

Dec. 20, 1960

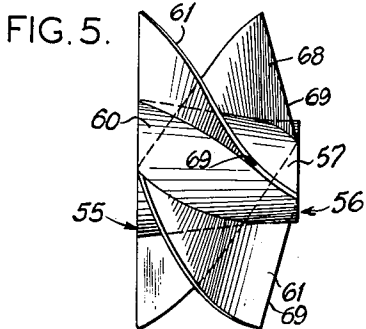
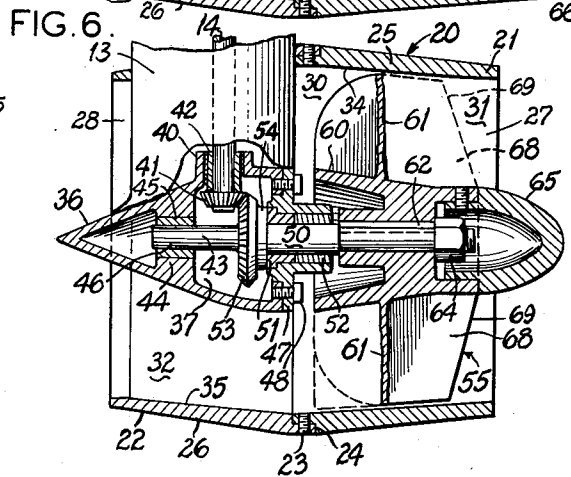
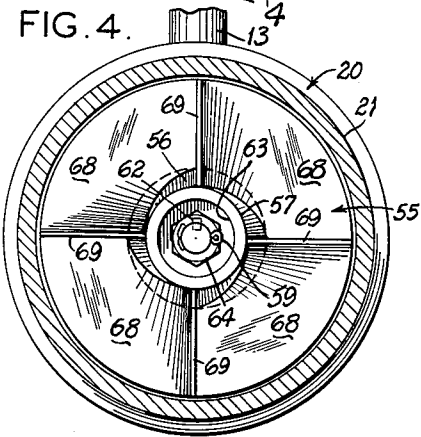
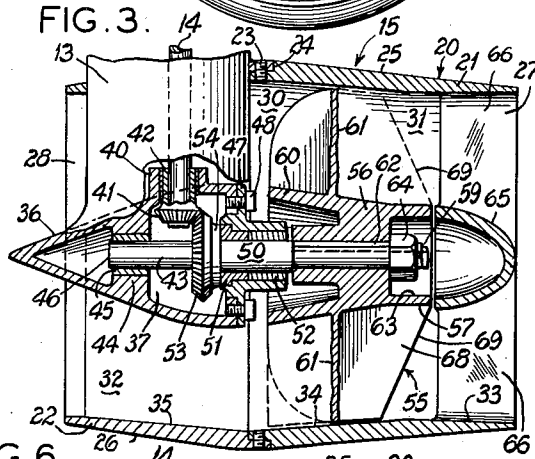
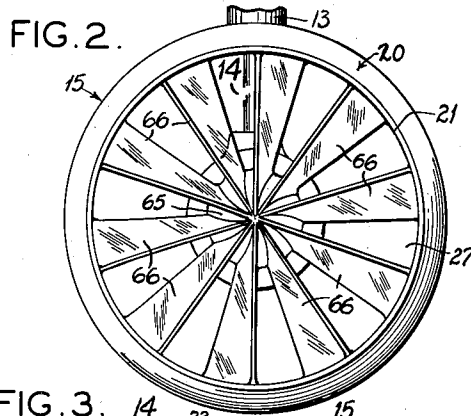
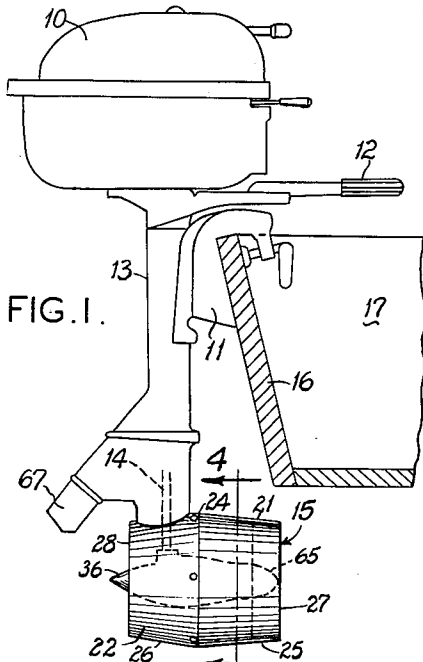
W. H. TINKER

2,965,065

HYDRAULIC JET PROPULSION UNITS FOR BOATS

Filed June 15, 1955

2 Sheets-Sheet 1



INVENTOR,
WALTER H. TINKER
BY *Ferry and Cohn*
ATTORNEYS.

