

WAKE ADAPTED PROPELLER DRIVE MECHANISM FOR DELAYING OR REDUCING CAVITATION

BACKGROUND OF THE INVENTION

This invention relates to a wake adapted propeller drive mechanism for delaying or reducing cavitation.

This invention relates particularly to a wake adapted propeller drive mechanism for delaying or reducing cavitation for a propeller drive mechanism which is mounted at the stern of a submerged symmetrical hull and which is held submerged beneath a water craft superstructure by a strut connected to the top of the hull and to the underside of the water craft superstructure.

When a hull is moved through water, a wake comes off of the hull. The wake is called a viscous wake.

The wake has a speed profile such that the boundary layer of the water closest to the hull tends to be dragged forward with the hull at a higher forward speed than the parts of the wake which are spaced farther outwardly from the surface of the hull.

Because water is a relatively dense medium, there is a significant increase in water pressure with increase in water depth.

The vapor pressure of water is about .5 pounds per square inch (PSI). If the pressure on a part of the surface of a propeller blade should drop below about .5 PSI, the

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water at that surface can vaporize and can cause cavitation and cavitation noise.

Cavitation, depending upon the extent and duration, can fracture or destroy a propeller.

In any event, cavitation produces a cavitation noise. Cavitation noise by itself can be undesirable in some operations.

A propeller mounted for rotation at the stern of a hull must therefore be constructed to be effective for different conditions of operation at different radial locations on the blades of the propeller and at different parts of the rotation of the propeller around the incoming wake. If during the rotation, a cross section at a particular radial location on a propeller blade encounters a high angle of attack (for example, an angle of attack in the order of about 25 degrees) with respect to the incoming wake at that radial location, a high lift condition can occur. The high lift condition can reduce the vapor pressure of the water on a part of the blade surface at that cross section to less than .5 PSI, resulting in cavitation on that surface. Encountering an excessive angle of attack (above about 30 degrees) with respect to the incoming wake can cause a stall condition. The stall condition is a breakdown of the flow over the low pressure blade surface.

If the cross section of the blade at a particular radial location has too low an angle of attack (for example, an angle of attack less than about 12 degrees) for the operating conditions in that part of the incoming wake, that part of the blade will not have optimal pull.

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If a hull also has some other structure (for example, a strut) attached to it, and if that structure projects into the wake ahead of the propeller, that structure can cause or can contribute to a deficit in the wake. Such a structure thus produces a further complication by causing the inflow velocity to the propeller, in that deficit portion of the wake, to slow down compared to the inflow velocity of other portions of the wake in which the propeller operates.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to construct a wake adapted propeller drive mechanism for delaying or reducing cavitation.

It is a related object of the present invention to construct a wake adapted propeller drive mechanism for delaying or reducing cavitation by eliminating or minimizing problems involved in prior art propeller drive mechanisms.

In the present invention a wake adapted propeller drive mechanism for delaying or reducing cavitation comprises a hull having a bow and a stern and a wake adapted propeller mounted for rotation at the stern of the hull so as to be rotatable in a wake produced by the forward motion of the hull through the water.

For a conventional, prior art propeller mounted for rotation in a plane aligned perpendicular to the axis longitudinal axis of the hull and the axis of the flow of the wake, the angle of attack of a propeller blade cross section, in at least certain critical radial

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portions, must be below a certain upper limit in order to avoid cavitation, cavitation noise

and/or stall as the cross section is rotated through the wake.

The wake adapted propeller drive mechanism of the present invention includes mounting means which mount the wake adapter propeller for rotation in a plane which is inclined to the longitudinal axis of the hull and the axis of flow of the wake and which skews the drive shaft of the wake adapted propeller sideways of the hull in a horizontal plane.

The angles of attack of the wake adapted propeller are adjusted, by said skew of the drive shaft, to be below said upper limits for corresponding radial portions of said conventional propeller so as to increase the ship's speed for the onset of propeller, stall, cavitation or cavitation noise.

In one specific embodiment of the present invention, the amount of the skew is effective to prevent any cavitation in any part of the wake until the angles of attack produce incipient cavitation all the way around the rotation of the wake adapted propeller through the wake.

In a specific embodiment of the present invention, the hull is a symmetrical hull and a strut is connected to the top of the hull and holds the hull submerged in the water beneath a water craft superstructure.

