United States Patent

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[54] **VARIABLE PITCH PROPELLER**
8 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **416/131,** 416/203
[51] **Int. Cl.** **B63h 3/00**
[50] **Field of Search** ..... 170/160.1, 160.27, 166, 170; 416/159, 18, 19 (Cursory), 203, 131, 141, 202, 102

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ABSTRACT: A propeller having differently dimensioned integrally connected blades positioned on a drive shaft in nonsymmetrical relationship. As the blades rotate with respect to the drive shaft, one of blades changes its blade angle of attack while the other remains at a constant blade angle of attack.

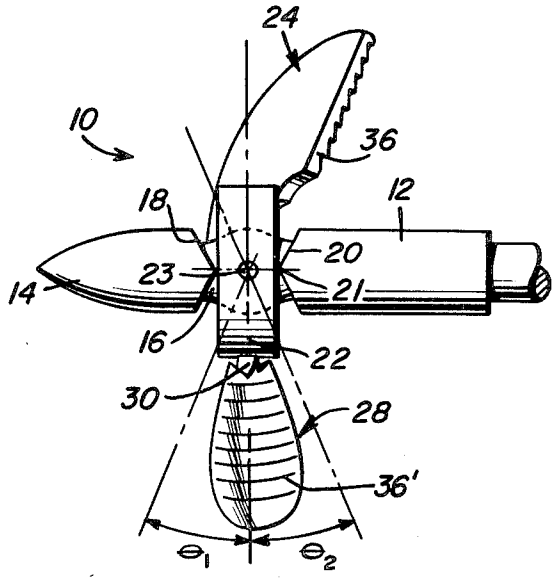


Fig. 1

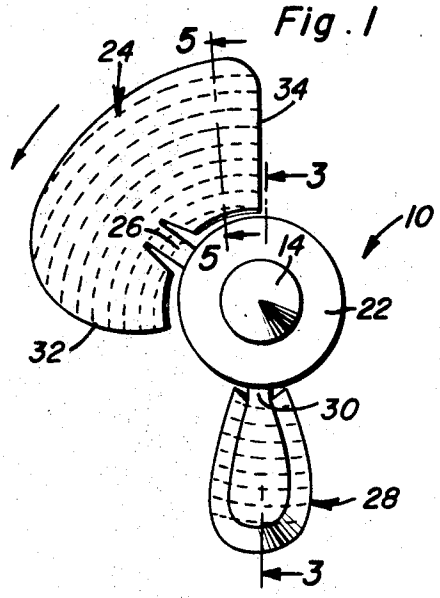


Fig. 2

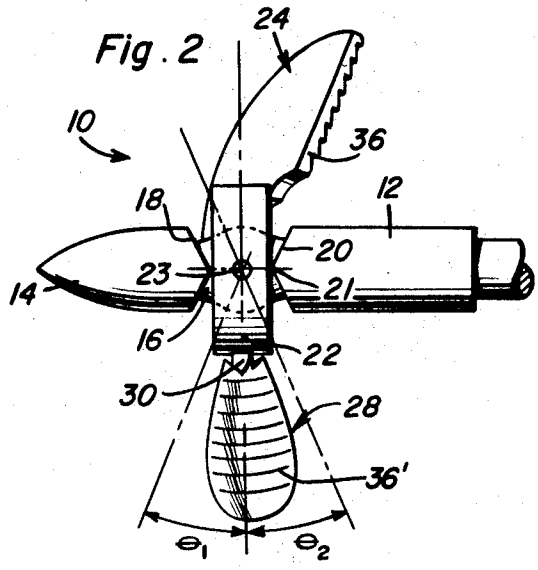


Fig. 3

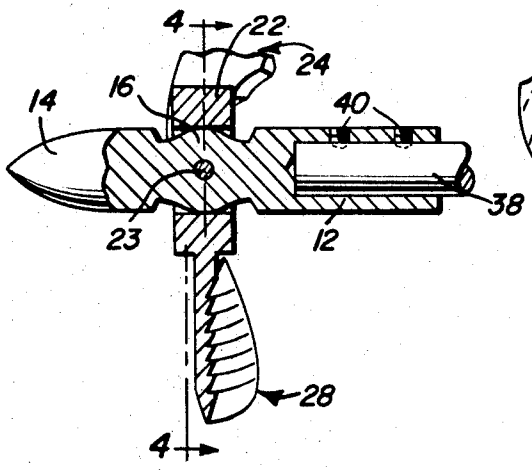


Fig. 4

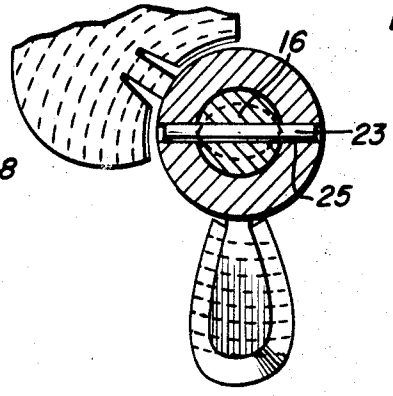


Fig. 5

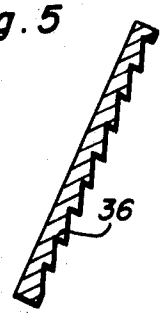
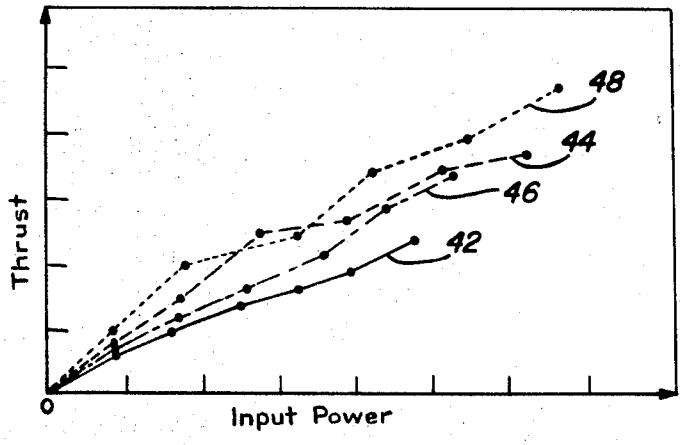


