

Nov. 4, 1969

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3,476,072

WATERCRAFT PROPULSION

Filed March 15, 1968

2 Sheets-Sheet 1

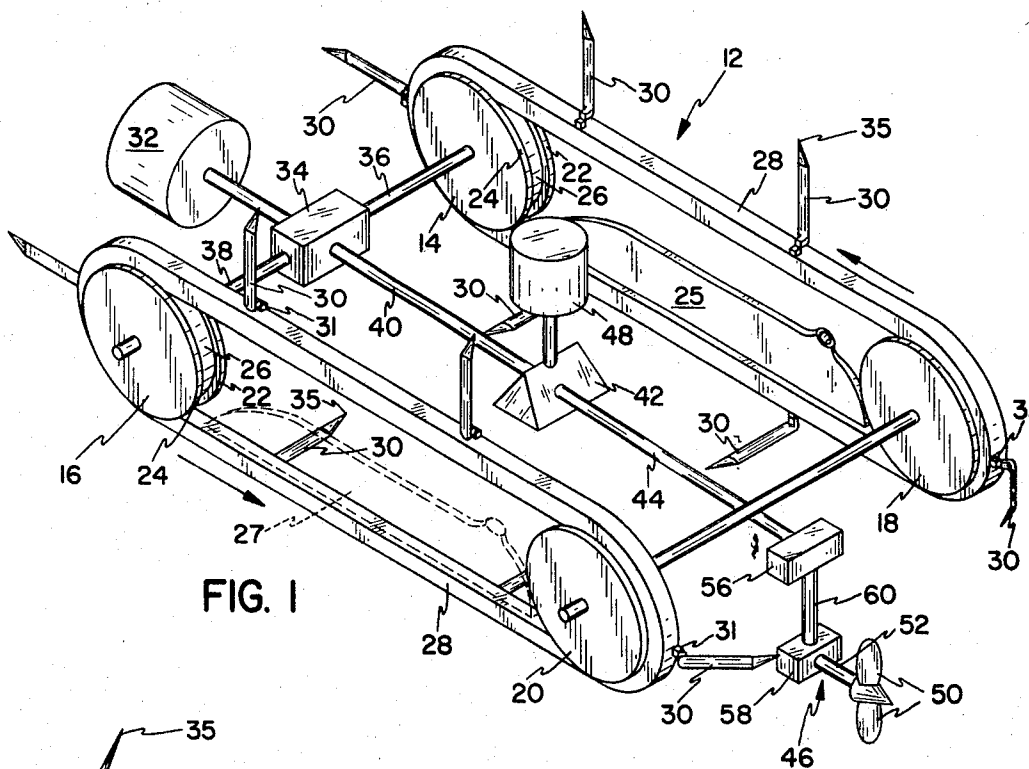


FIG. 1

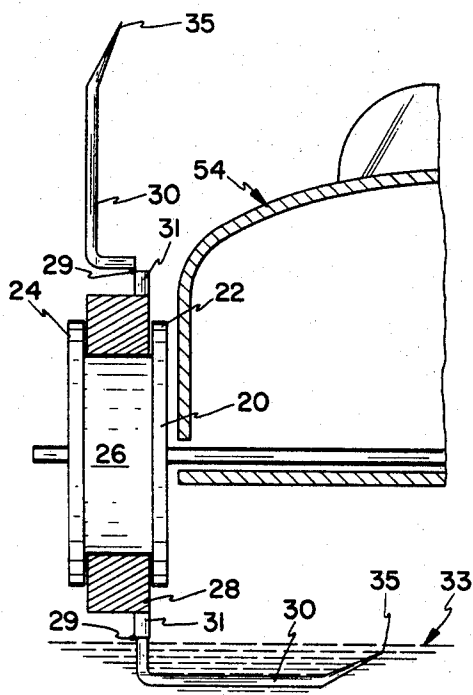


FIG. 2

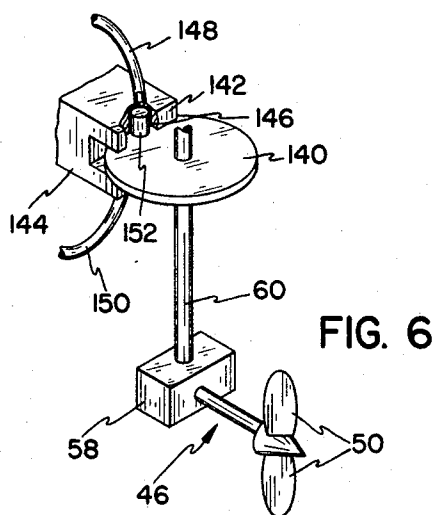


FIG. 6

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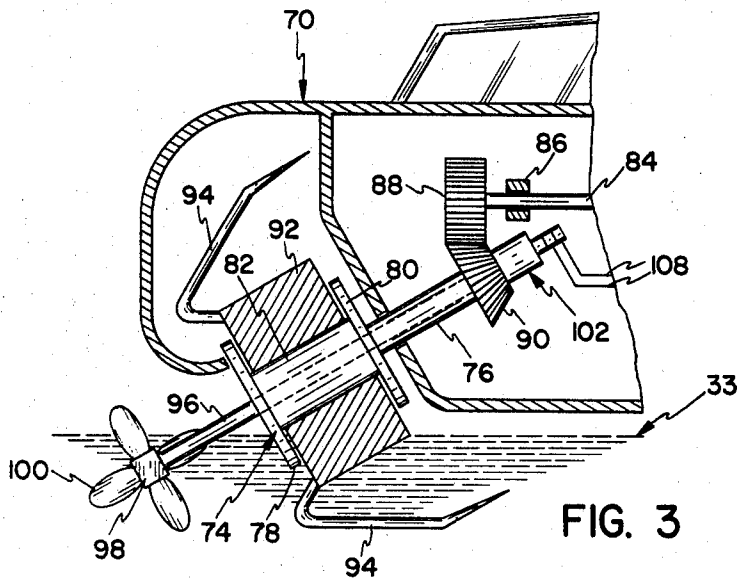


FIG. 3

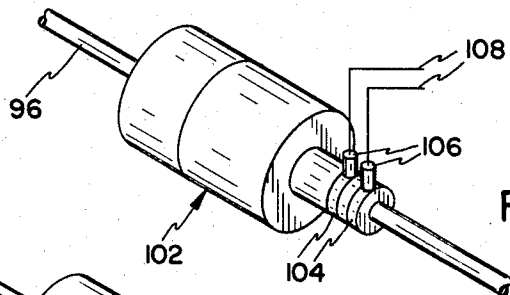


FIG. 4

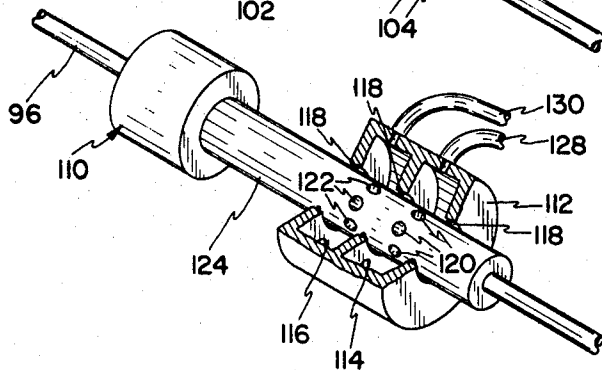


FIG. 5

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WATERCRAFT PROPULSION

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Continuation-in-part of application Ser. No. 518,970,
Dec. 30, 1965. This application Mar. 15, 1968, Ser.
No. 713,396

Int. Cl. B63b 5/00, 1/34, 1/24

U.S. Cl. 115—63

7 Claims

ABSTRACT OF THE DISCLOSURE

A hydrofoil propelled watercraft which presents drag structure to selectively increase the drag force on the watercraft at the low velocities to (a) develop an upward force acting upon the watercraft and causing the watercraft to be lifted upon hydrofoils at relatively low velocities and (b) provide a system for recovering a portion of the surplus energy expended at low velocities and directing the energy into the drive line to increase the efficiency of the power source or to auxiliary appliances. The hydrofoil blades are adapted to engage the water exclusively below and inside the outer periphery of the watercraft so that the outer limits of the reach of the hydrofoil blades is known.

The invention relates to improvements in hydrofoil watercraft vehicles and is a continuation-in-part of my copending patent application Ser. No. 518,970, filed Dec. 30, 1965, now U.S. Patent No. 3,403,654 and the entire specification of said copending patent application is incorporated herein.

