

May 31, 1960

L. R. MAXWELL ET AL

2,938,481

JET PROPELLED TORPEDO

Filed March 21, 1949

2 Sheets-Sheet 1

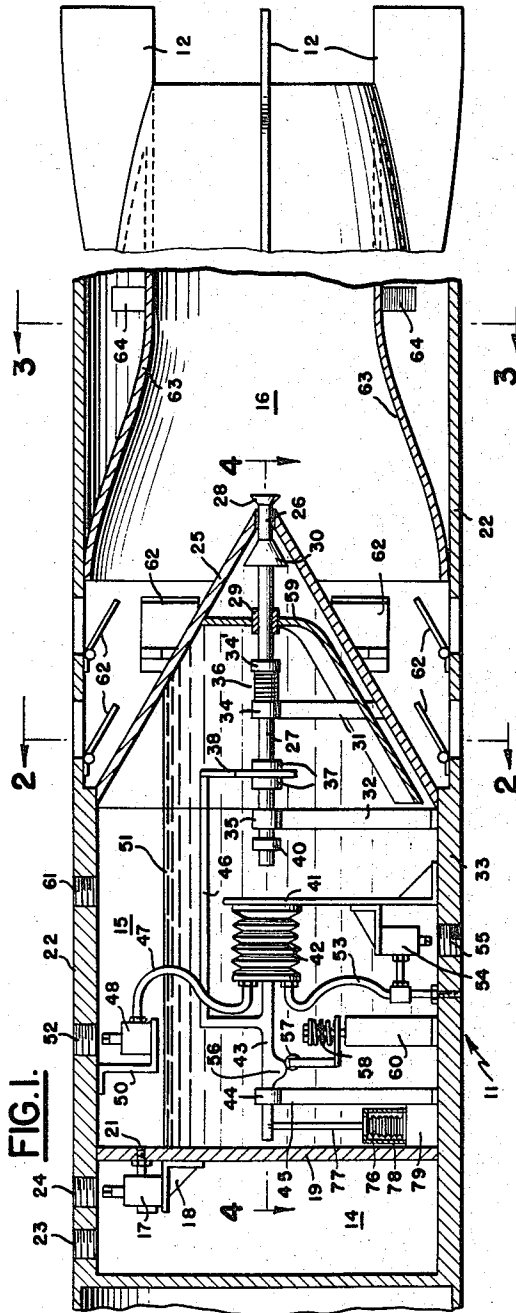


FIG. 3.

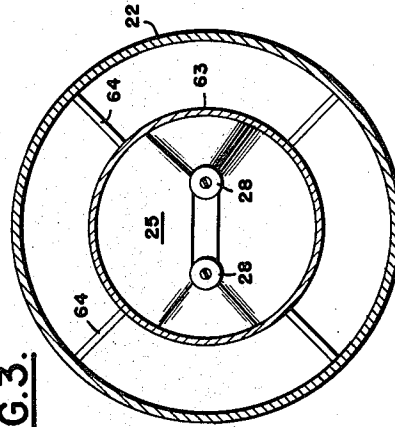
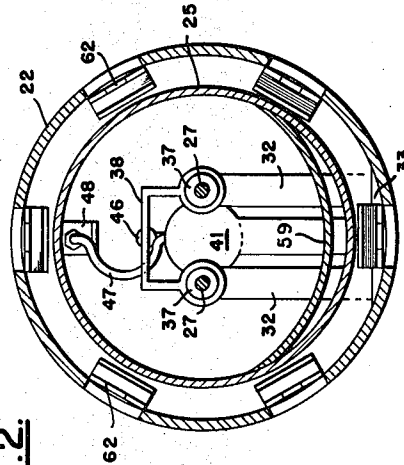


FIG. 2.



INVENTOR.
Louis R. Maxwell
BY Rufus K. Reber
Rufus K. Reber
Attorney

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FIG. 4.

