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[54] **APPARATUS FOR WATER JET PROPULSION**

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[52] **U.S. Cl.** **60/221,** 239/265, 239/39, 60/224

[51] **Int. Cl.** **B63h 11/10**

[58] **Field of Search** 60/221, 222; 415/147, 157, 148; 137/15.1, 15.2; 239/265.33, 265.37, 265.39, 265.41

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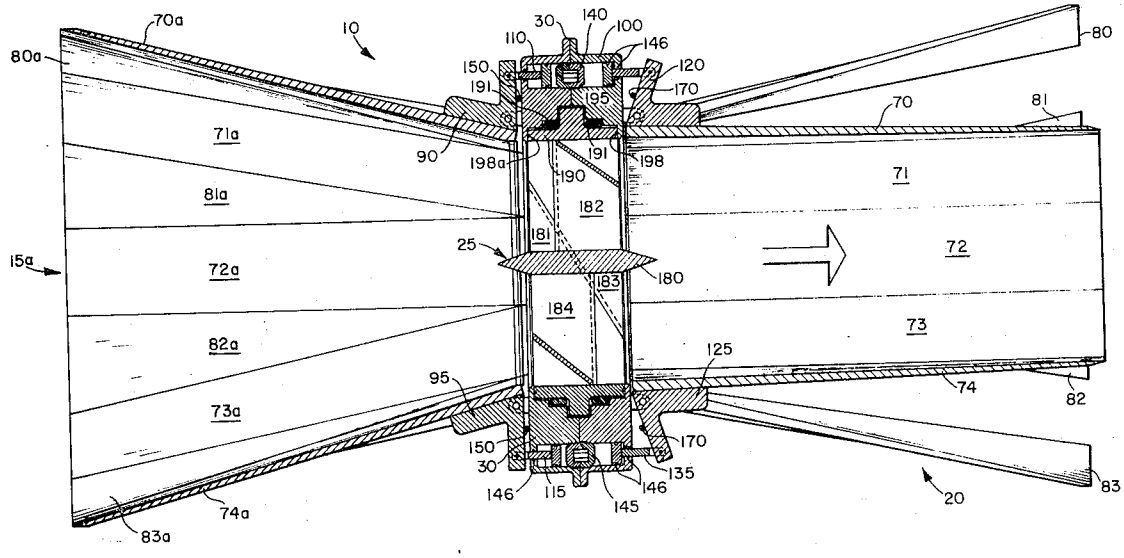
[57] **ABSTRACT**

Apparatus for water jet propulsion in which a screw propeller is integrally formed with a surrounding duct, which surrounding duct rotates with the screw propeller to eliminate blade-tip vortex. A duct comprised of alternately disposed movable and stationary segments, which movable elements are adjustably positioned to mate with the stationary segments to provide optionally either an intake duct with an optimum configuration to reduce cavitation or a discharge duct with an optimum configuration.