It has been found that hydrofoil watercraft will be lifted out of the water upon the hydrofoil blades during displacement only when a sufficient drag force is exerted so as to generate an upwardly directed lift force. At low to moderate velocities, air resistance is not sufficient drag to develop a lift force powerful enough to maintain the watercraft out of the water. The present invention provides a system for selectively generating artificial drag to develop the needed lift force to maintain the watercraft upon novel hydrofoil blades and at the same time serve as a supplemental source of energy at low to moderate velocities.

Devices which generate supplemental energy are known in the art, for example, see U.S. Patent 1,831,835. The known devices are designed to present as little resistance as possible to the normal forward movement of the vehicle to which they are attached.

It is a primary object of the invention to provide an auxiliary system for a watercraft hydrofoil vehicle to develop a drag force and at the same time provide a supplemental source of energy.

It is another important object of the invention to provide a novel hydrofoil blade arrangement to increase the efficiency and ease of handling of the watercraft.

Another important object of the invention is to provide a more efficient, safe watercraft vehicle.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagrammatic representation of one presently preferred embodiment of the hydrofoil blade drive system and drag unit;

FIGURE 2 is a schematic fragmentary illustration of a watercraft vehicle comprising the drive system embodiment of FIGURE 1 shown in partial cross section;

FIGURE 3 schematically shown another presently preferred embodiment of the drive system and drag unit;

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FIGURES 4 and 5 schematically illustrate two presently preferred embodiments of the generating system for converting the rotation of the drag unit to useful energy; and

FIGURE 6 is a schematic fragmentary perspective of presently preferred structure for controlling the amount of drag force developed by the drag unit.

With reference to FIGURES 1 and 2, the drive system, generally designated 12, comprises drive wheels 14 and 16 and idler wheels 18 and 20. The wheels are substantially identical and each wheel is provided with radially-extending peripheral flanges 22 and 24 which define a recessed, central groove 26 therebetween. The groove 26 is adapted to receive a portion of an endless driving track 28. The driving track 28 is preferably formed of somewhat yieldable material and is provided with a plurality of base members 31, integrally attached to the track at spaced locations 8 along the outer periphery. (See especially FIGURE 2.)

An air plenum 25 or 27 (FIGURE 1) is optionally located immediately above the lower inside portion of each track 28. Air forced through each air plenum 25 and 27 from a forced air system (not shown) will exert a downward force upon the adjacent track 28 which helps to prevent deformation of the part of the track spanning between the lower parts of the wheels 14 and 18, and 16 and 20. Thus, the track 28 will remain essentially linear even when there is considerable weight in the watercraft.

Each blade 30 is attached to the adjacent base member 31 by a laterally movable hinge 29 (see FIGURE 2). The hinge 29 is located on the outward edge of the base 31 and blade 30 so that each blade 30 may open vertically in response to centrifugal force when not opposed by a water-caused force and readily close to the illustrated horizontal position when a given blade engages the water 33. When a blade 30 is in the water 33 the tip 35 is directed inwardly. Significantly, the inward disposition of the hydrofoil blades 30 makes it possible for the operator of the hydrofoil craft to position the craft close to a dock or the like without causing damage to the hydrofoil blades or the dock.

The drive wheels 14 and 16 are powered by energy originating at a power source or motor 32 which is transmitted through a differential mechanism 34 and delivered to the respective drive wheels 14 and 16 through axles 36 and 28. The differential 34 is also connected by a drive shaft 40 and a differential 42 to an auxiliary shaft 44 comprising part of a drag unit 46. An auxiliary motor 48, preferably adapted to provide an essentially constant speed input, is also connected into the differential 42.

The drag unit 46 also comprises a pair of oppositely disposed impeller blades 50 which, desirably, have a selectively variable pitch (not shown). The drag unit 46 is maintained substantially below the lower-most portion of the buoyant watercraft structure 54 (FIGURE 2) and is mechanically connected to the shaft 44 through gearboxes 56 and 58 and connecting shaft 60.