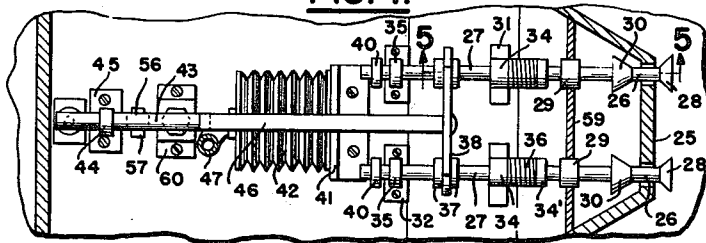


FIG. 5.

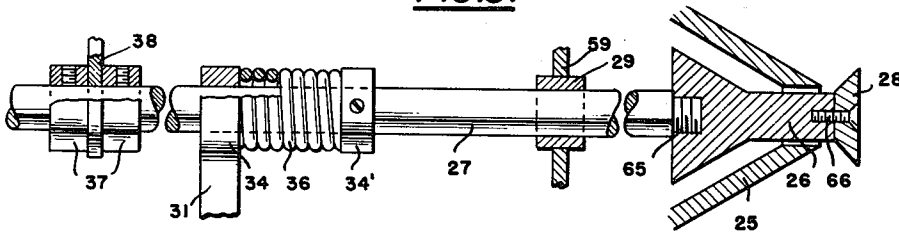


FIG. 6.

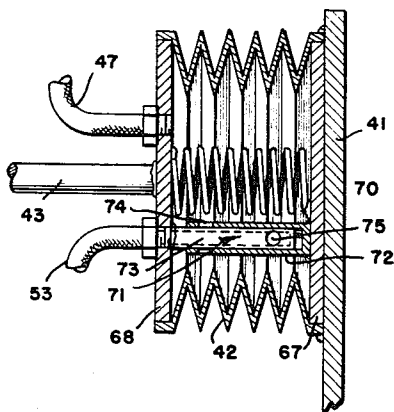


FIG. 7.

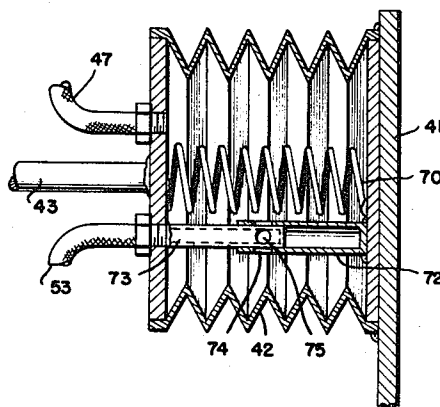
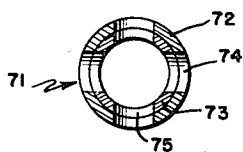


FIG. 8.



INVENTOR.
Louis R. Maxwell
BY **Rufus K. Reber**
Rufus K. Reber
Attorney

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JET PROPELLED TORPEDO

Louis Rigby Maxwell, 416 E. Leland St., Chevy Chase, Md., and Rufus King Reber, 3700 Massachusetts Ave. NW., Washington, D.C.

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6 Claims. (Cl. 114—20)

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The present invention relates to a jet propelled torpedo and more particularly to a torpedo in which the energy for propulsion is derived from the reaction of water with an explosive mixture.

Under the old type methods all torpedoes have been driven by some system of propellers, the power for these propellers being supplied by means of gas turbine engines which derive their energy from compressed air, or the combination of compressed oxygen and alcohol or other organic fuels. In other cases the torpedo has been entirely electrical, having self contained storage batteries and electric motors for supplying the power to drive the propellers. These older methods had many disadvantages, the foremost of which was that the torpedoes required elaborate, finely machined and adjusted parts to make up the gas turbine, thereby resulting in devices that were extremely expensive to construct. Furthermore, these critically adjusted mechanisms required periodic inspection and tests in order to insure their proper operation when needed, in addition to the serious disadvantage of limited speed and limited range due to their restricted fuel capacity.

