

April 2, 1963

C. W. F. HAMILTON

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HYDRAULIC JET PROPULSION APPARATUS FOR WATER-BORNE CRAFT

Filed Feb. 8, 1960

6 Sheets-Sheet 2

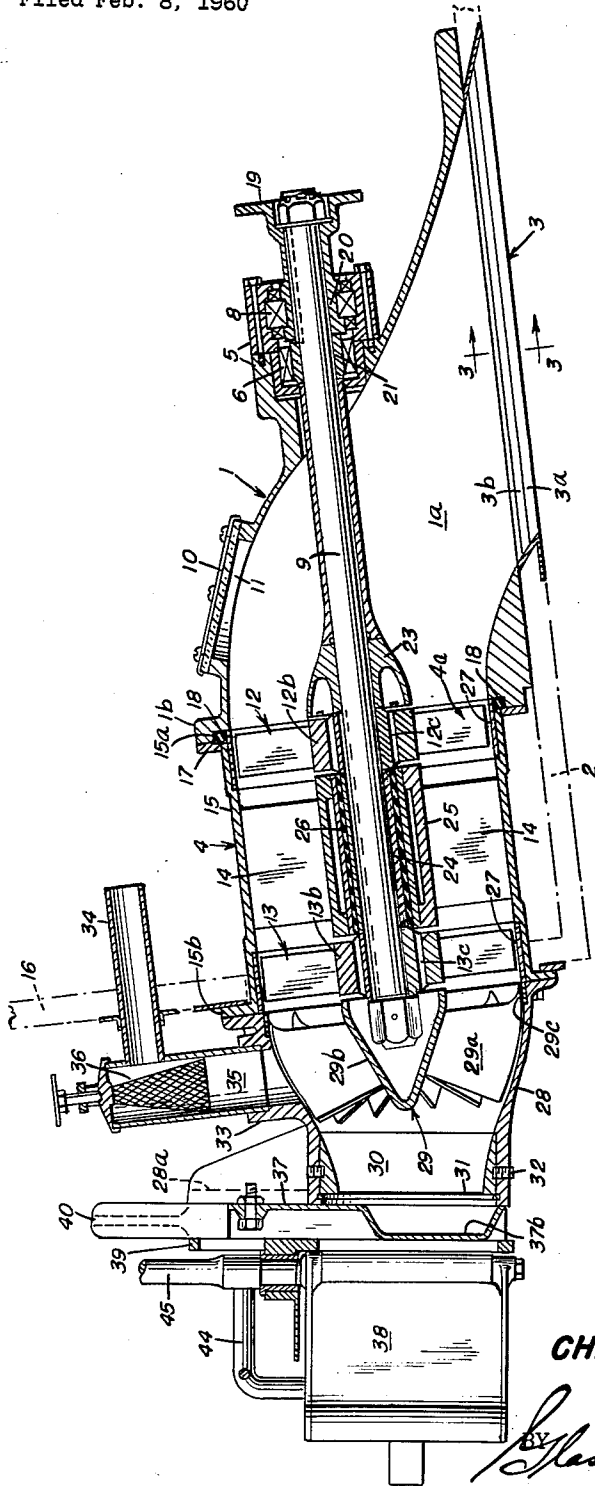


FIG. 2

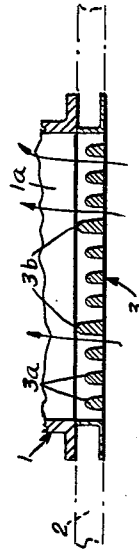


FIG. 3

INVENTOR

CHARLES W. F. HAMILTON

BY *Shawcross Downings Tebbels*
ATTORNEYS