4 Claims, 6 Drawing Figures



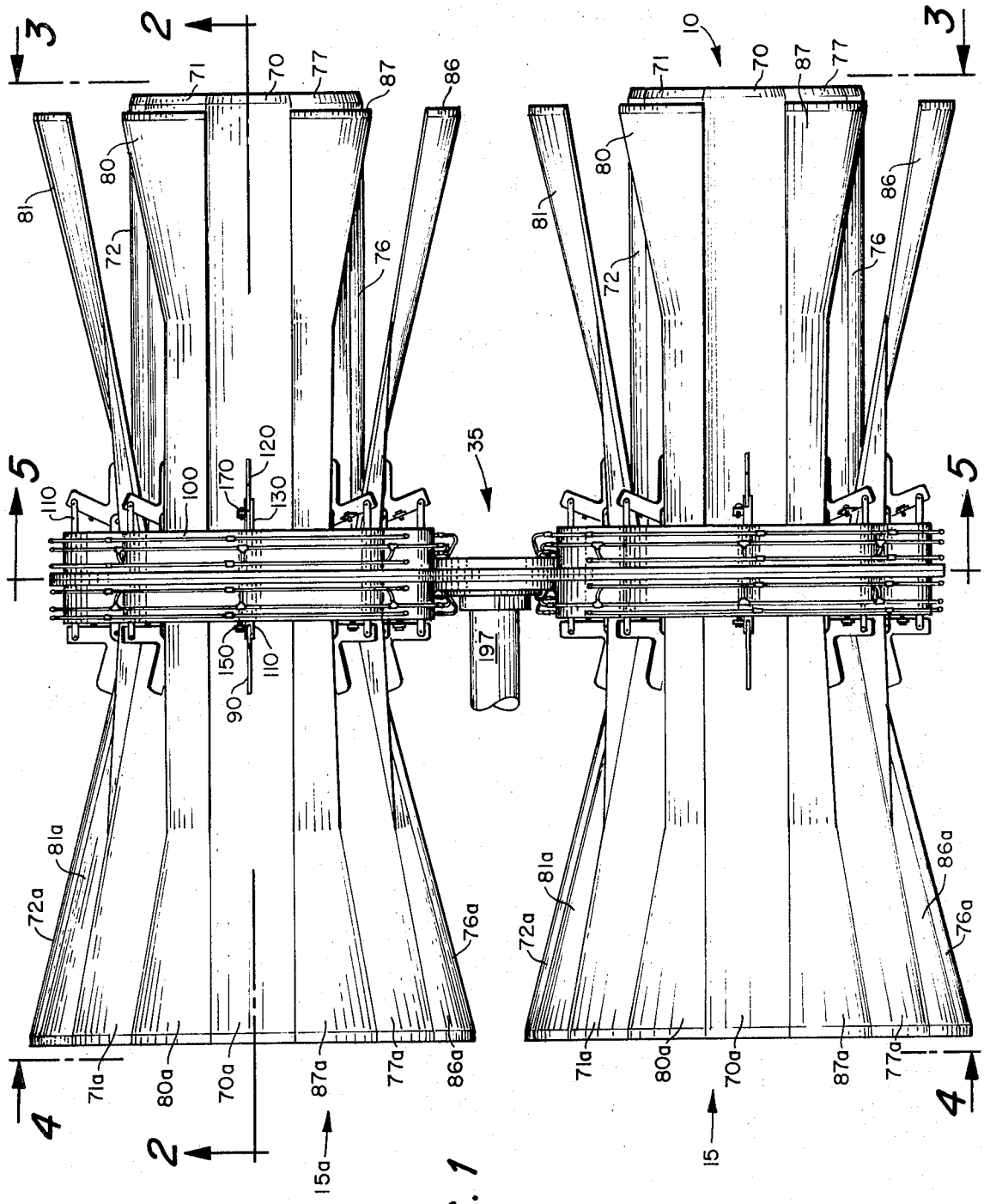


FIG. 1

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