Nov. 19, 1968 D. L. CURTIS 3,411,474

UNDERWATER PROPULSION SYSTEM

Filed Oct. 11, 1967

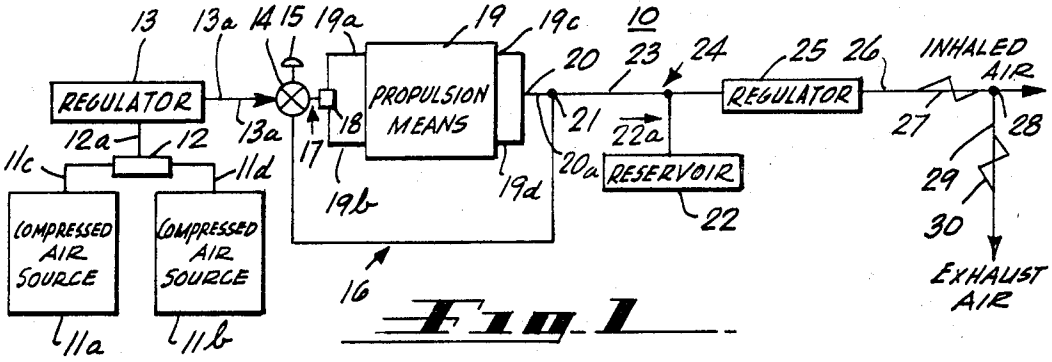


Fig. 1

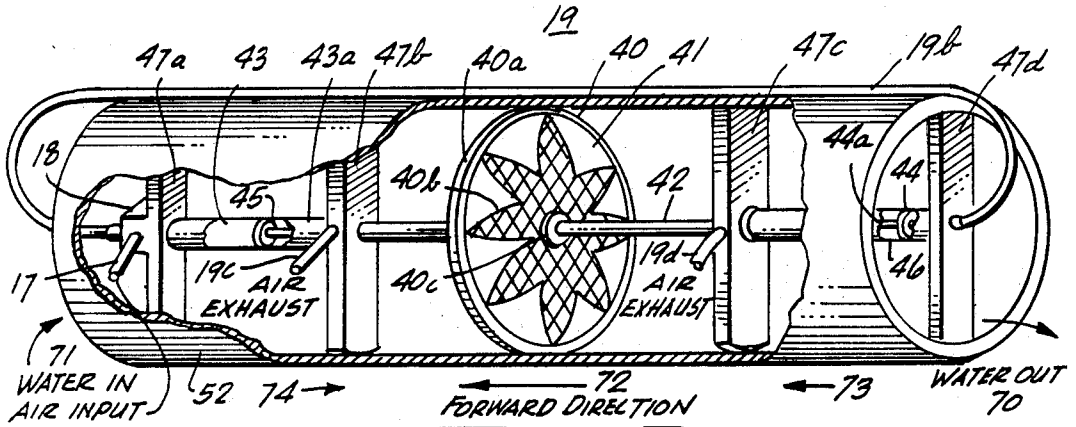
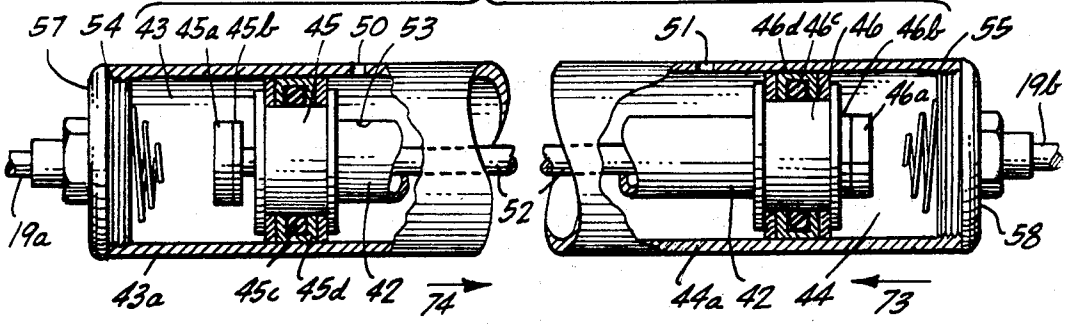


