Aug. 9, 1955 C. A. GONGWER 2,714,800

GASOLINE AIR-HYDROPULSE

Filed Oct. 28, 1950 3 Sheets-Sheet 1

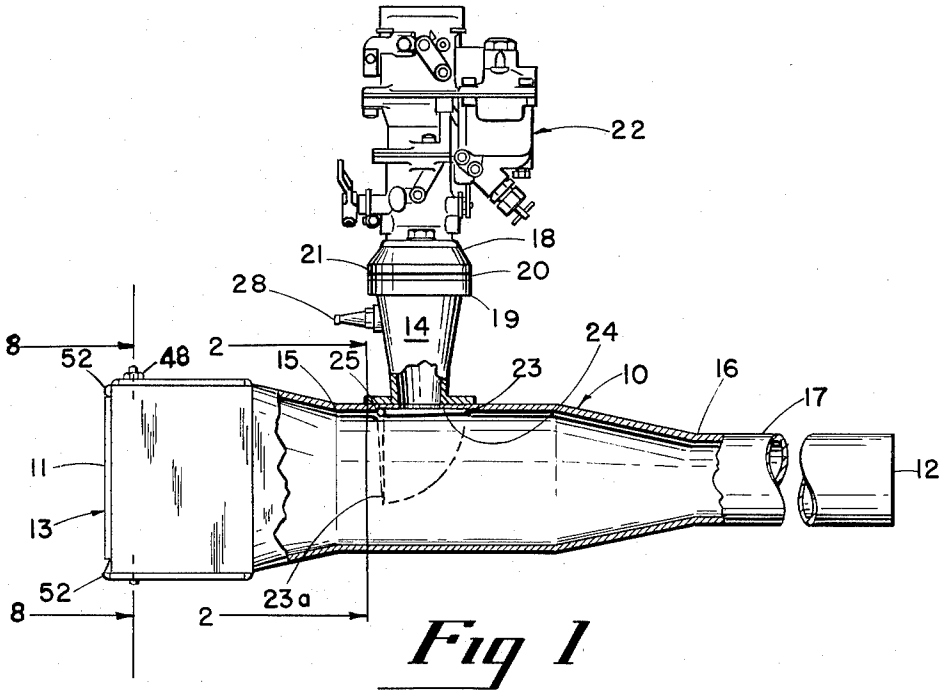


Fig 1

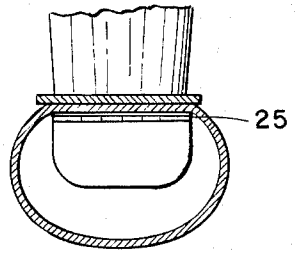


Fig 2

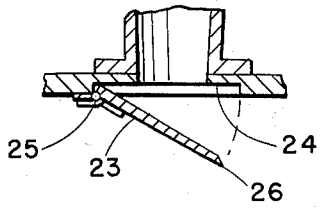


Fig 1a

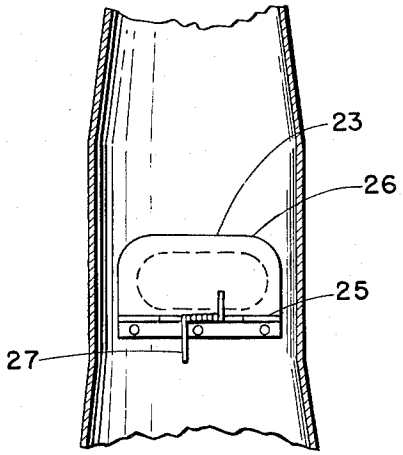


Fig 3

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GASOLINE AIR-HYDROPULSE

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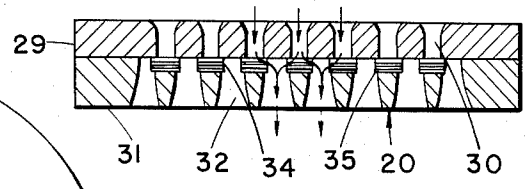


