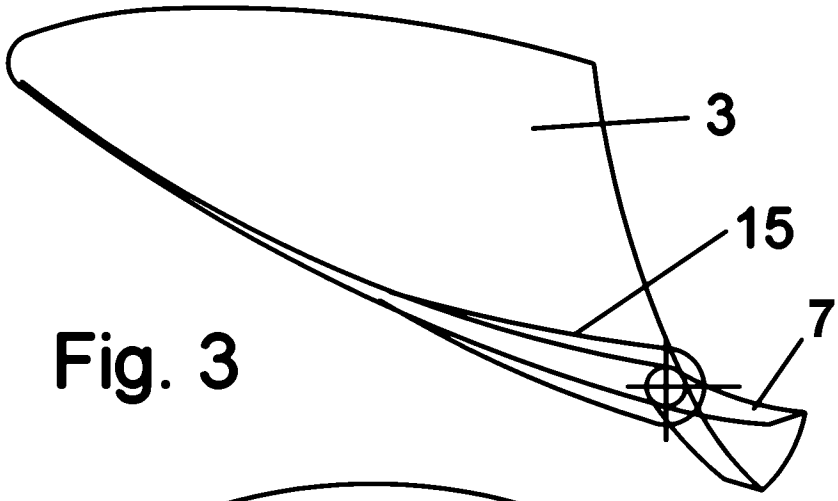

Fig. 3

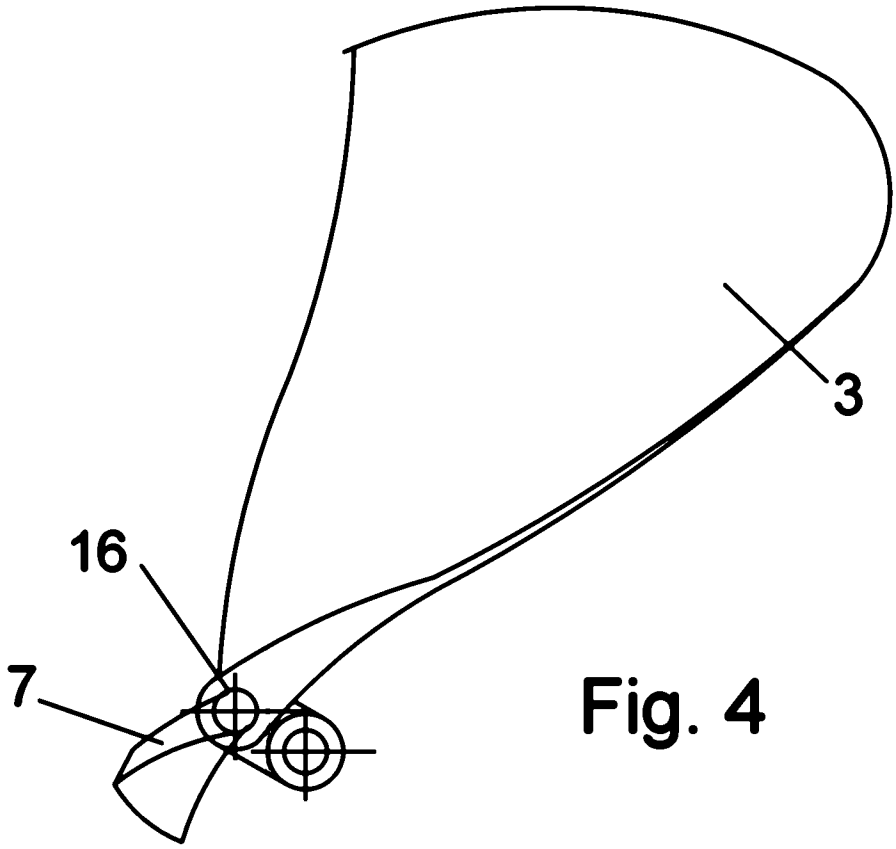

Fig. 4

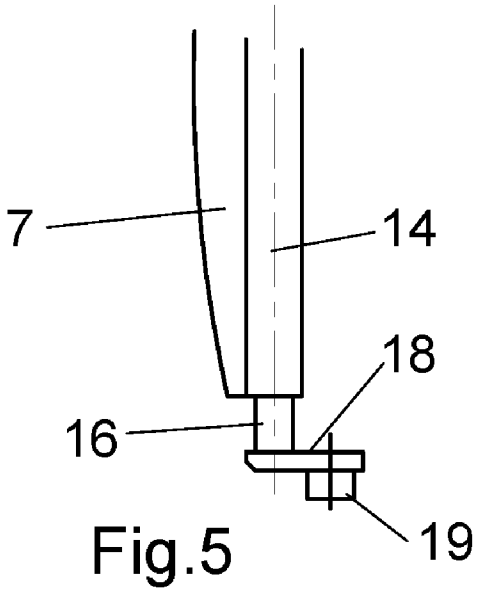

Fig.5

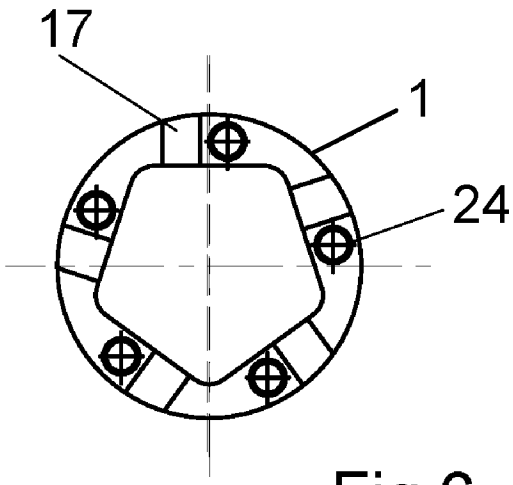

Fig.6

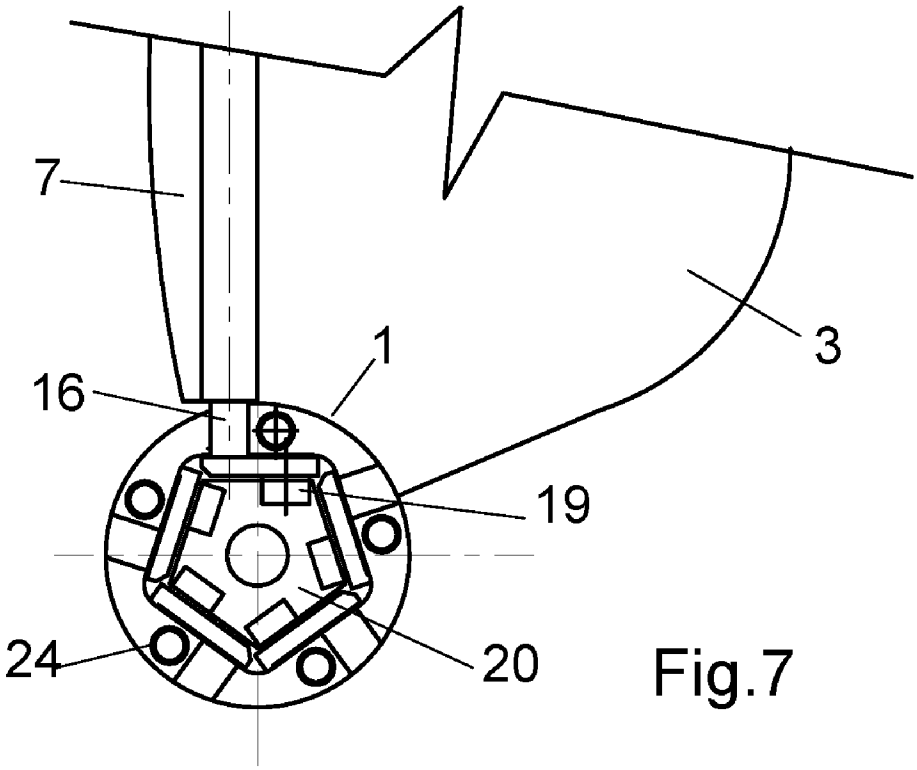