Fig. 2

Fig. 3



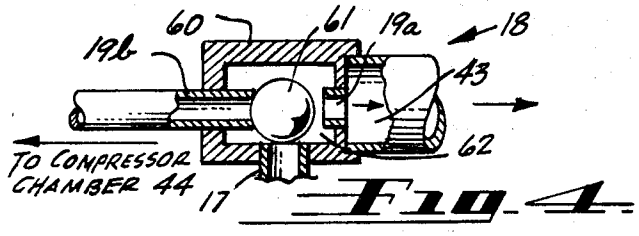


Fig. 4

INVENTOR.
DANIEL L. CURTIS
BY Franklin D. Jankosky
- ATTORNEY -

United States Patent Office 3,411,474 Patented Nov. 19, 1968

3,411,474

UNDERWATER PROPULSION SYSTEM

Daniel L. Curtis, Manhattan Beach., Calif., assignor to Litton Systems, Inc., Beverly Hills, Calif., a corporation of Maryland

Filed Oct. 11, 1967, Ser. No. 678,149
13 Claims. (Cl. 115—6.1)

ABSTRACT OF THE DISCLOSURE

An underwater propulsion system for effecting movement of a person through water. A compressed air source is adapted to regulator apparatus to provide compressed air at a sufficient pressure to operate a propulsion device in a reciprocating motion so as to provide thrust to a person incapable of swimming or to provide additonal thrust to a swimmer in addition to the thrust generated by swimming. An air reservoir may be incorporated in this system to provide a linear air flow to the propulsion device.

FIELD OF THE INVENTION

This invention relates to an underwater propulsion system and more particularly to a novel underwater propulsion system wherein the amount of air used from the compressed air source is equal to the ventilation requirement of the swimmer on a demand basis and extra thrust is provided by propulsion means with no additional air flow.

DESCRIPTION OF THE PRIOR ART

The concept of utilizing the stored energy contained in compressed air source to aid a swimmer in moving himself through the water is not new; however, means of efficiently harnessing the stored energy in some form of reliable underwater propulsion system has hitherto been the problem. A propeller is universally accepted as a highly efficient method of transforming rotational power into linear motion, but problems arise in transforming the stored energy in the compressed air tanks to rotational power. An alternate means of propulsion is an oscillating fin that would propel the swimmer in a similar manner to the action of a fish's tail. However, as a practical matter, its efficiency is difficult to predict and the required length of the fin may become unwieldy. In addition, an air motor utilizing a piston stroke and a spring return stroke has been advanced; however, the practicality of such a system is questioned.

Accordingly, it is an object of the present invention to provide an improved underwater propulsion system wherein the amount of air used from the compressed air source is equal to the ventilation requirements of a swimmer on a demand basis and extra thrust is provided with no additional air flow.

It is a further object of the present invention to provide an improved underwater propulsion means having a highly efficient means of effecting movement of a swimmer through the water.

It is a still further object of the present invention to provide an improved underwater propulsion means which is compact and light in weight.

It is another object of the present invention to provide an improved underwater propulsion system having an air reservoir to provide a reasonably smooth flow of air to operate the underwater propulsion means.

It is still another object of the present invention to provide an improved underwater propulsion means having piston means operating in a push-pull relationship.

It is yet another object of the present invention to provide an improved underwater propulsion means which includes spring means for conserving energy and ensuring piston means actuation.

SUMMARY OF THE INVENTION

In accordance with the objects set forth above, the present invention provides a novel underwater propulsion system for effecting movement of a swimmer through the water comprising at least one compressed air source, breathing means for providing air to the swimmer, regulator means coupled between the compressed air source and the breathing means for providing pressure levels, and propulsion means adapted to operate in a reciprocating motion in response to the aforementioned pressure levels. In addition to the above elements, a reasonably smooth flow of air through the propulsion means instead of the somewhat intermittent flow as determined by the swimmer's breathing pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects, advantages, and characteristic features of the present invention will become readily apparent from the following detailed description of preferred embodiments of the invention when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a functional block diagram of an underwater propulsion system in accordance with the present invention;