April 2, 1963

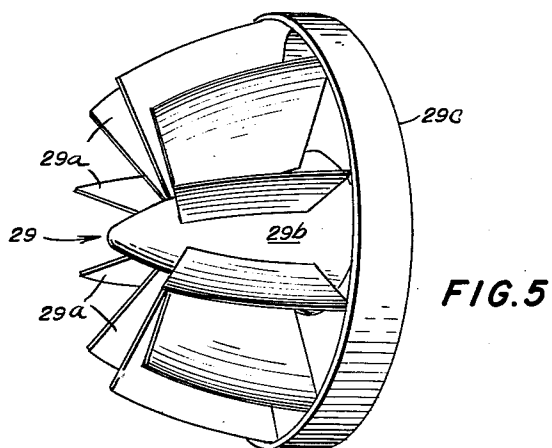
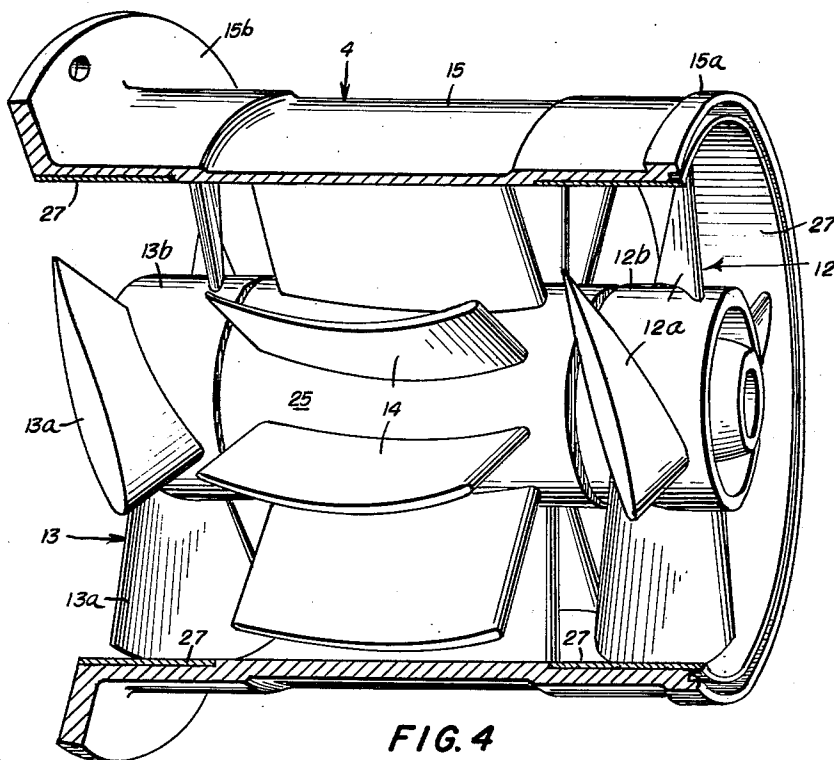
C. W. F. HAMILTON

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INVENTOR

CHARLES W. F. HAMILTON

BY

Glascock Downing Bebold

ATTORNEYS

April 2, 1963

C. W. F. HAMILTON

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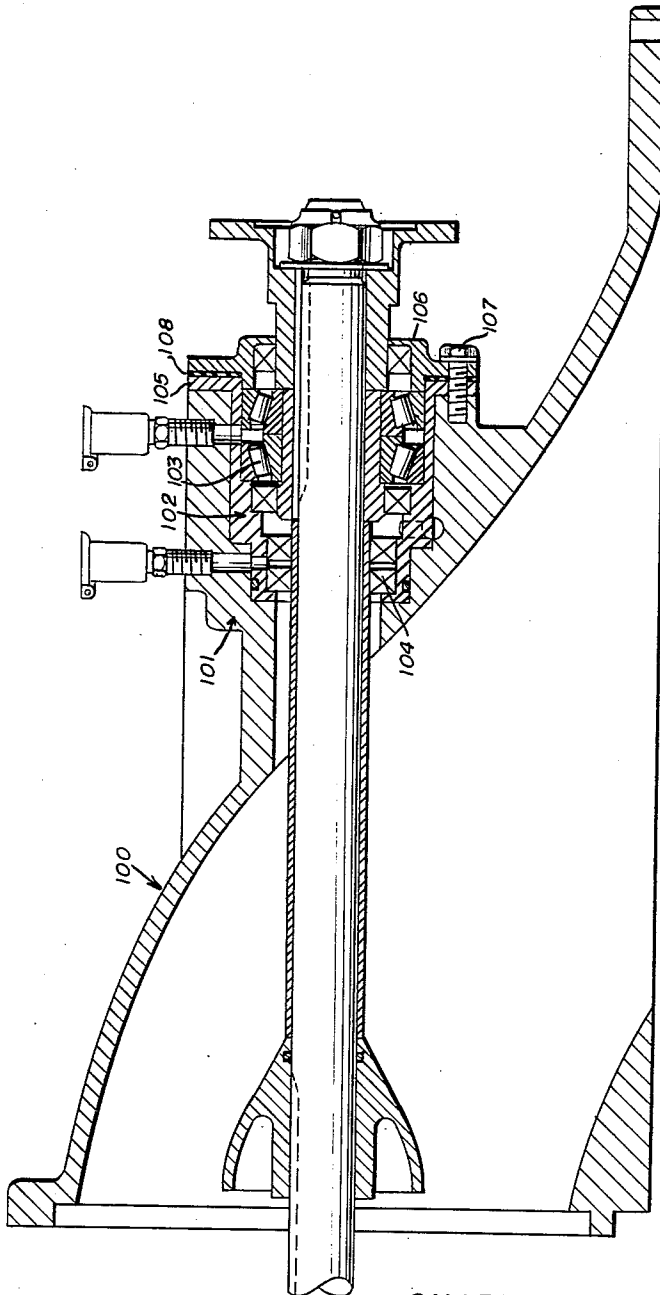