Fig.7

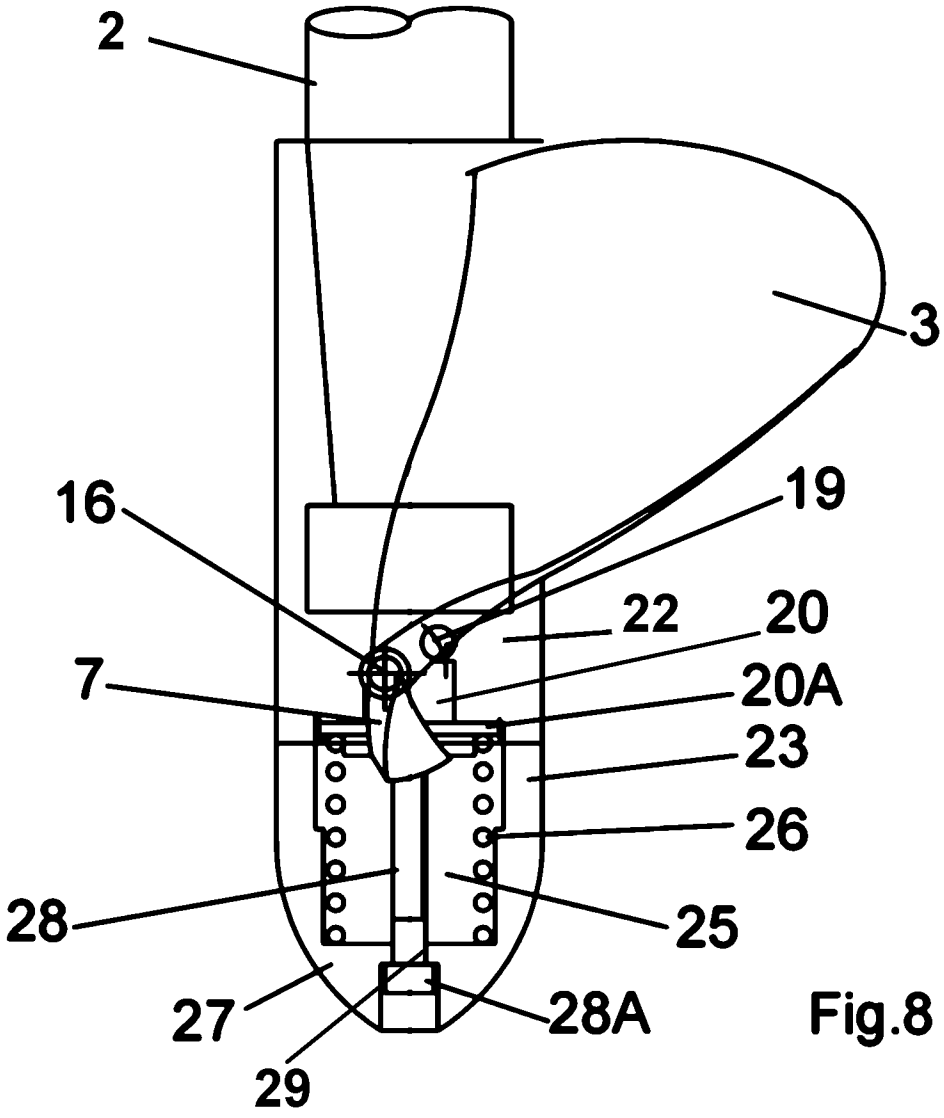

Fig.8

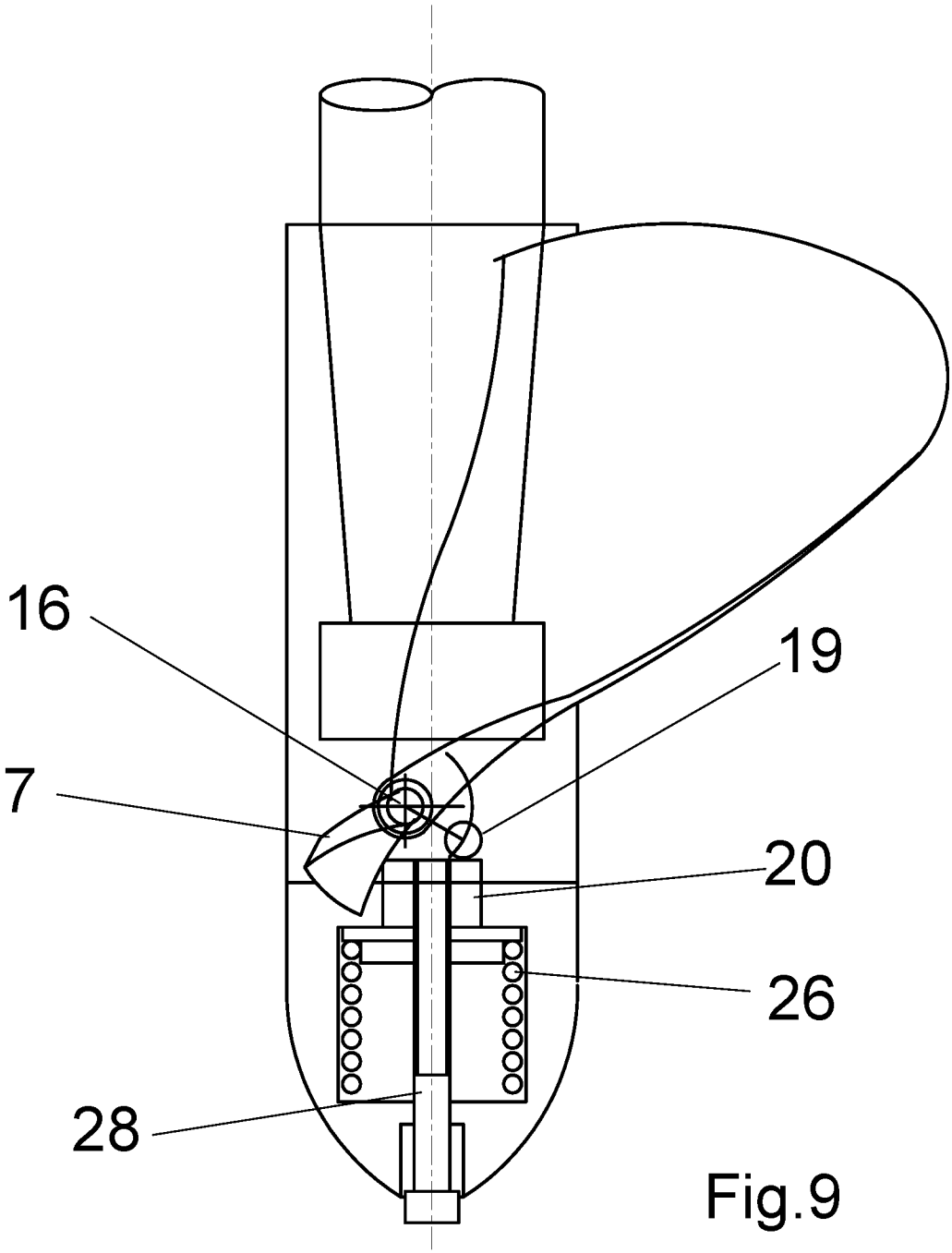

Fig.9

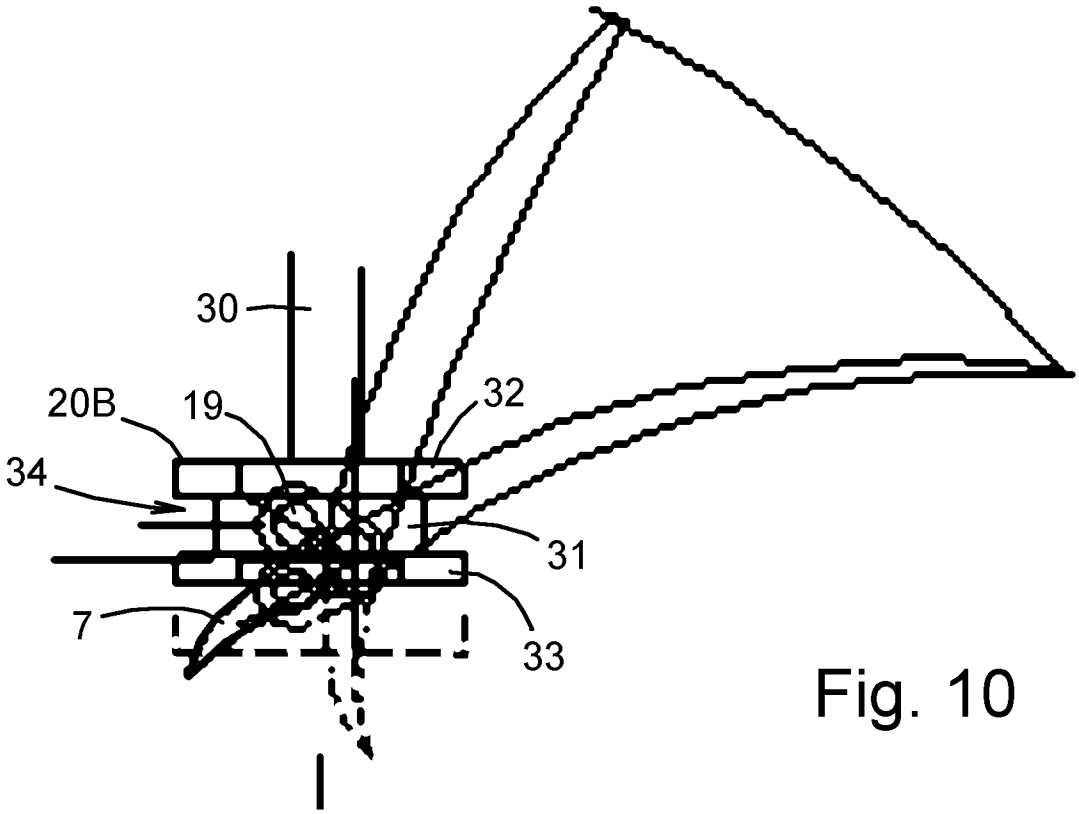

Fig. 10

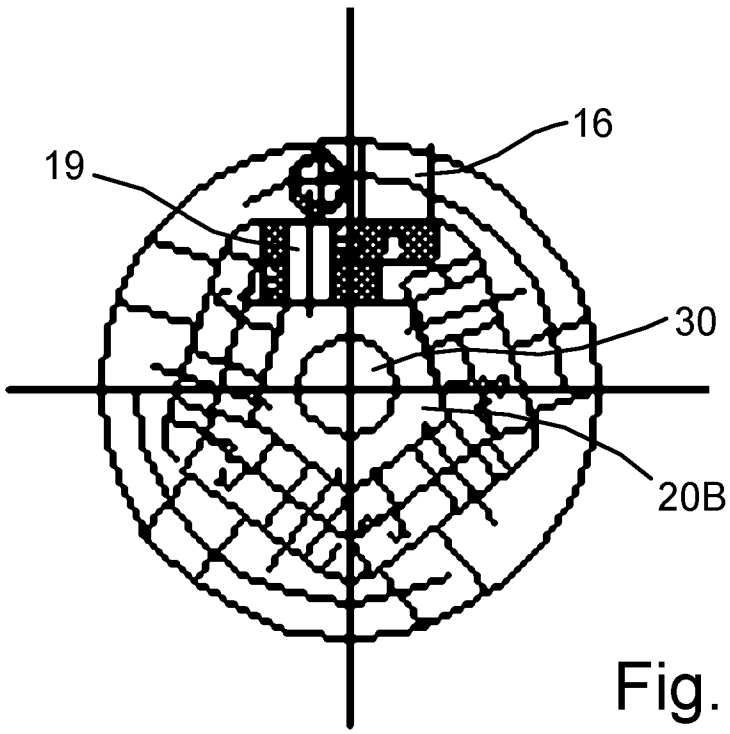

Fig. 11

Fig. 12