FIGURE 2 is a perspective view of an underwater propulsion means shown partially sectioned in accordance with the present invention;

FIGURE 3 is a plan view of the high pressure chambers shown partially sectioned in accordance with the present invention; and

FIGURE 4 is a side elevational view shown in section of the shuttle valve including connecting parts thereto in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGURE 1, there is shown one of the embodiments of an underwater propulsion system **10** constructed in accordance with the principles of this invention in which two compressed air sources **11***a* and **11***b* are connected in parallel. The use of the term "air" is understood to include other suitable gases which may serve to provide ventilation to the swimmer. One source may be the primary source and the other source may be the auxiliary source. These compressed air sources may be of a typical type of compressed air tanks worn by scuba divers. Depending upon the requirements of the underwater swimmer or scuba diver, one or two tanks may be carried by the diver. On the other hand, the compressed air sources **11***a* and **11***b* may represent large stationary compressed air tanks that are transported by a ship and pneumatic lines are then utilized to supply compressed air to a tethered diver. The compresed air sources **11***a* and **11***b* are connected to a switch **12** via pneumatic lines **11***c* and **11***d*, respectively. The switch **12** enables the diver to switch between the two air sources. The air is then fed to a first regulator **13** via a pneumatic line **12***a*. The first regulator **13** has an intermediate output pressure to a pneumatic line **13***a* of approximately 250 p.s.i.

The compressed air is then fed to a bypass valve **14**. The bypass valve **14** may be switched between a first and second position by a plunger **15**. In the first position, the compressed air would be fed to a propulsion means **19**, and in the second position, the compressed air would bypass the propulsion means **19** and be fed to a second regulator **25** via a bypass penumatic line **16**. The plunger **15** may be manually operated by the swimmer to shunt the air flow around the propulsion means **19**. The bypass valve **14** may be utilized by the swimmer, to shunt the

air flow, when he desires to remain stationary or in the event of a propulsion means failure, that might be caused by seaweed blockage, for example.

In the first position the compressed air is fed to the propulsion means **19** via a pneumatic line **17**. The pneumatic line **17** couples the output of the bypass valve **14** to a shuttle valve **18**. The shuttle valve **18** enables the compressed air to be alternately fed to opposite input ends of the propulsion means **19** via pneumatic lines **19***a* and **19***b*. The detailed operation of the shuttle valve **18** will be further explained in a later discussion of the propulsion means **19**. The compressed air is exhausted alternately from opposite ends of the propulsion means **19** via penumatic lines **19***c* and **19***d*. The exhaust lines are then joined together at a joint **20** and the compressed air is fed to another joint **21** via a pneumatic line **20***a*. The joint **21** connects the exhaust from the propulsion means **19** and the bypass pneumatic line **16**. The compressed air is then fed to the second regulator **25** via a pneumatic line **23**.

The second regulator **25** may be a conventional air demand regulator that is adjusted to maintain the air fed to the swimmer upon demand by the swimmer. The second regulator **25** senses the pressure of the environment of the swimmer, for example, if the swimmer is **30** feet underwater, the output of the second regulator **25** would be 15 p.s.i. The second regulator **25** is set to maintain a 100 p.s.i. drop across itself.

Thus, if the swimmer were at a depth of 30 feet, a pressure differential would be established between the first regulator **13** and the second regulator **25** of approximately 135 p.s.i., which is dropped across the propulsion means **19**. This pressure differential will vary depending upon the breathing of the swimmer. The air may then be fed on demand to the swimmer via a pneumatic line **26**. Also included within this line is a check valve **27** for allowing air to be fed to the swimmer and to prevent air from going back to the system. The swimmer exhaust air is fed out to the water via a pneumatic line **26**, a pneumatic line **29**, and a check valve **30**. The pneumatic lines **26** and **29** are connected at a joint **28** as shown. The check valve **30** allows swimmer exhaust air to be expelled to the water and prevents water from being inhaled by the swimmer.