The present invention has, among other advantages, that of eliminating costly propulsion machinery because its power for propulsion is obtained from the chemical reaction of a liquid fuel with water, the said fuel being fired in short spurts to give a series of forward thrusts. This elimination of propulsion machinery not only avoids mechanical failures which inevitably result, at times, in spite of rigid inspections, but it also means a considerable saving in space and weight which can more advantageously be used for a larger fuel capacity and therefore longer range. For the combined weight of motor and fuel, the present propulsion unit gives either greater speed for a given range, or a greater range for a given speed than for previous types of torpedo propulsion units. Furthermore, the instant invention develops considerable speed and power, and has comparatively few moving parts requiring maintenance or which may be a source of trouble. It has inherent simplicity, greater reliability and ruggedness, and its maximum speed is not limited to propeller cavitation.

An object of the present invention is the provision of a method and apparatus for driving a torpedo by jet propulsion.

Another object is the provision of a method and apparatus for propelling a torpedo by means of the chemical reaction of an explosive mixture with water.

A further object is the provision of a method and apparatus for propelling a torpedo in the form of a series of short pulses.

Still another object is to provide a torpedo in which the maximum speed is not limited by propeller cavitation.

Yet another object of the present invention is the provision of a torpedo having inherent simplicity, relatively few moving parts, and at the same time great reliability and ruggedness.

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A final object of the present invention is to provide a torpedo propulsion system wherein the combined weight of motor and fuel gives either a greater speed for a given range, or a greater range for a given speed, than previous torpedo propulsion systems.

Other objects and features of the invention will become apparent to those skilled in the art as the disclosure is made in the following detailed description of a preferred embodiment of the invention as illustrated in the accompanying sheets of drawings in which:

Fig. 1 is a longitudinal section of a torpedo using the improved propulsion apparatus.

Fig. 2 is an enlarged sectional view taken along the line 2—2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is an enlarged sectional view taken along the line 3—3 of Fig. 1, looking in the direction of the arrows.

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1, looking in the direction of the arrows.

Fig. 5 is a greatly enlarged sectional view taken along the line 5—5 of Fig. 4, looking in the direction of the arrows.

Fig. 6 is a greatly enlarged sectional view of the bellows, in a deflated state.

Fig. 7 is a greatly enlarged sectional view of the bellows in an inflated state.

Fig. 8 is an enlarged, detailed view of the sliding exhaust valve used in the bellows.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a torpedo indicated generally as 11, having cut-away sections at its head and tail, the steering mechanism for the rudders 12 being purposely omitted for the sake of clarity.

The torpedo 11 is made up of a war head 13, pressure compartment 14, fuel storage and operating compartment 15, and explosion chamber 16. The compartment 14, which is filled with some inert gas such as nitrogen, or the like, under high pressure, has within it a gas valve 17, fastened to a bracket 18 which is attached to a partition 19 whereby the valve 17 regulates the flow of gas through the pipe 21 into the compartment 15. Fitted so as to set down flush with the outside skin 22 are screw plates 23 and 24; plate 23 giving access to compartment 14 for the admission of the gas while plate 24 gives access to the valve 17 for the adjustment of its flow.

Compartment 15 is used to house the fuel supply and the mechanism which injects it into the explosion chamber 16. The partition 25, which divides compartment 15 from the explosion chamber 16 is somewhat funnel-shaped and tapers so that it narrows toward the tail of torpedo 11. At the narrowest point of partition 25 there are placed, side by side in the horizontal plane, a pair of tapered valves 26 (clearly shown in Figs. 3 and 4); the area around the valves 26, or the truncated portion of the cone formed by partition 25, being slightly elliptical in cross section so as to afford uniform location and ample seating for valves 26.

Each of the valves 26 is mounted at the end of a shaft 27 and has a small conical flange 28 on its end within explosion chamber 16 and a larger conical flange 30 which fits against the partition 25 to form a liquid-tight connection when the valves are closed. The shafts 27 are supported by rods 31 and 32 which are attached to the partition 25 and flooring 33 respectively; the said rods having sliding collars 34 and 35 for the free movement of shafts 27 therethrough. Mounted around the shafts 27, between sliding collars 34 and fixed collars 34', are compression springs 36 which act to aid valves 26 in seating tightly against partition 25, and to hold valves 26 closed when the liquid is not under pressure.