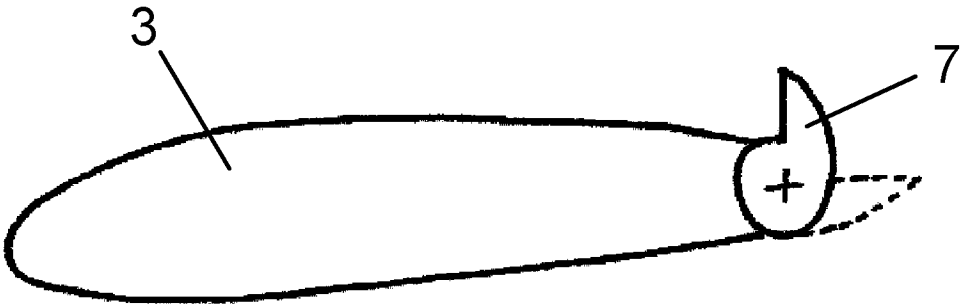

Fig. 13

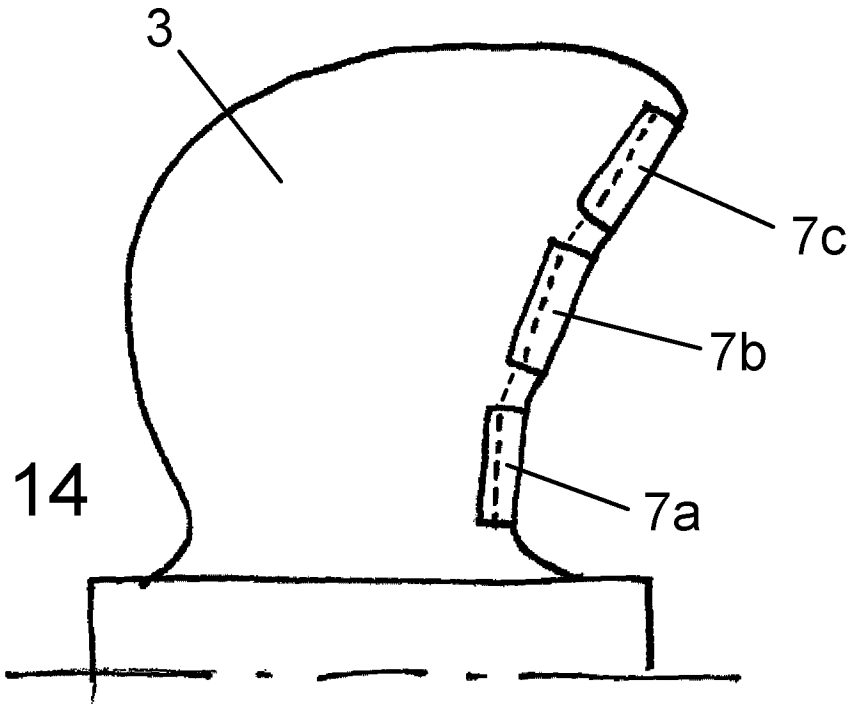

Fig. 14

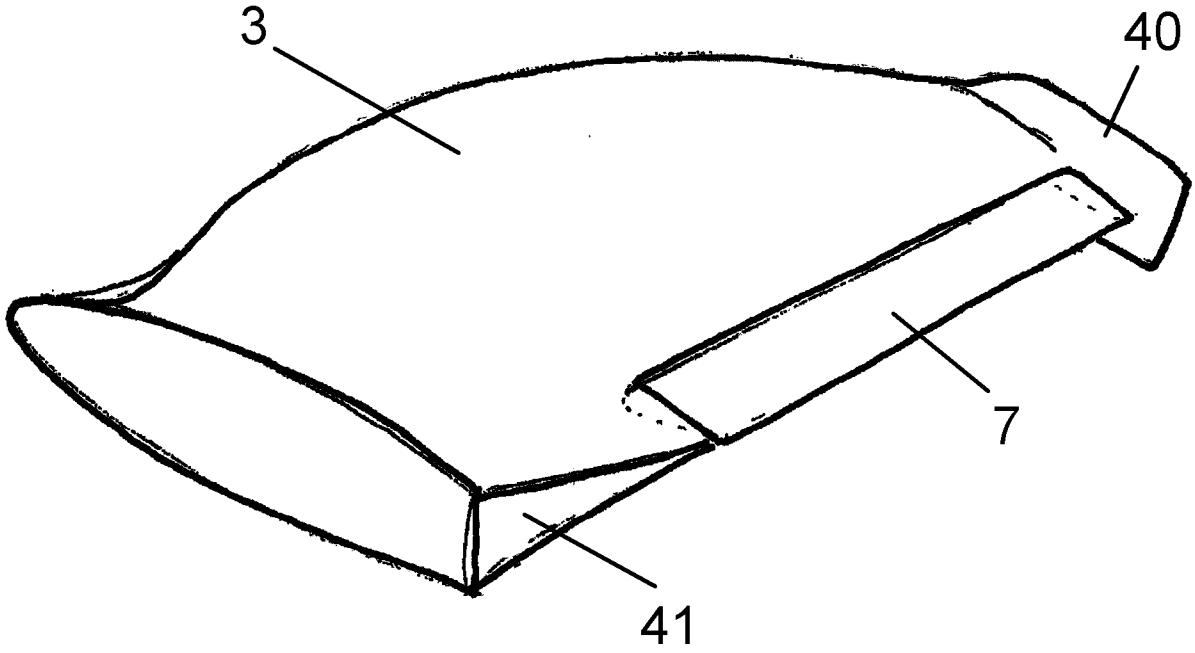

Fig. 15

Fig. 16

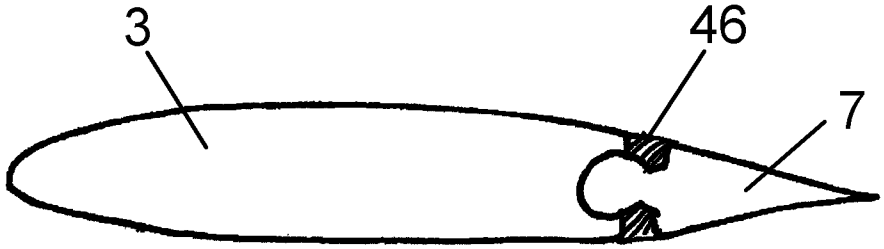

Fig. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/051464

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63H3/04 B63H3/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 550 484 A (STONE J & CO LTD; ERNEST CHARLES HATCHER) 11 January 1943 (1943-01-11) cited in the application page 3, line 15 - page 4, line 13; figures 1-5	1-7
A	GB 1 586 042 A (ONERA) 18 March 1981 (1981-03-18) page 1, line 54 - page 3, line 16; figures 1-12	1-7
A	DE 373 893 C (ANTON FLETTNER) 19 April 1923 (1923-04-19) page 2, line 31 - page 5, line 36; figures 1-22	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
3 October 2017	11/10/2017

Name and mailing address of the ISA/	Authorized officer
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2017/051464

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 550484 A	11-01-1943	NONE	
GB 1586042 A	18-03-1981	FR 2395187 A2	19-01-1979
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