Fig 10

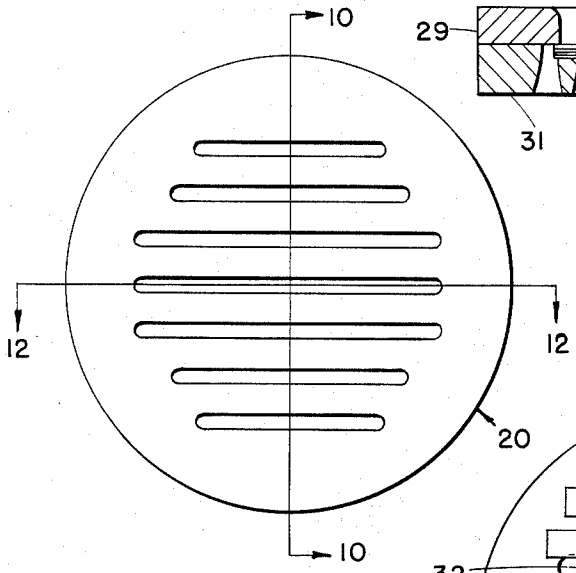
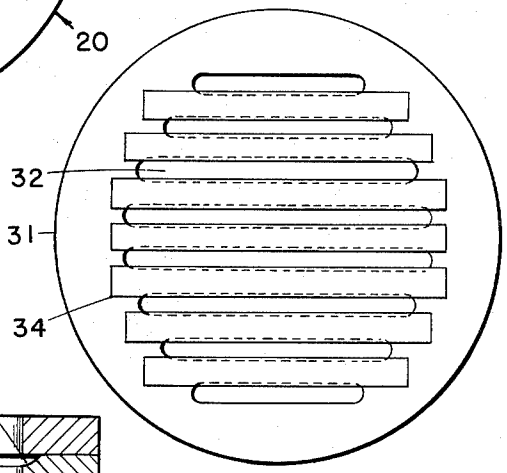


Fig 9



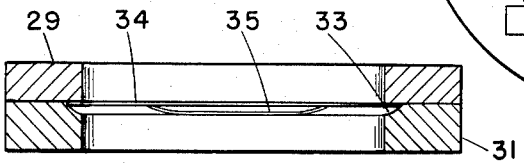


Fig 12

Fig 11

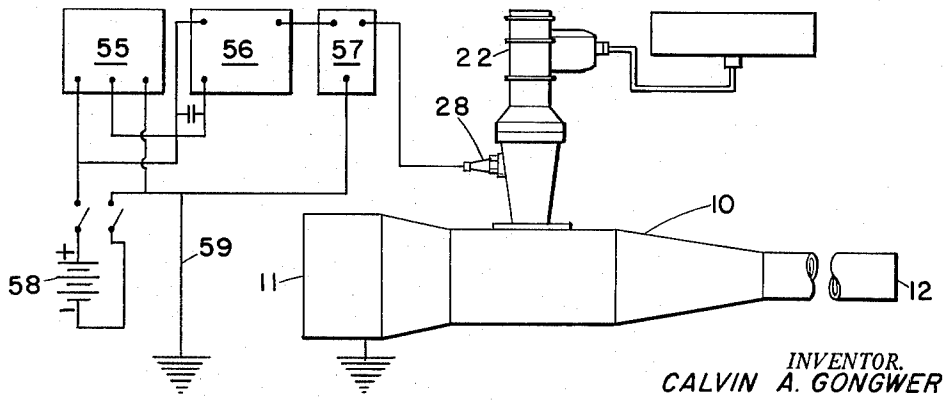


Fig 4

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GASOLINE AIR-HYDROPULSE

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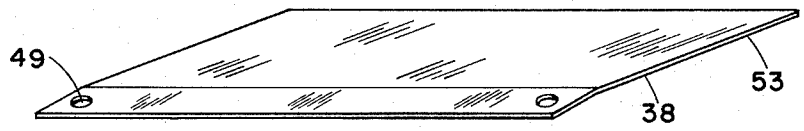