In the operation of the propulsion means **19**, the swimmer takes air, in his normal underwater breathing pattern, from the output of the second regulator **25**. Thus, the pressure differential between the first regulator **13** and the second regulator **25** is varied. This pressure differential provides the force to drive the propulsion means **19**. Since the breathing pattern of the swimmer may be somewhat intermittent, a small reservoir **22** may be connected to the line **23** via a pneumatic line **22***a* at a joint **24**. The utilization of the reservoir **22** ensures a reasonably smooth or linear flow of air through the propulsion means **19** instead of the somewhat intermittent flow as determined by the swimmer's breathing pattern. The reservoir **22** may be mounted either in the back region or the chest region of the swimmer.

Referring now to FIGURE 2, there is shown a plan view of the underwater propulsion means **19** and its associated components. A water check valve **40** and an associated flapper **41** are utilized to push the water out of the underwater propulsion means **19** in a direction of the arrow **70**. The water check valve **40** includes an outside ring **40***a*, a screen **40***b*, and an inner bushing **40***c*. The water check valve **40** is coupled to a connecting rod **42**. The propulsion means **19** may be housed in an open-ended cylinder **52**, which may be constructed of any suitable material.

In the operation of the propulsion means **19**, compressed air is fed into the shuttle valve **18** from the first regulator **13** via the pneumatic line **17**. This air may be either diverted to a first high pressure chamber **43** or to a second high pressure chamber **44** to provide reciprocating motion of this propulsion means. The first high pressure chamber **43** is utilized to operate the power stroke, in other words, the stroke which enables the water check valve **40** to push the water out of the propulsion means **19**, or the air may be utilized in the second high compression chamber **44** to return the water check valve **40** to a position where the power stroke may again be initiated. During the power stroke, the flapper **41** sets against the screen **40***b*, thus enabling the water to be forced out of the underwater propulsion means **19** in order to propel the swimmer in a forward direction as indicated by arrow **72**. On the return stroke the water check valve **40** is open, that is, the flapper **41** is not flush against the screen **40***b*. Thus, the reverse thrust of the propulsion means **19** is minimized and a fresh charge of water is allowed to pass through the check valve **40** in the direction of the arrow **71**. The duration of the return stroke, indicated by arrow **73**, will be considerably shorter in time than the forward stroke, indicated by arrow **74**, by virtue of the difference in water resistance. At the end of both the power stroke and the return stroke the exhaust air will be fed to the swimmer via the exhaust outlets **19***c* and **19***d*, respectively. Also shown on the FIGURE 2, are first and second pistons **45** and **46**, the power and return pistons, respectively. In addition, structural members **47**, *a* through *d*, which support the associated components within the open-ended cylinder **52**, are shown, along with the pneumatic line **19***b*, the input to the return stroke, and the pneumatic exhaust lines **19***c* and **19***d*. A preferred construction of the propulsion means **19** would be one that would allow a flow of a large mass of water with a small change in velocity. This type of construction would provide expelled water having a wake with minimum kinetic or wasted energy.

Referring now to FIGURE 3, there is shown a detailed view of the high compression chambers **43** and **44** and their respective associated components. The water check valve **40**, not shown, would be mounted onto the connecting rod **42**, as previously shown in FIGURE 2. In the operation of a power stroke, the compressed air is fed from the shuttle valve **18** to the first piston **45** via the pneumatic line **19***a*. A valve **45***a* would be forced against the piston **45** and the first piston **45** would travel in the direction indicated by the arrow **74**. The valve **45***a* may include a rubber valve seat **45***b*. The first piston **45** includes the O-ring **45***c* and a Teflon cap strip **45***d*. During the power stroke, the piston **45** would move the water check valve **40** until the piston passed a first exhaust vent **50**. At this time the shuttle valve **18** would allow compressed air to be fed to the second high compression chamber **44** via the input **19***b*. The second piston **46** is shown with its following associated components: a valve **46***a*, a rubber seat valve **46***b*, an O-ring **46***c*, and a Teflon cap strip **46***d*. A second exhaust vent **51** determines the length of the return stroke. The return stroke would operate in the same fashion as the power stroke but in the opposite direction, as indicated by arrow **73**. However, the flapper valve **41** would be open to allow a new supply of water to enter the propulsion means **19**.

