

Dec. 18, 1945.

C. D. VAN PATTEN

2,391,109

MARINE PROPULSION

Filed Aug. 20, 1941

2 Sheets-Sheet 1

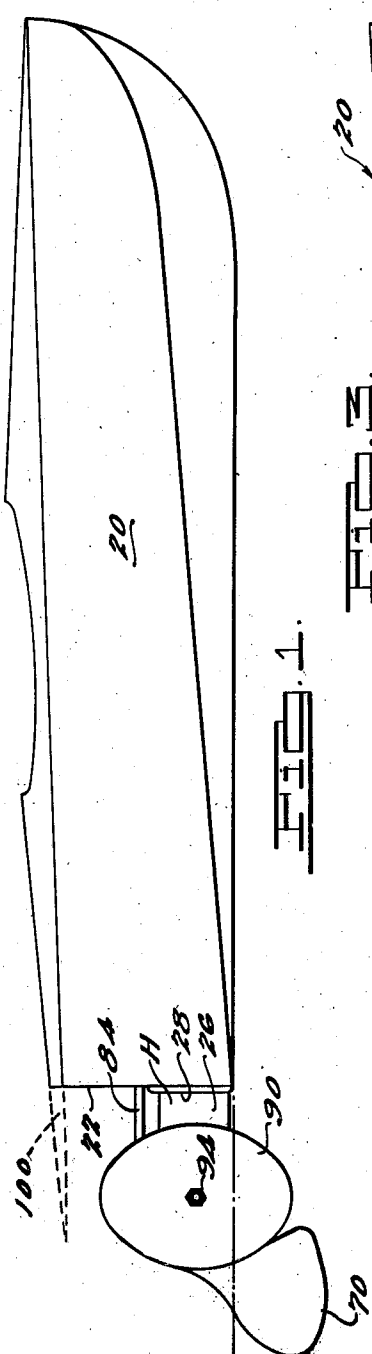


FIG. 1.

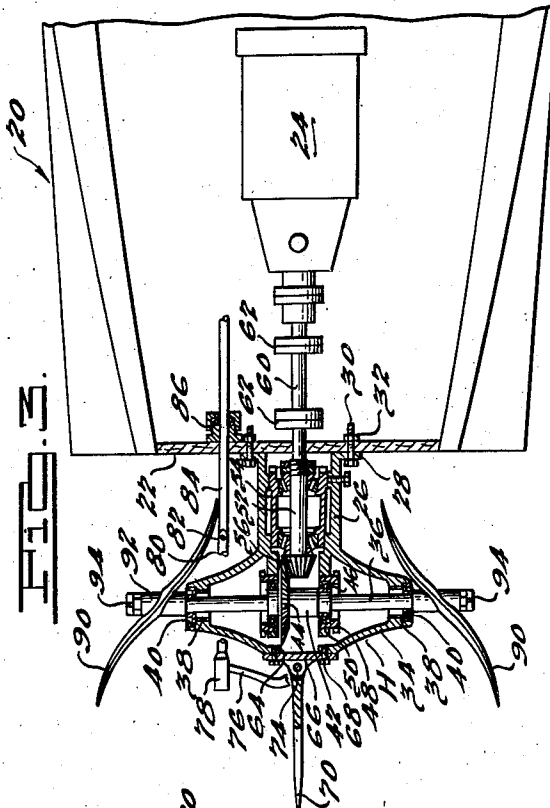
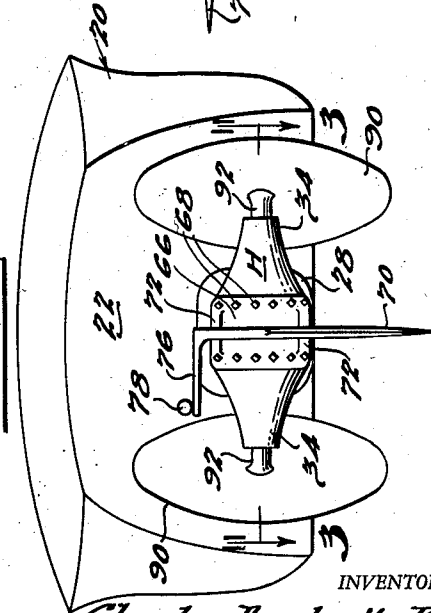


FIG. 2.



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2 Sheets-Sheet 2

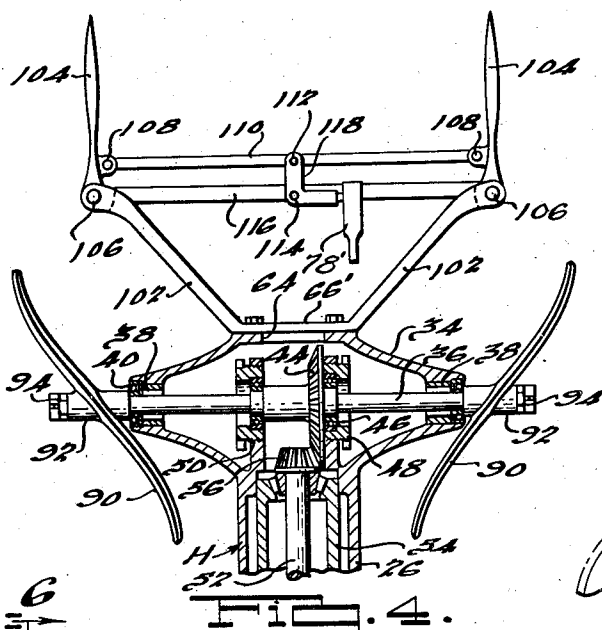


FIG. 4.

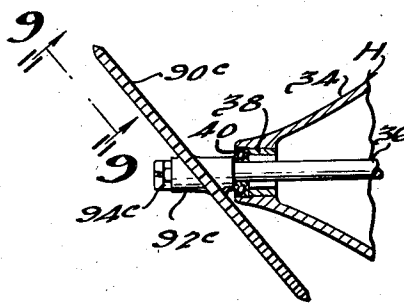


FIG. 8.

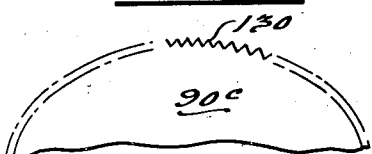


FIG. 9.

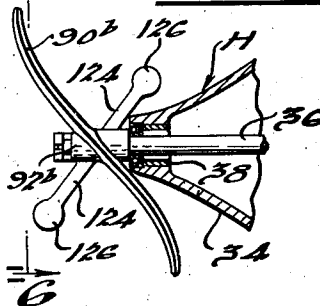


FIG. 5.