Fig. 6



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Fig. 7

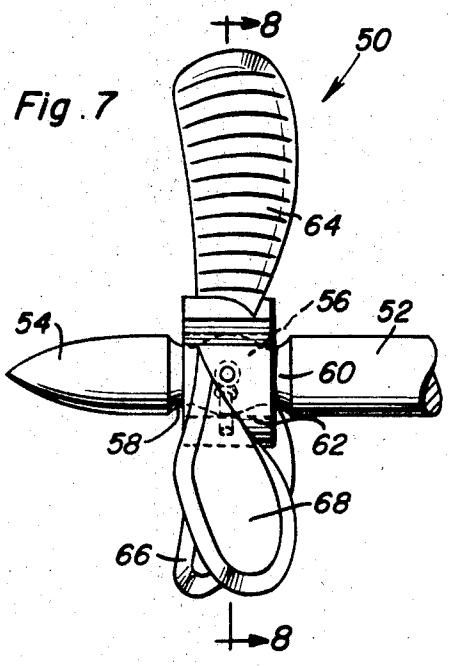


Fig. 8

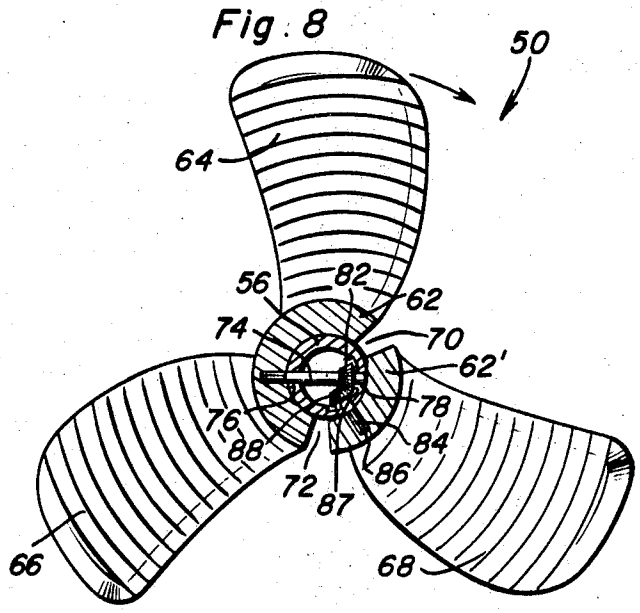


Fig. 9

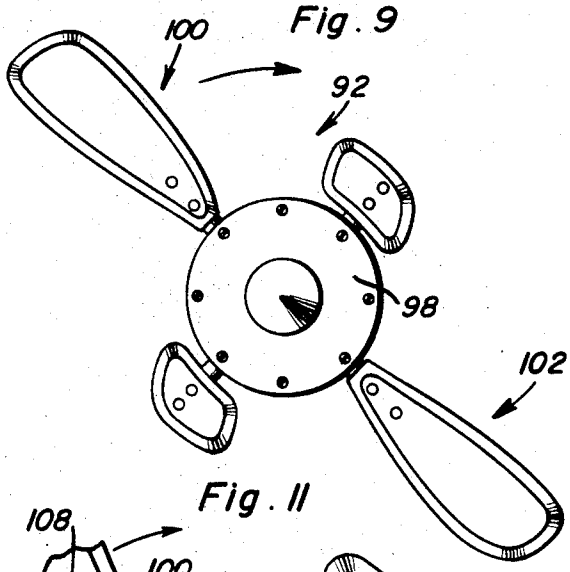


Fig. 10

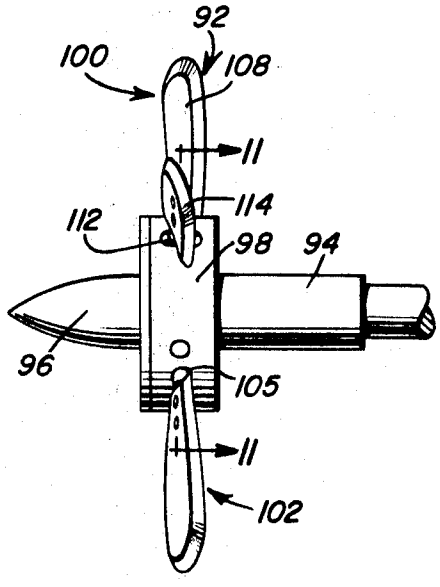
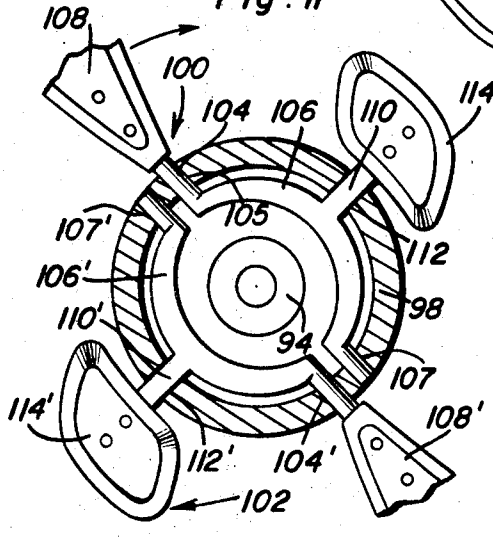