Dec. 20, 1960

W. H. TINKER

2,965,065

HYDRAULIC JET PROPULSION UNITS FOR BOATS

Filed June 15, 1955

2 Sheets-Sheet 2

FIG. 7.

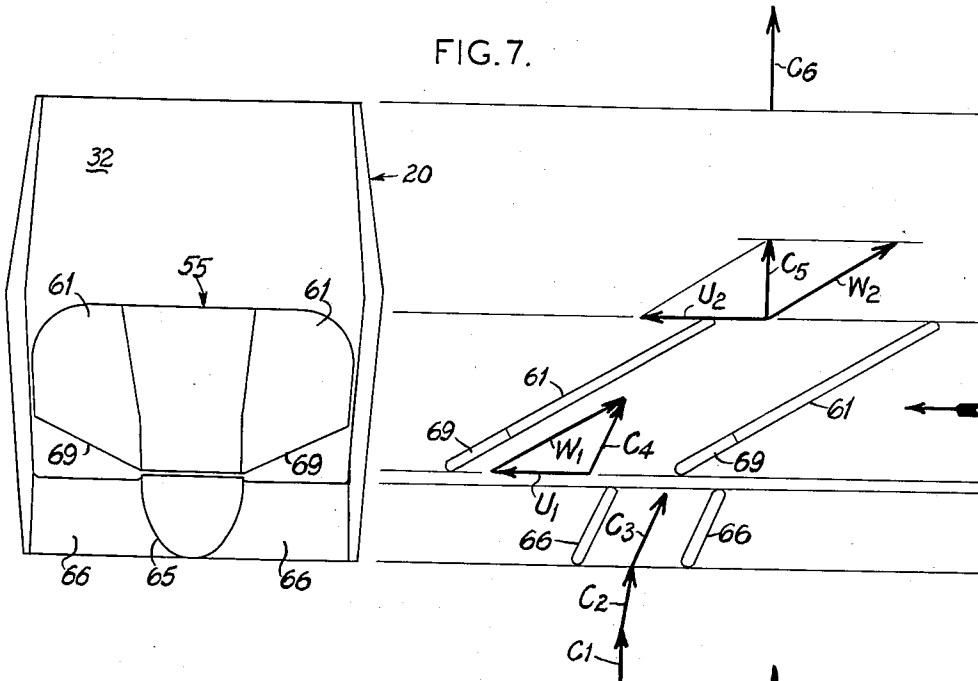
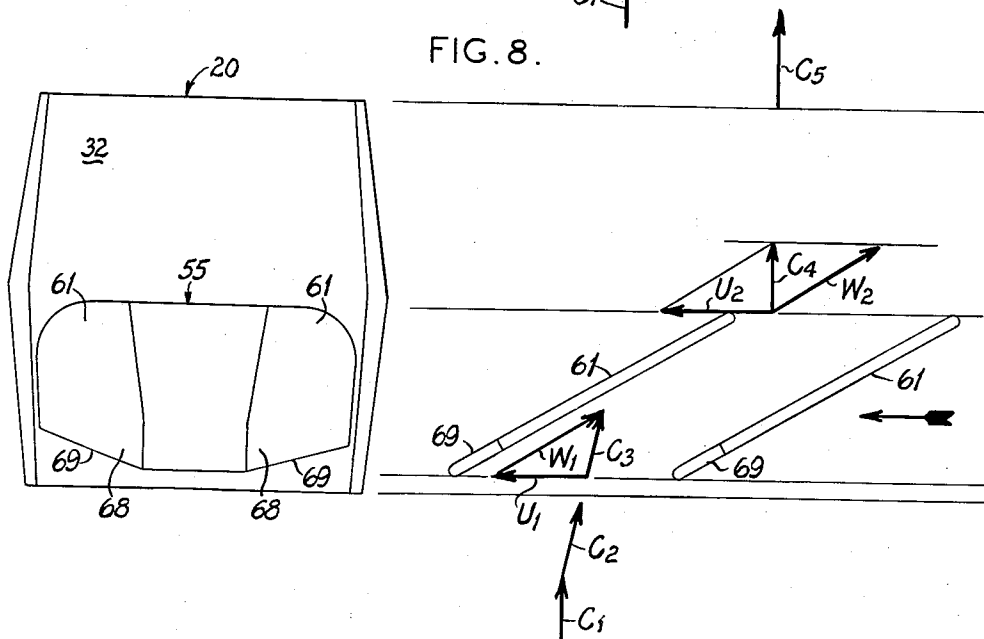


FIG. 8.