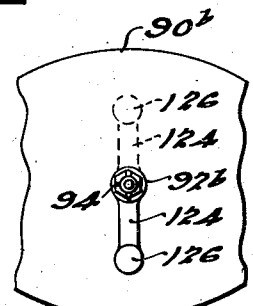


FIG. 6.

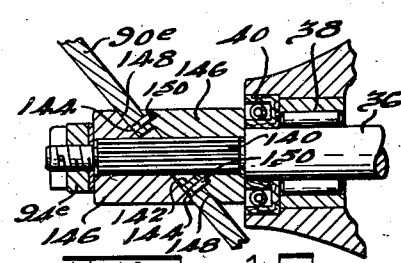


FIG. 10.

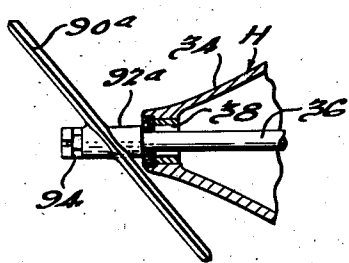


FIG. 7.

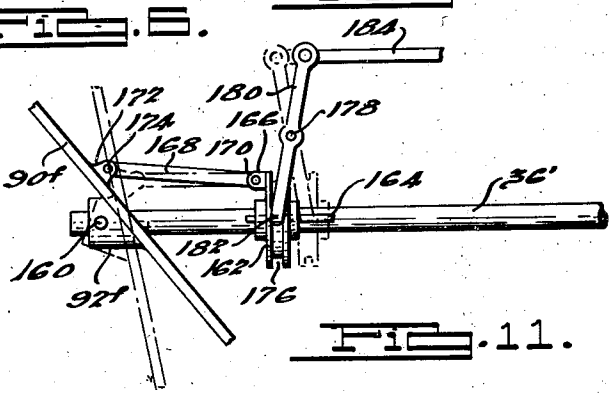


FIG. 11.

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MARINE PROPULSION

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Application August 20, 1941, Serial No. 407,533

14 Claims. (Cl. 115-49)

This invention relates to marine propulsion and has for its principal object the provision of a new and novel marine propulsion device that is simple in construction, efficient in operation and includes certain marked advantages over conventional screw type propulsion devices.

Objects of the invention include the provision of a marine propulsion device of particular advantage to shallow draft boats but in no sense limited thereto; the provision of a marine propulsion device comprising a unit securable as such to a boat hull and including a horizontally disposed line of shafting arranged in approximately perpendicular relationship with respect to the longitudinal center line of the boat and carrying a plurality of disc-like elements each arranged with the general plane of thickness thereof at an angle to the axis of rotation thereof and to a plane perpendicular to such axis of rotation; the provision of a structure as above described in which the unit includes a housing forming a gear casing and includes a driving shaft arranged in approximately perpendicular relationship with respect to the axis of the line of shafting carrying the discs, and suitably geared thereto; the provision of a construction as above described in which the unit includes rudder means supported thereby; the provision of a construction as above described in which the housing is provided with a cover plate for the gear chamber and the rudder means is carried by the cover plate; and the provision of a construction as above described in which the rudder means includes a plurality of rudders one positioned rearwardly of each of the disc-like elements.

Other objects of the invention include the provision of a marine propulsion device comprising a disc-like element adapted for rotation about a horizontal line disposed approximately perpendicularly with respect to the longitudinal axis of the boat and arranged with the general plane of the disc at an angle to its axis of rotation, those edges of the disc disposed more remote from the point of intersection of the plane of the disc with its axis of rotation being turned or warped in a direction tending to reduce the overall length of the disc measured in the direction of its axis of rotation; the provision of a marine propulsion device as above described in which the warping of the diametrically opposite sides of the disc occurs along a sine curve; and the provision of a construction as above described in which the amount of warping or bending of the diametrically opposite sides of the disc is such as to bring the edges of the disc at the point of maximum

warping or bending thereof approximately into planes perpendicular to the axis of rotation of the disc.

Further objects of the invention include the provision of a marine propulsion device including a pair of cooperating hub members between the opposed faces of which a disc is adapted to be clamped, such opposed faces of the two hub members being disposed at an angle to the axis of rotation thereof and to a plane perpendicular thereto, whereby in service the angularity of the disc may be changed by substituting a different pair of hub members having different angularity between the opposed faces thereof; and the provision of a construction as above described in which means are provided for positively locking the disc to at least one of the hub members.

A further object of the invention is to provide a marine propulsion device in the form of a disc adapted to rotate about a horizontal axis disposed in approximately perpendicular relationship with respect to the longitudinal center line of the accompanying boat and disposed with the plane of thickness thereof at an angle to the axis of rotation and to a plane perpendicular thereto, the peripheral edges of the disc being formed to provide saw-like teeth.

Still another object of the present invention is the provision of a marine propulsion device including a disc-like element arranged for rotation about a horizontal line approximately perpendicular to the longitudinal axis of the boat and arranged with the general plane of thickness thereof at an angle to its axis of rotation and to a plane perpendicular thereto, together with means for dynamically balancing the disc; and the provision of a construction as above described in which balancing weights are associated with the disc in oppositely offset relation with respect to each centrally offset side thereof, the mass and position of the weight being such as to provide a dynamically balanced assembly.

Still further objects of the present invention include the provision of a marine propulsion device including a disc-like element arranged for rotation about an approximately horizontal line disposed in approximately perpendicular relationship with respect to the longitudinal center line of the associated boat and disposed with the general plane of thickness thereof at an angle to its axis of rotation and to a plane perpendicular thereto, together with means for varying the angularity of the plane of thickness of the disc-like element with respect to its axis of rotation during operation; and the provision of a marine

propulsion device including a horizontally disposed shaft arranged with its axis in approximately perpendicular relationship with respect to the associated boat and a disc-like element centrally mounted on the shaft in angularly adjustable relation with respect to the axis of the shaft, together with means cooperating with the disc enabling the angularity thereof with respect to the axis of the shaft to be varied during operation.