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About midway the length of shafts 27 are two fixed collars 37, between which moves a yoke 38 thereby to open and close the two valves 26 simultaneously; the shafts 27 also having fixed collars 40 at their extremities.

Supported by a bracket 41, having a large end plate, is a bellows 42, to the opposite end of which is attached a shaft 43 moving through a collar 44 on the end of a supporting bracket 45; the shaft 43 being attached by means of a connecting rod 46 to the yoke 38 whereby an expansion of bellows 42 is transmitted through the connecting rod 46 and yoke 38 to operate the two valves 26. Bellows 42 has a flexible intake pipe 47 at the extremity of which is a regulating valve 48, the valve 48 being mounted on bracket 50 so as to be in the area well above the level of the liquid fuel 51, and being reached by removable plate 52 in the outer skin 22. The bellows exhaust is conducted to the outside of the torpedo 11 through the use of a flexible exhaust pipe 53 having an exhaust regulating valve 54 therein which is reached through plate 55 in the flooring 33. Integral with the shaft 43, and forming a part thereof, is a cam 56 which cooperates with cam follower 57 to act against a tension spring 58 mounted on bracket 60. Removable plate 61 gives access, through the skin 22, to compartment 15 for the admission of the fuel 51.

Positioned across the tapered portion of partition 25 is an auxiliary partition or baffle plate 59, whose upper end is fastened to partition 25 and whose lower end is so shaped as to follow the contour of the lower portion of partition 25. Inserted in the baffle plate 59 are rubber grommets 29, or the like, which form substantially fluid tight connections with the two shafts 27 while at the same time permitting a free sliding action of the shafts 27 through the baffle plate 59.

Also located within the compartment 15 is a small pilot bellows 76 (whose operation will be more fully described hereinafter) having attached to one end thereof a rod 77 which may come into direct contact with the extremity of shaft 43. Bellows 76 which is encased within a container 78 mounted on base 79, has one of its ends rigidly fastened to container 78 and its other end movable whereby any contraction of the bellows causes the rod 77 to move away from engagement with shaft 43.

In the outer skin 22, and in a band completely encircling the explosion chamber 16, there are a plurality of hinged ports 62 whereby water is permitted to freely enter the explosion chamber prior to each explosion. The ports 62 are hinged to open inwardly into the explosion chamber 16 and may be very slightly spring-urged closed so as to insure prompt and effective closing under the impetus of each explosion, while at the same time offering negligible resistance to the inflow of water after each explosion. The forwardmost of the ports 62 are so situated in the outer skin 22 that they are immediately adjacent to the sloping partition 25 thereby minimizing turbulent pockets in the corners of the chamber 16. Adjoining the explosion chamber 16, and extending from the ports 62 to the tail of the device are inner walls 63 which taper very gradually toward the tail whereby the resulting funneling action aids in the expulsion of water after each explosion but at the same time offering no opposition to the flow therethrough. The inner walls 63 are supported by means of spiders 64 attached to the outer wall 22.

In Figs. 2 and 4 it can be more clearly seen how the valves 26 are mounted, and how they are actuated by the bellows 42 and associated linkages.

The construction of the valves 26, and their associated parts are more clearly shown in the enlarged view of Fig. 5 where it can be seen that shafts 27 are one continuous piece of metal on which are threaded the movable members 26, and the spring 36, while near one end is fastened the fixed collars 37 to guide the yoke 38. Fixed collar 40 is at one extreme end of the shaft 27 while the other extreme end has threads 65 whereby valve

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26 is screwed to shaft 27 by means of threads tapped into the conical flange 30. The smaller conical flange 28 is fastened to valve 26 by the set screw 66.