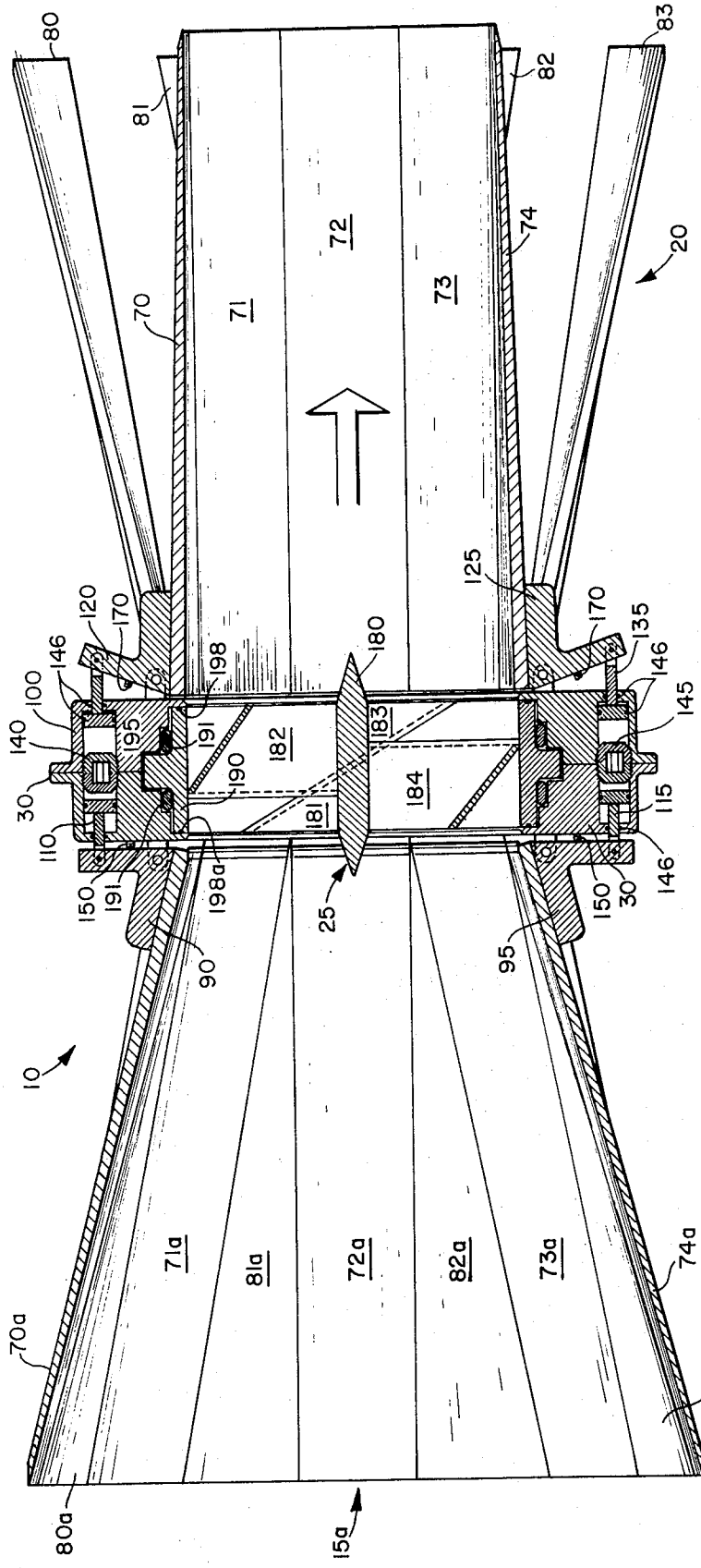

FIG. 2

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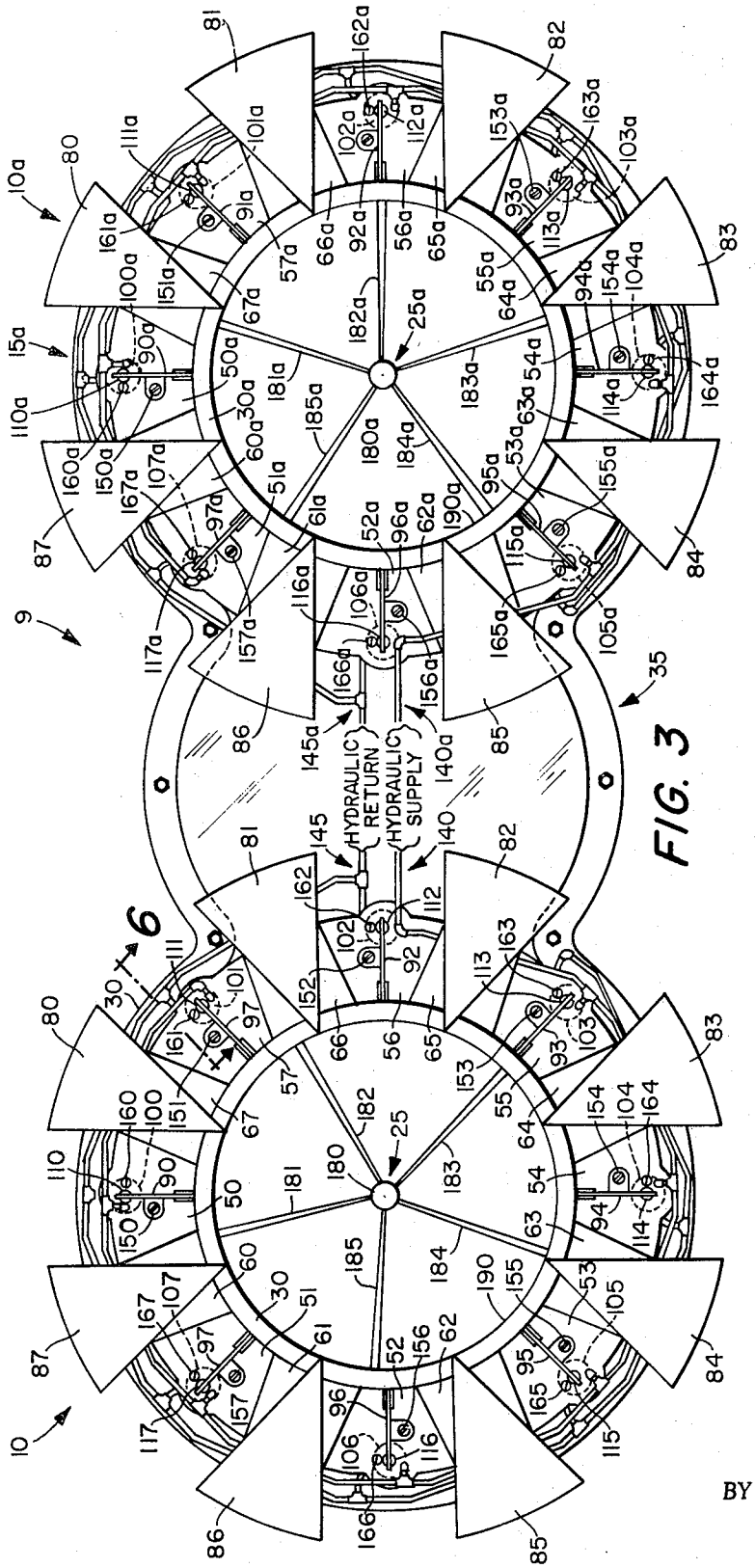