The above being among the objects of the present invention, the same consists in certain novel features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate suitable embodiments of the present invention and in which like numerals refer to like parts throughout the several different views,

Fig. 1 is a side elevational view of a boat provided with a marine propulsion device constructed in accordance with the present invention;

Fig. 2 is a rear elevational view of the boat and propulsion device illustrated in Fig. 1;

Fig. 3 is a fragmentary, enlarged, partially sectioned plan view of the rear end portion of the boat shown in the preceding figures and illustrating the propulsion device in horizontal section taken on the line 3—3 of Fig. 2;

Fig. 4 is a slightly enlarged, fragmentary, partially sectioned view of the same propelling mechanism as illustrated in Fig. 3 but equipped with a modified form of rudder construction;

Fig. 5 is a fragmentary partially sectioned view similar to a portion of the propulsion devices shown in Figs. 3 and 4 but illustrating the application of balancing weights to one of the driving discs;

Fig. 6 is a fragmentary partially sectioned view illustrating a slightly different form of disc structure from that shown in the preceding views;

Figs. 7 and 8 are views similar to Fig. 6 but illustrating still further modified forms of disc elements;

Fig. 9 is a partial face view of the disc shown in Fig. 8 taken looking in the direction of the arrows 9—9 in Fig. 8;

Fig. 10 is an enlarged sectional view taken axially through a modified form of disc construction and particularly illustrating the connection between the disc and its hub; and,

Fig. 11 is a more or less diagrammatic fragmentary view illustrating a modified form of construction in which the angularity of the disc with respect to the drive shaft may be varied during operation.

The present invention has been devised in an attempt to provide a marine propulsion device which eliminates the shortcomings of conventional screw propellers. The increases of speed in virtually all classes of vessels in recent years have been accompanied by a corresponding decrease in the propulsive coefficient as the displacement: power ratio has improved and engine power has gone up. As is obvious to students of the art, this diminution of propeller efficiency is due to the inherent and inescapable limitations of the screw form of propeller. This is not to say that vast strides in screw propeller design have not been made in late years. Much effort has been expended and the results are considerable, especially in the metallurgical and manufacturing aspects, but the screw at present

constitutes the principal limiting factor towards increase in vessel performance, economy and cruising radius. The substantial improvements in hull forms, structures and power plants of recent years have largely been inhibited by the limitations of the screw principle of propulsion and the device of the present invention largely disposes of those limitations inherent in screw propellers that has thus limited the advance in performance of boats as above described.

In its simplest form the present invention consists of a disc-like element mounted at the stern of the boat and arranged for rotation about a substantially horizontal axis disposed perpendicular to the longitudinal center line of the boat or to the direction of desired thrust thereon, the disc-like element being arranged with the general plane thereof disposed at an angle to its axis of rotation as well as to a plane perpendicular to such axis of rotation. It is preferably arranged so that in operation less than half of its diameter is immersed in the water. Thus in simple language it comprises a type of wobble plate arranged for rotation about a line perpendicular to the longitudinal axis of the boat and with the lower portion thereof immersed in the water. As the disc rotates, the two sides of the disc alternately exert pressure upon the water in varying oblique directions the reaction to which is a directly opposite thrust. Since two or more opposed discs or plates are normally employed, the varying oblique pressures are resolved into a linear propulsive thrust component in the direction of rotation. The action of the disc is somewhat analogous to that of sculling with an oar and when two discs of opposed angularity are employed the lateral components between the discs and the water are balanced and the resultant component of thrust is directed longitudinally of the boat. While ordinarily, from the standpoint of simplicity in construction, both discs will be mounted upon a single shaft, it will be appreciated that in the broader aspects of the invention this is not necessary as each disc may be mounted upon its own shaft if the two shafts are connected together for equal rotation and in such case the individual shafts may be disposed at an angle to each other either in a vertical plane, a horizontal plane, or in both.

In accordance with one phase of the present invention these discs form a part of a unitary structure that is applicable to and removable from the stern, or other suitably located support on or of a boat, as such. This unit includes a casing or housing for the disc shaft or shafts which housing is formed for removable securement to the stern of a boat. The housing or casing also serves to rotatably support a drive shaft suitably interconnected, as by gears or the like, with the disc shaft or shafts for applying driving movement thereto. Where the boat is of the in-board engine type, then the power shaft is preferably arranged to project through the stern of the boat within the area of securement of the casing thereto and interiorly of the boat is suitably connected to the engine. The device is adaptable to an outboard type of construction in which case the engine is mounted upon the housing or casing and the drive shaft suitably connected to the crankshaft of the engine.

The angularity of the disc with respect to its axis of rotation is somewhat analogous to the pitch of a propeller. For instance, a disc arranged in a plane perpendicular to its axis of rotation would be equivalent to a propeller having

a zero pitch, and as the angle of the plane of the disc increases with respect to a plane perpendicular to its axis of rotation it corresponds with increased pitch in a screw propeller. Experiments conducted up to the time of filing this application indicate that discs arranged with their general planes of thicknesses at angles from 35° to 45° with respect to a plane perpendicular to the axis of rotation thereof operate in a satisfactory manner, but it will be appreciated that further experiments will undoubtedly indicate that discs arranged with their planes of thicknesses at greater or lesser angles than those stated may be entirely satisfactory and practical.

It will be appreciated, of course, that these discs are subject to various modifications both in size, shape, mounting and speed of rotation, as well as in other respects a number of which are disclosed herein by way of explanation.

It will, of course, be appreciated that in the employment of the present invention it is preferable that the depth of immersion of the driving discs be approximately predetermined during normal operation. For that reason it is preferable, although not necessary in all cases, that the present invention be employed with boat hulls of the transom stern type inasmuch as with such types of hulls at any time speed in excess of that speed at which the water eddies or "bubbles" up back of the transom, and which for smaller boats at least may be in the approximate neighborhood of seven knots, the water will break away from the stern in a substantially smooth surface regardless of load, and thus predetermine the depth of immersion of the associated discs.

Referring now to the accompanying drawings and particularly to Figs. 1, 2 and 3 a conventional V-bottom type of boat is shown generally at 20 and as having a stern transom 22. As indicated best in Fig. 2 the lower edge of the transom 22 is straight and as previously explained this is a desirable characteristic of any boat to which the present invention is applied, although not necessary in the broader aspects of the present invention.

