Dec. 4, 1962 J. H. ANDRESEN, JR 3,066,638

PROPULSION SYSTEM FOR UNDERWATER DIVERS

Filed Sept. 1, 1960 2 Sheets-Sheet 1

FIG. 1

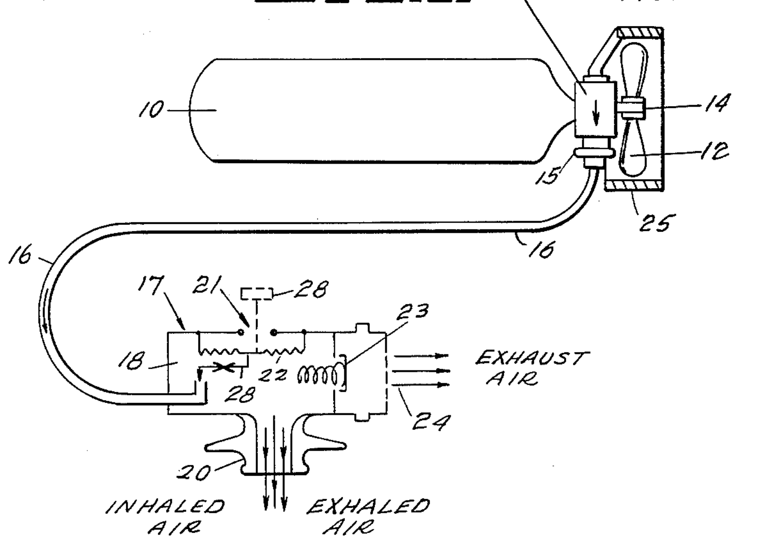
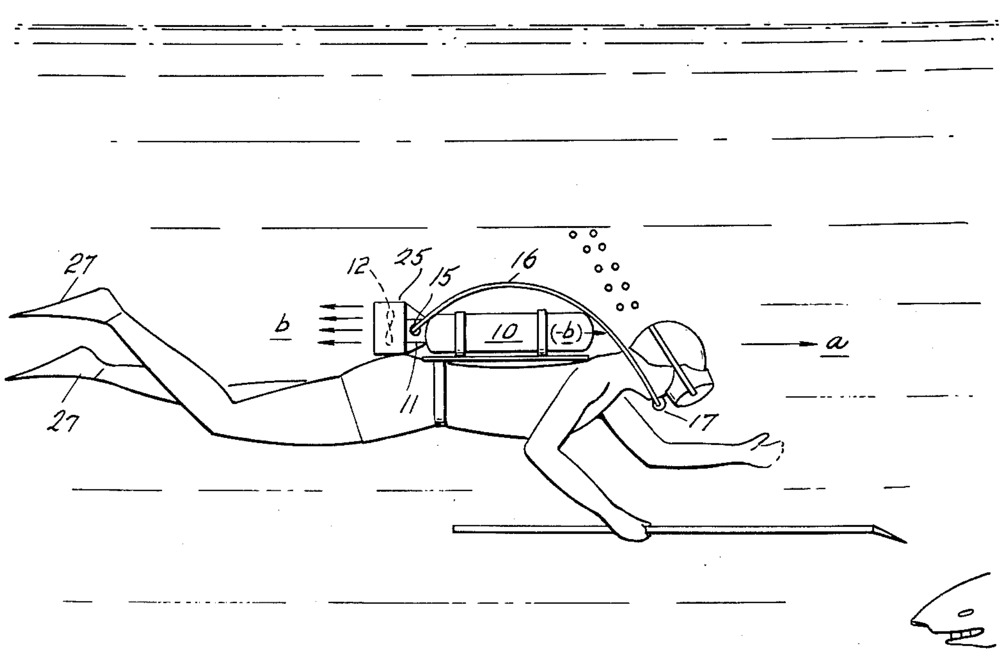