Fig. 11



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Fig. 12

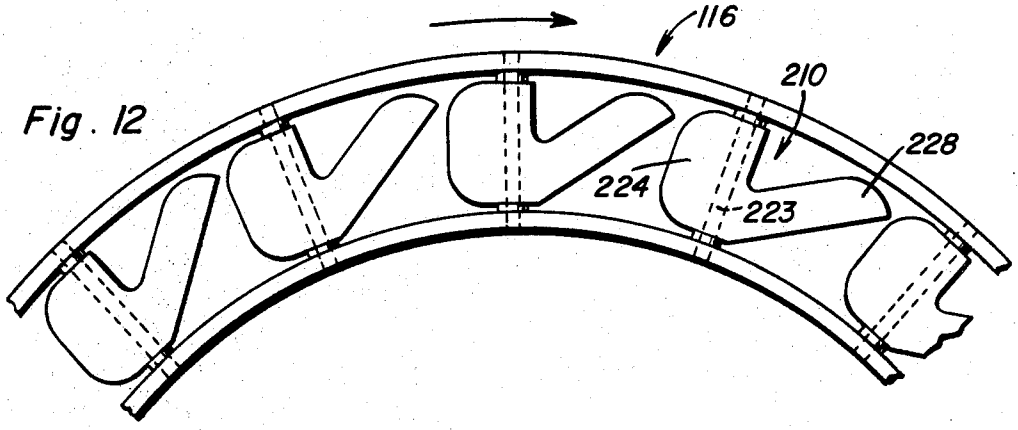


Fig. 13

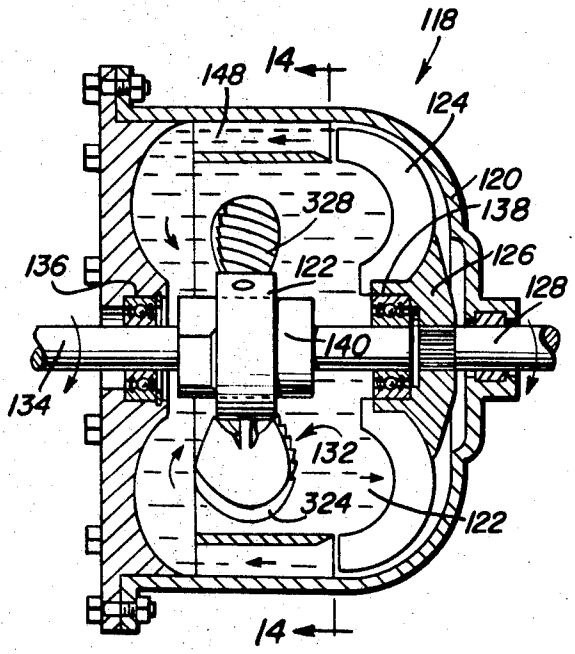


Fig. 14

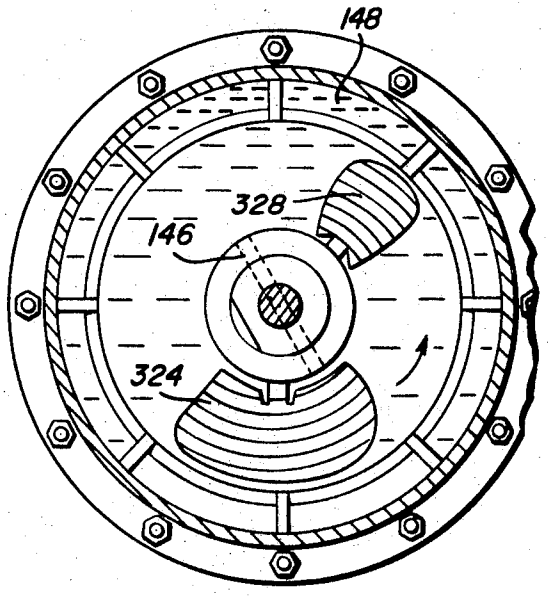
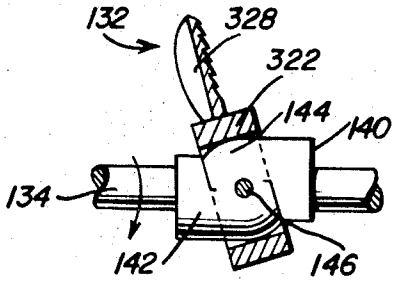


Fig. 15



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VARIABLE PITCH PROPELLER

The present invention relates to propellers and more particularly to an automatically adjustable blade assembly.

Propeller assemblies pivotally mounted on a rotating shaft have been proposed to compensate for and diminish the resistance of a propeller whenever a force is applied to change the direction of its axis of rotation. Such propellers have been somewhat successful in automatically opposing or overcoming various factors otherwise tending to cause dynamic unbalance and dynamic thrust unbalance. The blades employed in previous compensating propellers have been similarly dimensioned and disposed in symmetrical spaced relation about the axis of the rotating shaft.

