

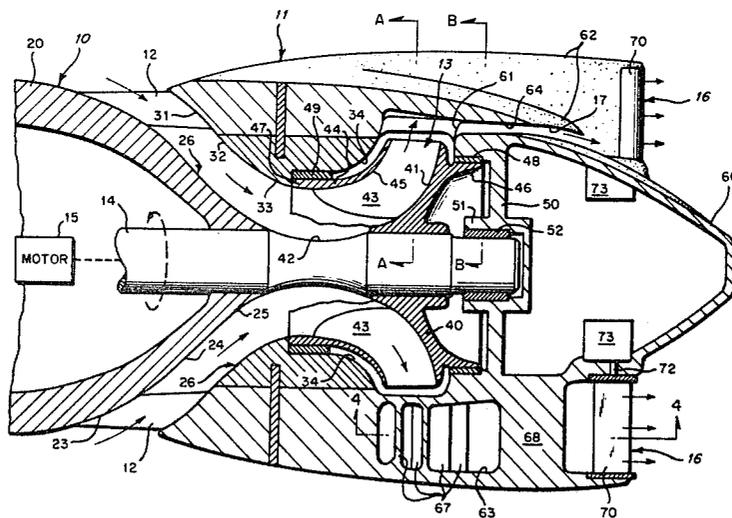
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represented by the Secretary of the Navy.**

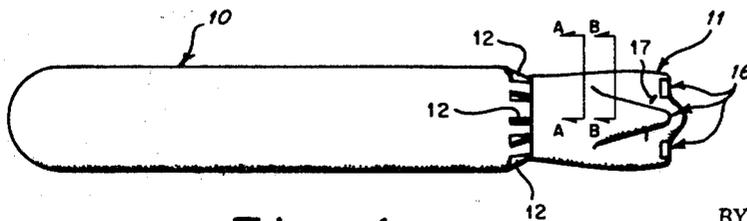
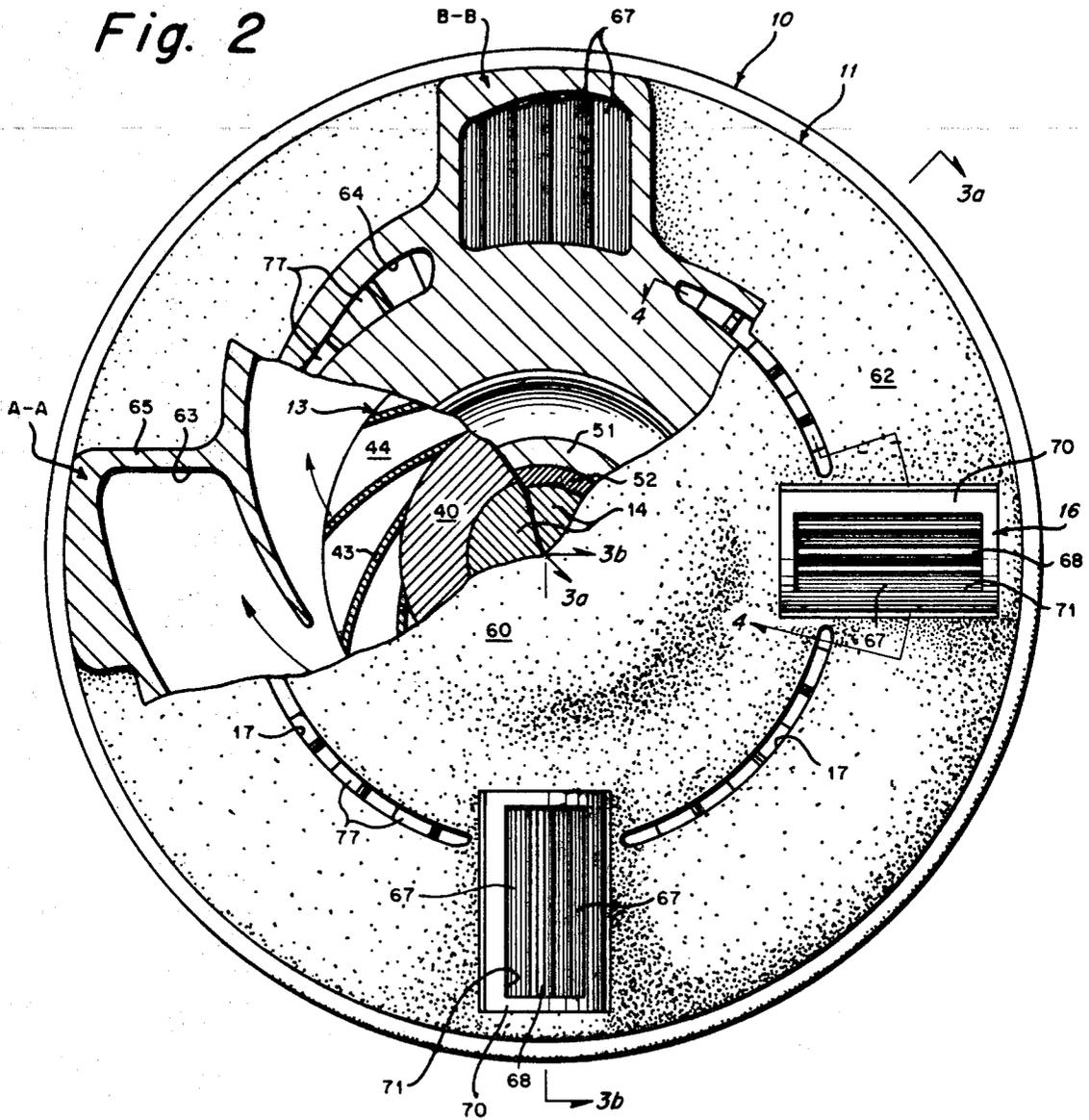
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[54] **VEHICLE PROPULSION SYSTEM**
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[51] Int. Cl..... **B63h 11/00**
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ABSTRACT: A propulsion system for fluid-submerged bodies, such as torpedoes or submarines, including a mixed flow impeller for increasing the energy of and for introducing radial and transverse direction components into a fluid flow directed therethrough and a pump casing connected by flow inlet vanes to the aft end of the submerged body which includes ducting terminating in exhaust openings having rotatable jet stream deflection cylinders for exhausting at least a major portion of the impeller exhaust to propel and steer the submerged body, and which may include ducting terminating in arcuately extending exhaust slots arranged between adjacent jet stream exhaust openings for exhausting a substantial portion of the flow to inhibit flow separation at the aft end of the pump casing.