FIG. 2



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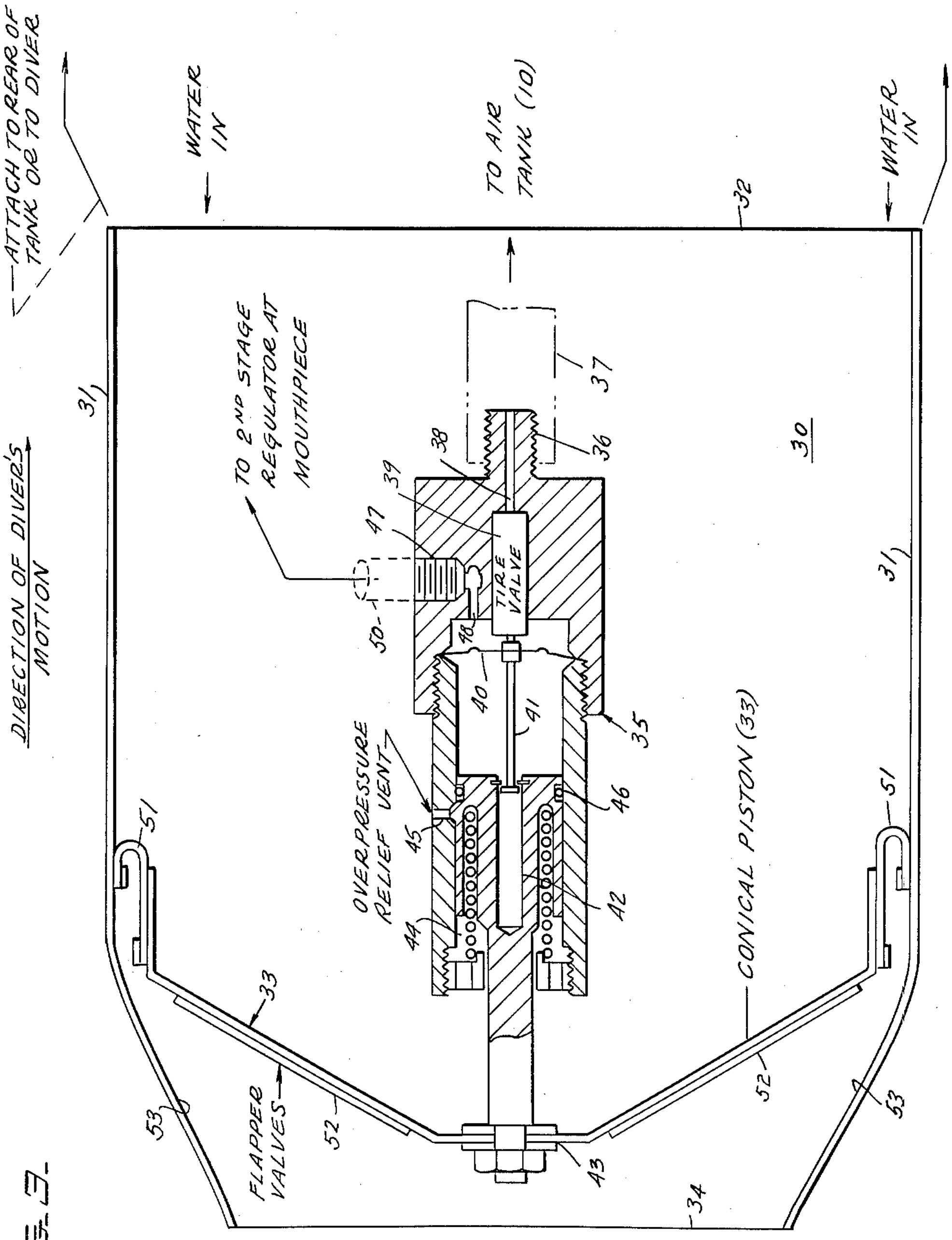

FIG. 3

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1

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PROPULSION SYSTEM FOR UNDERWATER DIVERS
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This invention relates to a propulsion system for underwater divers, and more particularly relates to a novel propulsion system incorporated in self-contained underwater breathing apparatus for the divers.