It will, of course, be appreciated that any desired number of propulsion units constructed in accordance with the present invention may be mounted upon the stern or other suitable portion of a boat where such portion is of sufficient width to accommodate them, but as a matter of illustration the boat 20 shown is assumed to be a relatively small boat with the transom 22 of a width suitable for accommodation of a single unit. Accordingly, there is shown mounted upon the transom 22 a propulsion unit including a housing indicated generally at H which forms a casing for the gear and bearing elements of the device as well as a support therefor. Where the invention is to be applied to an outboard engine type of construction, then the engine may be mounted directly on and above the casing or housing H with its crankshaft axis vertically disposed and suitably geared to the disc shaft or shafts in any well known and conventional manner. When the invention is applied to an inboard engine type of construction, then the engine is, of course, placed within the boat hull and is connected by a suitable drive shaft projecting through the stern of the boat and into the housing where it is suitably geared to the disc shaft or shafts. This latter type of construction is shown by way of illustration and in accordance therewith an engine 24 which may be of any suitable or conventional type but which will usually be of a conventional

internal combustion type is suitably mounted within the boat hull with the axis of its crankshaft preferably extending longitudinally of the hull and centrally thereof as indicated.

The particular casing or housing H shown by way of illustration includes a forwardly extending hollow portion 26 the forward end of which is provided with an outwardly directed encircling flange 28 abutting the rear surface of the transom 22 and through which bolts 30 extend and cooperate with nuts 32 to provide a mounting for the unit on the transom 22. If desired gaskets or other suitable sealing means (not shown) may be interposed between the flanges 28 and the transom 22 to provide a water-tight connection therebetween. Rearwardly of the portion 26 the housing H is provided on each side thereof with an outwardly extending hollow portion 34 of gradually reduced cross-sectional area centrally between and within which the driving disc shaft means is rotatably supported. While such driving disc shaft means may be either a single shaft or a pair of shafts suitably connected together adjacent their centers, for the purpose of illustration in the drawings a single shaft 36 is shown. The shaft 36 is arranged with its axis horizontal and perpendicular to the longitudinal center line of the boat 20 and is supported at the outer ends of the portions 34 by means of suitable bearings, here indicated as roller bearings 38. The shaft 36 projects outwardly beyond the ends of the portions 34 and is sealed against leakage to the housing portion 34 by means of suitable or conventional shaft sealing elements 40. The central portion of the shaft 36 may be suitably supported for rotation in any desired manner but in the particular case shown by way of illustration is non-rotatably received within a hub-like carrier 42 for a ring gear 44 mounted thereon for rotation concentrically with the shaft 36. The carrier 42 itself is mounted for rotation in bearings 46 on each side of the ring gear 44, the bearings 46 being each mounted in a suitable carrier 48 threadably received in a corresponding supporting wall 50 formed integrally with the housing H.

The engine 24 may be connected to the gear 44 in any suitable manner but in the present case, and as a matter of illustration, a pinion shaft 52 is rotatably mounted in a bearing carrier 54 axially adjustably mounted within the forward extension 26 of the housing H and at its rear end is provided with a pinion 56 integral therewith arranged in meshing relationship with respect to the ring gear 44. The carrier 54 being adjustable axially of the pinion shaft 52 and, therefore, longitudinally of the boat, and the ring gear 54 being axially adjustable through adjustment of the carriers 48, proper meshing relationship of the ring gear 44 and pinion 56 is provided for. The driving ratio established between the pinion 56 and ring gear 44 may be any desired and will, of course, vary with the relative power output of the engine, diameter and normal depth of immersion of the driving discs, as well as with other factors, but for the purpose of illustration it may be assumed that in the particular embodiment shown the pinion 56 will turn two to three times as fast as the ring gear 44.

As indicated in Fig. 3 the forward end of the pinion shaft 52 projects through the transom 22 within the area of the flange 28 and within the boat 20 is connected by a short shaft 60 and preferably a pair of universal joints 62 with the drive shaft for the engine 24. Thus operation of the engine 24 causes rotation of the pinion shaft 52

and pinion 56 and consequent rotation of the ring gear 44 and shaft 36. The rear end of the housing H is provided with an opening 64 therein through which the ring gear 44 and its mounting parts may be introduced into and removed from the interior of the housing and through which access may be gained to the bearing carriers 48 for the purpose of adjusting the position of the ring gear 44 axially thereof.

The opening 64 is closed by a removable cover plate 66 suitably secured in position by means of cap screws 68. The cover plate 66 also forms a support for a rudder 70 and for this purpose the cover plate 66 is provided with brackets 72 adjacent its upper and lower edges to which the rudder 70 is pivotally connected by means of pins such as 74, the pins 74 being arranged, of course, with their axes vertically disposed. The rudder 70 is provided with a laterally offset arm 76 the free end of which is connected by a ball joint 78 with a link 80 the forward end of which is pivotally connected as at 82 on a vertical axis with the rear end of a rod 84 which passes through the transom 22 and extends to any suitable type of steering wheel or the like (not shown). Suitable packing such as 86 may be provided in surrounding relation with respect to the rod 84 to prevent leakage of water through the stern of the boat around the rod 84.

The outer ends of the shaft 36 where they project outwardly beyond the corresponding ends of the housing H form the support for the angularly disposed discs which provide the propulsion means for the present invention. While one or more discs may be mounted on each end of the shaft 36, and where more than one is so mounted each outer end of the shaft may require additional support by an outboard bearing, for the purpose of illustration only one disc is shown mounted on each end of the shaft 36 and will usually be found sufficient for most purposes. Accordingly, there is shown fixed to each outer end of the shaft 36 outwardly beyond the corresponding end of the housing H a disc 90. Each disc 90 is provided with a hub 92 within which the corresponding end of the shaft 36 is non-rotatably received and it is secured in position thereon by means of a nut 94 threaded on the end of the shaft 36. Each disc 90 is arranged with the general plane of thickness thereof at an angle to the axis of the shaft 36 as well as to a plane perpendicular to such axis. As previously mentioned experiments to date have indicated that satisfactory results are obtained where the angle of the plane of thickness of the disc is arranged between 35° and 45° with respect to a plane perpendicular to the axis of rotation, but it is presumed that further experiments will indicate that disc angles both above and below this value may be employed and may be preferable under some conditions of operation. The discs 90 are arranged in opposed relationship, that is that edge of one disc which extends closest to the center line of the boat is arranged in the same angular relationship with respect to the axis of the shaft 36 as the corresponding edge of the other disc 90. It will be noted that the discs 90 are of a diameter such that they project below the plane of the bottom of the boat adjacent the transom 22 an amount somewhat less than half of the diameter of the discs. This means that when the boat 20 is running at a normal speed the water leaving the stern of the boat will flow substantially horizontally therefrom and, there-

fore, predetermine the depth of immersion of the discs 90 in such water.