FIG. 3

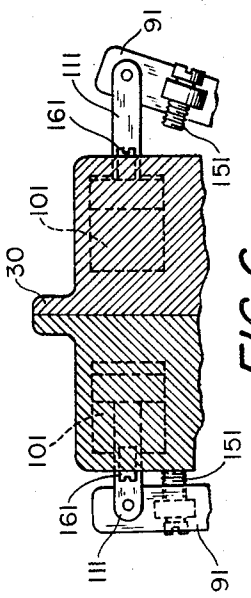

FIG. 6

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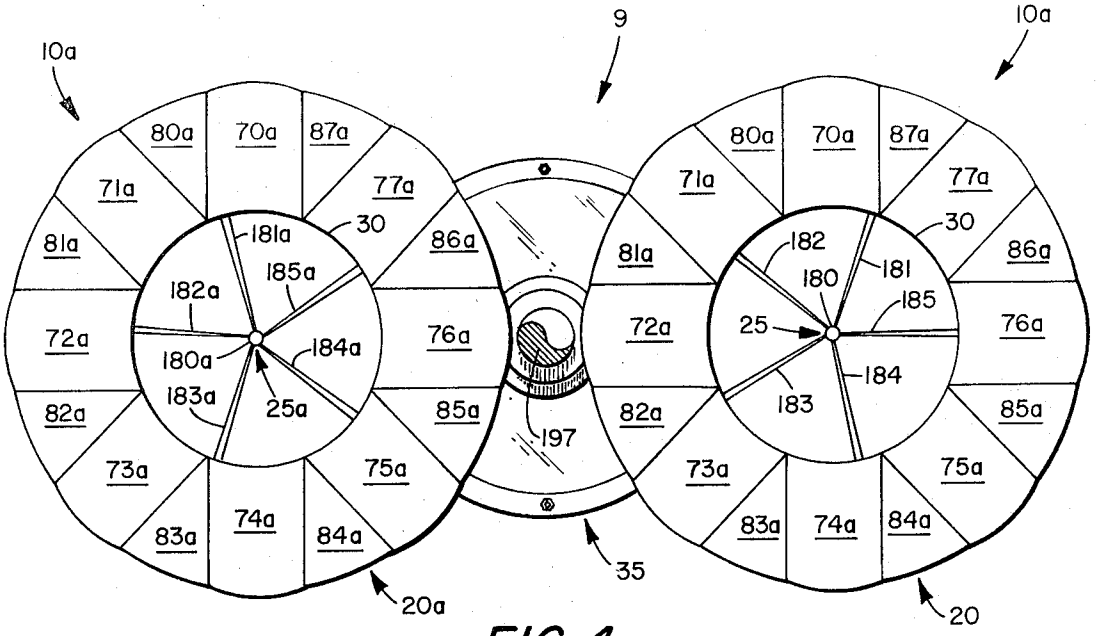

