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Strickland

[11] **3,795,213**

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[54] **DIVER OPERATED PROPULSION SYSTEM FOR AN UNDERWATER VEHICLE**

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[21] Appl. No.: **185,642**

[52] **U.S. Cl.** ..... **114/16 A**

[51] **Int. Cl.** **B63g 8/00**

[58] **Field of Search** .. 114/16 A, 16 R; 60/53 A, 51, 60/52 US; 61/69 R; 74/471 XY; 200/6 A; 244/83 E

[56] **References Cited**

UNITED STATES PATENTS

3,260,826	7/1966	Johnson	244/83 E
3,434,443	3/1969	Estabrook	114/16 R
3,293,381	12/1966	Eitel	200/6 A
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2,510,632	6/1950	Hemphill	60/52 US

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[57] **ABSTRACT**

A diver operated propulsion system for an underwater vehicle including: two pair of reversible thrusters, one pair of thrusters being mounted on the vehicle starboard and port for forward and reverse horizontal thrust and the other pair of thrusters being mounted on the vehicle forward and aft for up and down vertical thrust; a pair of elongated handle bar type of handgrips which are mounted on the vehicle port and starboard with their longitudinal axes aligned athwart the vehicle for rotation about their longitudinal axes, and pivotal up and down movements in a vertical plane; and actuators interconnecting the handgrips and the thrusters for actuating the port and starboard thrusters forward and reverse when the grips are rotated in opposite directions respectively, and actuating the forward and aft thrusters up and down when the grips are pivoted up and down respectively. With such an arrangement, a diver can utilize instinctive hand movements to maneuver the underwater vehicle forward, backward, up, down, and about vertical and pitch axes by simply selectively operating the pair of handgrips.

5 Claims, 7 Drawing Figures

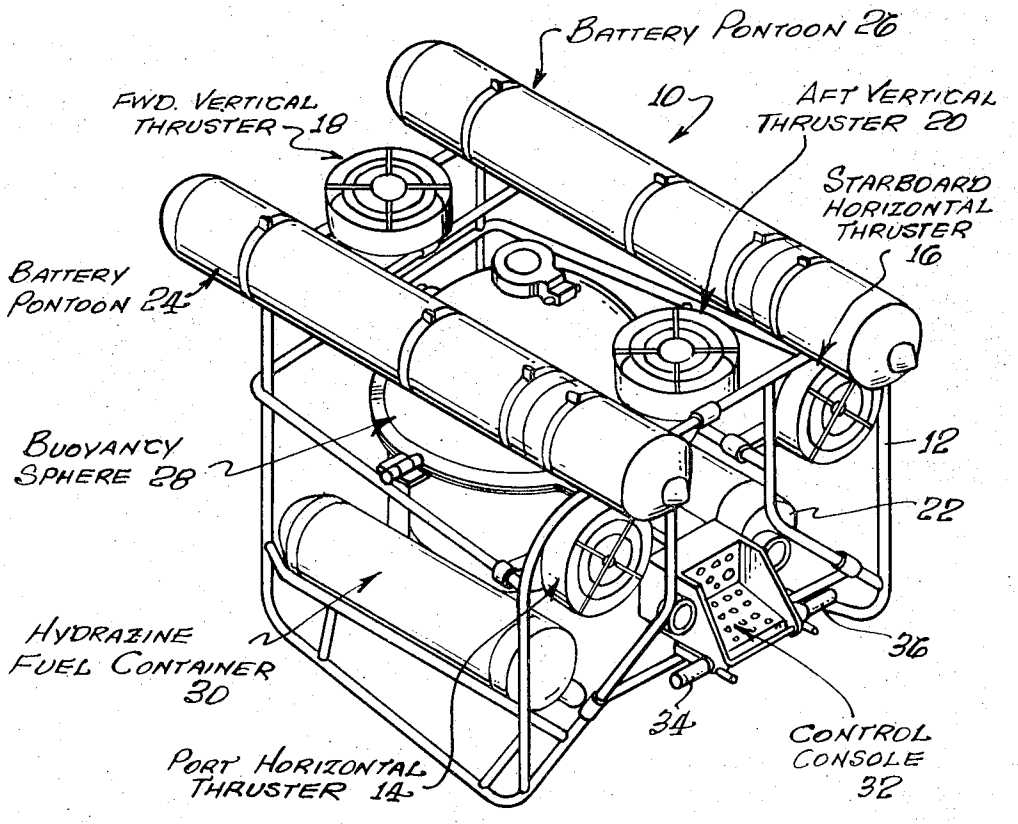
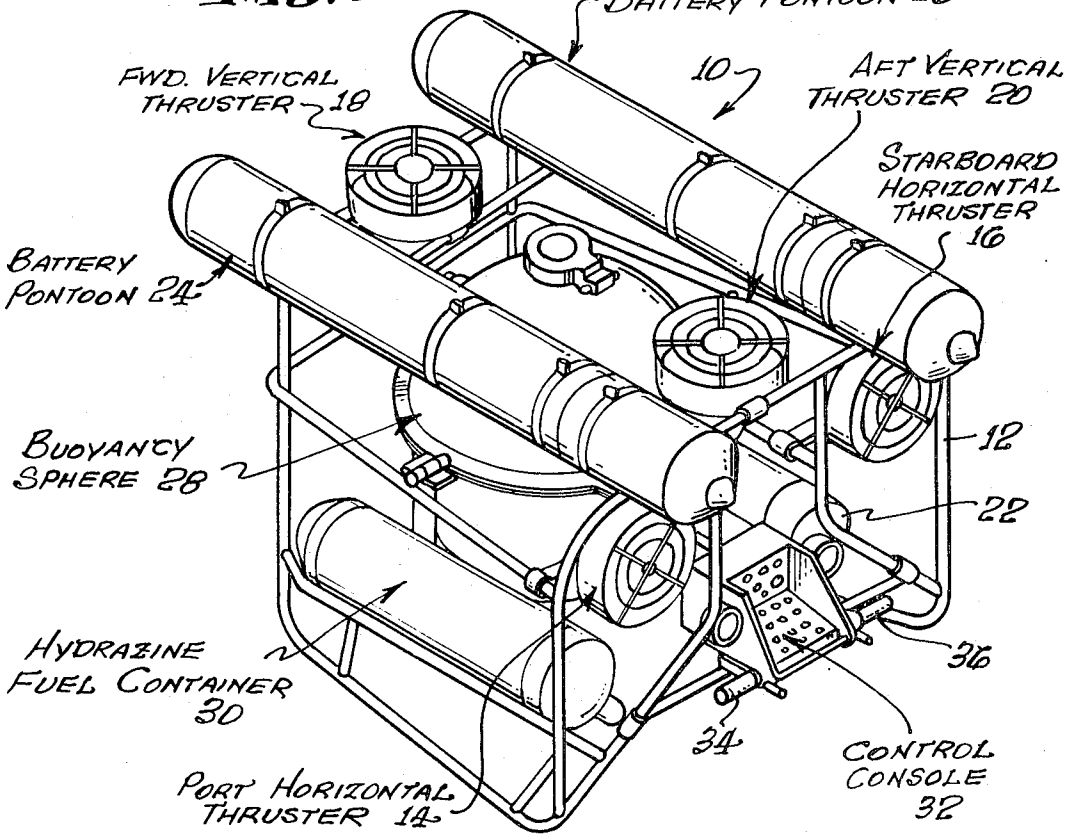