A basic concept of the present invention includes the integral connection of two dissimilar blades by a link permitting pivotal adjustment of the blade means so as to increase the efficiency of the propeller. The present invention also contemplates the addition of a spiral groove formed in the thrust surface of the propeller embodiments in order to diminish turbulence of the fluid immediately adjacent the propeller blades.

One of the principles underlying the present invention resides in the disproportionality of the thrust surfaces of the blade means. Thus, forces exerted upon differently dimensioned blade members under aerodynamic or marine conditions will vary and cause pivotal adjustment of the blade means until a point of dynamic balance is reached. This finally assumed position tends to avoid dynamic unbalance and dynamic thrust unbalance of the propeller otherwise produced. The same operating principles and blade design considerations may be used in a turbine rotor assembly or a fluid coupling assembly. Further, the present invention may be utilized in any machine where fluid resistance across a propeller changes as for example boat propellers, pumps, transmissions, vacuum cleaners, helicopters, wind tunnels, automobile fan blades, and the like.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a front elevational view illustrating one embodiment of the present invention.

FIG. 2 is a side elevational view of the propeller shown in FIG. 1.

FIG. 3 is a partial longitudinal sectional view taken along a plane passing through section line 3–3 of FIG. 1.

FIG. 4 is a partial transverse sectional view taken along a plane passing through section line 4–4 of FIG. 3.

FIG. 5 is a cross-sectional view illustrating the contour of a spiral groove formed in the thrust surface of the propeller shown in FIG. 1.

FIG. 6 is a graphical representation of test results comparing the performance of an automatically adjustable propeller assembly such as that illustrated in FIG. 1 with that of a conventional blade propeller.

FIG. 7 illustrates a side elevational view of the second embodiment of the present invention.

FIG. 8 is a transverse sectional view taken along a plane passing through section line 8–8 of FIG. 7.

FIG. 9 is a front elevational view of the third embodiment of the present invention.

FIG. 10 is a side elevational view of the third embodiment of the present invention.

FIG. 11 is a transverse sectional view taken along a plane passing through section line 11–11 of FIG. 10.

FIG. 12 is a partial front elevational view of a turbine rotor installation for blade assemblies constructed in accordance with the present invention.

FIG. 13 is a longitudinal sectional view through a fluid torque transmitter installation for the present invention.

FIG. 14 is a transverse sectional view taken through a plane indicated by section line 14–14 in FIG. 13.

FIG. 15 is a side section view showing the impeller assembly associated with the installation of FIGS. 13 and 14.

At the outset it must be emphasized that the following species have a common characteristic. In each species, a pair of blades are interconnected in nondiametrical relationship. As the blades rotate with respect to the drive shaft, one of the blades changes its blade angle of attack while the other remains at a constant blade angle of attack.

Referring to the drawings and initially to FIGS. 1—5, a first embodiment of the present invention is denoted by reference numeral 10 and is seen to include a shaft section 12 extending forwardly to a nose cone portion 14. An intermediate length of the shaft includes a spherical surface formation 16 having a center of curvature lying on the axis of shaft 12. Converging edged shoulders 18 and 20 are formed between the nose cone portion 14 and shaft 12 having vertices 21 spaced 180° apart. An annular hub 22 is concentrically positioned around the formation 16, and is caused to pivot forwardly and rearwardly with respect to the axis of shaft 12 by means of pivot pin 23 which extends diametrically through the formation 16 and is received within aligned bores 25 formed within hub 22. Thus, pin 23 establishes a pivot axis for hub 22 intersecting the rotational axis of shaft 12 at the center of curvature of formation 16, the pivot axis also being aligned between the vertices 21 of shoulders 18 and 20.

FIGS. 1 and 2 clearly illustrate the blade configuration of the first embodiment of the present invention wherein a first blade 24 is attached to hub 22 by means of a connecting portion 26 through which the blade axis extends. A second blade 28 is also attached to hub 22 by means of a connecting portion 30 which its blade axis extends. The second blade is dimensionally smaller than blade 24 and angularly spaced from one another by an amount ranging between 90° and 180°. In the illustrated embodiment, the blades are spaced apart by 125° between the respective blade axes. The blades are peripherally contoured in accordance with conventional blade design principles. In order to decrease the amount of turbulence resulting from propeller action in a fluid, a spiral groove is formed on the thrust face of both blades 24 and 28 as denoted by reference numeral 36 and 36′ in FIG. 2. FIG. 5 shows in cross section the groove formation.