FIG. 4

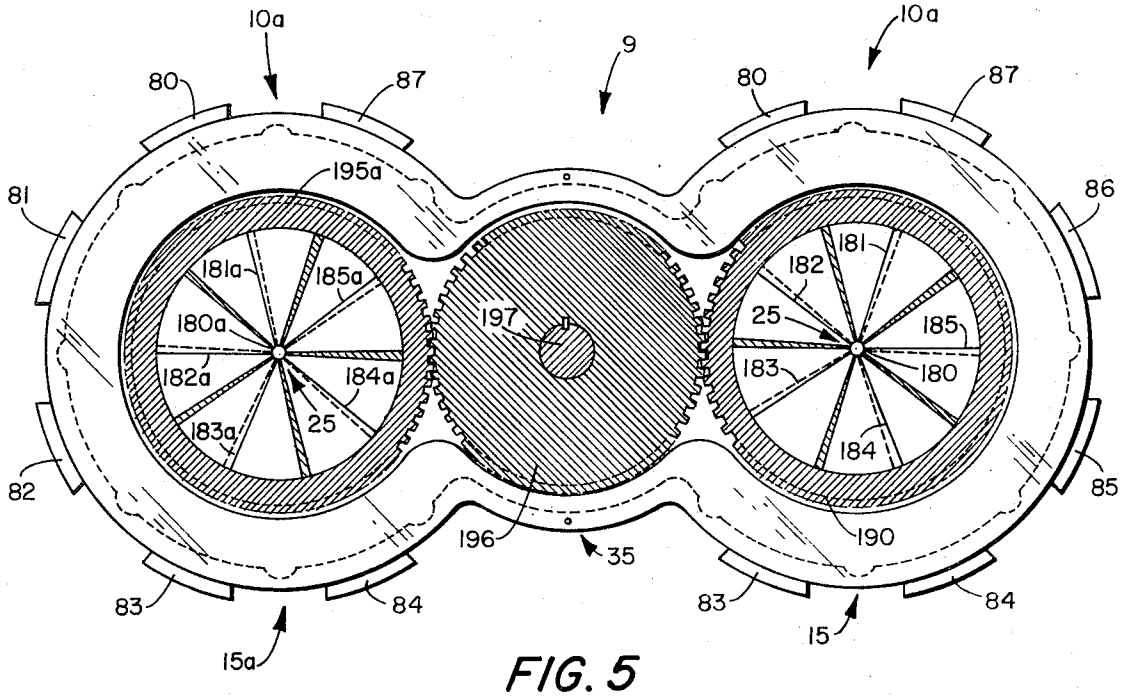

FIG. 5

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APPARATUS FOR WATER JET PROPULSION

BACKGROUND OF THE INVENTION

The present invention relates in general to apparatus for propelling water vehicles, and more particularly, to apparatus for propelling water vehicles by water-jet propulsion.

Heretofore, screw blades employed for propelling water vehicles were inefficient. Such inefficiency was primarily caused by blade-tip vortex and cavitation. Blade-tip vortex is caused by water passing across the top of fast moving blade-tips, which produces a circular vortex action. This action creates a turbulance and thereby decreases the efficiency of the blade-tips. Cavitation is a formation of small bubbles of water vapor resulting from a decrease of water pressure on the rear side of the rotating screw blades. When the water pressure is reduced to a point equal to or below the vapor pressure of the ambient water, the water vaporizes and forms small bubbles or cavities.

Both blade-tip vortex and cavitation, and particularly cavitation, produce noise which is objectionable. This is particularly so in connection with submarines when a quiet operation is desired.