FIG. 1.



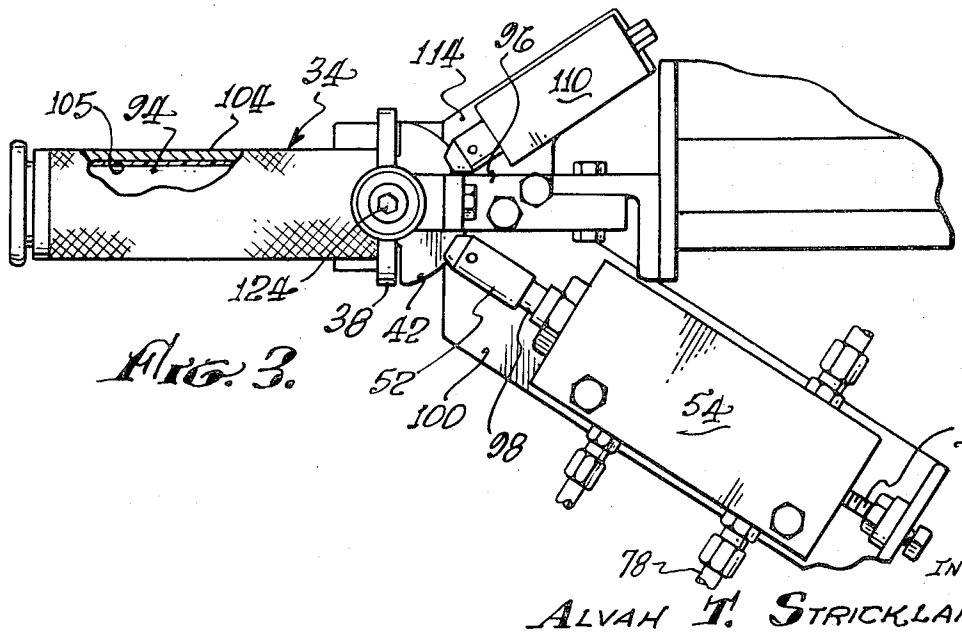


FIG. 3.