Referring to FIG. 3, a rotating power shaft 38 is received within a bore axially formed within the propeller shaft 12. The input shaft 38 is secured to the propeller assembly by means of setscrews 40 received within propeller shaft 12. The propeller blade assembly 10 may accordingly be rotated underwater in a marine installation for propulsion purposes by way of example. Under given conditions, the hub 22 and the blades will pivot to a predetermined pitch position on the shaft 12 between limits established by the shoulders 18 and 20. Forward and rearward pivotal displacement from a central position by amounts $\Theta 1$ and $\Theta 2$ is accommodated as depicted in FIG. 2. In a test model of the propeller assembly a value of 22° was selected for $\Theta 1$ and $\Theta 2$. In operation, as the blades pivot, the smaller blade 28 maintains a constant blade angle of attack while the blade angle of attack of the larger blade 24 varies.

FIG. 6 graphically represents test result data comparing the propeller structure of the aforementioned first embodiment with that of a conventional stationary pitch propeller. The graph shown in FIG. 6 is a plot of thrust as a function of shaft input power. The test results were obtained with a first embodiment propeller, excluding the spiral on the thrust face 36, placed in a closed fluid circuit through which water was circulated by the propeller assembly. In order to obtain the thrust-input power characteristics of the tested propellers, a test setup was arranged in a conduit forming part of the fluid circuit. A valve member in the circuit was first manipulated to an open position permitting free circulation representing a no-load condition upon the propeller. Then, the valve was manipulated to a half-opened position to load the propeller assembly by restricting flow through the circuit. All the curves were plotted up to a maximum thrust obtainable, by

measuring the power drawn by an electric motor driving the propeller assembly and metering flow through the circuit by static and dynamic pressure sensors. The lowermost curve **42** represents a no-load condition for a stationary pitch, conventional propeller. The curve denoted by reference numeral **44** represents the no-load characteristics of the propeller of the present invention. As will be observed, the present propeller exhibits greater thrust at any particular input power over the entire range plotted. The curve denoted by **46** represents the characteristics of a stationary pitch propeller of the conventional type under load. The uppermost plotted curve denoted by **48** represents the load characteristics of the present propeller. Hereagain it will be observed that the present propeller structure exhibits greater thrust over the entire range of input power.

FIGS. **7** and **8** illustrate a second embodiment of the present invention and is seen to include a propeller assembly generally denoted by reference numeral **50**. This second propeller embodiment includes a shaft section **52** extending forwardly to a nose cone portion **54**. An intermediately disposed spherical shell formation **56** is coaxially formed between shaft **52** and nose cone portion **54**. Further, the formation **56** has a center of curvature coincident with the axis of shaft **52**. Inwardly tapering shoulders **58** and **60** join nose cone portion **54** and shaft **52** to the spherical formation **56** to limit pivotal motion of an arcuate hub section **62** mounted upon the formation **56**, in a manner similar to that of the first embodiment. Blade members **64** and **66** are integrally connected to a first hub portion **62**. The blade members are contoured in a conventional manner and are displaced from one another by 120°. A second hub section **62'** is disposed in circumferentially spaced relation to the first mentioned hub portion **62** and mounts a third blade member **68** which is identical to members **64** and **66**. Circumferential spaces **70** and **72** separate hub portions **62** and **62'**, thereby permitting pivotal displacement of hub section **62** with respect to hub section **62'** as hereinafter explained.

A first pin **74** is splined at one end thereof to hub section **62** and passes through a journal bore **76** in formation **56**. The opposite end of pin **74** is journaled in bore **78**. The bores **76** and **78** are formed within formation **56** in a manner permitting rotation of pin **74** with respect to the formation **56**. A first bevel gear **82** is mounted upon pin **74** adjacent aperture **78**. A second pin **84** is splined to hub section **62'** as indicated by **86** and passes radially inwardly through a radial bore **87** for attachment at an opposite end to a second bevel gear **88** meshing with the first mentioned bevel gear **82**.