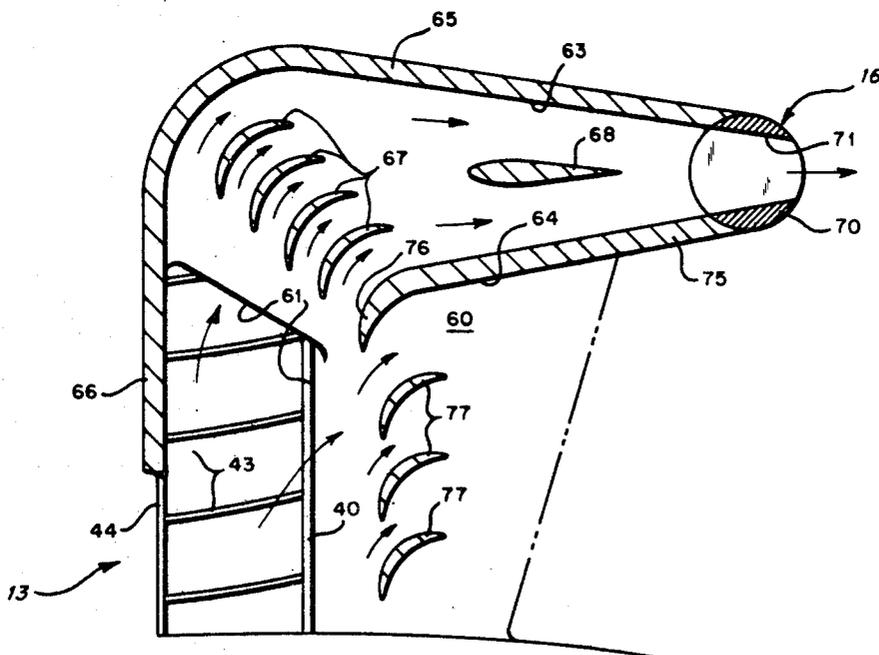
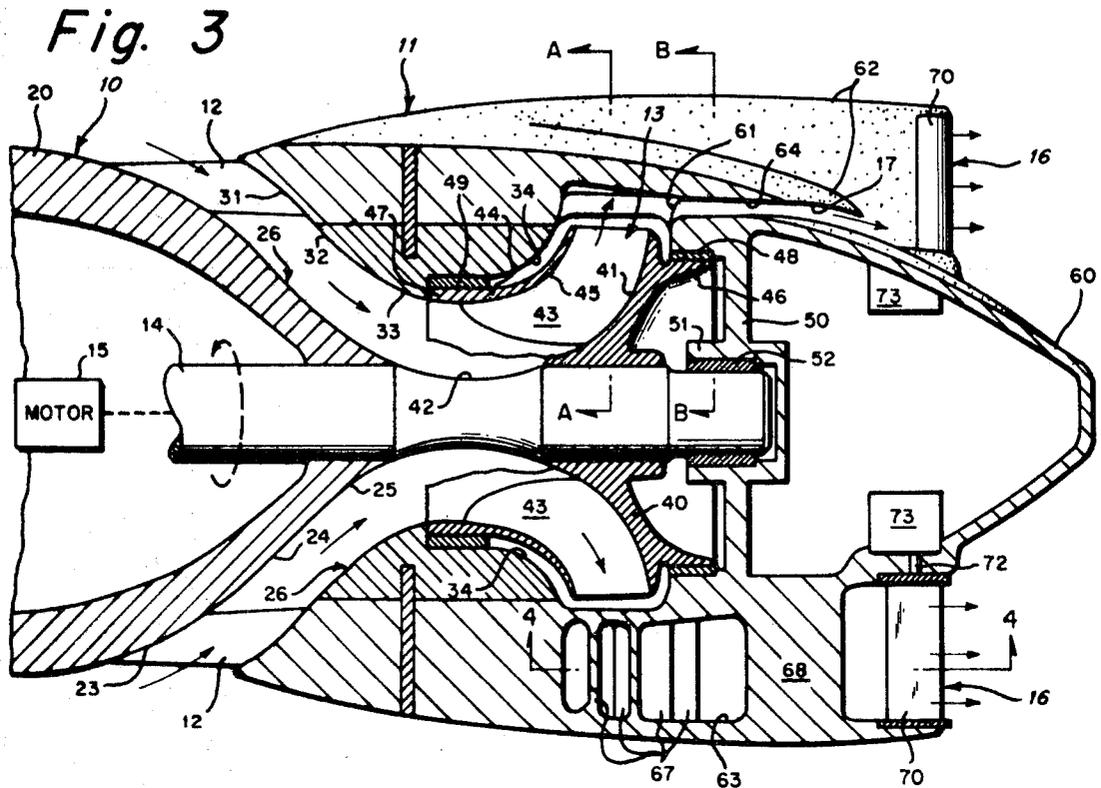