In the enlarged detailed views of Figs. 6 and 7 there can be seen the bellows 42 in deflated and inflated positions, respectively. Bellows 42 has one of its end plates 67 attached to the bracket 41 for support and its other end plate 68 rigidly fastened to the shaft 43 whereby any inflation of bellows 42 will move the shaft 43. Within the bellows 42, and attached between the end plates 67 and 68 is a spring 70 to enable the bellows to inflate even though the pressure admitted into the bellows cannot exceed that outside. Also within the bellows 42 is a bellows exhaust valve 71 consisting of telescoping sleeves, or the like, having a fixed sleeve 72 joined at one extremity to the end plate 67, and having a movable sleeve 73 slidable within the fixed sleeve 72. The fixed sleeve 72 has drilled transversely through it a pair of holes 74, while the movable sleeve 73 has a corresponding pair of holes 75, whereby when the bellows 42 is in its fully inflated position, the holes 74 and 75 are in alignment thereby cooperating to form a continuous passageway to the exhaust pipe 53.

The view of Fig. 8 more clearly shows the construction of the bellows exhaust valve 71, and how the transverse holes 74 and 75 line up when in the exhaust position.

In the operation of the present invention some inert gas, such as nitrogen, or the like, is stored under high pressure in the chamber 14 by means of the entrance plate 23, while the fuel compartment 15 is filled, by means of plate 61, with some type of water reactive chemical 51, such as a liquid alloy composed of potassium-sodium, or similar components. It has been found that an alloy of the order of 80% potassium and 20% sodium functions very efficiently. The liquid alloy 51 essentially fills all of compartment 15 except for the uppermost portion so that the level of the fluid does not reach the pipe 21, or the valve 48.

When the device is in its stored condition, previous to being set into operation, the main bellows 42 is maintained in a collapsed state holding the internal spring 70 within the bellows under compression; this being accomplished due to the fact that in this condition the rod 77, attached to pilot bellows 76 extends over the end of shaft 43, thereby effectively locking this shaft into immobility. Thus the pilot bellows 76 and rod 77 function somewhat like a trigger and act to keep the device from operating until desired.

To set the device in operation, the valve 17, which is reached through plate 24, is opened thereby permitting the gas in chamber 14 to pass through pipe 21 into compartment 15 whereby the liquid alloy 51 is put under pressure. As the pressure on the liquid 51 builds up, it causes the pilot bellows 76 to collapse, and in so doing it moves the rod 77 out of engagement with the shaft 43, and once it is clear the main bellows 42 flies open under the influence of compressed spring 70. Located within the bellows container 78, but not shown, there is a latching arrangement whereby once the pilot bellows collapses it is locked in this position, so that the rod 77 remains clear of shaft 43 even though the pressure of the fluid 51 reduces.

Simultaneously with the entrance of gas into compartment 15 a portion of it passes through the regulating valve 48 and intake pipe 47, into the bellows 42, so that the system will continue to function automatically once it has been triggered; the movement of the inflating bellows 42 moving shaft 43, which by means of connecting rod 46 transmits a like movement to yoke 38. Yoke 38 moves along the two shafts 27 until it contacts the collars 37, fixed to the shafts 27, whereby the shafts 27 are likewise moved in their supporting rods 31 and 32 to simultaneously open the two valves 26. When the valves 26 are opened, as is illustrated in the view of Fig. 1, the

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liquid alloy which is under pressure due to the inert gas in chamber 14, immediately starts to flow into explosion chamber 16, and because chamber 16 is already full of water that has entered through the ports 62 located around the chamber 16, the alloy reacts with the water to cause an instantaneous explosion.

The mechanism which operates the valves 26, and which will be more completely described hereinafter functions to close these valves after they have been opened only momentarily, and then after a short pause the valves are again momentarily opened, with the result that the alloy 51 is injected into chamber 16 in a series of short spurts; each spurt causing an explosion. Each explosion generates gas at a high pressure near the forward end of the explosion chamber. This explosion pressure causes the hinged ports 62 to close and accelerates the motion of the water in the after part of the chamber. Simultaneously, there is a forward thrust on the torpedo equal to the time rate of change of the momentum imparted to the water column. The gas in explosion chamber 16 expands until the pressure inside the forward end of the chamber becomes less than the water pressure just outside the ports 62, at which time the ports will then open and water will again start streaming through the chamber acting to flush out the residual gases. After a suitable time interval following the opening of the ports 62, fuel is again injected into chamber 16 and the above cycle is repeated. Thus the steps of admitting water into the forward end of the explosion chamber, and then intermittently and forcibly expelling it at the after end of the chamber imparts to the torpedo a series of thrusts which easily drives it at great speed.