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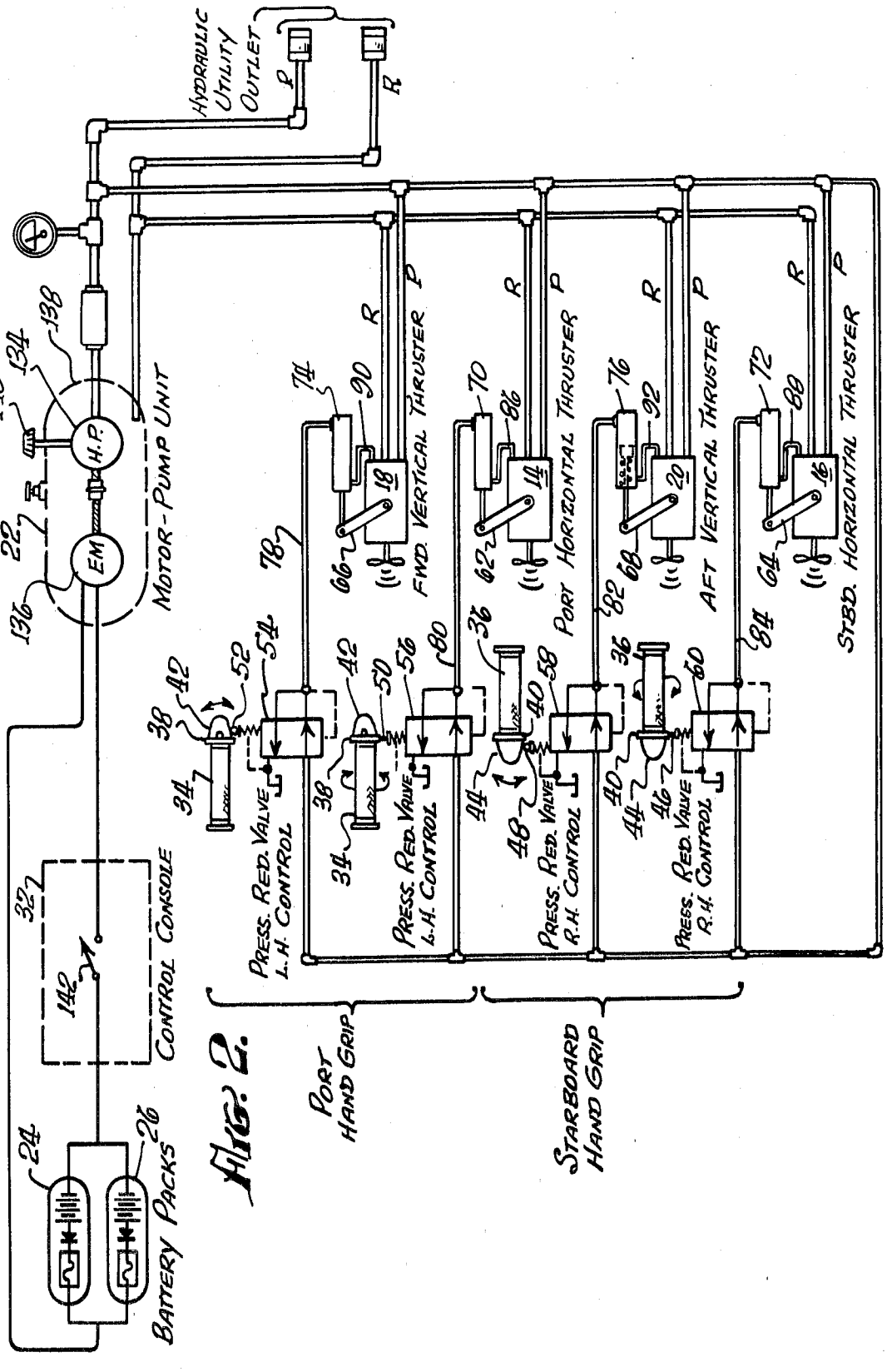

HYDRAULIC UTILITY OUTLET
P
R
MOTOR-PUMP UNIT
H.P.
EM
CONTROL CONSOLE
BATTERY PACKS
PRESS. RED. VALVE L.H. CONTROL
PRESS. RED. VALVE L.H. CONTROL
PRESS. RED. VALVE R.H. CONTROL
PRESS. RED. VALVE R.H. CONTROL
FWD. VERTICAL THRUSTER
PORT HORIZONTAL THRUSTER
AFT VERTICAL THRUSTER
STBD. HORIZONTAL THRUSTER
PORT HAND GRIP
STARBOARD HAND GRIP

FIG. 2.