The discs 90 in Figs. 1 to 6, inclusive, are illustrated as having those marginal edge portions thereof spaced from each other axially of the axis of rotation by the greatest amount as being bent or curved out of the general plane of the discs toward a position more nearly perpendicular to the axis of rotation, this being a preferred arrangement as will hereinafter be more specifically described. However, for the purpose of explaining the action of the discs 90 upon the water and how a propulsive thrust is obtained thereby, it is believed that it will be preferable for the moment to assume that the discs 90 are flat as indicated in Fig. 7 and not curved or warped as shown in the preceding views. From an inspection of Fig. 7 it will be noted that the disc 90a there shown is identical to the disc 90 previously described except that it is perfectly flat or coplanar, but is disposed with the plane of its thickness at the same angle with respect to the axis of rotation as the general plane of the disc 90 shown in the preceding views.

In operation the discs 90, when the boat is traveling in a forwardly direction, rotate in a direction to carry their upper edges forwardly and their lower edges rearwardly. The lower portions only of the discs being immersed in the water during normal operation and in moving relatively rearwardly with respect to the boat alternately presents one surface and then the other surface thereof in an oblique position against the water thus tending to press the water in contact therewith both rearwardly and laterally with respect to the axis of rotation of the discs. The two discs being arranged in opposed relationship the lateral thrust components offset one another with the result that the resultant force of the discs acting upon the water is exerted in the direction of the longitudinal center line of the associated boat hull. When a perfectly flat disc such as the disc 90a illustrated in Fig. 7 is employed, there is a definite maximum degree of immersion of the disc during normal running operation that should not be exceeded. This is because of the fact a negative thrust component is incurred where the relative depth of immersion and angle of the disc are such that the nominal or running load water lines of the disc intersect at the fore and aft and perpendicular positions of the disc rotation since, in this situation, a portion of the immersed area of the disc moves relatively forward during the working part of the cycle. With a flat disc the maximum depth of immersion possible before incurring this negative thrust component is calculated according to the equation:

$$M = K \sqrt{\tan \theta}$$

where

M=Depth of immersion as a fraction of diameter.

θ=Angle of disc with plane of rotation.

K=Coefficient experimentally determined as .2125.

Besides producing a negative thrust where immersed too deeply as above pointed out the flat disc, such as illustrated in Fig. 7, has a source of loss which is present regardless of the depth of immersion that is occasioned by the downward and upward travel of the disc at an acute angle to the surface of the water at the beginning and end of the cycle and the lifting of a quantity of water above the normal water line at the end of the working portion of the cycle, which concomitants of the action accomplish no useful work.

This lifting of the water at the end of the working cycle is somewhat analogous to the lifting of the water by a non-feathering paddle wheel.

The above described disadvantages of the completely flat disc, both from excessive depth of immersion during normal running conditions and the tendency to lift water above the normal surface of the water at the end of each working cycle of the disc may be substantially avoided by properly warping or bending the discs in the manner illustrated in Figs. 1 to 6, inclusive. This formation of the disc is obtained by warping or bending the outer tips of the disc towards the plane of rotation thus maintaining the surface of the discs more nearly constantly vertical. Preferably the axially outer tips of the disc are warped axially inwardly until the plane of the extreme margins of the bent portion approaches parallelism with the plane of rotation. The warping of the disc serves a function somewhat analogous to the feathering of the blades of a paddle wheel but without the necessity for oscillation of the blades and its attendant problems and power absorption. The most important function of the warped conformation is, of course, the elimination of the opposing or negative thrust components or retarding action inherent in a flat disc having a diameter-draft-angle function outside of the critical limits previously mentioned.

It is, of course, true that the warped disc has the effect of accelerating the pressure upon the water more suddenly than does the flat disc but, at the optimum angles and degree and nature of warpage of disc curvature, the acceleration of pressure does not approach the proportions of impact.

With a warped disc neither the maximum nor the optimum depth of immersion appears to be mathematically calculable since the degree and nature of warping can be so accomplished as to eliminate this negative thrust component at any practical disc tangent angle and at any depth of immersion up to 50% of the diameter. Rather, the maximum depth of immersion appears to be dependent on the size and design of the gear housing which must obviously be above the bottom of the transom 22 of the boat 20 and which size and design are in turn determined upon the gear size and design. At the present time it appears, both from the standpoint of logic and from experimentations, that the optimum nature of warping consists of a simple bend in a sine curve of the outer portions of the tip of the disc toward the plane of rotation which curve extends from and is tangent to a central flat portion adjacent to the hub of the disc and is also tangent to the plane of rotation at the tips.

At the lowest boat speeds where the transom is not clear of the stern eddies and the disc is almost or totally submerged, the efficiency of the propulsion device of the present invention undoubtedly falls considerably but an entirely adequate thrust component is still produced due, it would appear, to the greater head of water which naturally exists at the bottom of the disc than at the top. At these lowest speeds, perhaps four miles per hour, the comparatively low propulsive coefficient does not appear to affect the operating economy perceptibly. It is possible that the economy would be effected more noticeably as the size of the vessel increases but it is assuredly practical to operate the vessel slightly faster than this eddy or "bubble" range, say seven miles per hour, the greater share of the time.

The question also arises regarding constancy

of immersion in a seaway. In this respect it may be said that it has been entirely possible with only a slight alteration from normal hull form to maintain constancy of immersion at least equal and comparable to a conventional screw propelled vessel. In the case of lifting the disc element of the present invention clear of the water and the resultant racing of the engine, the effects are far less serious and annoying than with a screw due to the lower rate of rotation and the absence of individual and separate blades. Further, cavitation and racing will continue intermittently for an appreciable time after re-immersion of a screw propeller while the disc of the present invention bites immediately upon reaching the water.

Comparisons in the performance of a boat equipped with a conventional type of screw propeller and with a propulsion device constructed in accordance with the present invention indicate increases in speed of the boat with the same engine of as much as 20% by the use of the present invention. A consideration of the inherent sources of loss in a screw propelled boat as compared to a boat propelled by mechanism constructed in accordance with the present invention is explanatory of the reasons why such increased performance is possible.

The major sources of loss in the propulsion device of the present invention can be resolved into a practical particular or quantity which might be termed orbicular loss and which is the sum of the losses due to the downward, upward and sideward movement and acceleration of water resulting from the obliquity of pressure application of the disc. This source of loss possesses, in certain ways, an analogy in the loss which is the torsional component of the pressure on the aft faces of the blades of the screw propeller, the corollary of which is the rotation of the thrust column.