The size and location of the ports 62, the shape of the explosion chamber 16, and the contour of side walls 63 are all keyed to facilitate the free and unrestricted flow of water through the device. After each explosion, with its resulting expulsion of water, it is most important that the explosion chamber 16 be immediately refilled with water so as to not only avoid negative pressures inside the chamber, but also in preparation for the next cycle, and it is for this reason that ports 62 are made large and freely opening and are located in a band encircling the device so that water may enter simultaneously from all sides.

In order that the intermittent injections of fuel into explosion chamber 16 may be properly timed so as to obtain maximum benefit from the thrusts, it is desirable that the valves 26 be opened quickly, remain open for a short period, and then close quickly, and for this purpose the regulating valve 48 and exhaust valve 54 are made adjustable. Through the regulation of valve 48 the flow of the inert gas entering the bellows 42 is controlled thereby determining the number of cycles per second that valves 26 operate, while on the other hand the flow of exhaust gas from the bellows is determined by valve 54 whereby the optimum time for the valves 26 to remain open is obtained. The number of times the valves 26 open per second is nearly independent of the pressure in chamber 15. It has also been found that even though the open time for the valves 26 increases with decreasing chamber pressure, this combined with decreased rates of flow of the fuel at the lower pressures results in an approximately constant amount of fuel being injected for each cycle.

The spring 58, in cooperation with cam surface 56 and cam follower 57, acts to aid the bellows 42, and its associated linkages, in quickly opening and closing the valves 26. For example, when the bellows starts to inflate, cam follower 57 moves along the left hand portion of cam surface 56 and simultaneously the valves 26 begin to very gradually unseat. However, once the follower 57 has reached the crest of 56, it sharply runs down the slope on the opposite side whereby spring 58 sharply applies a force to snap open the valves 26 the remaining

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distance. The reverse process follows in closing the valves, and after somewhat gradually closing, they are snapped shut due to the added impetus of spring 58. The view of Fig. 1 illustrates the position of cam and cam follower when the valves are fully open.

The procedure of closing the valves 26 is accomplished when the bellows 42 has expanded its full extent and has thereby caused an alignment of the holes 74 and 75 in telescoping sleeves 72 and 73 so as to form an exhaust passage through pipe 53. The gas within bellows 42 immediately begins to flow through pipe 53 and exhaust valve 54 to the outside of the torpedo. As has been mentioned hereinbefore, the adjustment of input valve 48 determines the number of cycles per second that the valves 26 operate, while exhaust valve 54 regulates the time during which valves 26 are open. Under normal adjustment the valve 54 will exhaust the gas from bellows 42 in the order of 10 times as fast as valve 48 permits the gas to enter the bellows, with the result that when the bellows is fully extended and the holes 74 and 75 are in alignment for exhaust, the pressure will decrease in the bellows even though a limited quantity of gas is still entering. As the pressure in the bellows reduces, the greater pressure on the outside of it, due to the pressure of fluid 51, aided by the spring 36, will cause the bellows to deflate, even against the force of spring 70. Meanwhile, the cam follower 57 has been advancing along cam surface 56, and when it passes the crest of 56, the added force of spring 58 causes the valves 26 to quickly close. From then on the cycle repeats automatically.

The small conical flanges 28, situated as part of the valves 26, and located within the explosion chamber 16 serve the purpose of spreading out and diffusing the liquid alloy over a larger area of the explosion chamber when the alloy is injected thereby insuring a more instantaneous explosion.