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The wake adapted propeller of this embodiment of the invention rotates, at least in part, in both the wake produced by the forward motion of the submerged hull through the water and in a deficit, upper portion of the wake.

The adjusted angles of attack of the wake adapted propeller prevent stall and cavitation in the deficit upper portion of the wake as well as in the other parts of the wake producing a substantial increase in propulsion efficiency.

The adjusted angles of attack of the cross sections of the blades of the wake adapted propeller are greater, in the lower half portion of the wake, than the effective angles of attack of the conventional propeller to produce a substantial increase in propulsion efficiency of the wake adapted propeller.

Methods and apparatus which incorporate the features described above and which are effective to function as described above constitute further, specific objects of the invention.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings, which by way of illustration, show preferred embodiments of the present invention and the principles thereof and what are now considered to be the best modes contemplated for applying these principles.

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Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

BRIEF DESCRIPTION OF THE DRAWING VIEWS

Figure 1 is a pictorial view drawn to illustrate the speed profile of the wake incoming to a propeller mounted for rotation at the stern of a symmetrical hull which is held submerged by an upper strut. The strut contributes to a deficit in the upper portion of the wake. Figure 1 illustrates, in the pull out cross section at the lower right hand part of Figure 1, how the speed profile of the viscous wake of the strut combines with the decreasing water pressure near the surface to produce a deficit wake within the viscous wake produced by the submerged hull.

Figure 2 is a fragmentary top plan view taken along the line and in the direction indicated by the arrow 2 in Figure 1.

Figure 3 is a cross section through a blade of the propeller shown in Figure 1. Figure 3 is taken along the line indicated by the arrow 3 in Figure 1. Figure 3 is taken about half way out the radial length of the blade from the propeller hub. Figure 3 also includes a diagram illustrating how the angle of attack of the blade is affected by the flow velocity conditions encountered as that blade cross section rotates through a radial band in

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the uppermost, vertical part of the wake 9 (as shown in Figure 1). In this part of the wake the angle of attack of the blade cross section in this radial band is dependent on the design blade angle of attack, the velocity of the blade due to rotation of the propeller ($V_{\text{due to rotation}}$), and the deficit velocity ($V_{\text{deficit}}=.3$). In the part of the wake that is not in the deficit the angle of attack of the blade cross section is dependent on the design blade angle of attack, the velocity of the blade due to rotation of the propeller ($V_{\text{due to rotation}}$), and the wake velocity ($V_{\text{wake}}=.5$).

Figure 4 is a view like Figure 3 of the cross section of the propeller blade at the radial location indicated by the arrow 3 in the Figure 1, but Figure 4 includes diagrams to indicate pressure distributions existing on the upper (as viewed in Figure 4) surface of the blade cross section. Figure 4 shows the relationship between the design pressure distribution (for that radial location of the cross section on the blade), the pressure distribution resulting from just the incoming wake velocity at that radial location on the blade (indicated by the circled reference numeral 1 in Figure 3 and Figure 4), and the different pressure distribution resulting from movement through the deficit (resulting from the reduced speed of the incoming wake produced by the wake deficit). This pressure distribution deficit is shown under the line indicated by the circled reference numeral 2 in Figure 4 and correlates to the deficit relative velocity line indicated by the circled reference numeral 2 in Figure 3. Figure 4 illustrates how the pressure distribution

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drops below a cavitation limit across a substantial extent of the pressure distribution deficit. This is shown by the cross hatched portion under the pressure distribution deficit line 2 projecting above the upper (as viewed in Figure 4) surface of the cross section of the blade. Cavitation and cavitation noise, stall and loss of lift can therefore be produced on this blade surface for this design blade angle of attack. In viewing Figures 3 and 4 it can be helpful to keep in mind that the blade cross section is being rotated through a radial band in the deficit wake at a fixed radial distance corresponding to the geometric position of the radial band existing between the .4 and the .6 numerals shown in the bottom part of the pull out cross section of the wake illustrated in the lower right hand portion of Figure 1.

Figure 5 is a pictorial view like Figure 1 and shows one prior art construction in which a stator blade is fixed in position on the top of the submerged hull just in advance of the propeller to redirect the direction of the flow (of the wake and the deficit wake) incoming into that upper portion of the rotation of the propeller. The fixed stator was used to redirect the incoming flow to reduce the angle of attack the propeller blades in the upper portion of the wake.