If desired, the amount of drag produced by the auxiliary drag unit 46 may be controlled by the structure illustrated in FIGURE 6. More specifically, the connecting shaft 60 is joined integrally with a braking disk 140. The peripheral edge of the braking disk 140 is displaced between jaws 142 and 144, each of which contains a blind bore 146 which is in fluid communication with hydraulic lines 148 and 150. A cylinder 152 with a reciprocable piston (not shown) is situated within each blind bore 146. Each piston is adapted to move in response to pressure from the hydraulic lines 148 and 150 to exert a controlled amount of braking force against disk 140.

Therefore, when increased pressure is developed in the hydraulic lines and 148 and 150, such as by application of a conventional brake pedal (not shown), each pis-

ton 152 will be forced against the braking disk 140 and inhibit rotation of the drag unit 46 proportional to the force exerted. Normally the brake would be applied initially as the watercraft begins its forward movement in order that the increased drag forces would cause the watercraft to be lifted upon the hydrofoil blades at the earliest possible point in time. The brake would then be gradually released as air resistance to the forward movement of the hydrofoil craft makes maximum drag through the unit 46 unnecessary.

Reference is now made to FIGURE 3 which schematically illustrates another presently preferred embodiment of the invention. More specifically, another configuration of buoyant watercraft structure, generally designated 79, is adapted to carry a driving mechanism positioned in angular relation with respect to the vertical.

The driving mechanism comprises a driving wheel 74 which is joined to a drive shaft 76. The driving wheel 74 is provided with peripheral flanges 78 and 80 which define a recess or groove 82 therebetween in the circumference of the wheel 74. The drive shaft 76 is driven by energy from a power source (not shown) through a primary shaft 84, supported by suitable bearing structure 86, and through drive gears 88 and 90. An endless flexible track 92 is disposed upon the wheel 74 within the groove 82, the track 92 being substantially the same as track 28 illustrated in FIGURES 1 and 2. Track 92 carries a plurality of spaced, rigidly attached hydrofoil blade 94 which are directed toward the structure 70 and pass through the water 33 horizontally when in the lowermost position.

An auxiliary shaft 96 is disposed coaxially with the drive shaft 76 and is attached through a gear arrangement 98 to a multi-blade screw impeller 100. The remote end of the shaft 96 is attached to an armature (not shown) in an auxiliary motor 102.

The auxiliary motor 102, best shown in FIGURE 4, is a conventional electrical motor provided with a split ring assembly 104 and associated brushes 106. Electrical wires 108 may be connected to any suitable appliance or power storage device.

Alternatively, the motor may be a vane-driven hydraulic motor 110 (FIGURE 5) of any suitable conventional type. In the illustrated embodiment, the motor 110 is coupled to a fluid conducting shaft 124 which carries an outer jacket 112. The jacket forms two essentially independent chambers 114 and 116 sealed from the exterior and from each other by seals 118. Chambers 114 and 116 are respectively in independent communication with apertures 120 and 122, each series of apertures being in exclusive communication with an independent channel extending longitudinally through the shaft 124 to the conventional vane-driven hydraulic motor 110. Each chamber 114 and 116 is connected by hydraulic lines 128 and 130 to a hydraulic generator or the like.

In the operation of the present invention, each track 28 (FIGURE 1) is rotated by the prime mover 32 through the drive wheels 14 and 16. The hydrofoil blades 30, hingedly attached to the base members 31 move horizontally through the water with the tracks to lift and propel the watercraft. When a hydrofoil blade approaches the upper portion of the idler wheels 18 and 20, centrifugal force causes the blade 30 to open outwardly against the hinge 29 and remain in extended position (see FIGURE 2) until again forced horizontal by contact with the water surface.

The horizontal, inwardly directed position of the hydrofoil blades 30 as they are forced through the water makes it possible for the watercraft to be propelled and at the same time prevent lateral extension of the hydrofoil blades beyond the outer periphery of the watercraft.

Initially, the drag unit 46 will restrain the watercraft vehicle opposite to the force exerted upon the vehicle by the hydrofoil blades and generate an upwardly-directed force which will urge the watercraft upward out of the water. The amount of drag exerted by the unit 46 will be

proportional to the pitch of the impeller blades 50. The forces acting upon the impellers 50 will cause the impeller blades 50 and the shaft 52 to rotate. At relatively low forward speeds, part of the energy resulting from the rotation of the shaft 52 may be converted to usable energy.