FIG. 9

INVENTOR

CHARLES W. F. HAMILTON

BY *Grant Downing Keble*

ATTORNEYS

April 2, 1963

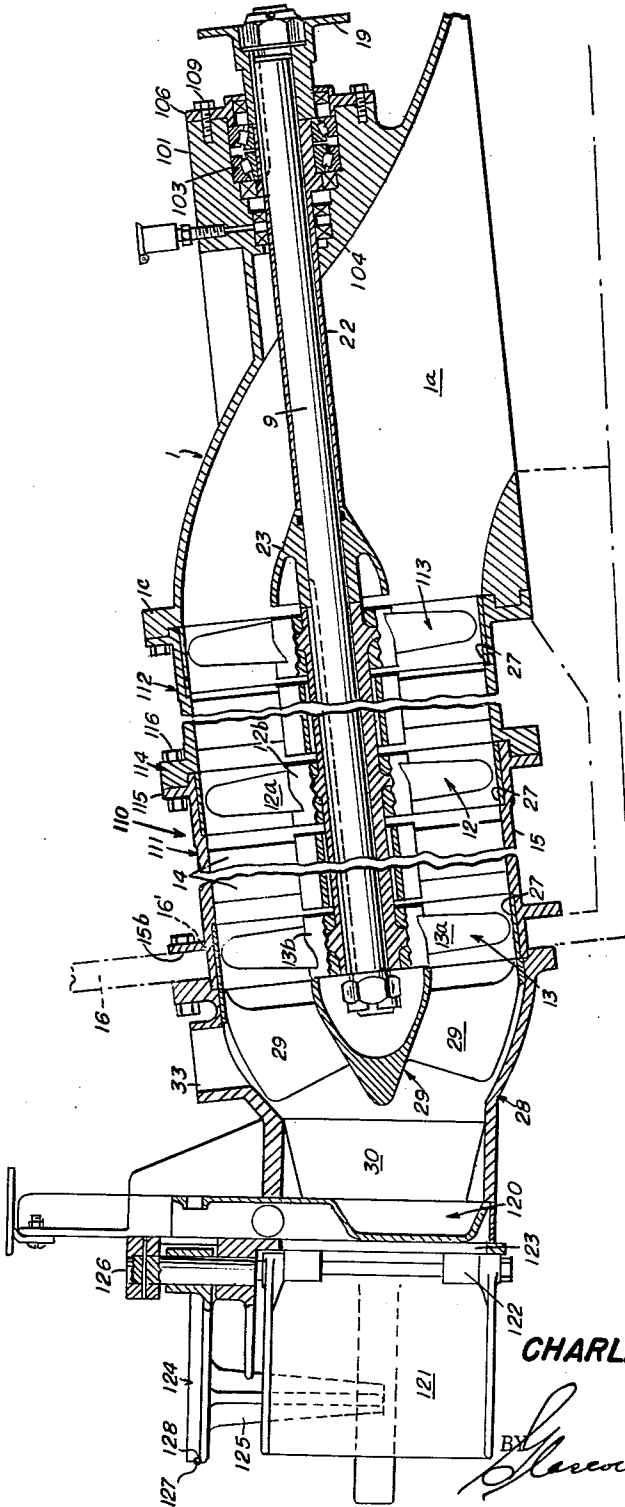
C. W. F. HAMILTON

3,083,529

HYDRAULIC JET PROPULSION APPARATUS FOR WATER-BORNE CRAFT

Filed Feb. 8, 1960

6 Sheets-Sheet 6



INVENTOR

CHARLES W.F. HAMILTON

BY

BY Sarah Downing Seibold
ATTORNEYS

ATTORNEYS

1

2

3,083,529

HYDRAULIC JET PROPULSION APPARATUS FOR WATER-BORNE CRAFT

Charles W. F. Hamilton, Irishman Creek, Private Bag, 5
Timaru, New Zealand

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8 Claims. (Cl. 60—35.54)

The invention relates to hydraulic jet propulsion apparatus for water-borne craft, and is a continuation-in-part of my co-pending application Serial No. 758,445, filed September 2, 1958, now Patent No. 3,007,305 issued November 7, 1961.