Figure 6 is a fragmentary top plan view taken along the line and in the direction indicated by the arrow 6 in Figure 5. Figure 6 indicates, by the flow arrows shown in

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Figure 6, how the wake incoming to the propeller is changed in direction by the fixed stator in this part of the wake.

Figure 7 is a diagrammatic view like Figure 1 and Figure 5 but showing a wake adapted propeller drive mechanism for delaying or reducing cavitation and constructed in accordance with one embodiment of the present invention. In Figure 7 the drive shaft for the propeller is skewed sideways, off the longitudinal axis of the submerged hull. The propeller drive mechanism shown in Figure 7 mounts the wake adapted propeller for rotation in a plane that is inclined to the axis of flow of the wake, and the mechanism skews or offsets the drive shaft of the wake adapted propeller sideways of the hull.

Figure 8 is a fragmentary top plan view taken along the line and in the direction indicated by the arrow 8 in Figure 7 showing the angle of skew of the drive shaft for the propeller with respect to the longitudinal axis of the submerged hull.

Figure 9 is a diagrammatic view which illustrates how the skewing or offset of the propeller drive shaft as illustrated in Figures 7 and 8 adjusts the angle of attack of a blade cross section at a particular radial location on a propeller blade (as compared to the angle of attack of a conventional on axis propeller drive as shown in Figure 1) both to lower the angle of attack as the blade rotates through the upper and deficit portion of the wake and to increase the angle of attack as the blade cross section rotates through the bottom portion of the wake. The angles of attack of the blade cross section as shown in the lower

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part of Figure 9 are somewhat exaggerated in illustration to help understand the function produced by the skew of the drive shaft of the propeller as illustrated in Figures 7 and 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One of the preferred embodiments of the wake adapted propeller drive mechanism of the present invention is illustrated in and will be described in more detail below with reference to Figures 7, 8 and 9 of the drawings.

It is believed that the new modes of operation and that the benefits of the wake adapted propeller drive mechanism of the present invention can best be understood by first considering how problems of cavitation and cavitation noise and stall occur in the operation of conventional or prior art propeller drive mechanisms.

The problems of cavitation and cavitation noise occurring in the operation of conventional or prior art propeller drive mechanisms will therefore be described first and with reference to Figures 1-6 of the drawings.

As noted above, under the Background of the Invention heading in this application, when a hull is moved through water, a wake comes off of the hull. The wake is called a viscous wake. The wake has a speed profile such that the boundary layer of the

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water closest to the hull tends to be dragged forward with the hull at a higher forward speed than the parts of the wake which are spaced farther outwardly from the surface of the hull.

Also, because water is a relatively dense medium, there is a significant increase in water pressure with increase in water depth.

If a hull also has some other structure (for example, a strut) attached to it, and if that structure projects into the wake, that structure can cause or can contribute to a deficit in the viscous wake produced by the hull. Such a projecting structure can produce its own viscous wake having its own velocity profile. If the wake from the projecting structure mixes with a part of the wake produced by the hull, the velocity profile in the mixed (deficit) part of the hull wake can be different from the velocity profile in other, non-mixed parts of the viscous wake produced by the hull.

A propeller mounted for rotation at the stern of the hull must therefore be constructed to be effective for different conditions of operation at different radial locations on the blades of the propeller and at different parts of rotation of the propeller around the incoming wake.

If a cross section of a propeller blade at a particular radial location on the propeller blade has an excessive angle of attack (for example, an angle of attack in excess of about 30 degrees) with respect to the incoming wake or deficit at that radial location, a very low

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pressure stall condition can occur on the top surface of the blade. A low pressure condition can be below the vapor pressure of the water on a part of the blade surface at that cross section to less than about .5 pounds per square inch (PSI). When the vapor pressure falls to less than .5 PSI the water in that area can vaporize, forming a temporary void or a cavity and producing cavitation and cavitation noise on that surface when the void or cavity is subsequently compressed back to a liquid and possibly loss of lift or stall.

It should be noted also that if the cross section of the blade at a particular radial location has too low an angle of attack (for example, an angle of attack less than about 12 degrees) for the operating conditions in that part of the incoming wake, that part of the blade will not have optimal pull.