In operation of the second propeller embodiment **50**, pivotal displacement of the hub section **62** with respect to shaft **52** causes rotation of associated bevel gear **82**, this motion being transmitted to bevel gear **88**. Because bevel gear **88** is meshed with bevel gear **82**, this pivotal displacement is linked to hub section **62'** thereby causing simultaneous pivotal displacement of all blade members. Blades **64** and **66** are fixedly mounted on hub section **62** and while they are of the same dimension and contour as the third blade **68**, they form an equivalent blade assembly which is different in effective dimension and effective pressure center than blade **68**. As the blades pivot, the angle of attack of linked blades **64** and **66** varies while the angle of attack of the smaller blade **68** remains constant.

A third propeller embodiment of the present invention is represented in FIGS. **9—11** and is denoted by reference numeral **92**. Referring in particular to FIG. **10**, the third embodiment includes a shaft portion **94** extending forwardly to a nose cone portion **96**. A hollow hub **98** fixedly interconnects nose cone portion **96** and shaft portion **94**. Pivotally mounted within this hub is a first blade assembly generally denoted by reference numeral **100** and a second blade assembly denoted by **102**. The first blade assembly **100** includes a stem portion **104** as shown in FIG. **11** rotatably received within journal bore **105** of hub **98**. The stem extends inwardly to an arcuate linking portion **106** connected to a stem portion **107** journaled by hub **98** about a pivot axis extending through bore **105** offset from the rotational axis of the shaft **94**. An elongated blade member **108** is connected to stem **104**. A second stem portion **110** is attached to the arcuate linking portion **106** and extends outwardly through an elongated slot **112** formed within hub **98**. The external appearance of slot **112** is seen in FIG. **10**. A foreshortened blade member **114** is connected to the outward end of stem **110** so that stems **104** and **110** are substantially perpendicular to one another.

The second blade assembly **102** is identical to that of **100** and is pivotally mounted in hub **98** about a parallel pivot axis offset from the rotational axis of shaft **94** on the opposite side. For purposes of convenience, component portions of the second blade assembly **102** have been numbered in the same manner as the components of the first blade assembly **100** except that the numbering of the second blade assembly **102** is primed.

In operation of the propeller assembly **92**, rotation of shaft **94** causes rotation of blade members **108** and **108'** about its rotational axis while forward or rearward pivotal displacement of the blade members occurs with respect to the parallel spaced pivotal axes aforementioned until the blade members assume predetermined pitch positions under given conditions. When the blades rotate, the blade angle of attack of each small blade **114,114'** remains constant while the blade angle of attack of the larger blades **108,108'** varies.

Referring to FIG. **12**, a turbine rotor assembly **116** is shown and is seen to include a plurality of peripherally mounted vane assemblies **210** which are similar to the first mentioned propeller embodiment **10** shown in FIG. **1**. The pivot pin **223** of each vane assembly is radially disposed and the blade members **224** and **228** pivot thereabout to predetermined pitch positions. The present embodiment is contemplated as being useful in efficiently converting the rotor assembly kinetic energy of fluid into rotational energy of a turbine. When the vane assembly rotates, the blade angle of attack of member **224** remains constant while the blade angle of attack of member **228** varies.

FIGS. **13** and **14** illustrate an application of the present invention in a fluid torque transmitter **118** having a housing **120**. A conventional driven turbine blade assembly **126** is enclosed within the housing which receives fluid energy through a toroidal flow chamber **122**. The fluid transmitter also includes an impeller assembly **132** mounted upon an input or drive shaft **134** journaled in sealed relation within housing **120** by bearing assemblies **136** and **138**, the latter being received within a bored aperture in turbine rotor hub **126**. It is contemplated that any of the aforementioned embodiments **10**, **50** or **92** may be utilized as the impeller assembly except that pivotal displacement is restricted to movement in one direction from a central position. Thus, the shaft **134** mounts a formation **140** having offset portions **142** and **144** as shown in FIG. **15**. As will be observed from FIG. **15**, rearward pivotal displacement of the blade assembly is prevented when hub **322** is parallel to hub portions **142** and **144**. A pin **146** is received within diametrically aligned apertures formed in hub **322** and the hub portion **144** thereby establishing a pivotal axis for the blade assembly.