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VEHICLE PROPULSION SYSTEM

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention generally relates to propulsion systems and more particularly relates to jet propulsion systems of the type including an impeller arranged in a duct for adding energy to a fluid flow passing therethrough and being exhausted for propulsion.

Cavitation and radiated noise have long plagued designers of underwater vehicles such as torpedoes and submarines. While it is known to interpose axial flow impellers in duct work for introducing energy into a fluid flow exhausted to propel the vehicle, further reductions in radiated noise levels of submarines, torpedoes and the like propelled in such a manner are desirable.

SUMMARY OF THE INVENTION

It is the general purpose of this invention to provide an improved propulsion system characterized by reduced flow velocities over the impeller blades in order to reduce the level of radiated noise. More particularly, it is an object that the improved propulsion system also inhibit flow separation at the aft end of the vehicle. Briefly, the general purpose and objects of the invention are accomplished by providing an impeller of a mixed flow type which not only increases the flow energy but also introduces radial and circumferential direction components to the axial component and at the same time reduces the flow velocity relative to the impeller blades. Additionally, the invention contemplates enveloping the impeller in a pump casing having duct work formed therein for diverting a portion of the increased energy flow to primary jet stream propulsion exhaust openings and a lesser portion of the flow to arcuately extending slots arranged between adjacent exhaust openings at the exhaust end of the pump casing and configured to inject flow for preventing flow separation at the aft end of the vehicle. The invention additionally contemplates the use of inlet flow vanes for connecting the pump casing to the vehicle and for reducing turbulence in the intake flow of fluid directed to the impeller, and contemplates an improved internal ducting configuration further reducing radiated noise.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 represents a side view of a torpedo including a propulsion system according to the invention;

FIG. 2 represents an enlarged rear view of the torpedo of FIG. 1, which view has portions broken away to expose sectors A-A and B-B taken in cross section generally along respective lines A-A and B-B of FIGS. 1 and 3;

FIG. 3 represents an enlarged longitudinal view in cross section of the aft end of the torpedo of FIG. 1 taken from two, axially intersecting planes extending through lines 3a-3a and 3b-3b of FIG. 2; and

FIG. 4 represents a planar development of a curved view of a portion in cross section of the aft end of FIG. 3 taken generally along the longitudinal line 4-4 of FIG. 3 and along the curved line 4-4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A side view of a torpedo 10 including an embodiment of a propulsion system according to the invention is generally shown in FIG. 1. The torpedo 10 includes a casing generally designated 11 which is attached to the aft end of the torpedo 10 by a plurality of inflow vanes 12, more clearly shown in FIG. 3, which additionally function to reduce turbulence in a fluid inflow taken into the propulsion system through the

annular, radially converging spacing between the aft end of the torpedo 10 and confronting end of the pump casing 11. Referring to FIGS. 2 and 3, an impeller generally designated 13 is fixed to a drive shaft 14 which is mounted for driven rotation by a drive source such as the motor indicated at 15 and which protrudes beyond the aft end of the torpedo along the longitudinal axis thereof. The impeller 13 is shown in cross section in the segment of A-A of FIG. 2 taken generally along line A-A whose location is more precisely shown in FIG. 3. Generally, the impeller 13 causes a fluid flow to be drawn in through the annular influx area defined by the inflow vanes 12, the forward end of the pump casing 11 and the aft end of the torpedo 10 and to be diverted through ducting and exhausted through four symmetrically positioned, circularly arranged jet stream steering exhaust openings 16 and also through four generally circularly arranged slots 17 arcuately extending between adjacent steering jet exhaust openings 16. Segments A-A and B-B of FIG. 2 represent partial cross sections of the propulsion pump casing 11 at different distances from the aft end of the impeller 13 in order to indicate transverse cross sections of internal ducts which exhaust through the openings 16 and the slots 17. Generally, the ducts are arranged and configured so that about 75 percent of the high-energy exhaust from the impeller 13 is directed through the jet steering openings 16 to enable primary propulsion and steering of the torpedo 10, while approximately 25 percent is exhausted through the arcuate slots 17 to prevent or inhibit fluid flow separation at the aft end of the pump casing 11.

The longitudinal view in cross section of the aft end of the torpedo 10 and the casing 11 of FIG. 3 more particularly illustrate the innerconnection of the casing 11 to the torpedo 10. The outer periphery of the aft end of the torpedo housing 20 is streamlined and may be visualized as comprising a body of revolution generated by a curve rotated about the axis of the drive shaft 14 and generally extending from the outer periphery of the torpedo 10 through a convex curve as at 23, a region of transition as at 24, and a concave portion as at 25 forming a streamlined boundary conducive to smooth flow through a converging annular duct generally indicated at 26 formed by the aft end of the housing 20 and the confronting periphery of the pump casing 11. The confronting periphery of the pump casing 11 may also be visualized as being a body of revolution generated by a curve having an initial concave portion as at 31 extending through a transition region as at 32 to a convex portion 33 terminating at the impeller 13. Generally, the duct 26 is so formed that the confronting periphery of the housing 20 and pump casing 11 diverge slightly immediately in front of the impeller 13. While the inflow vanes 12 interconnecting the casing 11 to the torpedo 10, as by bolting to the torpedo housing frame, not shown, as indicated in FIG. 1 as being arranged in equiangularly spaced, radially extending planes, it is contemplated that the vanes 12 could be obliquely aligned to introduce a vortex flow to the impeller 13 circulating in the direction of impeller rotation to further reduce the flow velocity relative to the impeller blades.