An object of the invention is to provide a jet propulsion apparatus in which efficient use is made of the kinetic energy of the intake water by suitable shaping of an intake chamber, and reducing turbulence and straightening the flow of the intake water through the intake chamber to a pump means by locating a suitably shaped intake screen at the entrance to the intake chamber, with the shaping of the intake screen also being such as to minimize clogging of the screen by solid matter carried in the water drawn through the screen.

Another object of the invention is to provide a jet propulsion apparatus including means whereby a pump forming part of the apparatus may be readily dismantled from the rear through the transom or stern of the craft without disturbing the intake or driving shaft joints or seals.

A further object of the invention is to provide a jet propulsion apparatus with means permitting the pump means thereof to include an extra stage or stages thereof boosting the performance of the apparatus by effecting additional pressurization in the jet.

Yet a further object of the invention is to provide a jet propulsion apparatus in which the efficiency is increased, the manufacture simplified, and the mounting in and removal from the craft greatly facilitated.

Still another object of the invention is to arrange a discharge pipe so as to achieve an efficient conversion of pressure energy into axial kinetic energy at a discharge outlet or nozzle.

An additional object of the invention is to provide a jet propulsion apparatus including means defining an improved off-take for auxiliary water services through filter means which is at least partly self-cleaning.

Other objects and advantages of the invention will be apparent from the following description.

Generally, the present apparatus includes an intake section into which water can be drawn through screen means arranged across an intake opening of the intake section, a pump means detachably secured to the intake section and arranged to receive water drawn through the intake section, a discharge section detachably secured to the pump means at an end thereof remote from the intake section and arranged to receive water discharged by the pump means and to direct the water whereby the same is discharged from the apparatus in the form of a jet, drive transmission means whereby power can be transmitted to the pump means for operation thereof and control means operably associated with the discharge section whereby the direction of a jet of water discharged from the apparatus can be controlled so as to propel the craft in a desired direction.

The drive transmission means may receive power from any suitable source, such as an internal combustion engine.

Apparatus constituting embodiments of the invention will now be described in more detail by way of example of how the invention can be carried into effect and with reference to the accompanying drawings in which:

FIGURE 1 is a plan view of the apparatus;

FIGURE 2 is a vertical axial sectional view of the apparatus;

FIGURE 3 is a transverse sectional view of the intake screen, taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a perspective view of the pump, partly broken away;

FIGURE 5 is a perspective view of a part of the discharge section,

FIGURE 6 is a perspective view of the discharge section and a part of the control means,

FIGURE 7 is a side elevational view of the discharge section and control means, partly broken away, and showing one operative position of a part of the control means,

FIGURE 8 is a view similar to that of FIGURE 7 but showing another operative position of the said part of the control means,

FIGURE 9 is a vertical sectional view of a further form of intake section, and,

FIGURE 10 is a vertical, axial, sectional view of an apparatus including a three-stage pump.

Referring to FIG. 2, there is shown an intake section 1, pump section 4, discharge section 28 and control means 37 for the discharge section. The intake section 1 is provided with an intake passage 1a communicating with an intake opening 1b substantially flush with the bottom surface of hull 2 of the craft in which the apparatus is installed. Fitted within the intake opening 1b is an intake screen in the form of a grill 3 including parallel bars 3a and 3b disposed lengthwise of the hull 2. As is shown more clearly in FIGURE 3, the bars 3a and 3b are of tapered or wedge-shaped cross-section, with the taper being directed inwardly into the intake passage 1a. This particular shape of the bars assists in preventing solid matter from becoming jammed in the grill 3, and such matter which may lodge on the grill is easily swept therefrom due to the direction in which the bars are positioned. The bars 3b are of greater cross-sectional area than the bars 3a, thereby providing a strong and sturdy unit, and keeping the wetted area to a minimum. It is possible, however, if desired, for the bars 3a and 3b to be of the same cross-sectional area.

The space between the lower edges of the bars is preferably not more than half the depth of the bars in order to assure adequate straightening of the inflow of water through the grill 3 into the intake passage 1a, in the direction indicated by the arrows in FIGURE 3. It has been ascertained that this initial straightening of the inflow by means of the grill improves the efficiency of the apparatus, particularly when the boat is turning. Cross-ties or the like between the bars 3a and 3b of the grill 3 should not be used (FIGURES 2 and 3), as they tend to collect weeds and other foreign matter, and are hard to clean, but if for any reason such cross-ties are found to be necessary, such cross-ties should be fixed to the upper edges of the bars and faired in the direction of the flow of water through the grill.