In operation of the fluid transmitter **118**, the rotating impeller assembly **132** assumes a predetermined pitch position under a given load condition to cause toroidal flow of fluid through the blades **124** of the turbine rotor and the guide channels **148** of the housing for transmission of rotational torque to the turbine rotor shaft **128**. The blades **324** and **328** exhibit blade attack characteristics as discussed previously in connection with FIGS. **1—4**.

In each of the foregoing embodiments of the invention, the pivoted hub or hub section moves to a predetermined pitch position determined by the pressure exerted on the thrust faces of the blade or blades, carried by the hub or hub section, by the fluid medium as well as the centrifugal forces acting on the blades during rotation. Further, since there are at least two

blades having either dimensionally different contours or thrust face areas, and such blades have pressure centers radially spaced from the rotational axis on opposite sides, the resulting differences in thrusts and/or moment arms will affect the pitch position assumed because the blades are mechanically interconnected. Thus, the relative blade dimensions and contours are selected in order to cause pivotal movement of the blades to pitch positions calculated to be ideal for given fluid conditions under which the propeller, vane or impeller assembly is to operate. The asymmetrical arrangement of the blades on the hub provides for greater design selection so as to make possible higher efficiencies under varying fluid conditions contemplated during operation of the blade assembly.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

I claim:

1. A bladed rotor device comprising a first blade, a second blade having a substantially different blade area than the first blade and positioned in nondiametrical relation thereto, a hub link connecting the blades, support means connected to the link for enabling pivotal motion of the linked blades about the axis of the support means, the pivotal motion causing the blade angle of attack of one blade to vary while the blade angle of other blade remains constant.

2. The structure of claim 1 wherein the link is a hub portion and further wherein a drive shaft axially passes through the hub portion, the support means comprises a pivot pin diametrically extending through the shaft and the hub portion, the shaft having an arcuate surface with a center of curvature coinciding with the pin, the shaft having shoulder surfaces for limiting movement of the hub portion.

3. The structure of claim 1 together with a hub having first and second apertures therein, a third oversized aperture formed in perpendicular relation to the first and second apertures, the support means including separated pin elements journaled in the first and second apertures, an arcuate strip connecting the elements to serve as the link, the first blade being outwardly attached to one of the pin elements so that it can execute the varying angles of attack, and an element passing through the third aperture for connecting the second blade to the link for allowing the blade to maintain a constant angle of attack.

4. The structure of claim 3 wherein a complemental set of blades are similarly connected with a second link within the housing for executing identical rotational characteristics, the resulting structure being symmetrical.

5. The structure of claim 1 wherein the first blade includes two integrally connected blade elements spaced 120° from each other, said second blade being a single blade element positioned 120° from both blade elements of said first blade, and wherein the link means include gear members for causing simultaneous pivotal movement of said first and second blades.

6. The device set forth in claim 1 together with spiral grooves formed in thrust surfaces of the blades for reducing thrust imbalance.

7. In a turbine rotor, a vane assembly comprising a plurality of bladed members spaced peripherally around the rotor, each said bladed member comprising a first blade portion, a second blade portion substantially different in dimension and angularly oriented from said first blade portion, a rocking hub portion on which said blade portions are connected, a shaft pivotally mounting the hub portion so that each bladed member executes limited movement relative to said shaft whereby in each bladed member the first blade portion executes rotation with a constant blade angle of attack and the second blade portion executes rotation with a varying blade angle of attack.

8. In a fluid torque transmitting device an input impeller comprising an input shaft, a bladed rotor including a blade, a second blade substantially different in dimension and obliquely oriented with respect to said first blade, a rocking hub on which said blades are mounted, pin means pivotally mounting said hub to the shaft enabling the first blade to execute rotation with a constant blade angle of attack while the second blade executes rotation only with a varying blade angle of attack.