INVENTOR,
WALTER H. TINKER,
BY *Terry and Cohn*
ATTORNEYS.

1

2,965,065

HYDRAULIC JET PROPULSION UNITS FOR BOATS

Walter H. Tinker, P.O. Box 287, Frankfort, Ohio

Filed June 15, 1955, Ser. No. 515,661

5 Claims. (Cl. 115—42)

This invention relates to improved means for displacing water, and generally to such improvements as adapted to the field of boat propulsion, and particularly to hydraulic jet propulsion means for an outboard motor unit.

The conventional marine propeller agitates much of the circumjacent liquid without realizing useful propulsive effects, such agitation being caused by many undesirable turbulence or cavitation effects exhibited by the propeller regardless of size. These disadvantageous displacement effects, which are of the type not usefully applying a propulsive thrust, have heretofore been accepted as unavoidable. As a result, the usual open marine propeller has inefficient components when utilized on vessels of various types even though such a propeller has an inherently high mass-to-velocity ratio. It is a major objective of this invention to overcome the above mentioned shortcomings of conventional screw propellers, i.e., to increase the efficiency of converting power applied to a drive shaft to effective forward thrust of a boat as achieved by a substantial reduction and minimization of non-useful displacement and cavitation about and in the propulsion unit.

Another important objective is realized in the provision of a liquid displacement unit which utilizes a relatively small mechanism adapted to handle efficiently high flow rates with a minimum of cavitation through the displacement system while operating at high revolutions per minute, the mechanism adding only small pressure head increments per pound of fluid delivered through the system, and avoiding any large changes in relative velocities of such flow.

A still further highly important object is realized by the provision of inlet blading that is structurally arranged so as to impart a pre-rotation to the water flow in the space ahead of said blading and ahead of the propulsion unit, and to the water flow through the inlet channels formed by such blading and prior to entrance to the impeller. Of further advantage, the inlet blading is arranged with respect to the impeller of the unit so as to cause the pre-rotation effect of the incoming water flow in a direction opposite the direction of rotation of the impeller, thus enabling an axial flow delivery from the impeller.

An important objective of the improvements is to effect a prerotation of the liquid intake stream in space ahead of the unit, and in the inlet channels, all in a direction opposed to the impeller rotation, the flow accelerating through such inlet channels prior to introduction to the impeller inlet. Such prerotation serves markedly to reduce shock and cavitation losses, and hence results in this otherwise lost energy being inherently reflected in propulsive thrust.

An important objective of the invention is afforded by the provision of a rotary impeller which is hereinafter referred to as a "no lift" type. The action of the impeller is such that, although the relative velocity between a particle of water and the impeller blade portions contacted thereby remains substantially constant, the absolute ve-

2

locity of the water flowing through the device is increased to provide a useful thrust. This increase in absolute velocity is due to a centrifugal pressure head produced by increases in the inner and outer diameters of the impeller blades along the length of the impeller.

A further object is to allow for a useful force effect on the outer diverging shell of the structure at inlet, which supplements the thrust of the water flow through the impeller.

The foregoing and numerous other objects of the invention will more clearly appear from the following detailed description of a preferred embodiment and a modification thereof, particularly when considered in connection with the accompanying drawings, in which:

Fig. 1 is a side elevational view of an outboard motor unit attached to a boat, the unit showing one embodiment of the improved hydraulic jet propulsion means;

Fig. 2 is an enlarged front end view of the propulsion unit shown in Fig. 1;

Fig. 3 is a cross sectional view of the propulsion unit of Fig. 1 as seen along a longitudinal vertical plane passed therethrough;

Fig. 4 is an enlarged view in cross section as seen along line 4—4 of Fig. 1;

Fig. 5 is a side elevational view of the impeller shown in Fig. 4;

Fig. 6 is a modified form of the hydraulic jet propulsion means, showing a view in cross section as seen along a longitudinal vertical plane passed therethrough;

Fig. 7 is an expanded view of the species shown in Fig. 3 showing the angular setting of the impeller blades and prerotation vanes, and showing the direction and magnitude of the velocities, and

Fig. 8 is an expanded view of the species shown in Fig. 3 showing the angular setting of the impeller blades, and showing the direction and magnitude of the velocities.