Surface or skin friction obviously exists in the operation of both the screw propeller and the disc of the present invention but is a complete loss only in the case of the screw. A minor part of the skin friction in the disc of the present invention results in loss due to adhesion and consequent lifting of water at the end of the working portion of the cycle, while the greater part of this friction provides a positive thrust component.

A head resistance without skin friction and rather comparable to the rolling resistance of a wheel results momentarily each time the disc of the present invention becomes parallel to the center line of the boat but, unless the section of the disc is tremendously thick, this resistance is negligible.

In addition, the screw propeller is subject to a source of loss not incurred by the disc of the present invention. This source of loss is occasionally termed "profile" or edge loss and is the loss due to that portion of the torsional resistance not resultant from the pressure on the aft faces of the blades nor from skin friction. It is the loss due to the plain edgewise resistance of the blades to rotation in the water where no thrust load or skin friction are considered, the factors in which are the thickness and sectional shape of the blades, the diameter of the propeller and the peripheral speed.

The rates at which these foregoing items of loss vary in the two types of propelling means, relative to the several dimensions, proportions, ratios, speeds and loadings, are the key to accurate comparison and judgment between the screw propeller and the disc of the present invention.

For practical purposes of consideration the item which is termed orbicular loss in the case of the disc of the present invention probably varies virtually in direct proportion to the required specific power absorption. The counterpart of this loss in the case of the screw propeller increases at a much more rapid rate with increase in the required specific power absorption since increases in power in relation to displacement and resistance necessitates increases of pitch, diameter and/or peripheral speed, and as has been previously remarked, losses tend to go up at an even more accelerated rate with increases in these dimensions beyond certain well established practical proportions and limits.

Skin friction undoubtedly varies at the same rate in both the screw and disc of the present invention in relation to peripheral speed, but since the attendant loss in the case of the disc of the present invention is a considerably smaller proportion, it is obvious that the disc of the present invention possesses an advantage here especially in the higher speed ranges.

Inasmuch as the screw only is subject to blade edge resistance or "profile loss" and since this item is very considerable and increases at an accelerated rate with increases in peripheral speed, sectional thickness and shape, and diameter, it is evident that here another point of advantage falls to the disc of the present invention.

Additional advantages of the present invention due to the elimination of all water immersed appendages, as for instance propeller shafts and struts, excepting only the steering appendages, and the elimination of the resultant reduction of the resistance of these appendages in passing through the water, are self-evident and need little comment. With improvements in the displacement: power ratio, the proportion of appendages in screw propeller driven craft has increased considerably in most cases. Appendage resistance in the faster classes of screw driven vessels accounts for upward of 20% of the total resistance, and in some cases much more, so that a most worth while net gain in vessel performance is had on this score alone by the use of the present invention.

Also self-evident is the advantage of the present invention in permissible structural sections and resultant durability of the working elements since blade edge or profile loss does not exist in the operation of the disc of the present invention. Furthermore on this score is the fact that since shafts, hubs, etc., are nominally out of the water in the use of the present invention their size and design are not limited by consideration to resistance to passage through water.

From the foregoing consideration of the relative losses in screw propeller propulsion devices as compared to the present invention, those skilled in the art will readily appreciate the advantages of the present invention as compared to screw propellers and the possibility of obtaining increased performance in vessels equipped with the present invention over those equipped with conventional screw propelling means.

It might be noted at this point that during operation of a boat provided with a propelling means constructed in accordance with the present invention, a small amount of water will adhere to the discs on emerging from the water and will be thrown off of the periphery thereof in the form of fine spray. To obviate the possibility of any of such spray being carried inboard to the discomfort of the passengers it will usually be preferable to provide a hood or shield, such for

instance as is indicated in Fig. 1 by dotted lines at 100, secured to the hull of the boat in overlying relationship with respect to the discs 90.

Steering of a boat propelled in accordance with the present invention creates no problem where twin opposed discs are employed as shown. A single rudder mounted centrally between the two discs as shown and explained in connection with Figs. 1, 2 and 3 has been found to give adequate steering in the medium and higher speed ranges. A preferred form of rudder arrangement which gives entirely satisfactory control at all speeds and astern is illustrated in Fig. 4.

Referring to Fig. 4 it will be noted that the construction there shown is identical to that previously shown excepting only the steering apparatus. Consequently, a description of the steering apparatus only will be sufficient to completely disclose the structure there shown. In this construction it will be noted that the cover plate 66 is replaced by a similar cover plate 66' except that in this case the plate 66' is provided at each side thereof with a pair of vertically spaced rearwardly and outwardly projecting arms 102 the outer ends of which extend into substantial alignment, longitudinally of the boat, with the centers of the corresponding discs 90. Between the arms 102 on each side of the cover plate 66 a rudder element 104 is pivotally mounted upon a vertical axis 106. The two rudders 104 at a point rearwardly of their corresponding pivot 106 are each pivotally connected as at 108 to the outer end of a corresponding cross-link 110 the inner ends of which are pivotally connected together as at 112 which thus constrains them to approximately equal pivotal movement. Pivotaly mounted at 114 about a vertical axis and on a cross-arm 116 connecting the outer ends of the upper arms 102 is a bellcrank 118 one arm of which is pivotally connected to the inner ends of the links 110 by the same pivot pin 112 which interconnects such links. The other arm of the bellcrank 118 is connected to a ball joint 78', corresponding to the ball joint 78 previously described and which is connected to a suitable steering wheel or the like within the hull of the boat.

Because of the obliquity of the discs 90 it will be appreciated by those skilled in the art that a condition of dynamic unbalance theoretically results due to the center of mass of the two opposite halves of each disc being spaced from each other axially of the axis of rotation. As a matter of fact this apparent unbalance has proven to be of little practical importance primarily due to the fact that the thrust of the disc in the water offsets the forces arising from this unbalanced condition to a greater or lesser extent. However, where it is desired to eliminate this condition of unbalance resort may be had to a construction such as illustrated in Fig. 5. The disc 90b in Fig. 5 may be considered identical to the disc 90 previously described and as being provided with a hub 92b identical with the hub 92 of the disc 90. Projecting outwardly from the hub 92b on diametrically opposite sides thereof are a pair of arms 124 each terminating in a weight 126. The arms 124 preferably lie approximately in a plane disposed at the same angle to the plane of rotation as the central portion of the disc 90b but on the opposite side thereof the plane of rotation passing centrally through the disc 90b. The arms 124 and weights 126 are of a sufficient mass to dynamically balance the corresponding half of the disc 90b with respect to the central plane of rotation between them under rotating conditions.