Attempts have been made to overcome the problems arising out of blade-tip vortex and cavitation. One arrangement has been to surround the blade screw with a duct fitted closely to the tips of the blades to assist in reducing blade-tip vortex. However, there appears to be a need of some clearance between the fast moving blade-tips and the stationary surrounding metal duct. This clearance produces a leakage path which permits a turbulance similar to blade-tip vortex. Fluid passing through a constricted opening under great pressure and at a high velocity is to some extent abrasive. The abrasive action wears away both the blade-tip and surrounding duct, which results in an increase in the clearance. The increase in clearance, in turn, increases the amount of blade-tip turbulance.

Presently existing water-jet apparatus for propelling water vehicles employ an intake duct or a discharge duct with a combined configuration for the intake side and for the discharge side. The combined configuration is a compromise between the optimum shape for an intake duct and the optimum shape for a discharge duct. While such a combined shape is more efficient than attempting to reverse the engines with a unit having an optimum shape for the intake side and an optimum shape for the discharge side, such a unit would provide reduced power when the engines are reversed. Such a configuration, which is sometimes referred to as the "English Curve," is quite inefficient and tends to lack usefulness for a water-jet propulsion system.

SUMMARY OF THE INVENTION

Apparatus for propelling water vehicles by water-jet propulsion, in which a propeller is formed with a surrounding duct fixed thereto. The surrounding duct rotates with the propeller for reducing blade-tip vortex. As a further feature, the drive shaft for the propeller can optionally be set-off from the axis of the hub to increase the effective face area of the propeller.

A duct for water-jet propulsion apparatus having alternately disposed movable and stationary segments, in which the movable segments are adjustably positioned in mating relation with the stationary segments to provide optionally either an optimum configuration as an intake duct to reduce cavitation or an optimum configuration as a discharge duct. An intake duct for water-jet propulsion having a frusto-conical configuration to reduce cavitation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of the apparatus of the present invention for propelling water vehicles by water-jet propulsion.

FIG. **2** is a vertical section of the apparatus shown in FIG. **1** taken along line **2—2** of FIG. **1.**

FIG. **3** is an end view of the apparatus shown in FIGS. **1** and **2** taken along the line **3—3** of FIG. **1** at the aft end of the apparatus.

FIG. **4** is an end view of the apparatus shown in FIGS. **1** and **2** taken along the line **4—4** of FIG. **1** at the forward end of the apparatus.

FIG. **5** is a vertical section view taken along line **5—5** of FIG. **2.**

FIG. **6** is a section taken along line **6—6** of FIG. **3.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Illustrated in FIGS. **1–5** is a twin water jet propulsion apparatus **9** embodying the present invention, which comprises identical water jet propulsion apparatus **10** and **10***a*. Hence, the water jet propulsion apparatus **10** will be described in detail hereinafter and like parts for the water jet propulsion apparatus **10***a* will be designated by the same reference numeral but with a suffix "*a*."

The water jet propulsion apparatus **10** (FIG. **2**) comprises ducts **15** and **20** at opposite ends thereof. Joining the confronting ends of the ducts **15** and **20** is a screw propeller **25** which is disposed within a cylindrical housing **30.** Rotating the screw propellers **25** and **25***a* is a common drive arrangement **35** (FIGS. **4** and **5**).

Either duct **15** or duct **20** can be adjustably employed as the intake duct or as the discharge duct. For purposes of convenience, in the description to follow the duct **15** will be described as the intake duct and the duct **20** will be described as the discharge duct.

The intake duct **15** in the preferred embodiment has a configuration of a truncated cone to reduce cavitation and comprises 16 segments. Segments **50–57** are movable segments and segments **60–67** are stationary segments. The movable segments **50–57** and the fixed segments **60–67** are alternately disposed to form the periphery wall of the duct **15.** The stationary segments are fixed at proximal ends thereof to the housing **30** (FIG. **2**). The movable segments are pivotally connected at their proximal ends to the housing **30.** In the exemplary embodiment for the intake duct **15,** the movable segments **50–57** are extended angularly relative to the housing **30** and mate with the fixed segments **60–67** (FIG. **3**) to form a relatively smooth inner frusto-conical wall for the path of travel of water advancing toward the propeller screw **25,** which may be referred to as the optimum configuration of an intake duct. Thus, as an intake duct, the movable segments fan out angularly relative to the housing **30** to mate with the stationary segments.