Referring now by characters of reference to the drawing, it is noted that the engine and tank assembly generally indicated at 10 is attached through the usual swivel connection to a clamp 11, and for steering purposes is provided with a retractible control arm or tiller 12. Located in a hollow column 13 is a vertical drive shaft 14, a portion of which is shown in Figs. 1, 3 and 6, the drive shaft 14 constituting a power source for the displacement unit to be described, and which is generally indicated at 15 in Fig. 1. The propulsion unit 15, as shown in Fig. 1, normally operates submerged in the water. Fig. 1 shows the clamp 11 attached to the stern end 16 of a boat 17.

The propulsion unit 15 includes an enclosing annular shell generally indicated at 20 consisting in the present embodiment of a pair of sections 21 and 22. These shell sections 21 and 22 are connected by screw elements 23 along an interfitting stepped formation 24 provided along mating peripheries of such sections. The outer wall 25 of forward shell section 21 diverges rearwardly, while the outer wall 26 of rear shell section 22 converges rearwardly.

The annular shell 20 provides a fore and aft channel therethrough having an inlet port 27 and a discharge port 28, the channel including an impeller passage portion 30, an intake passage portion 31 extending forwardly therefrom, and a discharge passage portion 32 extending rearwardly therefrom. The annular inner wall 33 defining intake passage portion 31 is substantially cylindrical, the annular inner wall 34 defining the impeller passage portion 30 diverges rearwardly from the impeller inlet to the impeller outlet, and the annular inner wall 35 defining discharge passage portion 32 converges rearwardly.

The hollow column 13 extends downwardly through section 22 of shell 20, and carries a conical hub 36 that is located in discharge passage portion 32. The hub 36

provides an internal gear chamber 37 that is open at the forward end, and includes an upstanding boss 40 which communicates with the gear chamber 37. Drive shaft 14 extends through boss 40 and into chamber 37. A driving gear 41 is secured to the lower end of drive shaft 14, the gear 41 including a shank 42 that is normally located in boss 40 and serves as a bearing for the end of shaft 14.

An impeller shaft 43 is carried by hub 36, and is disposed in a horizontal position along the center longitudinal axis of the channel formed by annular shell 20. The hub 36 includes a web portion 44 that carries a radial bearing 45 adapted to receive and journal the rear end 46 of impeller shaft 43. The otherwise open forward end of hub 36 is closed by a cap plate 47 that is secured by cap screws 48 to hub 36. A portion 50 of impeller shaft 43 is journaled in a cap thrust bearing 51 and in bearing seal 52, the bearings 51 and 52 being mounted in cap plate 47. A pinion 53 is secured to impeller shaft 43, and is located in gear chamber 37 so as to engage and mesh with driving gear 41. Disposed between pinion 53 and cap bearing 51 is a thrust washer 54. The impeller shaft 43 extends forwardly of hub 36 and into the impeller passage portion 30.

The impeller 55 mounted on impeller shaft 43 is perhaps more clearly shown in Fig. 5. This impeller 55 includes a hub 56 which consists of a forward, cylindrical portion 57 and a rearwardly divergent portion 60 at the rear. A plurality of impeller blades 61 are carried by the divergent hub portion 60 and extend outwardly, the blades 61 being arranged to realize an impeller of "no lift" type. A "no lift" type of impeller includes an impeller in which the blades 61 are flat and arranged with no pitch change axially from the impeller inlet to the impeller outlet for any given streamline. In other words, the blades 61 are arranged so that the relative velocity of the water flow from point to point along the impeller blades axially through the impeller remains substantially constant. Of course, the absolute velocity of the water flow leaving the device immediately behind the impeller is greater than the absolute velocity ahead of the impeller, such increase being caused by the increase in static or centrifugal pressure at the impeller outlet that is realized solely by the divergent hub and peripheral shell. The relative velocity of the water flow along the impeller blades is not changed by changes in blade pitch from impeller inlet to outlet. In Fig. 5 there is shown a "no pitch change" blade arrangement. The pitches are of course different at the hub than at the periphery of the blading, but there is no pitch change at either place. The head pressure is developed by centrifugal force due to the action of the divergent hub portion 60 on the water flow, as is more fully explained subsequently, and not by any pitch change in the blading 61.