Underwater breathing apparatus of the self-contained type is known as scuba. Conventional scuba of the open circuit type uses compressed air (or mixture of oxygen and helium). The compresesd air is contained in one or more cylindrical tanks at 2000 to 3000 p.s.i. pressure. The tank or tanks are fastened to the back of the diver. The tank air is reduced in pressure and metered at the local water pressure of the diver's depth. A one or two stage demand regulator is employed.

The regulator operates through the slight reduction in pressure (e.g. 1 or 2 inches of water pressure), in the mouthpiece or face mask. The dived effects the regulator air release by his act in attempting to inhale. The regulator throttles the compressed air in the exact amount thus called for by the diver, in a manner well known in the art. When the pressure in the air storage cylinders is down to about 300–500 p.s.i., the diver surfaces, and the tanks are replaced.

The diver equipped with scuba uses rubber fins on his feet to aid in his underwater swimming and locomotion. Where a large underwater area is to be explored, the effort in his swimming is relatively great. Further, his resultant air consumption is high. To alleviate this effort and problem, propulsion aids are often used by the diver. One such propulsion device is a small battery-operated torpedo-like submarine that pulls the diver. Another is an underwater sled or hand-held vane towed by surface craft.

In accordance with my present invention a small compressed air operated motor is attached to the diver. The compressed air that drives this motor is the same air from the scuba tanks which the diver subsequently breathes. The air motor rotates a water propeller. The energy in the compressed air supply is thus used to propel the diver each times he takes a breath. In the conventional scuba this energy is wasted through throttling in the pressure regulator. The diver still may wear fins on his feet for maneuvering, and to aid in propulsion.

It is accordingly an object of the present invention to provide a novel propulsion system for scuba divers.

Another object of the present invention is to provide a novel propulsion system incorporating an air motor driven by the compressed air of a scuba equipped diver.

A further object of the present invention is to provide a diver propulsion system incorporated in a scuba that is activated upon the diver's breathing of the supplied air.

Still another object of the present invention is to provide a diver propulsion system using an air motor driven by energy of the compressed air in a scuba as it is reduced in pressure for the diver for his breathing.

These and other objects of my invention will become more apparent from the following description of an exemplary embodiment thereof, illustrated in the drawings, in which:

FIGURE 1 is a diagrammatic assembly of an exemplary form of the invention system, incorporated in a scuba.

FIGURE 2 illustrates a diver using the scuba assembly of FIGURE 1.

FIGURE 3 is a diagrammatic representation of a modified form of the invention hereof.

2

The compressed air cylinder **10** used for diving typically holds 70 cubic feet of air measured at sea level pressure, condensed as to 150 atmospheres at the start of a dive. Such tanks are used at 2000 to 3000 p.s.i., as aforesaid. A diver breathes at the rate of approximately 1 cubic foot per minute, regardless of the ambient hydrostatic pressure. At 33 foot depth (2 atmospheres), with the first stage of a regulator set at 5 atmospheres, an energy rate of 9.3 H.P. is available. This is derived directly:

$$\frac{(150-5)\times 14.7\times 144\times 1}{33,000}$$

When the tank is expended to only 15 atmospheres, the energy rate at 33 foot depth is, correspondingly, 0.65 H.P. This is derived by:

$$\frac{(15-5)\times 14.7\times 144\times 1}{33,000}$$

The air is drawn intermittently from the tank **10**, and the compressed air operated motor **11** is a relatively small one. The motor **11** structure is secured to the neck **10'** of tank **10**, through which the compressed air flows into the motor. A propeller **12** is driven by the motor **11**. Even with a power conversion efficiency of only 25%, from air pressure reduction to propeller propulsion, the resultant power is adequate to drive the diver at greater than normal swimming speed even at the lower tank pressure. However, two or more tanks (**10**) may be paralleled, in a conventional manner, to extend the duration of the dive.