FIG. 4.

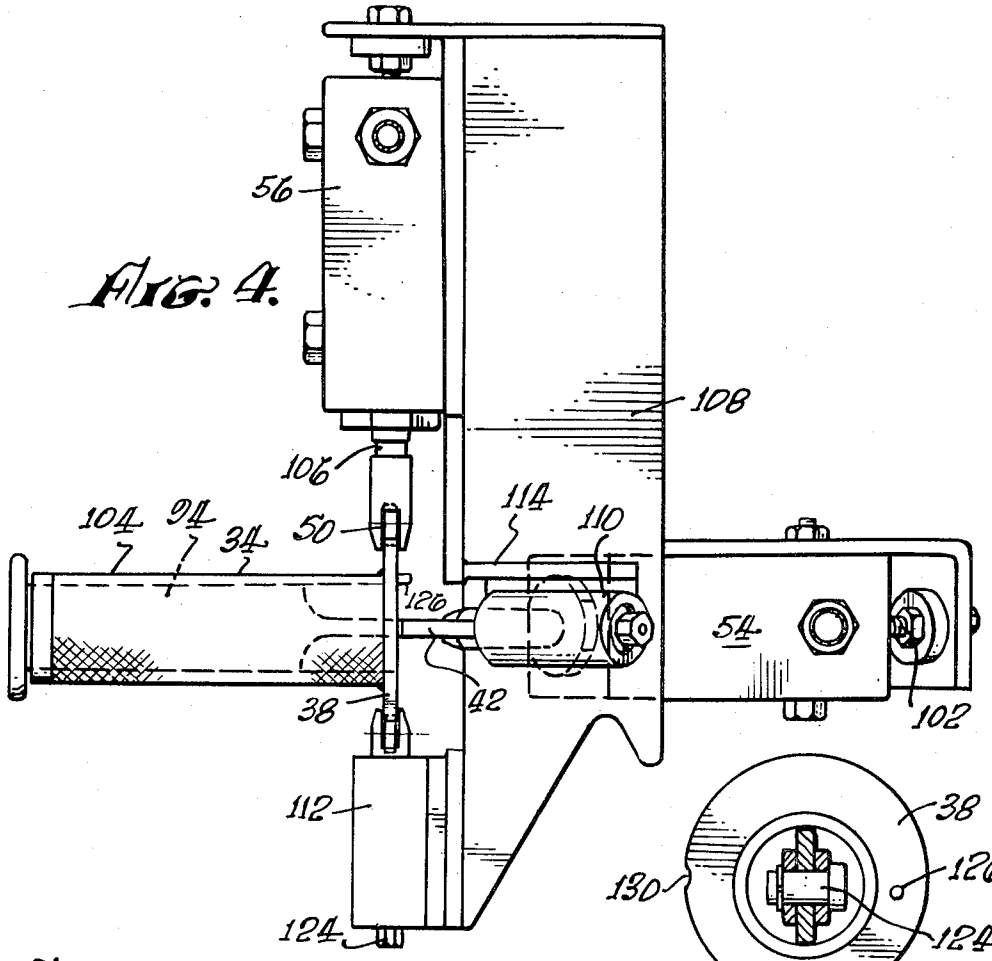


FIG. 6.

FIG. 5.

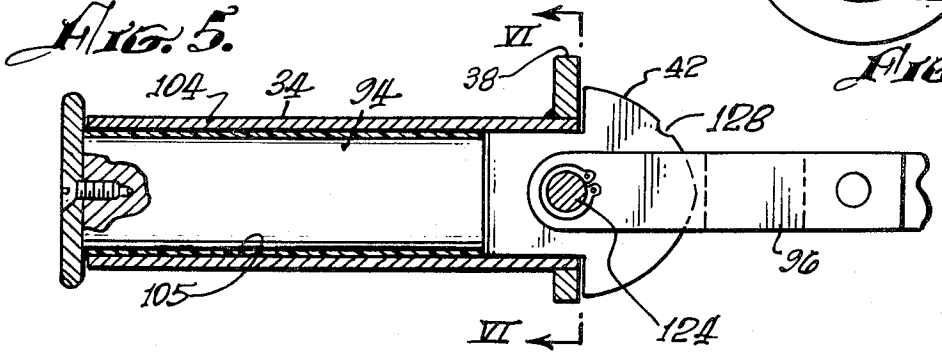
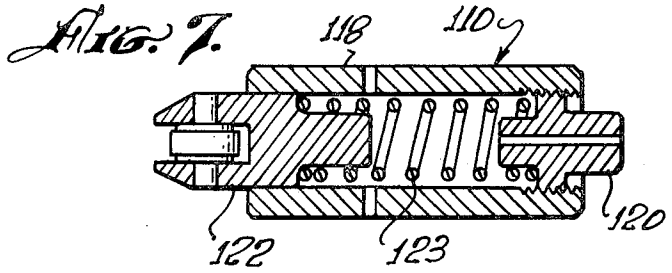


FIG. 7.