The fact that the illustrated "no lift" impeller 55 increases centrifugal pressure without materially altering the relative velocity between the water particles and the impeller blade portions contacted thereby permits a large quantity of flow with minimum turbulence. This large flow results in a depression of the static pressure at the entrance to the impeller, so that a static pressure differential is established between the zone immediately in front of the impeller and a zone far enough upstream from the propulsion device to be unaffected thereby. However, the total heads and total energies in these two zones are substantially the same. It will be evident then that the static pressure differential is accompanied by an opposite differential in velocity head between these two zones. Moreover, since the flow passages through the impeller blading 61 are rotating, the acceleration of the water between these two zones has a rotational component. In other words, there is a prerotation of the flow ahead of impeller 55, and it has been found that this prerotation is in a direction opposite to the direction of rotation of the impeller itself.

The blades 61 include flat inlet portions 68 that extend forwardly and inwardly to realize a taper at the constant

diameter, cylindrical hub portion 57, as is shown in Figs. 3, 5 and 6. This inlet blading portion 68 is formed as an integral continuation of blades 61, and includes oblique or tapered leading edges 69. The inlet blading portions 68 have no pitch change, and it will be noted that there is no diameter change at either the hub 56 or shell section 21 where the inlet blading portions 68 are located. This inlet arrangement affords inlet channels about the cylindrical hub portion 57, and which enables the water flow to enter the blade channels before the centrifugal effects take place.

The impeller 55 is fastened to shaft 43 by key 62 (Fig. 4). A recessed formation 63 is provided at the forward end of cylindrical hub portion 57, and is adapted to receive a nut 64 that is utilized to fasten impeller 55 to impeller shaft 43. A pin 59 is passed through shaft 43 to prevent unintentional loosening of nut 64. As is clear from Fig. 3, the impeller 55 is located in the impeller passage portion 30 formed by shell 20.

Located in the intake passage portion 31 is a center element 65 that constitutes a forwardly convergent nose or hub aligned with the hub 56 of impeller 55, and arranged along the longitudinal axis of the channel formed in shell 20. A plurality of inlet vanes 66 extend radially outwardly from center element 65 to shell 20, the vanes 66 being spaced and inclined so as to form inclined inlet channels therebetween. The inlet vanes 66 extend substantially from the inlet port 27 rearwardly into the intake passage portion 31. For purposes which will be explained later, the vanes 66 assist in producing prerotation of the water in space ahead of the vanes and to the water flow through the intake passage portion 31, the prerotation being in a direction opposite to the direction of rotation of the impeller 55.

The prerotation blading 66 is oblique to the incoming flow of water if the incoming relative flow is looked at some distance in front of the unit 15. As the incoming relative flow approaches the unit 15, assuming the boat is moving forwardly in the water, there is a pressure unbalance by virtue of the very low pressure at the impeller inlet and the higher static pressure of the water externally of the unit. The effect of this pressure difference is felt in the inlet channels formed by the inlet prerotation blading 66. This pressure difference tends to provide a force that accelerates the water toward and through the prerotation blading 66. The inclined inlet channels formed by the blading 66 exert a control effect upon the prerotation of the water and assist in orienting the flow passing into the impeller channel.

Assuming that the boat is moving forwardly, there is a component of relative water flow in a direction longitudinally or axially of the unit 15, and other components in a direction substantially along the inclined inlet channels formed by inlet blading 66. As a result, there is a rotation of the water in space ahead of the inlet blading 66, and in the intake passage portion 31 ahead of the impeller 55. The direction of such prerotation is in a direction opposite (clockwise in Fig. 2) to the direction of rotation (counterclockwise in Figs. 2 and 4) of the impeller 55.

The rotating flow of water is then delivered into the inlet of impeller 55. The blading 61 moves the water flow from the intake passage portion 31 to the discharge passage portion 32, and because of its particular "no lift" arrangement maintains the relative velocity of the water flow through the impeller along the impeller blades substantially constant. The rotating water flow through the impeller 55 is increased in its centrifugal pressure as the radius of rotation is regularly increased by divergent hub portion 60 and by peripheral divergence of shell section 21. Because the prerotation is in an opposite direction to impeller rotation, the impeller 55 delivers the water flow to the discharge passage portion 32 in substantially an axial direction, and hence delivers such flow axially out of discharge port 28. The absolute velocity

5

of the water flow leaving the device behind the impeller is greater than upon entering, and thrust is thereby provided.