Figure 1 is a pictorial view which includes diagrams to illustrate and to help understand the comments set out immediately above.

Figure 1 shows a conventional, prior art propeller drive mechanism mounted at the stern of a symmetrical, submerged hull 13.

The symmetrical hull 13 has a longitudinal axis 15.

A strut 17 is connected to the top of the hull 13 and supports a water craft superstructure (not shown in Figure 1) which extends above the surface of the water.

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Water craft having symmetrical submerged hulls and above water superstructure of this kind are illustrated and described in my U.S. Patent No. 5,592,895 issued January 14, 1997. See, for example, Figure 4 of U.S. Patent No. 5,592,895.

U.S. Patent No. 5,592,895 is incorporated by reference in this application.

As illustrated in Figure 1, the conventional propeller drive mechanism 10 mounted for rotation at the stern of the hull 13 has a propeller hub 19 driven by a drive shaft 22. The axis of rotation of the drive shaft 22 is coincident with the longitudinal axis 15 of the hull 13.

Four blades 21 extend radially outwardly from the hub 19. It is recognized there could be any number of blades. The blades 21 are rotatable in a plane, or planar band, 30 which extends perpendicularly to the longitudinal axis 15 of the hull 15 and the axis of rotation of the drive shaft 22. This plane, or planar band, of rotation of the blades 21 is parallel to the interface surface 28 (see Figure 2) extending between the forward end of the hub 19 and the stern end of the hull 13.

The viscous wake produced by the hull 13 causes the water inflowing to the conventional propeller drive mechanism 10 to follow the flow lines indicated by the arrows 33 in Figure 1 and Figure 2.

The wake has a speed profile such that the boundary layer of the water closest to the hull 13 tends to be dragged forward with the hull at a higher forward speed than the

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parts of the wake which are spaced farther outwardly from the surface of the hull. The

slowest velocity of the wake from the hull 13 incoming into the propeller drive

mechanism 10 will be at the hub. In this band, or sector, the water in the wake tends to be

moving forward with the hull 13 at or nearly at the forward speed of the hull itself, so the

incoming velocity of the wake to the propeller in this innermost band will be near zero.

The speed profile of the wake velocity is indicated diagrammatically by the reference numeral 32 in the lower part of Figure 1. The speed profile illustrated is that speed profile which exists just in front of the propeller blades 21. The speed profile shows the incoming wake velocity as varying in bands extending radially outwardly from the hub 19 and having values ranging from .0 to 1.0 in a direction going radially outwardly from the hub 19.

The outermost band indicated by number 1.0 would be a band of water moving past the outer tips of the blades 21 and at the full forward speed of the hull 13. A band located about half way out the radial extent of the blade 21 would be incoming into the propeller drive mechanism at a speed of about 0.5, that is, at one half the speed of forward movement of the hull 13 through the water.

Similarly, the strut 17 produces a speed profile in the water behind the strut 17. This speed profile is indicated diagrammatically in Figure 1 by the reference numeral 34. The viscous wake produced by the strut 17 combines with the wake of the hull 13 to

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further change the nature of the flow incoming to the propeller drive mechanism 10 in the portion of the viscous wake of the hull where the two wakes (the wake of the hull and the wake of the strut) are combined. This portion of the wake is termed the deficit wake and is diagrammatically indicated in the pull out cross section of the wake distribution shown in the lower right hand part of Figure 1.

The speed profile of the wake from the strut 17 combines with the speed profile of the wake from the hull 13 to further reduce the speed of the water incoming in to the propeller drive mechanism 10 in the deficit wake portion of the wake.

Figure 1 also illustrates, as shown by the block arrow 36, how increasing depth causes an increase in pressure. The converse is that decreasing depth decreases the water pressure and reduces the amount of difference between the actual water pressure and the 0.5 PSI pressure at which water can vaporize and cause cavitation.

The more shallow the depth at which a portion of the blade 21 operates, the greater the chance of the low pressure producing a condition which can result in a vapor pressure less than 0.5 PSI (and resulting cavitation and cavitation noise).

The problem of cavitation resulting from the decrease in water pressure on a blade surface below the critical 0.5 PSI incipient cavitation limit is illustrated in more detail in Figures 3 and 4 and will now be described with reference to Figures 3 and 4.