DIVER OPERATED PROPULSION SYSTEM FOR AN UNDERWATER VEHICLE

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

A science has developed in calculating the work capabilities of divers at various ocean depths. Before a diver enters the water, a study is usually made whether it is feasible for a diver to perform the required work at the depth involved. In some instances, the required work entails repositioning an object from one bottom location to another location on the ocean floor or retrieving the object to the ocean surface. When the object becomes too heavy for the diver, lift lines must be attached from a surface craft so as to carry out the desired operation. In repositioning an object, this latter method is not entirely satisfactory because it is extremely difficult to place the object at the new desired location. In order to overcome this problem, an underwater work vehicle or "underwater forklift" termed the "buoyancy transport vehicle" was devised by Estabrook and is set forth in his U.S. Pat. No. 3,434,443. This vehicle is operated by a diver and has a pair of motorcycle like handgrips which are manipulated to cause the vehicle to go in desired directions.

SUMMARY OF THE INVENTION

The present invention provides a unique combination of handgrips, thrusters, and interconnecting actuating means for enabling a diver to utilize instinctive hand movements to maneuver an underwater vehicle forward, backward, up, down, and about vertical and pitch axes by simply selectively operating the pair of handgrips. This has been accomplished by providing two pair of reversible thrusters, one pair of thrusters being mounted on the vehicle starboard and port for forward and reverse horizontal thrust and the other pair of thrusters being mounted on the vehicle forward and aft for up and down vertical thrust; a pair of elongated handle bar type of handgrips; means mounting the pair of handgrips on the vehicle port and starboard with their longitudinal axes aligned athwart the vehicle for rotation about their longitudinal axes, and pivotal up and down movements in a vertical plane; and means interconnecting the handgrips mounting means and the thrusters for actuating the port and starboard thrusters forward and reverse when the grips are rotated in opposite directions respectively, and actuating the forward and aft thrusters up and down when the grips are pivoted up and down respectively. Other aspects of the invention will be set forth in detail hereinbelow in the description of the preferred embodiment.

STATEMENT OF THE OBJECTS OF INVENTION

An object of the present invention is to provide a diver controlled propulsion system for an underwater vehicle which will enable the diver to utilize instinctive hand movements to maneuver the vehicle in desired directions.

Another object is to provide a diver controlled propulsion system for an underwater vehicle which is operable by instinctive hand movements of the diver, reliable in operation, and easy to manufacture.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric illustration of the buoyancy transport vehicle with the hand control system shown at the aft end thereof;

FIG. 2 is a schematic illustration of the hand control system and the thrusters for propelling the buoyancy transport vehicle;

FIG. 3 is a rear view (with respect to the buoyancy transport vehicle) of the port handgrip of the control system;

FIG. 4 is a top view of the port handgrip of the control system;

FIG. 5 is a rear view of the port handgrip, like FIG. 3 with portions of the assembly removed to illustrate various details;

FIG. 6 is a view taken along VI—VI of FIG. 5; and

FIG. 7 is a cross-sectional illustration of a return cam follower assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown in FIG. 1 the buoyancy transport vehicle **10** which is similar to the vehicle described in U. S. Pat. No. 3,434,443. The vehicle includes a frame **12** upon which there are mounted port and starboard horizontal thrusters **14** and **16**, a forward vertical thruster **18**, and an aft thruster **20**. The thrusters may be powered by an electro-hydraulic motor-pump unit **22** which, in turn, receives electric power for its motor from batteries housed within port and starboard battery pontoons **24** and **26**. The buoyancy of the vehicle **10** may be controlled by a buoyancy sphere **28** which is selectively ballasted by gas generated from the decomposition of liquid hydrazine which is stored within a hydrazine fuel container **30**. At the aft end of the vehicle, and in a convenient location for operation by a diver, is located a control console **32** upon which there are mounted port and starboard handgrips **34** and **36** for selectively and independently actuating each of the thrusters in an on, off, or reverse mode. Each handgrip is mounted on the vehicle for pivotal up and down swinging movement and rotation about its longitudinal axis.