The action of impeller blades 61 and prerotation vanes 66 on the water flow in the device shown in Fig. 3 is best illustrated in Fig. 7 wherein an expanded view of the impeller blades 61 and vanes 66 is shown along with vector diagrams showing the direction and magnitude of the water flow velocities. As explained previously, when the boat moves forwardly there is an initial water flow velocity relative to the craft and the propulsion unit, this initial velocity being installed by vector C1. Because of the lower pressures existing within the channels formed by vanes 66, this initial water flow is given a slight prerotation in the direction of such channels and ahead of the vanes 66 as is illustrated by vector C2. This water flow then enters the channels formed by straight vanes 66 and is accelerated because of the lower pressures existing within such channels, this accelerated water flow being illustrated by vector C3. The prerotating flow C3 then enters the impeller. It is seen that the water flow through vanes 66 and entering the impeller 55 is in a direction opposed to the direction of impeller rotation.

Upon entering the impeller 55, the water flow velocity C4 in combination with the impeller peripheral velocity illustrated by vector U1, results in a water flow velocity relative to blades 61 illustrated by vector W1. Since there is no pitch change of blades 61, the relative velocity flow W1 continues through the impeller at a substantially constant rate and is illustrated at the impeller outlet by vector W2 having the same direction and magnitude as vector W1. However, at the impeller outlet the impeller peripheral velocity is substantially higher due to the expanded or divergent hub and shell, which is illustrated by vector U2. It will be noted that no head pressure has been produced by any change in either of vectors C or W but totally in a change by vector U, i.e., centrifugal or static pressure head. It will now be apparent that a higher static pressure exists at the impeller outlet than at the inlet to the system. The absolute velocity of the water flow leaving the impeller 55 is in a direction axially of the device and is represented by vector C5. The convergent discharge passage 32 causes acceleration of the water flow by its convergence and the fact that the pressure is diminishing. Therefore, the velocity of the water flow leaving the device illustrated by vector C6 is substantially higher than that illustrated by vector C1, the increase of velocity being the basis of useful thrust.

An exhaust pipe C7 (Fig. 1) extends downwardly and rearwardly from hollow column 13, and serves to direct the exhaust gases into the water flow as it leaves discharge port 28, thus tending to a small degree to induce greater flow through the channel formed by shell 20.

Fig. 6 illustrates a modified form of the hydraulic jet propulsion unit. For purposes of clarity and comparison, the elements shown in Fig. 6 are given the same reference numerals as the corresponding elements of the structure shown in Fig. 3. The propulsion unit of Fig. 6 is exactly the same in structure and assembly as the unit disclosed in Fig. 3, except that the inlet blading 66 of Fig. 3 is eliminated, and that the shell section 21 is terminated substantially at the entrance to the impeller passage portion 31. The impeller 55 is of the same construction including inlet prerotation blading 68 that is inclined as a continuation of the no-pitch-change blades 61. This inclination of the inlet blading 68 causes a prerotation of the water flow in space ahead of such blading 68, and in the inlet channels formed by the blading 68. The inclined position of inlet blading 68, and the low pressure zone formed inside shell section 21 about the impeller blading 61 causes the water flow to rotate or whirl oppositely to the direction of rotation of the impeller 55 by virtue of the pressure externally of the unit forcing water toward and into the inlet channels formed by inlet blading 68.

6

Assume for instance that the propulsion unit of Fig. 6 is mounted in operative position on a boat, similar to the showing of Fig. 1, and that the boat is moving forwardly. Then this forward motion of the boat and unit with respect to the ambient water results in a positive intake of water through the inlet channels defined by blading 68. As explained, the pressure differences exerted through the inlet channels formed by inclined inlet blading 68, and by the relative water flow toward the unit causes a prerotation of the water in space ahead of the blading 68 and in the inlet channels formed by the blading 68. This prerotation is in a direction opposed to the direction of rotation of the impeller 55. Obviously, the degree of rotation is somewhat less than in the structure shown in Figs. 1-4 in which the prerotation is caused by blading 66, yet is sufficient to realize efficient operational results.