For example, with reference to FIGURE 1, the rotation in shaft 52 is transferred through shaft 44 to the differential mechanism 42. The drive shaft 40 has a velocity greater than the velocity of the shaft 44 because, due to the slip of the hydrofoils 30 through the water, the drive wheels 14 and 16 are rotating faster than the forward velocity of the watercraft driving mechanism 12. The difference velocity, termed the slip velocity, is compensated in the differential 42 by the motor 48. Thus, the input velocity from the shaft 44 is caused to match the velocity of the shaft 40 and the energy generated by the drag unit 46 may be channeled into the drive system to increase the efficiency of the drive system.

Similarly, with respect to FIGURE 3 the motors 102 or 110 may operate to provide an output rotational velocity in the shaft 96 to compensate for the slip velocity exhibited by the shaft 76. Thus, the motors 102 or 110 may perform the same function as the motor 48 in FIGURE 1.

Alternately, with respect to FIGURE 3, the motion of the impeller 100 causes rotation of the shaft 96 which turns the armature (not shown) in the motor 102 so that electrical energy may be conducted through wires 108 to a storage device or auxiliary appliance. Alternatively, the motion of the impeller 100 may be used to pump fluid through the shaft 96 where it is pumped by the motor 110 through the apertures 120 to develop an increase pressure in the chamber 114. The pressure is transported through tube 128 to a hydraulic generator or the like and thereafter returned through the hydraulic tube 130, the chamber 116, and apertures 122.

It is apparent from the foregoing that I have invented a new and useful improvement in hydrofoil watercraft which accommodates a greater degree of safety and economy in the operation of the vehicle. Moreover, the drag device importantly serves the dual purpose of developing sufficient drag to lift the hydrofoil vehicle out of the water and at the same time accommodates partial recovery of wasted energy to be used with auxiliary devices or to increase the efficiency of the drive system.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. In a hydrofoil watercraft comprising a buoyant structure and at least one attached movable track presenting a plurality of hydrofoil blades and power means to drive the track and blades through the water, the improvement comprising: (a) drag means with means for selectively resisting the forward movement of the watercraft caused by the rearward displacement of the blades, the resisting means comprising structure for exerting maximum resistance only when the buoyant structure is in the water whereby a lift force is developed which initially elevates the structure out of the water, and for exerting resistance which incrementally decreases with the speed of the watercraft when the structure is out of the water, the drag means further comprising means which rotate in response to movement through the water, and (b) means associated with the drag means and responsive to the motion of the drag means to develop usable auxiliary energy.

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2. In a hydrofoil watercraft as defined in claim 1 wherein the drag means develops a drag force which is dependent upon the rate of rotation of the rotating means and further comprising brake means operative against the drag means to selectively limit the rate of rotation of the rotating means.

3. In a watercraft as defined in claim 1 wherein said drag means comprises an output rotating shaft and wherein the associated means is a differential mechanism and associated motor, actuated by the output shaft, which cooperate to divert energy from the movement of the drag means for conversion to useful energy.

4. In a watercraft as defined in claim 1 wherein said associated means further comprises means remotely connected to the drag means to develop electrical energy from the motion of the rotating means for storage or for operation of auxiliary appliances.

5. In a watercraft as defined in claim 1 wherein the last mentioned means further comprises means to develop hydraulic energy from the motion of the rotating means.

6. In a hydrofoil watercraft comprising a buoyant hull and attached driving track, the track carrying a plurality of elongated hydrofoil blades mounted at one end upon the track and extending exclusively downwardly and inwardly relative to the watercraft when engaged with supporting water and terminating in a free end and moved

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by a power source also carried by the buoyant hull, so that the plurality of hydrofoil blades carried by the endless track engage the water at a location below and inside the peripheral edges of the remainder of the watercraft, the blades being automatically positioned, when removed from the water, so as to pass adjacent to but not over the buoyant hull.

7. In a watercraft as defined in claim 6 further comprising selectively adjustable drag impeller structure adapted to engage the water and develop a drag force of predetermined magnitude, the impeller structure being adapted to rotate by relative displacement of the water and the impeller structure, and structure for converting the rotation of the drag impeller to usable energy.

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ANDREW H. FARRELL, Primary Examiner

U.S. Cl. X.R.

114—66.5