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Figure 3 is a cross section through a blade of the propeller shown in Figure 1.

Figure 3 is taken along the line indicated by the arrow 3 in Figure 1. Figure 3 is taken about half way out the radial length of the blade from the propeller hub. Figure 3 also includes a diagram illustrating how the angle of attack of the blade is affected by the flow velocity conditions encountered as that blade cross section rotates through a radial band in the uppermost, vertical part of the wake 9 (as shown in Figure 1). See also the text of the description of the drawing view of Figure 3 as set out under the sub-title "Brief Description of the Drawing Views" above.

Figure 4 is a view like Figure 3 of the cross section of the propeller blade at the radial location indicated by the arrow 3 in the Figure 1, but Figure 4 includes diagrams to indicate pressure distributions existing on the upper (as viewed in Figure 4) surface of the blade cross section. Figure 4 shows the relationship between the design pressure distribution (for that radial location of the cross section on the blade), the pressure distribution resulting from just the incoming wake velocity at that radial location on the blade (indicated by the circled reference numeral 1 in Figure 3 and Figure 4), and the different pressure distribution resulting from movement through the deficit (resulting from the reduced speed of the incoming wake produced by the wake deficit). This pressure distribution deficit is shown under the line indicated by the circled reference

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numeral 2 in Figure 4 and correlates to the deficit relative velocity line indicated by the

circled reference numeral 2 in Figure 3. As the blade angle of attack increases the

pressure on the upper surface decreases; and when sufficiently high angles of attack are

encountered the low pressure can drop below the cavitation limit or cause the blade to

stall (flow breakdown). Figure 4 illustrates how the pressure distribution drops below a

cavitation limit across a substantial extent of the pressure distribution deficit. This is

shown by the cross hatched portion under the pressure distribution deficit line 2

projecting above the upper (as viewed in Figure 4) surface of the cross section of the

blade. Cavitation and cavitation noise or stall can therefore be produced on this blade

surface for this design blade angle of attack. The design blade angle of attack produces

an actual angle of attack which is too high in the deficit wake and which causes stall and

cavitation and cavitation noise as the cross section of the blade rotates through the

decreased incoming flow velocity in the deficit wake. In viewing Figures 3 and 4 it can

be helpful to keep in mind that the blade cross section is being rotated through a radial

band in the deficit wake at a fixed radial distance corresponding to the geometric position

of the radial band existing between the .4 and the .6 numerals shown in the bottom part

of the pull out cross section of the wake illustrated in the lower right hand portion of

Figure 1.

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One prior art technique for avoiding excessive angles of attack in the upper, deficit wake portion of the wake distribution shown in Figure 1, was to change the angle of incoming flow to the propeller drive mechanism 10 in that upper, deficit wake part of the overall wake. Changing the angle of incoming flow changes the angle of attack of the propeller blade. This prior art is shown in Figures 5 and 6.

Figure 5 is a pictorial view like Figure 1 and shows one prior art construction in which a stator blade 40 is fixed in position on the top of the submerged hull 13 just in advance of the propeller drive mechanism 10 to redirect the direction of the flow (of the wake and the deficit wake) incoming into that upper portion of the rotation of the propeller blades 21. The fixed stator 40 was used to redirect the incoming flow to reduce the angle of attack of the propeller blades 21 in the upper portion of the wake.

Figure 6 is a fragmentary top plan view taken along the line and in the direction indicated by the arrow 6 in Figure 5. Figure 6 indicates, by the flow arrows 42 shown in Figure 6, how the wake incoming to the propeller is changed in direction by the fixed stator 40 in this part of the wake.

A wake adapted propeller drive mechanism for delaying or reducing cavitation and constructed in accordance with one embodiment of the present invention is illustrated in Figures 7, 8 and 9 and is indicated generally by the reference numeral 11 in Figures 7 and 8.

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It should be noted that, while the wake adapted propeller drive mechanism 11 of the present invention is illustrated and described in Figures 7 and 8 as used with a symmetrical, submerged hull, the wake adapted propeller drive mechanism of the present invention is also useful for any wake distribution resulting from any hull structure.

The present invention has particular utility in any wake distribution in which there is also a deficit wake within the wake distribution.