The grill 3 may be made of a metallic or non-metallic material, and in the first situation, the metal used may be dissimilar to that of the main body of the apparatus so as to concentrate any corrosion on the more readily and easily renewable grill in preference to allowing corrosion to occur within the body of the apparatus, with this being a particular application of the principle of sacrificial corrosion.

Water is drawn into and through the intake passage 1a by the action of a two-stage, axial-flow pump within section 4 which is detachably secured to the rear end of the intake section 1 in a manner to be later described. The intake passage 1a leading from the grill 3 to the pump section 4 defines in longitudinal section a shallow, elongated S-curve, as shown in FIGURE 2, with the upper wall of the passage 1a meeting the undersurface of

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the hull 2 at a slight angle or merging with it in an ample radius so as to improve and smooth the flow of water into and through the passage 1a and into the pump section 4. The cross-sectional shape of the passage 1a blends from a section which corresponds to the plan shape of the grill 3 at the intake opening 1b of the passage 1a, to a circular section corresponding to that of the pump section 4.

In the central part of the upper wall of the intake section 1 is located a housing 5 in which are mounted a water seal 6 and a combination thrust and journal bearing 8, provided for drive shaft 9 of a pump 4a.

A removable, transparent window 10 is adapted to be secured over an inspection and servicing opening 11 in the upper part of the intake section 1 to permit inspection of the grill 3, and removal of the window 10 providing access through the opening 11 for cleaning of the grill and of the forward part of the pump 4a.

The pump 4a includes a pair of impellers 12 and 13, arranged at the forward and rearward end portions of the pump, respectively, and a set of stationary guide vanes 14. The impellers 12 and 13 and guide vanes 14 are located within a cylindrical casing 15 which, at its rear end portion, extends through an aperture 16' in transom 16 of the craft. At its forward end, the casing 15 is provided with a flange 15a having a slightly larger diameter than the body of the casing 15. The flange 15a is positioned within a corresponding recess in a flange 1b at the rear end of the intake section 1, and is held therein by a split, annular ring 17 which is bolted or otherwise attached to the flange 1b to secure the pump section 4 to the intake section 1. A seal between the pump section 4 and the intake section 1 is effected by means of an O-ring or other flexible seal 18, as shown in FIGURE 2.

At its rear or after end, the casing 15 is provided with a flange 15b of relatively large diameter, and the flange lies against the rear face of the transom 16, and is secured thereto. With this arrangement, the casing 15 may be readily removed rearwardly through the transom without disturbing the intake section 1 or removing the drive shaft 9.

The axis of the drive shaft 9 is on or parallel to a vertical plane passing through the fore and aft axis of the hull, and is approximately parallel to the said axis, but may be inclined slightly upwardly from its rear to its front end so as to facilitate the installation of an internal combustion engine or other prime mover where-by power is transmitted through the shaft 9 to the pump 4a.

Mounted on the drive shaft 9 and retained thereon by nuts at each end of the shaft are a coupling 19, an adaptor 20, a wear sleeve 21, a thrust sleeve 22, a fairing 23, the impeller 12, a bearing sleeve 24, and the impeller 13, respectively. The coupling 19, adaptor 20, impellers 12 and 13, bearing sleeve 24, and wear sleeve 21 are keyed to the shaft 9, so as to allow wearing parts to be easily replaced, and permit suitable material to be selected to withstand corrosion, abrasion, or wear which occurs in different places.

Alternatively, certain of the above components may be made integral with neighboring components or with the shaft 9, and in particular, the thrust sleeve 22 may be integral with the shaft 9.

The guide vanes 14 are rigidly attached to or are integral with a hollow boss 25 in which is fixedly mounted a fluted rubber bearing 26 surrounding the bearing sleeve 24. A pair of wear rings 27 are disposed within the forward and rearward end portions of the casing 15 around the impellers 12 and 13, and are retained therein by means of an interference fit.

As shown in FIGURE 4, the impellers 12 and 13 are of identical form and each has four blades 12a and 13a, respectively, with the blades being of hydrofoil section, and being mounted on or integral with central bosses 12b

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and 13b, respectively. The leading edges of the blades are approximately 90° with the wear rings 27 at their outer edges, thereby reducing the tendency for solid matter to wedge in the clearance gap between the blades and the wear rings 27. If it is so desired, the blade tips may be narrower than the blade roots, and this is accomplished by tapering the trailing edges of the blades so that the radial disposition of the leading edges is maintained. An adequate clearance is allowed between the impeller blades 12a and 13a, and the vanes 14, so as to avoid the trapping of solid matter which may enter the apparatus through the grid 3.