Generally, as shown in FIG. 3, the impeller 13 is positioned within a correspondingly shaped, internal, annular cavity 34 formed in the casing 11 and includes a generally conical hub 40 mounted on the shaft 14 and having a concavely curved surface 41 for diverting the incoming flow generally radially relative to the axis of the drive shaft 14. The drive shaft 14 includes a concavely curved annular portion as at 42 located between the housing 20 and the impeller hub 40 so that generally a continuously curved flow boundary is provided which extends from the outer periphery of the housing 20 through the regions 23, 24 and 25, the shaft portion 42 and the curved portion 41 of the hub 40. A plurality of curved impeller blades 43, shown in transverse cross section in FIG. 2, are connected to the hub 40, and extend axially to connect with the interior wall of an annular suction shroud 44, in turn, positioned forwardly of the hub 40 and generally concentrically to the shaft 14. The blade-confronting surface

45 of the suction shroud 44 is convexly curved generally to conform to an extension of the curved portion 33 of the pump casing 11 also facilitating a diversion of the flow from the impeller 13 generally radially and transversely of the drive shaft axis. The impeller 13, therefore, has an annular suction inlet of reduced diameter compared to the diameter of the impeller 13 at its annular exhaust outlet extending about its lateral periphery.

An annular wearing or seal ring 46 extends longitudinally from the aft end of the hub 40 having a diameter equal to or slightly larger than the outer cylindrical periphery of the suction shroud 44 which mates coaxially with a stationary wearing ring 49. A pair of ring members 48 and 49 are connected to and recessed within the pump casing 11 in confrontation with the impeller wearing surfaces 46 and 47 in order to reduce the size of the annular spacings between the pump casing 11 and the ends of the impeller 13 to a desired tolerance and impede the feedback of flow of the high-energy fluid exhausted from the impeller 13. The pump casing 11 further includes a circular bulkhead 50 having an axially located annular flange 51 forming a seat for an annular bearing 52 within which the extended end of the drive shaft 14 is journaled for rotation.

In general, viewing the pump casing 11 from the aft end, the centrally located portion 60 of the casing 11 generally has a cuplike configuration whose innermost ends form the radially innermost sides of the duct work terminating in the discharge openings 16 and the slots 17. As shown in FIG. 4, the portion 60 of the casing 11 has a generally trapezoidal shape adjacent to the casing walls and opening 61 formed in each quadrant adjacent the impeller 13 through which flows the high-energy stream of fluid being exhausted from the impeller 13. The encircling, radially outermost portion 62 of the pump casing 11 is configured to form generally longitudinally extending ducts 63 communicating with the exhaust openings 16. As indicated in FIG. 4 the side of the duct 63 toward which impeller rotation occurs is formed by a generally L-shaped bulkhead 65 whose interior, transversely extending end 66 encompasses the passage bounded otherwise by the wall and opening 61. Curved turning vanes 67 are positioned at the bend in the L-shaped duct 63 for deflecting impeller exhaust flow from a generally transverse movement into a generally longitudinal movement toward the exhaust opening 16. An outlet vane 68 is positioned intermediate the curved turning vanes 67 and the opening 16 to reduce turbulence.

Steering control of the torpedo 10 is effected by radially oriented rotatable cylinders 70 mounted in the openings 16 having an aperture 71 extending transversely therethrough which has a rectangular configuration in cross section and has sides converging at the efflux end to accelerate the jet stream flow being exhausted therethrough. The cylinders 70 are connected by shafts 72 to conventional hydraulic actuators 73 which are mounted on the interior of the casing in the cavity between the bulkhead 50 and the shroud cup portion 60 and which may be controlled in a conventional manner to rotate the cylinders 70 and enable maneuvering of the torpedo 10. For example, unless a rolling movement were desired, the cylinders 70 oriented along the same line passing through the torpedo axis would be rotated in the same direction to cause deflection of the jet stream exhaust at an angle relative to the longitudinal axis of the torpedo 10, causing the torpedo 10 to turn.