The construction, therefore, effects the dynamic balance of the assembly. The arms 124 are, of course, preferably of such length that the weights 126 will not become immersed in the water during rotation of the disc under normal running conditions.

It will, of course, be appreciated that because of the circular continuity of the discs 90 a boat propelled by a propulsion device constructed in accordance with the present invention will be capable of operating in weedy waters without danger of the propelling mechanism becoming fouled in the weeds, and this feature is of major importance in some localities. It is also of importance when employed for propelling motor torpedo boats or similar shallow draft vessels in warfare. In this connection it is common practice to protect harbors or other waters from attack by such vessels by laying metallic cables or nets over or close to the surface of the water to be protected. Under such circumstances if a conventional screw propeller propelled type of boat attempts to enter such water the cables or nets become fouled in the propeller and thus render the boat useless and vulnerable to attack. By the use of the disc propelling means of the present invention such boats are enabled to pass over such cables or nets with no difficulty at all and may even be aided in such case particularly if such cables or nets are sufficiently anchored to provide a substantial surface against which the thrust of the discs may be exerted.

In fact the present invention particularly lends itself to modification to facilitate the destruction of the cables or nets above referred to and the manner of accomplishing this is illustrated in Figs. 8 and 9. Although in this connection either the straight or the warped discs may be employed the disc 90c illustrated in Figs. 8 and 9 is shown as a perfectly flat disc for the purpose of illustration. Its peripheral surface is formed to provide a plurality of relatively small cutting teeth 130. In this case the disc 90c, or at least the peripheral portion thereof, is preferably formed from a material equivalent to that found in certain types of cutting tools. Obviously should a boat equipped with driving discs such as the disc 90c shown in Figs. 8 and 9 come in contact with a metal cable or net and could be maneuvered to bring the disc 90c into any degree of sustained contact with such cables or nets the strands thereof will be quickly severed by the cutting action of the teeth 130 thereon when the disc is rotating.

In the constructions thus far described the discs 90 in each case have been illustrated as being provided with an integral hub structure or at least one that is permanently fixed with respect thereto. Under such conditions if it is desired to replace a disc such as 90 with one having a greater or lesser angularity with respect to the plane of rotation, as may become desirable from observing certain operating characteristics of the associated boat, it will, of course, be necessary to replace the entire disc and hub structure by one of the desired angularity. The necessity of making such complete replacement may be overcome to a great extent by the construction illustrated in Fig. 10.

Referring now to Fig. 10 it will be noted that the outer end of the shaft 36 where it is adapted to receive a driving disc is slightly reduced in diameter and splined as indicated at 140. The disc 90e in this case is made up without a hub but with a central opening 142 preferably elongated

in the direction of obliquity of the disc 90e and preferably with a plurality of smaller openings 144 arranged in a circle concentric with the center of the disc 90e and angularly spaced from one another about such circle. The hub in this case is made up of a pair of parts 146 each having a central splined bore for reception on the portion 140 of the shaft 36 and opposed axially directed faces 148 arranged at an obliquity with respect to the plane of rotation corresponding with that desired for the disc 90e. One of the hub members 146 may be provided with a plurality of pins 150 secured therein and arranged in a circle and angularly spaced from one another corresponding to the openings 144 so as to be receivable in the openings 144 and thereby positively lock the disc 90e against relative rotation with respect thereto. The disc 90e is interposed between the faces 148 of the hub members 146 with the pins 150 received in the openings 144 and the nut 94e in being drawn up firmly clamps the disc 90e between the hub members 146 and fixes it at the desired angle with respect to the plane of rotation. With this construction various sets of hub members 146 may be provided with varying angularities of the faces 148 thereof so that in event it is desired to change the angle of a disc 90e all that is required is a pair of hub members 146 having cooperating faces 148 of the required angularity. Under such circumstances the disc member 90e and hub members 146 are removed from the shaft 36 upon removal of the nut 94e, upon which the new set of hub members with the disc 90e between them may be replaced on the shaft 36, the nut 94e replaced, and the structure is then ready for operation. The hub members 146 being relatively economical to manufacture permits the angularity of a disc such as 90e to be changed at a minimum of cost.

It may be found desirable under some circumstances to be able to vary the angularity of the driving discs during operation and under such circumstances a construction such as disclosed in Fig. 11, or it equivalent, may be resorted to. Referring to Fig. 11 which illustrates one end only of the drive shaft and a single disc associated therewith, it will be understood that the shaft 36' corresponds with the shaft 36 previously described and may be supported and carried in the same or a similar manner. On the outer end of the shaft 36' a disc 90f is mounted. The disc 90f is provided with a fixed hub 92f through which the shaft 36' projects. A pin 160 projects through the hub 92f and diametrically through the shaft 36' and the bore of the hub 92f is elongated in a direction transverse to its axis and in a direction perpendicular to the axis of the pin 160 so that the disc 90f may swing about the axis of the pin 160 which, of course, restrains the disc 90f to equal rotation with the shaft 36'. Axially inwardly of the disc 90f a ring-like member 162 is mounted on the shaft 36' for movement axially thereof but is maintained against relative rotation thereon by means of one or more keys 164. The member 162 is provided with an outwardly projecting ear 166 thereon to which one end of a link 168 is pivotally connected as at 170. The opposite end of the link 168 is pivotally connected to an ear 172 formed on the disc 90f as at 174. Thus the position of the member 162 axially of the shaft 36' determines the angularity of the plane of thickness of the disc 90f with respect to the plane of rotation of the disc. In order to control the position of the member 162 on the

shaft 36', the member 162 is provided with a peripheral groove 176. Pivotaly supported as at 178, on the housing H or otherwise, is a lever 180 having a yoke end 182 slidably engaged in the groove 176 at diametrically opposite points thereof. The upper end of the lever 180 may be pivotally connected by any suitable means such as a link 184 with any suitable type or form of control member operation of which causes pivotal movement of the lever 180 about its pivot point 178. As will be readily appreciated by the construction described the angularity of the disc 90f may be adjusted during its rotation so that any desired angularity thereof, within reasonable limits, may be obtained during operation of the propulsion device.