Pneumatic motor **11** is preferably of the positive displacement type. It may be one of several known compressed air motor constructions. Its displacement in the exemplary system is 0.5 to 1.0 cu. in. per turn of its output shaft **14**. Propeller **12** is secured directly to motor output shaft **14** in the exemplary embodiment. The use of "air" herein, and in the claims, is to be understood to be generically inclusive of other gases used, as a combination of oxygen and helium.

The output or air exhaust duct of motor **11** is fed into a reducing valve **15**. Reducing valve **15** is proportioned to reduce the incident (tank) pressure to an absolute pressure somewhat higher than that at the lowest depth the diver intends to go to. As an example, for a lowest diver descent of 60 feet, the pressure output of reducing valve **15** is set to 5 atmospheres. The output from the low pressure side of valve **15** is led through hose **16** to air demand regulator **17**. Hose **16** is at intermediate pressure.

The air demand regulator **17** may be a conventional type that regulates the flow of air supply to the diver. Regulator **17** does not release a continuous flow of air, except on demand. The inhaling and exhaling occurs through rubber mouthpiece **20**. The air from hose **16** enters regulator **20** at a control valve **18**. An aperture **21** admits ambient water pressure against control diaphragm **22**, coupled to control valve **18**. A check valve **23** leads exhaust air to output end **24**.

The propeller has a guard **25** about it, anchored on motor **11**. Each time the diver inhales air through mouthpiece **20**, control valve is opened to admit air from intermediate pressure hose **16**. This causes air pressure from tank **10** to expand through air motor **11** and pass through the first stage reducing valve **15**. The motor thereupon operates to rotate propeller **12**. The result is a thrust *b* (see FIGURE 2). This thrust *b* reacts to move the tank **10** attached to motor **11**, reversed into the swimming direction *a*. With the tank **10** strapped to the diver, the forward (reaction) propulsive thrust ($-b$) is added to his forward drive in the direction *a*. This added thrust ($-b$)

prevents fatigue and increases the range of the diver for a given supply of air in tank **10**.

In using the invention system the diver has the tank **10** (or tanks) strapped on his back, as shown in FIGURE 2, with the propeller directed rearwardly of the divers swimming direction *a*. The diver is attired with a mask **26** and foot fins **27**, **27**. As the diver attempts to inhale, the diaphragm **22** of demand regulator **17** moves inwardly, opening control valve **18** through the mechanical linkage **28** to the intermediate pressure in hose **16**. As long as the diver attempts to inhale, air flows through the control valve **18** and into his lungs through mouthpiece **20**. When he exhales, the higher pressure created in the regulator **17** closes the control valve and opens the check valve **23**, letting the expired air escape in the water.

When the air (thus breathed) flows out of hose **16**, the intermediate pressure at the output of the first stage reducer valve **15** drops. Valve **15** is similar to the second stage regulator **17** in principle, except that a spring holds its control valve open until a predetermined pressure is reached in the output part. When the output pressure of valve **15** (at hose **16**) is thus lowered through a breath taken, the high pressure air from the motor (**11**) exhaust flows through the valve **15** to hose **16**. This air, coming through the air motor **11** rotates its shaft **14** to which the propeller **12** is secured. The cylindrical shield **25** increases the effectiveness of propulsion.

The speed of a body in water is approximately proportional to the cube root of the net propulsive power applied to it. The ratio of speeds increment derived from the invention system from a full compressed tank (**10**) and one depleted is the ratio of the cube roots of the corresponding power application to the propeller **12** (assuming reasonsably equivalent power conversion efficiency). As derived above, the available energy rate to air motor **11** by the invention system is 9.3 H.P. with the tank (**10**) at 150 atmospheres; and 0.65 H.P., at 15 atmospheres. Hence the speed range provided by the invention is 9.3 to 0.65=2.4 to 1. Such speed ratio is not excessive and very useful in practice. Further the waning power supplement provides the diver with a valuable warning when his tank pressure is getting low.