In a like manner, the discharge duct **20** includes 16 segments. In the exemplary embodiment, the discharge duct **20** has a cylindrical configuration formed by eight movable segments **70–77,** which are retracted angularly relative to the housing **30** to mate with adjacent

movable segments thereof for the discharge of water expelled by the propeller screw **25.** This configuration may be referred to as the optimum configuration for a discharge duct. The movable segments are pivotally connected to the proximal ends thereof to the housing **30** (FIG. 2) and the stationary segments are fixed at their proximal ends to the housing **30.** When the movable segments are retracted angularly relative to the housing **30,** they form the inner cylindrical wall of the duct **20** for the discharge flow of the water (FIG. **4**).

Connected to the movable segments **50–57** for the duct **15** are angular actuating arms **90–97,** respectively. Each arm has one leg thereof fixed to its associated movable segment for imparting an angularly extending or retracting movement thereto relative to the housing **30.** At the junction between the legs, the actuating arms **90–97** are pivotally connected for pivotal movement to the housing **30** by means of suitable ears and pins. Mounted on the housing **30** are suitable hydraulic cylinders **100–107.** Pistons **110–117** are disposed within the cylinders **100–107,** respectively, and are connected through their piston rods to the other legs of the arms **90–97,** respectively, for imparting thereto a pivotal movement. Thus, imparting rectilinear movement to the pistons **110–117** causes the actuating arms **90–97,** respectively, to extend or retract the movable segments **50–57,** respectively, of the duct **15** angularly relative to the housing **30.**

In a like manner, connected to the movable segments **70–77** for the duct **20** are angular actuating arms **120–127,** respectively. Each arm has one leg thereof fixed to its associated movable segment for imparting an extending or retracting angular movement thereto relative to the housing **30.** At the junction between the legs, the actuating arms **120–127** are pivotally connected for pivotal movement to the housing **30** by means of suitable ears and pins. Pistons **130–137** are disposed within the cylinders **100–107,** respectively, and are connected through their piston rods to the other legs of the arms **120–127,** respectively. The pistons **130–137** are oppositely located in the cylinders **100–107,** respectively, with respect to the pistons **110–117.** Intermediate the pistons **130–137** and pistons **110–117** are sealing plugs **140–147,** respectively.

For actuating the pistons **110–117** and the pistons **130–137** within the cylinders **100–107** to impart a reciprocating movement thereto, fluid under pressure is supplied to each side of the hydraulic cylinders **100–107.** Toward this end, a network of hydraulic supply conduits **140** and a network of hydraulic return conduits **145** supply positive fluid pressure to each end of each side of the cylinders **100–107.** A suitable source of fluid under pressure, not shown, is connected to the network **140** and **145.** The hydraulic supply conduits **140** are connected to the lowest pressure point in each side of the hydraulic **100–107** and the hydraulic return conduits **145** are connected to the highest pressure point in each side of the hydraulic cylinders **100–107,** whereby positive fluid pressure is alternately applied to each end of each side of the hydraulic cylinders **100–107** while the return network is opened to permit fluid on the other end of each side of the hydraulic cylinders **100–107** to be evacuated. An automatic bleed arrangement is provided, since any entraped air will rise and will be entraped to be carried out with the fluid in its exhaust cycle. Conventional O-rings **146** are provided as fluid seals for the hydraulic system.