The outer edges of the blades 12a and 13a adjacent the wear rings 27, may be chamfered to provide a greater clearance between such edges and the wear rings 27 at the forward faces than at the rear faces thereof. Since the water at the rear faces of the blades is at a higher pressure than the water at the front faces, when the pump is in operation, leakage of water through the clearance between the outer edges of the blades and the wear rings 27 is from rear to front, and the chamfering of the outer edges of the blades minimizes the risk of damage to the blades by the trapping of particles of solid matter between the blades and wear rings.

The stationary guide vanes 14 are arranged with intake angles following known practice, with their outlet angles being so arranged that water leaving the vanes has a tangential component of velocity opposing that of the impellers. In this way, it is possible to impose a greater proportion of the load on the impeller 13 than on the impeller 12, without producing an excessive tangential component of velocity at the outlet to the impeller 13, and without requiring different blading on the impellers 12 and 13. This arrangement minimizes the tendency to cavitation at the impeller 12, such as is liable to occur when it is heavily loaded.

Lubrication of the bearing 26 when the pump 4a is in operation, is effected by means of water passing forwardly through the pump from the higher pressure area at the rear of the rear impeller 13, through holes 13c in the boss 13b of such impeller, and thence through the passages of the bearing 26 and through similar holes 12c in the boss 12b of the forward impeller 12, and through the clearance between the boss 12b and the fairing 23 into the main flow of water through the intake passage 1a and pump section 4.

Water is discharged from the pump into the discharge section 28, which consists of a tail pipe 28a having a flange at its forward end. This flange is bolted to the rear flange 15b of the pump casing 15 by means of the bolts securing the flange 15b to the transom of the boat. Within the forward part of the tail pipe is positioned a flow straightening vane assembly 29, shown in detail in FIGURE 5, and consisting of a plurality of flow straightening vanes 29a, which are rigidly fixed to or are integral with a central fairing 29b and an outer ring 29c. The vanes 29a are arranged with appropriate inlet angles in accordance with known practice, but differ from conventional pump output straightening vanes in that the same extend axially into a section of reduced area within the tail pipe 28a. This has been found advantageous as the residual angular velocity of water leaving conventional guide vanes is greatly increased, due to conservation of angular momentum as the cross-sectional area of the tail pipe is reduced, and considerable thrust may be lost in this way. The vanes 29a are preferably of fine hydrofoil section, and are preferably five or more in number.

The acceleration chamber formed by the tail pipe 28a and the vane assembly 29 is of annular cross-section at its forward end, merging smoothly into a circular-cross section of smaller area near its rear or outlet end.

A replaceable nozzle 30 is mounted within the rear end portion of the tail pipe 28a, and is provided with a bore which converges continuously from the forward to the rearward end of the nozzle. Alternatively, the bore

may converge from the forward end of the nozzle to blend into a parallel section of the nozzle near its rearward end. Preferably, the axis of the bore is askew to the axis of the outer surface of the nozzle with the nozzle being retained in the tail pipe 28a by means of a circlip 31 and by radial set screws 32 which are tapped through the wall of the tail pipe 28a, and bear in a circumferential groove of the nozzle 30. By selection of a nozzle 30 having a bore of appropriate size, the discharge velocity and flow characteristics of the apparatus may be cheaply and simply matched to the requirements of any of the various engines and hulls to which the apparatus may be applied, and by rotating the nozzle 30 in the tail-pipe 28a, so as to vary the angular disposition of the bore of the nozzle, fine corrections may be made to the steering trim of the craft. In crafts which are sensitive to fore and aft trim, a single nozzle 30 having a skew bore can be turned through 180 degrees to provide two alternative discharge elevation angles.

An off-take means 33 for an auxiliary water service pipe 34 (FIGURES 1 and 2) is provided in the top wall of the tail pipe 28a, and the off-take incorporates a cylindrical filter chamber 35 in which is contained a removable conical filter element 36 so arranged that stones or heavy matter which may have been drawn into the filter element can fall back into the tail pipe 28a when the pump is stopped.