The opposite longitudinal side 75 of the duct 63 terminates in a turning vane 76 which causes a diversion of a proportion of the impeller exhaust flow from the duct 64 terminating in the arcuately curved slot 17 and in which are arranged curved turning vanes 77. The flow section between the walls and opening 61 is sized, so the turning vanes 67, 76, and 77 are configured so that approximately 75 percent of the exhaust from the impeller 13 is diverted through the L-shaped steering ducts 63 and exhausted through the steering cylinders 70 with openings 16 and the remaining 25 percent of the flow is diverted by the vanes 76 and 77 and exhausted through the

arcuately extending ducts 64 terminating in the slots 17. The exact proportion is selected so that a sufficient flow from the slots 17 is established to prevent flow separation at the aft end 60 of the pump casing 11.

In operation, water is sucked in past the turbulence-reducing inlet vanes 12 and through the influx duct 26 by the impeller 13. The impeller 13 not only adds energy to the flow, increasing its rate, but also diverts the flow from a generally axially movement to a generally radial movement relative to the impeller axis and is again deflected generally longitudinally in spaced relation to the impeller axis through the ducts 63 and 64 by the turning vanes 67, 76, and 77. Thereby, the velocity of the flow relative to the impeller blades 43 and the casing 11 is reduced, and a reduction in radiated noise is effected.

The embodiment of the invention shown in the drawings was designed to conform to external size limitations with respect to both the major diameters of the vehicle and the overall length of the vehicle. The concavely curved portion 42 was adopted to provide an adequate inlet area to the impeller 13 and at the same time minimize all diameters at the inlet of the impeller 13 which is advantageous relative to cavitation and efficiency. If diameter limitations permit, other embodiments could be designed which would eliminate concavely curved portion 42 of shaft 14, and curved portion 41 of hub 40 would be extended to provide an equivalent smooth flow channel. The slots 17 are essential to the reduced length embodiment illustrated in order to avoid separation at the aft end of the pump casing 11. However, if the space were available to elongate the aft end of the pump casing 11 to present a streamlined conical tapered aft configuration, the slots 17 and the internal passages associated therewith could be eliminated.

Obviously many other modifications and variations of the present invention are possible in view of the above teaching. It is therefore to be understood that within the scope as the appended claims the invention may be practiced otherwise than as specifically described

We claim:

1. A propulsion system for a vehicle, comprising:

flow channelling means extending from fluid influx areas arranged adjacent the lateral periphery of the vehicle; mixed-flow-impeller means connected to the vehicle for driven rotation about an axis including an annular hub portion arranged to receive flow from said flow-channelling means and having a concavely curved exterior surface for diverting a flow generally radially of said impeller means, a plurality of blades extending from and being connected to said hub portion and being curved for exhausting a flow of increased energy generally transversely of said impeller axis, and an annular suction shroud having a convexly curved interior surface connected to said blades, said convex surface of said suction shroud coacting with said concave surface of said hub portion enabling a radial and axial flow through said impeller means;

said flow-channelling means comprising a first flow channel boundary surface carried by an impeller-confronting portion of the vehicle comprising a body of revolution about said impeller axis generated by a first curve having a convex portion adjacent said influx areas and extending through a concave portion adjacent said impeller means, the extension of said first boundary surface conforming to said concave surface of said hub portion, a propulsion pump casing connected to the vehicle about said impeller means having a second flow channel boundary surface confronting said first boundary surface comprising a body of revolution about said impeller axis generated by a second curve having a concave portion adjacent said influx areas and extending in diverging relation to said first curve through a convex portion adjacent said impeller means, the extension of said second boundary surface conforming to said convex surface of said suction shroud;

an impeller drive shaft connected to the vehicle for driven rotation and having said hub portion connected thereto, said shaft having a concavely curved annular surface positioned intermediate said hub portion and said first boundary surface conforming to the adjacent portion of the extension of said concave portion of said first boundary surface along said concave surface of said hub portion, said suction shroud being positioned in spaced, encircling relation to said annular surface of said shaft; and

ducting means formed in said pump casing arranged to receive said increased energy flow exhausted from said impeller means and configured for diverting and exhausting said flow to propel the vehicle.