A more continuous thrust may be arranged, than the intermittent one described. Smoothing of the propulsive impulses can be obtained by causing air to flow continuously through the mouthpiece. Towards this end a manually operated button **28**, indicated in dotted lines, extends through aperture **21** and is used to depress diaphragm **22** of regulator **17**. In such operation the air is breathed in during inhaling and wasted through valve **23** with the exhaust air during exhaling.

An alternative method is to use a second compressed air cylinder in the underwater diving, exclusively for propulsion. Such system affords the propulsion for the diver, under manual control of a valve corresponding to the second regulatory stage as described hereinabove. The motor **11** and propeller **12** are a reciprocating air motor system **30** to effect a pulsating jet to provide linear propulsion to the diver. System **30** comprises a cylindrical housing **31**, at one end (**32**) of which the water input lies. This end **31** also is attached to the rear of the air tank (**10**) or to the diver. The reciprocating motor system **30** has rubber flapper valves **52**, **52** on a conical piston **33** that pumps the input water in a pulsating mode to "water out" at end **34**, and effect the propulsive force to propel the diver in the opposite (reaction) direction.

The exemplary system **30** contains a reciprocating piston type of air motor **35**, the end coupling **36** of which is coupled by a line (**37**) to the air tank (**10**). The input bore **38** connected to an automobile tire-type valve **39** that in turn abuts the center of a snap spring **40** used with the second tank in the manner of the system shown in FIGURES 1 and 2; as will now be understood by those skilled in the art.

A modification is feasible wherein the intermediate air pressure can be regulated to some higher pressure such as 10 atmospheres, and the motor (**11**) placed in the line between the first and second stages previously described. The propulsive force by such arrangement is not as high initially as by the previous system described. However, the pressure remains more sustained and uniform as the tank air is depleted.

The propulsive means: rotary motor (**11**) described hereinabove in conjunction with screw propeller **12** (FIGURES 1 and 2), may take other forms without departing from the present invention. FIGURE 3 illustrates a rod **41** coupled to snap spring **40** operates the piston **42** that is connected to the apex **43** of the conical piston **33**. A coaxial restoring spring **44** for the piston **42** coacts in sustaining the reciprocating action as will be understood by those skilled in the art. An over-pressure relief valve **45** and an O ring seal **46**, the pump motor **35** constitute the basic components. A threaded opening **47** and bore **48** communicates between the chamber **49** of the motor **35** and a line **50** (shown in dotted lines) to the second stage regulator (as **17**), at its mouthpiece.

The conical piston **33** is reciprocatably supported in housing **31** through a rubberized fabric seal **51**. The nozzle **53** at the exit end (**34**) of housing **31** is suitably proportioned for the propulsive jet action of the water reciprocatably ejected through the flapper valves **52**, **52** by the piston **33**. A smooth linear propulsive force is thus supplied to the diver by the air drive reciprocating system **30**.

Although the invention has been set forth in conjunction with exemplary embodiments thereof, it is to be understood that modifications may be made within its broader spirit and scope as defined in the following claims.

I claim:

1. Underwater propulsion apparatus of the character described comprising a high pressure air tank, an air motor with an air input connection coupled to the tank, water propulsion means driven by said air motor, and pneumatic means extending from said air motor for passing air from said tank thereto to effect its driving, said air motor being of the reciprocatory type, said water propulsion means including flapper valves to effect linear propulsion upon reciprocatory displacements by said motor.

2. Underwater propulsion apparatus as claimed in claim 1, in which said pneumatic means includes a reducer valve in connection with said motor.

3. Underwater propulsion apparatus of the character described comprising a high pressure air tank with an air output connection, an air motor with an air input connection coupled to the tank air output connection, said air motor being physically securable with said tank, water propulsion means driven by said air motor in a propulsive direction substantially parallel to the tank longitudinal axis, and pneumatic means extending from the air output connection of said air motor responsive to breathing of a diver for passing air from said tank through said air motor to drive said propeller and contribute propulsion to an underwater diver wearing the apparatus in said propulsive direction; both said air motor and said water propulsion means being of the reciprocatory type, said water propulsion means operating on water ambient about the diver.

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