Control means 37 is carried by the tail pipe 28a and is arranged rearwardly of the discharge outlet of the tail pipe. The control means consists of a gate 37a by means of which stopping and reversing of the craft are accomplished, and a pair of deflectors 38, which are arranged aft of the gate and by means of which steering of the craft is effected. The gate 37a includes a plate provided with rearwardly projecting guide flanges 37' inset from each side edge of the plate, and the plate is formed at its lower end portion with a recess 37b. The recess has a concave face which, in the lowered position of the gate shown in FIGURES 2 and 7, is presented to the outlet opening of the tail pipe 28a.

The gate 37a is slidable upwardly and downwardly within a housing consisting of a bracket 28b on the tail pipe 28a, a rear cover 39, and a pair of spacers 40 arranged between the bracket 28b and cover 39. There is one spacer on each side of the gate 37a, and the spacers 40 are extended upwardly above the bracket 28b and cover 39 to form guides for the gate in its upward and downward sliding movement within the housing. The gate housing so formed is maintained in an assembled condition by bolts 41 which extend through registering apertures in the cover 39, spacers 40, and brackets 28b, as shown in FIGURES 1 and 6.

Each of the flanges 37' is provided with a pair of stops 42 (FIGURES 7 and 8), the stops on each flange being spaced one above the other as shown. A pair of rollers 43 are positioned one on each side of the gate 37a between the stops 42 of the flanges 37', within the channels provided at each side of the gate by the inset of the flanges 37' from the side edges of the gate and consequently from the spacers 40. When the gate is raised, the rollers 43 drop against the two lower stops 42, but as the gate is lowered, the hydraulic load thereon causes the rollers 43 to make rolling contact with the side edge portions of the gate and with the cover 39. The rollers 43 then move downwardly at half the speed of downward movement of the gate 37a, and this movement places the same in a favorable position to carry the hydraulic load imposed on the gate.

The rollers 43 may be made of suitable, non-metallic material, such as nylon, which has sufficient elasticity to allow the rollers to roll over small particles of grit which may lodge between the rollers and the bearing surfaces of the gate 37a or cover 39. An O-ring or other flexible sealing means may be arranged to prevent ingress of

grit to the fine clearances between the gate 37a and the bracket 28b of the tail pipe.

The deflectors 38 are pivoted in mountings 39a on the rear face of the cover 39, and are connected by arms 44 to a control shaft 45, by rotation of which the angular setting of the deflectors 38 can be altered to alter the angle of discharge of the jet of water issuing from the tail pipe 28a, and thereby change the direction of travel of the boat.

Referring to FIGURE 9, there is illustrated a further form of intake section, which section is indicated generally 100, and is of substantially the same structural detail as the intake section 1. It will be noted that a housing 101 is located on the central part of the upper wall of the section 100, and mounted within the housing is a further housing 102. The further housing 102 contains thrust bearing means 103 and water seals 104 for the drive shaft of the pump. As can be seen, the further housing 102 is provided with vertical, peripheral flange means 105 adapted to overlie the outer edge of the housing 101. A cap 106 is adapted to engage the flange 105 and bolt means 107 secure the cap and peripheral flange to the main housing 101. A gasket 108 may be positioned between the cap and the peripheral flange.

By virtue of this arrangement, there is provided a cartridge-type insert for housing the thrust bearings and seals, thereby facilitating the service and maintenance of the apparatus.

FIGURE 10 is generally along the lines of FIGURE 2, but it will be noted that in lieu of the two-stage pump shown in FIGURE 2, there is provided a three-stage pump. In this embodiment, pump 110 includes two sections, a rear section 111 which is similar to the pump 4a illustrated in FIGURE 2, and a forward section 112 which contains a single impeller 113. In this embodiment, corresponding parts are identified by the same reference numerals as used in FIGURE 2.

It will be noted that the forward end of the casing of section 112 is secured to the rear end of the intake section 1 by the same means shown in FIGURE 2. The rear end of the casing of the section 112 is provided with a flange 114 similar to flange 15a, and the same is bolted to flange means 115 at the forward end of the rear section by bolts or the like shown at 116. The opposite end of the rear section is attached to the front face of the transom.

By virtue of the third section or stage, there is effected a boosting of the performance of the apparatus, by providing additional pressurization in the jet. The acceleration speed is augmented as is the thrust, which, needless to say, improves the over-all operation of the apparatus. This embodiment also includes a gate 120 which is similar to the gate 37a, and a deflector gate 121 aft of the vertically movable gate 120, which deflector gate is mounted for turning movement from one side to the other for steering the craft. The gate 121 is pivoted in mountings 122 on a rear cover component 123 provided for the vertically movable gate. A quadrant 124 is disposed above the gate 121, and is provided with a pair of depending arms 125, with such arms being located on opposite sides of the gate. The quadrant is mounted for movement relative to the transom of the boat as indicated at 126, and steering cables 127 are attached to groove 128 of the quadrant. Hydraulic means of conventional type are operatively associated with the cables, and with a control lever in the forward portion of the craft. By moving the control lever in one direction, the quadrant 124 will be simultaneously moved in the desired direction, and obviously movement of the control lever in the opposite direction will move the quadrant, and of course the gate, in the opposite direction.