As illustrated in FIG. 2, each handgrip **34** and **36** respectively has a horizontal thruster cam **38** and **40** respectively in a vertical plane which is perpendicular to the longitudinal axis of the handgrip and is operable by rotation of the handgrip, and a vertical thruster cam **42** and **44** respectively lying in a vertical plane which includes the longitudinal axis of the handgrip and is operable by swinging movement of the grip. The starboard handgrip **36** is capable, through its cam **40**, to operate on a cam follower **46** to actuate the starboard horizontal thruster **16** in an on, off, or reverse mode by selectively rotating the handgrip, and, through its cam **44**, to operate on a cam follower **48** to actuate the aft vertical

thruster 20 in an on, off, or reverse mode by selectively swinging this handgrip. The port handgrip 34 is capable, through its cam 38, to operate on a cam follower 50 to actuate the port horizontal thruster 14 in an on, off, or reverse mode by selectively rotating the handgrip, and, through its cam 42, to operate on a cam follower 52 to actuate the forward vertical thruster 18 in an on, off, or reverse mode by selectively swinging the handgrip. It should be understood that the vertical thruster cams 42 and 44 of the handgrips 34 and 36 could be altered in their operation to operate the aft vertical thruster 20 and forward vertical thruster 18 respectively in their various modes rather than the aforementioned description of the preferred embodiment without departing from the scope of the invention. It should be noted that the arrangement described in this paragraph enables a diver to operate the underwater vehicle 10 by natural instinctive movements of the pair of handgrips 34 and 36.

The horizontal and vertical thruster cams 38, 40, 42, and 44 may operate on pressure reducing piston and rod hydraulic cylinder valves 54, 56, 58, and 60 which, in turn, control pressurized hydraulic fluid for operating the thrusters 18, 14, 20, and 16 in the on, off, and reverse modes. The pressure reducing valves may be of a standard type, such as are obtainable from Fluid Controls, Inc. under Type 1 PD13. The thrusters may be provided with lever arms 62, 64, 66, and 68 which are moved by spring return piston and rod hydraulic cylinder actuators 70, 72, 74, and 76 respectively, the cylinder actuators being trunnion mounted to the thrusters. The pressure reducing valves 54, 56, 58, and 60 each have a regulated output pressure line 78, 80, 82, and 84 respectively which developes a high pressure, or middle pressure, or no pressure to the spring return hydraulic cylinders. The spring return hydraulic cylinders 70, 72, 74, and 76 have fluid return lines 86, 88, 90, and 92 which dump fluid into the thruster casings. From these casings, the hydraulic fluid may be returned into the main hydraulic system which is illustrated in FIG. 2.

An upward movement of the port handgrip 34 causes the vertical thruster cam 42 to depress the cam follower 52 and the plunger of the pressure reducing valve 54. This results in an increase in regulated outlet pressure on the line 78 in proportion to the upward movement of the handle. This pressure acts on the spring return hydraulic cylinder 74 to push the motor control lever 66 on the forward vertical thruster 18 to the left position as illustrated in FIG. 2. In this position, the thruster 18 provides a downward thrust which causes the vehicle to move upward, Downward movement of the handgrip 34 results in a low or no pressure on the line 78 which causes the lever 66 to assume a right position (not shown) which results in an upward directed thrusting causing a downward motion of the vehicle. When the handgrip 34 is in a neutral position, an intermediate pressure on line 78 causes the handle 66 to assume a middle position which results in an off condition of the thruster 18.

When the handgrip 34 is rotated counterclockwise (when viewed from its port end), the horizontal thruster cam 38 depresses the cam follower 50 and the plunger of valve 56 to deliver a high pressure to the regulated pressure line 80 so as to cause the control arm 62 of thruster 14 to assume a left position as illustrated in FIG. 2. This results in a rotation of the propeller of thruster 14 to move the vehicle in a reverse direction. When the handgrip 34 is rotated in a clockwise direction, a low or no pressure is present delivered to the regulated pressure line 80 causing the lever arm 64 to assume a right position (not shown) which causes the port horizontal thruster 14 to move the vehicle in a forward direction. When the handgrip 34 is in a neutral rotated position, an intermediate pressure exists on line 80 causing the lever 62 to assume a middle position and the port horizontal thruster 14 to be in an off no rotation condition. It should still be understood that this is a description of a preferred embodiment and the movements of the vehicle can be reverse from that described above by utilizing opposite handed props on the thrusters or by interchanging the pressure and return ports on the thrusters. The operation of the handgrip 36 in relationship to the thrusters 20 and 16 is similar to that as described for the handgrip 34.