2. A system according to claim 1 wherein said ducting further comprises:

a plurality of ducts communicating with said impeller means and terminating in a plurality of exhaust openings circularly arranged in spaced relation about an extension of said impeller axis.

3. A system according to claim 2 further comprising: a plurality of inflow vanes connected between said first and second boundary surfaces adjacent said influx area for reducing inflow turbulence and interconnecting said pump casing to the vehicle.

4. A system according to claim 3 further comprising: said drive shaft having an end extending through said hub portion of said impeller means; and said pump casing including a bulk head having an annular bearing and positioned on the exhaust side of said impeller means, said extended end of said shaft being journaled for rotation in said bearing.

5. A system according to claim 4 further comprising: a first annular wearing surface formed on the external periphery of said suction shroud;

a second annular wearing surface extending toward said bulkhead from said hub portion; and first and second wearing surfaces surrounded by stationary wearing rings in confronting relation to said first and said second wearing surfaces for impeding flow feedback.

6. A system according to claim 5 wherein said ducting means further comprises: another plurality of ducts communicating with said impeller means and terminating in arcuately extending slots interspersed between adjacent ones of said exhaust openings.

7. A propulsion system for a vehicle comprising: flow channeling means extending from fluid influx areas arranged adjacent the lateral periphery of the vehicle; mixed flow-impeller means connected to the vehicle for driven rotation about an axis and configured to divert a fluid flow received from said flow-channelling means and to exhaust a flow of increased energy generally radially and transversely of said axis;

a first plurality of ducts arranged to receive said increased energy flow exhausted from said impeller means and configured for diverting said flow terminating in primary exhaust openings for directing a flow to propel the vehicle

and being circularly arranged in spaced relation about an extension of said impeller axis; and

a second plurality of ducts arranged to receive said increased energy flow and configured for diversion thereof terminating in arcuately extending slots interspersed between adjacent ones of said primary exhaust openings for directing a flow to prevent separation at the aft end of the vehicle.

8. A system according to claim 7 further comprising: means connected to said steering cylinders for rotating said cylinders to steer the vehicle.

a plurality of jet stream steering cylinders rotatably mounted in said primary exhaust openings on axes extending through said extension of impeller axis and each having a transverse aperture extending therethrough having a rectangular configuration in cross section and converging sides terminating to form a jet stream exhaust outlet; and

9. A system according to claim 7 wherein said ducts of said first plurality each further comprise:

a duct having a bend formed therein intermediate its ends, having an influx end arranged to receive said transversely directed, increased energy flow from said impeller means and terminating in one of said primary exhaust openings;

a plurality of curved flow-detecting vanes arranged in spaced relation in said bend of said duct to deflect the oncoming flow from said impeller means toward said primary exhaust openings; and

efflux vane mounted in said duct intermediate said flow-deflecting vanes and said primary exhaust opening.

10. A system according to claim 9 further comprising: each of said second plurality of ducts communicating with said influx end of a respective one of said ducts of said first plurality adjacent said impeller means.

11. A system according to claim 10 further comprising: a plurality of turning vanes arranged in spaced relation in each duct of said second plurality for diverting a portion of the impinging increased energy flow from said impeller means to said arcuately extending slots.

12. A system according to claim 11 further comprising: a boundary wall of each of said ducts in said first plurality positioned adjacent said duct of said second plurality terminating in a curved, flow-diverting vane for diverting a first portion of the oncoming flow from said impeller means to said duct of said first plurality and a second portion to said duct of said second plurality.

13. A system according to claim 7 further comprising: a pump casing connected to the vehicle and encircling said impeller means;

said pump casing including a convex portion longitudinally aligned with an extension of said impeller axis and having a plurality of apertures permitting exhausting of said increased energy flow from said impeller means; and

said pump casing including an encircling portion forming with said convex casing portion said first and second pluralities of ducts terminating in said openings and said slots.

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