It is also contemplated to impart the desired vertical movement to the gate 120 by means of a hydraulic pump (not shown) although, of course, this can be accomplished manually.

The invention further encompasses the concept of

dividing the intake passage of the intake section and the grid at the intake opening into two components, with the two components of the intake passage merging into a single component in advance of the pump. This arrangement is particularly efficacious when the invention is used with a hull provided with a keel, and in such situation, the two components of the intake opening and grid are located one on each side of the keel.

In a further application of this principle, the divisions of the intake opening and the grid may be located one on each side of the hull, so that water is drawn in from each side of the craft by the operation of the pump means.

Various constructional modifications of the apparatus hereinabove described and illustrated are possible, without departing from the spirit and scope of the invention. I claim:

1. As a part of propulsion apparatus for water craft including means defining a water-conveying conduit having an inlet end and a restricted outlet end, a pump within said conduit for drawing water into the conduit through said inlet end and discharging the water as a propulsion jet through said outlet end, a discharge section defining the restricted outlet end of the conduit and which section includes a discharge nozzle and an acceleration chamber, the acceleration chamber being arranged between the pump and the discharge nozzle for providing a passage means for the flow of water from the pump to the nozzle, said passage means being provided with an inlet and an outlet end and having a cross-section which is annular at said inlet and which merges smoothly into a circular section of smaller area at said outlet end, said passage means having a forward portion and an aft portion, said forward portion extending for at least half of the distance from said inlet to said outlet end of the passage means and converging continuously from said inlet to its junction with the aft portion and a plurality of straightening vanes located within said forward portion of annular cross-section extending axially within said forward portion for substantially the full length thereof.

2. An apparatus as claimed in claim 1, in which said discharge nozzle is of generally annular form provided with a substantially cylindrical external surface and a bore of converging circular cross-section, and including a tail pipe defining a part of the discharge section at the rear end of said acceleration chamber with said discharge nozzle being removably positioned within a bore having a substantially cylindrical inner surface provided in said tail pipe.

3. An apparatus as claimed in claim 1, further including means constituting a take-off for auxiliary water services located between said inlet end and outlet end and communicating with said acceleration chamber.

4. An apparatus as claimed in claim 1, including an outer ring within which said straightening vanes are rigidly mounted, and said outer ring being fitted tightly within a cylindrical recess in said acceleration chamber at the inlet end of said passage means.

5. An apparatus as claimed in claim 1, in which the bore of said discharge nozzle converges continuously from the forward end to the aft end of said nozzle.

6. A water craft and propulsion means therefor, comprising conduit means for supplying water to the propulsion pump means and a discharge nozzle through which

the water is discharged as a propulsive jet, a tail pipe for said conduit means, said discharge nozzle being of generally annular form provided with a substantially cylindrical external surface and a bore of converging circular cross-section, the bore being inclined to the axis of the cylindrical external surface, fastening means at selected stations along the cylindrical external surface so that the nozzle may be secured in the tail pipe in more than one selected position of angular alignment whereby adjustment of the nozzle may be effected for easy pre-setting of the trim of the watercraft.

7. The water craft and propulsion means as claimed in claim 6 including means removably connecting the nozzle in said tail pipe.

8. As a part of propulsion apparatus for water craft including means defining a water-conveying conduit having an inlet end and a restricted outlet end, a pump within said conduit for drawing water into the conduit through said inlet end and discharging the water as a propulsive jet through said outlet end, a discharge section defining the restricted outlet end of the conduit and which section includes a discharge nozzle and an acceleration chamber, the acceleration chamber being arranged between the pump and the discharge nozzle for providing a passage means for the flow of water from the pump to the nozzle, said passage means being provided with an inlet and an outlet end and having a cross-section which is annular at said inlet and which merges smoothly into a section of smaller area at said outlet end, said passage means having a forward portion and an aft portion, said forward portion converging continuously from said inlet to its junction with the aft portion and a plurality of straightening vanes located within said forward portion of annular cross-section extending axially within said forward portion.

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