For limiting the angular extent of movement of the movable segments **50–57** for the duct **15** so as to enable the movable segments **50–57** and the fixed segments **60–67** to mate properly in the intake adjusted position or the discharge adjusted position, adjustment screws **150–157** are mounted on the arms **90–97,** respectively. The screws **150–157** adjustably engage the housing **30** to limit the angular extent of travel of the associated actuater arm and permit adjustment thereof for proper mating of the movable segments **50–57** with the fixed segments **60–61.** Adjustment screws **160–167** on the cylinders **100–107,** respectively, limit the linear extent of travel of the pistons **110–117,** respectively, and permit adjustment thereof for proper mating of the movable segments **50–57** in the discharge mode for the duct **15.**

Similarly, adjustment screws similar to adjustment screw **170** for the actuating arm **120** are adjustably mounted on the actuating arms **121–127,** respectively, for engagement with the housing **30** to limit the angular extent of the movable segments **70–77** for the duct **20** so as to enable the movable segments **70–77** to properly mate in the intake adjusted position or the discharge adjusted position with the stationary segments **80–87.** The adjustment screws, which are similar to the adjustment screws **150–157** previously described, limit the movement of the movable segments **70–77** by restricting the angular extent of the pivotal movement of the actuating arms **120–127** toward the housing **30.** Adjustment screws, not shown, on the cylinders **100–107,** respectively, similar to the adjustment screws **160–167,** limit the linear extent of the travel of the pistons **130–137,** respectively, and permit adjustment thereof for proper mating of the movable segments **70–77** in the discharge mode of the duct **20.**

From the foregoing, it is to be observed that the duct **15** is selectively formed into the shape of a truncated cone and functions in this mode as the intake duct. Water enters the wide end of the duct **15** and impinges on the sloping inner walls of the duct **15.** This action creates a pressure head which is converted into a velocity head as the water advances toward the screw propeller **25.** The duct **15** gradually decreases in cross-sectional areas in the downstream direction. As the water proceeds through the screw propeller **25,** it is accelerated and discharged through the cylindrical shape which is the exemplary configuration for a discharge duct.

Disposed within the housing **30** in the path of travel of water advancing through the duct **15** is the screw propeller **25.** The screw propeller **25** comprises a hub **180** which extends in the direction of travel of the water from the duct **15** toward the duct **20.** Fixed to the hub or core **180** are screw blades **181–185.** As is well-known, the hub **180** rotates fitted with radiating blades **181–185,** which are arranged in a spiral configuration. The hub **180** is smaller than the inner core of conventional or shaft driven screw propellers.

According to the present invention, a cylindrical tube, sleeve, duct or collar **190** is fixed to the distal ends of the screw blades **181–185** for rotation therewith. The duct **190** may be integrally formed with the distal ends of the blades **181–185** or welded thereto. Suitable bearings, such as roller bearings **191,** are disposed between the rotating duct **190** and the housing

30, which serve as thrust bearings as well as anti-friction bearings.

Integrally formed with the duct **190** is a driven gear **195** for imparting rotation to the screw propeller **25** and the surrounding duct **190.** Meshing with the gears **195** and **195***a* is a centrally located drive gear **196** (FIG. **5**), which is keyed to a drive shaft **197** of the vehicle. O-rings **198** seal off the gear box to reduce the seepage of water thereinto and to reduce the escape of gear lubricant into the water.

By virtue of the duct **190** being fixed to the distal ends of the screw blades **181–185** for rotation therewith and by eliminating clearance between the tip of the screw blades and the duct surrounding the screw propeller, blade-tip turbulance is substantially eliminated.

The cavitation is substantially reduced by increasing the pressure on the back side of the screw blades **181–185,** which is achieved by the acceleration of intake water in the frusto-conically shaped intake duct of the present invention.

I claim:

1. A duct for fluid jet propulsion apparatus comprising:

a housing;

a plurality of movable segments pivotally connected to said housing;

a plurality of stationary segments fixed to said housing;

said movable segments and said stationary segments being alternately disposed and in adjacent relation about said housing; and

means connected to said movable segments for pivoting said movable segments relative to said housing into selective mated positions with adjacent segments for at times forming a desired configuration as an intake duct and at other times forming a desired configuration as a discharge duct,

said movable segments fan out pivotally from said housing into angular expansion for mating relation with said stationary segments to form a desired configuration as an intake duct.

2. A duct as claimed in claim **1** wherein said movable segments are retracted angularly with respect to said housing for mating relation with adjacent movable segments to form a desired configuration as a discharge duct.

3. A duct as claimed in claim **2** wherein said means includes an hydraulic system.

4. A duct as claimed in claim **3** and comprising adjustment means for restricting the extent of movement of said movable segments.

* * * * *