As the rotating water flow moves through the inlet channels formed by inlet blading 68 (Fig. 6), the flow is accelerated, but the head pressure is not increased because of the constant diameter of cylindrical hub portion 57. The water flow then is moved by impeller blades 61 rearwardly to the discharge passage portion 32. Because of the particular arrangement of impeller blades 61 to provide a "no lift" characteristic, as has been previously defined, the relative velocity of the water flow through the impeller 55 in a direction along the impeller blades 61 remains substantially constant. The head pressure of the water flow is increased as it moves rearwardly through the impeller since the radius of the rotating water flow is increased regularly by divergent hub portion 60 and divergence of periphery of impeller 55. However, the impeller blades 61 above do not cause any increase of head pressure because there is no change in blade pitch. Since the prerotation of the water flow caused by inlet blading portion 68 is opposed to the direction of impeller rotation, the water flow from the impeller blades 61 into and out of shell portion 22 is substantially axially.

Referring now to Fig. 8 in which the angular setting of the impeller blades and the vector diagrams of the velocities through the device shown in Fig. 6 are illustrated, it will be noted that the initial velocity ahead of the propulsion unit is represented by vector C1. Because of the pressure differences exerted through the inlet channels formed by inclined inlet blade portions 68, the water flow C1 is accelerated and rotated ahead of the impeller in a direction opposed to the direction of impeller rotation as is illustrated by vector C2. Of course, the degree of rotation of flow C2 ahead of the impeller in Fig. 8 is less than the degree of rotation of flow C3 ahead of the impeller in Fig. 7 because vanes 66 are absent. However, the water flow C2 in Fig. 8 enters the impeller as illustrated by vector C3.

The rotation of impeller 55 causes a peripheral velocity at the inlet as represented by vector U1, which when combined with water flow C3 results in a water flow having a relative velocity along the blades 61 represented by vector W1. Because the blades 61 are flat and have no pitch change from inlet to outlet, the relative velocity W1 remains substantially constant and is represented by vector W2 at the impeller outlet. Again, it will appear that the impeller peripheral velocity is substantially higher at the outlet because of the expanded or divergent hub and shell structure, such peripheral velocity being represented by vector U2. The combination of water flow W2 and U2 results in an axial discharge flow from the impeller 55 represented by vector C4. The magnitude of velocity C4 appears to be substantially that of velocity C2 from the diagram of Fig. 8, but it must be remembered that an increase in head pressure has been produced by the centrifugal effects previously described. Hence, the convergent discharge passage 32 causes acceleration of the water flow which results in a discharge flow represented by vector C5 that is of greater velocity than vector C1, such increase being the basis of useful thrust.

The description of features of design and elements of

structure of the present hydraulic jet propulsion units reveals a marked departure from earlier submerged displacement devices for the purpose of propelling a boat. These units are designed to move a relatively large volume of liquid at a relatively low velocity, with minimal frictional losses, and with minimal pressures through all parts of the flow system. Because these units operate on a low head, large volume principle, they require energy values of only a low order per pound of liquid moved through the system.

Although the invention has been described by making detailed reference to a preferred embodiment and a single modification thereof, such detail is to be understood in an instructive, rather than in any restrictive sense, many variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. A propulsion unit for boats comprising a shell having a fore-and-aft channel extending therethrough, the channel including a rearwardly diverging impeller passage portion, an impeller mounted in said impeller passage portion, said impeller including a rearwardly divergent hub portion and a plurality of inclined blades extending outwardly from said divergent hub portion, said blades having no pitch change along the length thereof, means for rotating said impeller to drive water through said impeller passage portion, whereby the centrifugal pressure of said water is increased by the increasing radii of the flow paths between said rearwardly divergent hub portion and said rearwardly divergent impeller passage portion of said channel in said shell and the pressure of said water just ahead of the impeller is depressed to produce a prerotation of the water in space ahead of the rotating impeller in a direction opposed to the direction of rotation of the impeller, and a plurality of stationary vanes fixed to said shell ahead of said impeller and being inclined in the same direction as said impeller blades to control the prerotating water flow prior to its entrance into the impeller.

2. A propulsion unit for boats comprising a shell having a fore-and-aft channel extending therethrough, the channel including a rearwardly converging discharge passage portion and a rearwardly diverging impeller passage portion ahead of said discharge passage portion, an impeller mounted in said impeller passage portion, said impeller including a rearwardly divergent hub portion and a plurality of inclined blades extending outwardly from said divergent hub portion, said blades having no pitch change along the length thereof, and means for rotating said impeller to drive water through said impeller passage portion, whereby the centrifugal pressure of said water is increased by the increasing radii of the flow paths between said rearwardly divergent hub portion and said rearwardly divergent impeller passage portion of said channel in said shell and the pressure of said water just ahead of the impeller is depressed to produce a prerotation of the water in space ahead of the rotating impeller in a direction opposed to the direction of rotation of the impeller.