A vent valve connecting rod **52**, is shown, having opposite ends connected to valves **45***a* and **46***a*, respectively. The valves **45***a* and **46***a* are utilized in order that no substantial back pressure interferes with the respective strokes of the pistons **45** and **46**. For example, when the propulsion means **19** is operating in its return stroke, the valve **46***a* will be flush against the piston **46**. In turn, the valve **45***a* will be separated from the piston **45** to allow any air in the first high pressure chamber **43** to be released through vent **53** of the connecting rod **42** via the space provided between the vent valve connecting rod **52** and connecting rod **42**. On the other hand, when the power stroke is initiated, air in the high compression chamber **44** will also be released through vent **53** of the connecting rod **42** via this space provided betweeen vent valve connecting rod **52** and connecting rod **42**. Two springs **54** and **55** are attached to the outermost ends of

cylinders 43*a* and 44*a*, respectively. The springs 54 and 55 are positioned to prevent sudden stops of pistons 45 and 46, respectively, in order to conserve energy. The conservation of energy occurs by way of the rebound induced by the respective springs. In addition, the springs 54 and 55 are utilized to close the valves 45*a* and 46*a*, respectively, so that the pistons 45 and 46 are in readiness for their respective strokes. It is pointed out at this time, that the springs 54 and 55 are not utilized to maintain the reciprocating motion of the respective pistons 45 and 46 in the sense of a spring that is utilized to fully return a piston for subsequent strokes.

Referring now to FIGURE 4, a detailed view of the shuttle valve 18 is shown. The shuttle valve 18 includes a housing 60, a shuttle ball 61 and a chamber 62. In the operation of the shuttle valve 18, compressed air is fed into the chamber 62 via the pneumatic input line 17, and this air may be diverted to either of the high pressure chambers 43 and 44. During the power stroke, the shuttle ball 61, will be against pneumatic input line 19*b*, as shown. Assuming that the power stroke has ended, the pressure at the input to the power stroke compression chamber 43 drops. Prior to this time leakage has occurred to allow air to accumulate on the return chamber side of the ball; therefore, when this aforementioned pressure drops, the shuttle ball 61 is forced against the pneumatic input line 19*a*, thus the inlet air is routed to the return stroke compression chamber 44. At the end of the return stroke, the pressure at the input to the return stroke piston drops and the buildup of leakage pressure on the power chamber side of the ball results in forcing the shuttle ball 61 against the pneumatic input line 19*b*, and compressed air is then routed to the power stroke compression chamber 44 via pneumatic input line 19*a*. Thus, compressed air is alternately fed to the high compression chambers 43 and 44 to ensure a reciprocating motion of the propulsion means 19.

In addition to a swimmer using the underwater propulsion system 10 to provide additional thrust to aid his swimming in water, the system 10 may also be adapted to the body of a person incapable of swimming so as to provide ventilation and to move the person through the water.

What is claimed is:

1. An underwater propulsion system for effecting movement of a person through water comprising:
- at least one compressed gas source;
- propulsion means for moving a swimmer through water, said propulsion means adapted to operate in a reciprocating motion, said propulsion means including first and second piston means operating in a push-pull fashion for providing thrust, said piston means having a predetermined length of stroke, said piston means further having spring means for conserving energy and ensuring piston means actuation;
- ventilation means for providing gas to said swimmer;
- regulator means for providing pressure to operate said propulsion means and for providing gas to said ventilation means, said regulator means having first and second inputs connected to said gas source and to said propulsion means, respectively, and first and second outputs connected to said propulsion means and said ventilation means, respectively; and
- diverter means coupled between said first output of said regulator means and said piston means for ensuring said reciprocating motion.

2. An underwater propulsion system as recited in claim 1 wherein said regulator means includes a gas reservoir adapted to provide a linear flow of gas to said propulsion means.