Structures in Figures 7, 8 and 9 which correspond to structures in Figures 1-6 are indicated by like reference numerals.

In Figures 7 and 8 the wake adapted propeller drive mechanism 11 of the present invention is shown mounted at the stern end of a symmetrical hull 13 which has a longitudinal axis 15.

The symmetrical hull 13 is held submerged beneath the surface of the water by a strut 17 which is attached to the top of the hull 13 and which is also attached (on its upper end) to a water craft superstructure (not shown in Figures 7 and 8) which extends above the surface of the water.

The wake adapted propeller drive mechanism 11 of the present invention comprises a rotatable propeller hub 19 and a plurality of propeller blades 21 extending radially outwardly from the hub 19.

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The propeller is shown as having four blades 21 in Figures 7 and 8, but the propeller can have fewer blades or more blades.

The hub 19 and blades 21 are rotated by a drive shaft 23 having an axis 25.

In accordance with the present invention the axis 25 is not coincident or parallel with the longitudinal axis 15 of the hull 13 but is instead skewed at an angle 27, as best shown in Figures 7 and 8. This offset or skew 27 of the drive shaft 25 and the mounting of the hub for rotation on the stern of the hull 13 along the inclined surface 29 at the end of the hull (see Figure 8) causes the propeller blades 21 to rotate in a plane (or planar band) 31 (see Figure 7) which is inclined to the axis of flow coming into the propeller.

The flow of the water coming into the propeller is indicated by the flow lines 33 in Figures 7 and 8.

The inclination of the plane of rotation 31 of the propeller blades 21 is determined by the skew 27 of the drive shaft 25 and is essentially the same as the inclination of the surface 29 shown in Figure 8.

The skew of the drive shaft 25 and the rotation of the propeller blades 21 in a plane that is inclined to the axis of flow of the water incoming to the propeller adjusts the angles of attack of the cross sections of the propeller blade 21 at different radial locations of the propeller blade 21 to keep the angles of attack below a cavitation limit (shown by the cavitation limit line in Figure 9). The adjusted angles of attack delay or reduce

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cavitation under all conditions of operation of the wake adapted propeller drive mechanism 11.

Figure 9 is a diagrammatic view which illustrates how the skewing or offset of the propeller drive shaft as illustrated in Figures 7 and 8 adjusts the angle of attack of a blade cross section at a particular radial location on a propeller blade (as compared to the angle of attack of a conventional on axis propeller drive as shown in Figure 1) both to lower the angle of attack as the blade rotates through the upper and deficit portion of the wake and to increase the angle of attack as the blade cross section rotates through the bottom portion of the wake. The adjustment to the blade angle of attack is controlled by the amount of skew in the propeller axis. As an example, 4° of skew would decrease the angle of attack by 4° at the top of the blade rotation and increase the angle by 4° at the bottom of the rotation. The variation in adjustment angle between the top (-4°) and the bottom ($+4^\circ$) would be sinusoidal. See the blade cross section inclinations shown at the bottom of Figure 9. The blade cross sections illustrated are the cross section of a blade at a radial location about half a blade length out from the hub. This blade cross section rotates through the Δ radial band of the incoming wake cross section shown in diagram in the top, right hand side part of Figure 9. In this band the incoming flow velocity in the lower (non-deficit part) of the wake is about .5 or one half the velocity of the velocity of the hull 13. The incoming flow velocity in the deficit wake decreases to .3 and briefly to

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.1 and then increases back to .3 and .5 as the blade cross section rotates through the deficit. The angles of attack of the blade cross section as shown in the lower part of Figure 9 are somewhat exaggerated in illustration to help understand the function produced by the skew of the drive shaft of the propeller as illustrated in Figures 7 and 8.

The adjusted angle of attack reduces the variation in angle of attack of the entire blade as it rotates all the way around and through the wake. The maximum angle of attack that is encountered in the wake deficit (top of rotation) is reduced by the value of the skew angle. The inception of cavitation and the angle of attack at the bottom of rotation is increased by the value of the skew angle.