3. A propulsion unit for boats comprising a shell having a fore-and-aft channel extending therethrough, the channel including a rearwardly converging discharge passage portion and a rearwardly diverging impeller passage portion ahead of said discharge passage portion and a cylindrical intake passage portion ahead of said impeller passage portion, an impeller mounted in said impeller passage portion and said intake passage portion, said impeller including a hub and a plurality of inclined blades extending outwardly from said hub, said hub including a cylindrical portion disposed within said cylindrical intake passage portion of said channel and a rearwardly divergent portion disposed within said divergent impeller passage portion of said channel, said blades having no pitch change along the length thereof, and means for rotating said impeller to drive water through said channel, whereby the

centrifugal pressure of said water is increased by the increasing radii of the flow paths between said rearwardly divergent hub portion and said rearwardly divergent impeller passage portion of said channel in said shell and the pressure of said water just ahead of the impeller is depressed to produce a prerotation of the water in space ahead of the rotating impeller in a direction opposed to the direction of rotation of the impeller.

4. A propulsion unit for boats comprising a shell having a fore-and-aft channel extending therethrough, the channel including a rearwardly converging discharge passage portion and a rearwardly diverging impeller passage portion ahead of said discharge passage portion and a cylindrical intake passage portion ahead of said impeller passage portion, an impeller mounted in said impeller passage portion and said intake passage portion, said impeller including a hub and a plurality of inclined blades extending outwardly from said hub, said hub including a cylindrical portion disposed within said cylindrical intake passage portion of said channel and a rearwardly divergent portion disposed within said divergent impeller passage portion of said channel, said blades having no pitch change along the length thereof and having rearwardly and outwardly tapered leading edges, and means for rotating said impeller to drive water through said channel, whereby the centrifugal pressure of said water is increased by the increasing radii of the flow paths between said rearwardly divergent hub portion and said rearwardly divergent impeller passage portion of said channel in said shell and the pressure of the water just ahead of the impeller is depressed to produce a prerotation of said water in space ahead of the rotating impeller in a direction opposed to the direction of rotation of the impeller.

5. A propulsion unit for boats comprising a shell having a fore-and-aft channel extending therethrough, the channel including a rearwardly converging discharge passage portion and a rearwardly diverging impeller passage portion ahead of said discharge passage portion and a cylindrical intake passage portion ahead of said impeller passage portion, an impeller mounted in said impeller passage portion and said intake passage portion, said impeller including a hub and a plurality of inclined blades extending outwardly from said hub, said hub including a cylindrical portion disposed within said cylindrical intake passage portion of said channel and a rearwardly divergent portion disposed within said divergent impeller passage portion of said channel, said blades having no pitch change along the length thereof and having rearwardly and outwardly tapered leading edges, means for rotating said impeller to drive water through said channel, whereby the centrifugal pressure of said water is increased by the increasing radii of the flow paths between said rearwardly divergent hub portion and said rearwardly divergent impeller passage portion of said channel in said shell and the pressure of said water just ahead of the impeller is depressed to produce a prerotation of the water in space ahead of the rotating impeller in a direction opposed to the direction of rotation of the impeller, and a plurality of stationary vanes within said cylindrical intake passage portion of said channel ahead of said impeller to control the prerotating water flow prior to its entrance into the impeller, said vanes being inclined in the same direction as said impeller blades and having no pitch change along the length thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

724,488	Murr	Apr. 17, 1903
779,473	Fried	Jan. 10, 1905
1,023,584	Muhlberg	Apr. 16, 1912
1,042,506	De Vallat	Oct. 29, 1912
1,518,502	Gill	Dec. 9, 1924

(Other references on following page)

2,965,065

9

UNITED STATES PATENTS

2,127,747	Luther -----	Aug. 23, 1938	2,623,688
2,427,032	Troller et al. -----	Sept. 9, 1947	2,648,192
2,435,236	Redding -----	Feb. 3, 1948	2,693,674
2,473,603	Miller -----	June 21, 1949	
2,566,373	Redding -----	Sept. 4, 1951	115,846
2,613,869	Anxionnaz et al. -----	Oct. 14, 1952	402,687

5

10

Davidson -----	Dec. 30, 1952
Lee -----	Aug. 11, 1953
Anxionnaz et al. -----	Nov. 9, 1954

FOREIGN PATENTS

Germany -----	Dec. 12, 1909
France -----	Oct. 14, 1909