3. An underwater propulsion system for effecting movement of swimmer through water comprising:
- at least one compressed air source;
- propulsion means for propelling the swimmer through water, said propulsion means having first and second inputs and first and second outputs, said propulsion means including piston means operating in a push-pull motion for providing thrust, said piston means having spring means for conserving energy and ensuring piston means actuation;
- first regulator means coupled between said air source and said first and second inputs of said propulsion means for providing compressed air to said propulsion means;
- diverter means for routing compressed air from said first regulator means between said first and second inputs of said propulsion means;
- first means for providing air to said swimmer; and
- second regulator means coupled between said first and second outputs of said propulsion means and said first means for providing air to said first means, said first regulator means and second regulator means adapted to provide a pressure for driving said propulsion means.

4. An underwater propulsion system as recited in claim 3, wherein said second regulator means are of a demand type operating in response to the breathing requirements of said swimmer.

5. An underwater propulsion system as recited in claim 4 wherein reservoir means are coupled between said first and second regulator means for providing a linear air flow to said propulsion means.

6. An underwater propulsion system as recited in claim 5 wherein said diverter means comprises shuttle ball means for diverting said compressed air between said first and second inputs of said propulsion means.

7. An underwater propulsion system as recited in claim 6 wherein bypass means are coupled in parallel to said propulsion means for routing said compressed air from said first regulator to said second regulator means, said bypass means including a plunger which may be mechanically actuated by said swimmer.

8. An underwater propulsion system as recited in claim 7 wherein said compressed air source includes compressed air tanks located a substantial distance from said swimmer and pneumatic air means for coupling said compressed air tanks to said first regulator means.

9. An underwater propulsion system as recited in claim 8 wherein said first means includes first and second check valve means for preventing swimmer's exhaust air from going back to said second regulator means and for preventing water from traveling to the swimmer by said first means, respectively.

10. A propulsion device powered by compressed air and operating in response to a breathing pattern established by a swimmer comprising:
- first and second high compression chambers;
- first and second piston means adapted to operate in said first and second high compression chambers, respectively, for providing the thrust of said propulsion device;
- connecting rod means connecting said first piston means to second piston means for operating said first and second piston means in a push-pull manner;
- water check means mounted on said connecting rod means centrally between said first and second high compression chambers for propelling water from said propulsion device;
- first and second valve means located within said first and second piston means, respectively, for relieving back pressure alternately in said first and second high compression chambers;
- a valve connecting rod coupling said first valve connecting means to said second valve connecting means;
- first and second spring means located within said first and second high compression chambers, respectively, for closing said first and second valve means on respective back strokes and for conserving energy;
- first and second vent means located in said first and second high compression chambers, respectively, for

determining the length of the respective strokes of said first and second piston means; and

third vent means located in said connecting rod for relieving the respective back pressures of said first and second high compression chambers.

11. A propulsion device as recited in claim **10** wherein said water check means includes a screen material and a flapper member adapted to allow water to pass through said water check means in a first direction and to prevent water from passing through said water check valve in a second direction.

12. A propulsion device as recited in claim **10** wherein an air reservoir means is connected to said compressed air for providing a linear air flow to said first and second piston means.

13. An underwater propulsion system for effecting movement of a swimmer through water comprising:

at least one compressed air source;

first means connected to said compressed air sources for providing switching between said air sources;

first regulator means coupled to the output of said first means for providing a first pressure state;

second regulator means for providing a second pressure state;

diverter means having a first input and first and second outputs for routing compressed air;

second means for routing compressed air;

bypass means having first and second outputs for distributing compressed air, said bypass means having

an input coupled to the output of said first regulator means, said bypass means having an actuator for routing said compressed air between said first and second outputs, said first and second outputs of said bypass means connected to said first input of said diverter means and said second means, respectively;

propulsion means for propelling said swimmer through water, said propulsion means having first and second inputs connected to said first and second outputs of said diverter means, respectively, said propulsion means further having first and second outputs connected to said second means;

reservoir means coupled between said first and second outputs of said propulsion means and said second regulator means for providing a linear flow of air to said propulsion means; and

third means connected to the output of said second regulator means for providing said swimmer with an air source.

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MILTON BUCHLER, *Primary Examiner.*

TRYGVE M. BLIX, *Assistant Examiner.*