Formal changes may be made in the specific embodiments of the invention described without departing from the spirit or substance of the broad invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. In a boat of the class wherein the hull terminates at its rear end in a transom, the combination with said transom of a propulsion unit mounted thereon and comprising a housing fixed to said transom, shaft means rotatably supported in said housing with the axis of rotation thereof disposed generally horizontally and transversely to the longitudinal center line of the boat, a drive shaft rotatably mounted within said housing, gearing connecting said drive shaft and said shaft means for simultaneous rotation, said shaft means projecting outwardly beyond said housing at opposite sides thereof, and a water displacement element comprising a disc-like member fixed to each outwardly projecting end of said shaft means with the plane of its thickness disposed at an angle to the axis of rotation of said shaft means and to a plane perpendicular thereto, said disc-like members being of such a size as to project below the lower edge of said transom.

2. In a boat of the class wherein the bottom is provided with a sharp rear edge from which the water flows substantially horizontally rearwardly during normal operation, the combination with said stern of a propulsion unit mounted thereon comprising a housing, a shaft rotatably mounted in said housing about a substantially horizontal axis extending perpendicular to the longitudinal center line of said boat and projecting beyond both sides of said housing, a drive shaft rotatably mounted in said housing in transverse relationship with respect to the first mentioned shaft, gearing connecting said drive shaft and the first mentioned shaft, said housing terminating at its bottom above the general plane of the lower edge of the stern of said boat, and a propulsion element fixed to each projecting end of said first mentioned shaft, said propulsion elements each comprising a disc-like member fixed for equal rotation with said first mentioned shaft and arranged with the general plane of thickness thereof at an angle to the axis of rotation of said first mentioned shaft and to a plane perpendicular thereto, said disc-like members projecting below said lower edge of said stern.

3. In combination with a boat having a transom, propulsion mechanism comprising, a rigid housing having a longitudinal centerline in substantial parallelism with the longitudinal centerline of said boat, a horizontally disposed shaft rotatably mounted in said housing disposed transversely to the longitudinal centerline thereof and projecting beyond opposite sides thereof, a

disc-like water engaging element secured to said shaft on each side of said housing each with the plane of its thickness disposed at an acute angle to a plane perpendicular to the axis of said shaft, a second generally horizontally extending shaft rotatably mounted in said housing in perpendicular relationship with respect to the first-mentioned shaft, gearing within said housing operatively interconnecting said shafts, and said housing being provided with a vertically directed surface arranged for securement to a complementarily disposed surface on said transom of said boat, said surface forming the sole area of contact between said mechanism and said hull.

4. In combination with a boat having a transom, propulsion mechanism comprising, a housing having a central portion, a horizontally and laterally directed tubular extension projecting from each of its laterally opposite sides, and an additional tubular extension projecting forwardly therefrom in approximately the same plane as the first-mentioned extensions, the last-mentioned extension terminating in a vertically directed attaching and supporting surface adapted for rigid securement to the transom of said boat, a horizontally directed transverse shaft in said housing rotatably supported in the first-mentioned extensions and projecting outwardly therebeyond, a second shaft rotatably supported in the last-mentioned extension, gearing within said housing operatively connecting said shafts for inter-related movements, and a pair of disc-like propulsion elements of substantially unbroken circular conformation, each secured to a corresponding end of the first-mentioned shaft exteriorly of said housing, and each arranged with its axis at an acute angle to the axis of said first-mentioned shaft.

5. A marine propeller comprising a generally circular disc-like element adapted to be mounted for rotation about a horizontal axis disposed transversely to the direction of movement, said element having its general plane of thickness arranged in non-perpendicular relationship with said axis, radially oppositely-disposed, axially-spaced segments thereof being warped toward tangency with a plane perpendicular to said axis.

6. A marine propulsion device comprising a plurality of disc-like elements of generally circular form mounted for rotation about a horizontal axis, said axis being disposed transversely to the normal direction of movement, the general planes of thickness of said respective elements being disposed non-perpendicular with respect to said axis, and said elements having axially-spaced, oppositely-disposed segments thereof warped toward tangency with planes perpendicular to said axis.

7. A marine propulsion device comprising a pair of generally circular disc-like elements mounted for rotation about a horizontal axis which axis is disposed transversely to the normal direction of travel, the respective planes of thickness of said elements being disposed in equal and opposite non-perpendicular relationship with said axis, said elements each having radially opposite, axially-spaced segments thereof warped toward tangency with planes perpendicular to said axis.

8. In combination with a water-borne craft having a transom, a propeller mounted abaft of said transom comprising a generally circular disc-like element; means mounting said element for rotation about a horizontal axis disposed transversely to the direction of travel, said element being constructed and arranged with its general plane of thickness in non-perpendicular rela-

tionship with said axis and having radially-oppositely disposed, axially-spaced segments thereof warped toward tangency with planes perpendicular to said axis.

9. In combination with a boat having a transom, a propeller mounted abaft of said transom comprising a generally circular disc-like element; means mounting said element for rotation about a horizontal axis disposed transversely to the normal direction of boat movement and for partial immersion only in the water supporting said boat during normal operation, said element having its general plane of thickness disposed in non-perpendicular relationship with said axis and being constructed and arranged such that the immersed fraction of the diameter thereof measured in a direction perpendicular to the surface of said water is equal to

$$K \sqrt{\tan \theta}$$

where θ is the angle of said disc with the plane of rotation and K is equal to .2125.

10. The combination according to claim 8 wherein a pair of complementary arranged elements are used.

11. The combination according to claim 9 wherein a pair of elements in complementarily opposed relation are mounted on a common axis of rotation and in spaced relation to each other longitudinally of said axis.

12. A marine propeller comprising a generally circular disc-like element adapted to be mounted

for rotation about a horizontal axis disposed transversely to the direction of movement, said element having its general plane of thickness arranged in non-perpendicular relationship with said axis, radially oppositely-disposed axially-spaced segments thereof being displaced from said plane of thickness such that at normal running immersion positive thrust is exerted throughout the entire immersed area of said element.

13. A marine propeller comprising a generally circular disc-like element adapted to be mounted for rotation about a horizontal axis disposed transversely to the direction of movement, said element having its general plane of thickness arranged in non-perpendicular relationship with said axis, radially oppositely-disposed, axially-spaced segments thereof being curved sinusoidally into tangency with planes perpendicular to said axis.

14. A marine propeller comprising a generally circular disc-like element adapted to be mounted for rotation about a horizontal axis disposed transversely to the direction of movement, said element having its general plane of thickness arranged in non-perpendicular relationship with said axis radially oppositely-disposed, axially-spaced segments thereof being curved into tangency with planes parallel to the plane of rotation.

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