The port handgrip 34 is illustrated in more detail in FIGS. 3, 4, and 5. The starboard handgrip 36 will not be described in detail since it is similar to handgrip 34. The handgrip 34 may include a cylinder 94 which is pivoted to the vehicle console 32 by a bracket 96. The vertical thruster cam 42 is connected to the end of this cylinder so as to be in operational engagement with the cam follower 52. The cam follower 52 is, in turn, connected to the aforementioned plunger 98 of the pressure reducing valve 54. This valve 54 may be mounted to the vehicle console 32 by a bracket 100, and at the end of this bracket, there may be a screw adjustment 102 for adjusting the output pressure of the valve over the regulated pressure line 78. The port handgrip also includes a tube 104 which is slidably mounted about the cylinder 94 for rotation thereabout. A teflon sleeve 105 between the tube 104 and the cylinder 94 affords smooth rotation of the tube 104 about the cylinder 94. The horizontal thruster cam 38 is connected about the starboard end of the tube 104 so as to be in operational engagement with the horizontal thruster cam 50 (see FIG. 4). This cam is, in turn, connected to the plunger 106 of the pressure reducing valve 56. This pressure reducing valve may be connected to the vehicle console 32 by a bracket 108.

It is desirable that both cams of the handgrip 34 return to a neutral position when the diver releases his hand therefrom. In regard to the vertical thruster cam 42, this return to the neutral position may be accomplished by a return cam follower assembly 110, and in regard to the horizontal thruster cam 38, the return to the neutral position may be accomplished by a return cam follower assembly 112. The return cam follower assemblies 110 and 112 may be mounted to the vehicle console 32 by the bracket 108. In the preferred embodiment, the centerline axis of the plunger of the return cam follower assembly 110 is located about 75° from the axis of the plunger 98 of the cam follower 52, and the centerline axis of the return cam follower assembly 112 is located about 180° from the axis of the plunger 106 of the cam follower 50.

The return cam follower assembly 110 is illustrated in detail in FIG. 7. This assembly may include a cylinder 118 with an adjustable stop 120 at one end and a cam plunger 122 located slidably within the other end. Between the stop 120 and the cam plunger 122, there is disposed a compression spring 123 which is of sufficient strength to overcome the bias force of the cam follower 52 so as to return the pressure reducing valve 54 to a neutral position when the diver releases his

hand from the handgrip **34.** All of the other return cam follower assemblies may be identical to the return cam follower assembly **110** described hereinabove.

As illustrated in FIGS. **3** and **5,** the vertical thruster cam **42** may extend substantially 150° about the pivotal axis **124** of the cylinder **94** so that substantially 75° of the camming surface is engageable with the cam follower **52** and the other 75° of the camming surface is engageable with the cam plunger **122** of the return cam follower assembly **110.** As illustrated in FIGS. **4** and **6,** the horizontal thruster cam **38** may extend substantially 360° about the tube **104** so that substantially 180° of the camming surface is engageable with the cam follower **50** and the other 180° of the camming surface is engageable with the cam plunger of the return cam follower assembly **112.** A stop **126** prevents rotation of the cam **38** through greater than 180°.

As illustrated in FIG. **5,** the camming surface of the vertical thruster cam **42** which engages with the return cam follower assembly **110** may have a detent **128** so as to enable the diver to sense a neutral no thrust position of the handgrip **34** for up and down swinging movements thereof. As illustrated in FIGS. **4** and **6,** the camming surface of the horizontal thruster cam **38** which engages with the return cam follower assembly **112** may be provided with a detent **130** so that the diver can sense the neutral no thrust position of the handgrip **34** for rotating movements thereof.

It is desirable that the movements of the handgrip **34** cause independent movements of the vertical thruster cam **42** and the horizontal thruster cam **38.** This may be accomplished by locating the longitudinal axis of the pivotal pin **124** so that it passes through the center of the horizontal thruster cam **38** and orthogonally intersects the longitudinal axis of the cylinder **94,** and locating the longitudinal axis of the valve plunger **106** (see FIG. **4**) in alignment with the center line of the pin **124.** With this arrangement, response of the cam followers **52** and **50** to swinging and rotational movements of the handgrip **34** will be independent of one another.

As illustrated in FIG. **2,** the power unit **22** may include a hydraulic variable displacement pressure compensated pump **134** which is driven by an electric motor **136.** Both the pump **134** and motor **136** may be completely immersed in a hydraulic reservoir **138** so that the inlet of the pump is capable of drawing liquid, such as oil, from this reservoir. A pressure compensator (not shown) may be operably connected to the pump and may have an adjustment knob **140** which extends from the reservoir casing **138** for selectively adjusting output pressure of the pump at a predetermined level above ambient. As illustrated in FIG. **2,** a switch **142** on the control console **32** may be utilized for applying battery power to the electric motor **136** within the power unit.