The function of the baffle plate 59, positioned across the tapered portion of partition 25, is to aid in the flow of fuel 51 so that substantially the entire fuel supply will feed through the valves 26. Without the baffle plate, the inert gas would cause the fuel to flow only until at such time when the fuel level is down to the level of the valves 26, after which the gas would escape through valves 26 without causing any fluid flow there-through. By means of the present arrangement, however, the lower edge of the baffle extends relatively near the bottom of compartment 15 and the fuel is forced between the baffle and the lower portion of partition 25, and thence to the valves 26. Thus the fuel 51 will feed until its level falls to the lower edge of the baffle before any gas escapes, resulting in the utilization of essentially the entire fuel supply.

While the above operation deals with a preferred embodiment of the present invention, it is to be understood the teachings may be applied to the propulsion of surface or underwater vessels as well as to torpedoes. However, in these cases the water entry valves, or ports, could be located at the forward end of the propulsion unit.

From the description and operation of the present invention, it can be clearly seen that there is provided a method and apparatus for driving a torpedo by jet propulsion through a series of short pulses caused by the chemical reaction of a liquid fuel with water. The device has inherent simplicity and consequently lower cost as well as great reliability and ruggedness. Furthermore, it has great speed and range, and its maximum speed is not limited by propeller cavitation.

Obviously many modifications and variations of the present 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.

The invention herein described may be manufactured and used by or for the Government of the United States

for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A reaction propelled device for propulsion through water comprising a first chamber containing an inert gas under pressure, a fuel chamber essentially conical shaped at one end and connecting with said first chamber at the other end, an explosion chamber having an exhaust opening through which water flows, a plurality of inwardly opening ports for the admission of water to said explosion chamber, the conical end of said fuel chamber extending into said explosion chamber and containing a plurality of valves for the admission of fuel into the explosion chamber, a water-reactive chemical partially filling said fuel chamber and under pressure from the inert gas, pressure responsive means for intermittently operating the above-mentioned valves to admit the water-reactive chemical into the explosion chamber, said chemical reacting with the water to cause intermittent explosions, each of the explosions forcibly closing the aforementioned ports and expelling the water through the exhaust opening to propel the device.

2. A reaction propelled device for propulsion through water comprising a first chamber containing an inert gas under pressure, a fuel chamber, an explosion chamber having an exhaust opening through which water flows, interconnecting means to apply said gas pressure to the fuel chamber, a plurality of valves connecting the fuel chamber and explosion chamber, means responsive to said gas pressure for intermittently operating the valves, a water-reactive chemical partially filling said fuel chamber, said gas pressure intermittently forcing the water-reactive chemical into the explosion chamber when the valves are operated thereby causing intermittent explosions, a plurality of ports for admitting water into said explosion chamber, each explosion acting to forcibly close said ports and expel the water through the exhaust opening.

3. The device of claim 2 wherein the means responsive to said gas pressure for operating the valves comprises an expandable bellows having a yoke connected to the valves.

4. A reaction propelling device for propulsion through water comprising a first chamber containing a pressurized

inert gas, a working compartment, a first pressure-responsive means coupling said first chamber and working compartment, an explosion chamber, said working compartment having an essentially conical shaped end projecting into said explosion chamber, valve means responsive to the pressure in the working compartment and operatively coupling said explosion chamber and said working compartment, said explosion chamber being substantially funnel-shaped and tapering away from said working compartment to an opening exposed to the water, said working compartment being partially filled with a water-reactive chemical fuel, a second pressure-responsive means mounted within said working compartment and having an outlet, a resilient pressure-actuated device coupled to said outlet and mechanically connected to said valve means to control the flow of said water-reactive chemical fuel into said explosion chamber.

5. The invention as defined in claim 4 but further characterized by said second pressure-responsive means comprising control means to cause said resilient pressure-actuated device to operate said valve means cyclically to permit said chemical fuel to flow into said explosion chamber, said control means comprising adjusting means to regulate the pressure in said resilient pressure actuated device so as to obtain any predetermined cycle.

6. The invention as defined in claim 5 but further characterized by said resilient pressure-actuated device having an exhaust valve, an exhaust regulating valve means coupled to said exhaust valve, said exhaust regulating valve means having an opening to the water and comprising adjustable means adjustable so as to regulate the duration of the flow of chemical fuel during each cycle of operation of said valve means.

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