The adjusted angles of attack of the cross sections of the blade of the wake adapted propeller are enough greater, in the lower half portion of the wake, than the effective angles of attack of the conventional propeller so as to produce a substantial increase in propulsion efficiency of the wake adapted propeller. The adjusted angles of attack of the cross sections of the blade of the wake adapted propeller are enough lower in the upper half portion of the wake to avoid cavitation or stall and the resultant acoustic noise and associated lost of blade lift resulting in an overall increase in propulsive efficiency.

The amount of skew of the drive shaft adjusts the angles of attack of the wake adapted propeller so as to be essentially 90 degrees out of phase with the decrease in the

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inflow velocity caused by the strut in the deficit part of the wake in the embodiment of the invention shown in Figures 7, 8 and 9.

While I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

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IN THE CLAIMS

1. A wake adapted propeller drive mechanism for delaying or reducing cavitation, said mechanism comprising,

a hull having a bow and a stern,

a wake adapted propeller having multiple, identically configured blades extending radially from a hub and mounted for rotation at the stern of the hull so as to be rotatable in a wake produced by the forward motion of the hull through the water, and

wherein, for a conventional propeller mounted for rotation in a plane aligned perpendicular to the axis of flow of the wake, the angle of attack of a cross section of a propeller blade must be below a certain upper limit in order to avoid, in at least certain critical radial portions, cavitation and cavitation noise, stall and loss of lift as the cross section is rotated through the wake,

said mechanism including mounting means which mount the wake adapted propeller for rotation in a plane that is inclined to the axis of flow of the wake and which skews the drive shaft of the wake adapted propeller sideways of the hull in a horizontal plane , and

wherein the angles of attack of the blade cross sections on the wake adapted propeller are adjusted, by said skew of the drive shaft, to be below said upper limits for

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corresponding radial portions of said conventional propeller so as not to produce cavitation or cavitation noise, or stall and loss of lift.

2. The mechanism defined in claim 1 wherein the amount of said skew is effective to prevent any cavitation in any part of the wake until the angles of attack produce incipient cavitation at other portions in the rotation of the wake adapted propeller through the wake.

3. A wake adapted propeller drive mechanism for delaying or reducing cavitation, said mechanism comprising,

a symmetrical hull having a bow and a stern,

a strut connected to the top of the hull and holding the hull submerged in the water beneath a water craft superstructure,

a wake adapted propeller having multiple, identical configured blades extending radially from a hub and mounted for rotation at the stern of the hull so as to be rotatable, at least in part, in both a wake produced by the forward motion of the submerged hull through the water and in a deficit, upper portion of the wake, and

wherein, for a conventional propeller mounted for rotation in a plane aligned perpendicular to the axis of flow of the wake, the angle of attack of a cross section of a propeller blade must be below a certain upper limit in order to avoid, in at least certain

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critical radial portions, cavitation and cavitation noise, stall and loss of lift as the cross

section is rotated through the deficit portion of the wake,

said mechanism including mounting means which mount the wake adapted propeller for rotation in a plane that is inclined to the axis of flow of the wake and which skews the drive shaft of the wake adapted propeller sideways of the hull in a horizontal plane, and

wherein the angles of attack of the blade cross sections on the wake adapted propeller are adjusted by said skew of the drive shaft to be below said upper limits for corresponding radial portions of said conventional propeller so as not to produce cavitation or cavitation noise.

4. The mechanism defined in claim 3 wherein the cross sections of a blade of the wake adapted propeller in the various radial portions of the blade are constructed to have an adjusted angle of attack which delays cavitation at each cross section until the inception of cavitation of the entire blade as it rotates all the way around and through the wake.

5. The mechanism defined in claim 3 wherein the adjusted angles of attack of the cross sections of the blades of the wake adapted propeller are enough greater, in the lower half portion of the wake, than the effective angles of attack of the conventional propeller to produce a substantial increase in propulsion efficiency of the wake adapted propeller.

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6. The mechanism defined in claim 3 wherein the strut slows the inflow velocity to

the wake adapted propeller in the deficit, upper portion of the wake and wherein the

amount of skew of the drive shaft adjust said angles of attack so as to be ninety degrees

out of phase with the decrease in the inflow velocity caused by the strut.

7. The mechanism defined in claim 3 wherein the adjusted angles of attack of the

cross sections of the blades of the wake adapted propeller are reduced enough, in the

deficit portion of the wake, to prevent inception of cavitation or stall as it rotates through

the deficit portion of the wake.