As illustrated in FIG. **2,** the thrusters **14** through **20,** pressure reducing valves **54** through **60** and spring biased cylinder actuators **70** through **76** may be hydraulically connected in parallel by pressure and return lines (R and P) to the pump **134** and reservoir **138** respectively.

In the operation of the propulsion system for the vehicle **10,** the diver grasps the left handgrip **34** with his left hand and the right handgrip **36** with his right hand and trails along behind the vehicle as it is propelled and controlled through various maneuvers in the water. When the diver desires to go forward with the vehicle, he rotates the handgrips **34** and **36** clockwise (when viewed from the port side) in the same manner that a motorcycle rider would cause his motorcycle to go forward. To reverse the vehicle, the diver rotates the handgrips in the opposite direction, and when the diver desires to stop forward or rearward motion of the vehicle, he releases these handgrips so that they will return to their no thrust position. In operation of this vehicle, it has been found that some divers prefer the grips to be rotated just opposite to that described hereinabove for forward and rearward motion of the vehicle. This may be accomplished by merely using opposite handed props on these thrusters **14** and **16.** In order to move the vehicle upwardly, the diver merely rotates the handgrips **34** and **36** in an upward direction, and when he wants the vehicle to go down, he moves the handgrips **34** and **36** downwardly. When he releases these handgrips, they return to their neutral positions and the thrusters **18** and **20** stop in their rotation. If the diver desires the vehicle to make a right turn, he will selectively operate the thrusters **14** and **16,** and if he desires the vehicle to be tilted in its pitch attitude, he may selectively operate the thrusters **18** and **20.**

With the invention described hereinabove, a hand control system is provided which enables a diver to utilize natural instinctive movements of his hands to cause the vehicle **10** to move to desired positions for transferring loads from one location on the ocean bottom to another location or raising these loads to the ocean surface. In accomplishing this purpose, a hook at the bottom of the vehicle can be attached to a load and any of the above movements can be accomplished.

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

I claim:

1. A diver operated propulsion system for an underwater vehicle comprising:

two pair of reversible thrusters, one pair of thrusters being mounted on the vehicle starboard and port for forward and reverse horizontal thrust and the other pair of thrusters being mounted on the vehicle forward and aft for up and down vertical thrust;

a pair of elongated handle bar type of handgrips;

means mounting the pair of handgrips on the vehicle port and starboard with their longitudinal axes aligned athwart the vehicle, for rotation about their longitudinal axes, and pivotal up and down movements in a vertical plane;

means interconnecting the hand grips and the thrusters for actuating the port and starboard thrusters forward and reverse when the grips are rotated in opposite directions respectively, and actuating the forward and aft thrusters up and down when the grips are pivoted up and down respectively;

each of said thrusters having a no thrust mode of operation;

the means interconnecting the handgrips and the thrusters further actuating the port and starboard thrusters to no thrust modes when the respective grips are rotated to middle rotated positions and actuating the forward and aft thrusters to no thrust modes when the respective grips are pivoted to middle pivoted positions;

means biasing each of the handgrips to its middle rotated and pivoted positions so that upon release of the handgrips by the diver all thrusters go to their no thrust modes;

each thruster having a lever which is movable to three positions to operate the thruster in its three modes of operation; and

the interconnecting means for actuating the thrusters comprising:

two pair of spring biased piston and rod hydraulic cylinder actuators mounted to the thrusters;

the rod of each cylinder actuator being connected to a respective thruster control lever;

a pressure reducing piston and plunger rod hydraulic cylinder valve hydraulically connected to each respective piston-cylinder actuator for applying to the cylinder high pressure, low-pressure, and no pressure corresponding to respective modes of operation of the respective thruster;

each handgrip having a pair of cams, one of the cams moving upon rotation of the handgrip and the other cam moving upon pivoting of the handgrip; and

each cam operating on a respective cylinder valve plunger rod for actuating the valve in its three pressure modes.

2. A propulsion system as claimed in claim **1** including:

a hydraulic pump and reservoir;

the thrusters, pressure reducing valves, and spring biased cylinder actuators being hydraulically connected in parallel by pressure and return lines to the pump and reservoir respectively.

3. A propulsion system as claimed in claim **2** including:

a pressure compensator operatively connected to the pump for selectively adjusting output pressure of the pump at a predetermined level above ambient.

4. A propulsion system as claimed in claim **3** including:

the pump being mounted within the reservoir.

5. A propulsion system as claimed in claim **4** including:

an electric motor for driving said pump; and

said motor also being mounted in the reservoir.

* * * * *