Fig 5

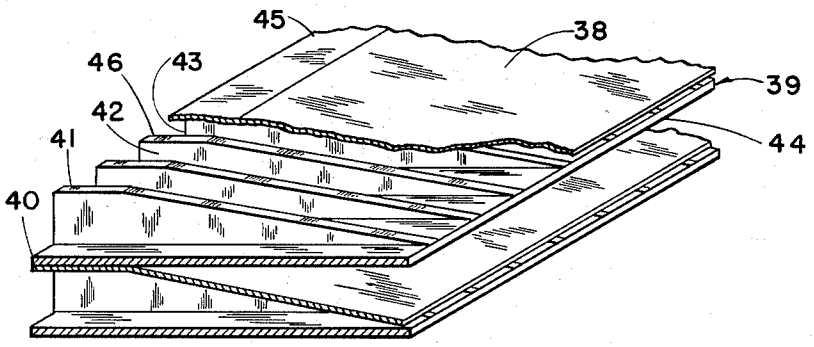


Fig 6

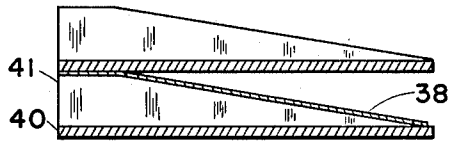


Fig 7

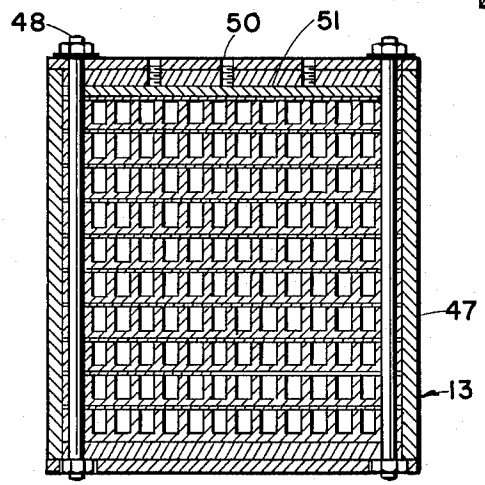


Fig 8

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2,714,800

GASOLINE AIR-HYDROPULSE

Calvin A. Gongwer, Azusa, Calif., assignor, by mesne assignments, to Aerojet-General Corporation, Cincinnati, Ohio, a corporation of Ohio

Application October 28, 1950, Serial No. 192,761

7 Claims. (Cl. 60—35.6)

This invention relates to propulsion of a device through a liquid medium and has for its principal object to provide relatively simple equipment for effectively permitting such a device or craft to operate in water by jet propulsion.

In the copending application of Calvin A. Gongwer et al., Serial No. 737,928, filed March 28, 1947, now Patent No. 2,522,945, dated September 19, 1950, and assigned to the same assignee as the present application, there is disclosed and claimed a jet-propelled device adapted to operate through water, and capable of using an easily obtainable fuel such as a carbureted mixture of gasoline and air. In the arrangement of that application, there is provided a duct with an inlet valve through which the water flows into the duct, and an exhaust opening at the rear through which the water and products of combustion leave the duct. Within the duct there is provided a combustion chamber into which is sent a burning fuel mixture. The gases of combustion escaping under pressure from the combustion chamber force the water on out the exit opening at high velocity to develop the propulsive thrust. In this arrangement, the provision of the combustion chamber, enables gas bubbles effectively to be formed periodically to eject the water.

By my present invention, I provide an arrangement which is an improvement over that disclosed in the said Gongwer application, in that I am able to dispense with the need for the combustion chamber in the duct while at the same time increasing the amount of thrust. I have found that this effective operation can be had by the provision of a movable or a hinged valve or flap located at the outlet of the combustion chamber into the duct. By reason of the fact that the combustion takes place in the combustion chamber substantially before the gases reach the duct, a high pressure is developed in the combustion chamber. The flap serves effectively to separate the gases in the combustion region from the water in the duct during the part of a cycle when there is a low pressure in the combustion region, while allowing free egress of the gases into the duct during the part of the cycle when the gases are under pressure. By this arrangement, the ignition device, ordinarily a spark plug, is never wetted, and the danger of quenching the burning gases by water in the combustion region is avoided.

The flap valve, moreover, also serves to form a good gas-water interface for the expanding gas bubble formed in the duct. By timing the explosions, and hence the entry of gases into the duct, a succession of gas bubbles and water slugs is forced out the exhaust opening with a corresponding intermittent entrance of water into the duct through the inlet valve.

Each explosion of fuel-air mixture produces a bubble of gas under pressure in the duct which closes the inlet valve while pushing the slug of water to the exit opening. The motion of the slug of water in a rearward direction lowers the pressure of the gas bubble behind it to about one-half atmosphere absolute, and hence the

pressure at the inlet valve is lowered sufficiently to cause the valve to open and let in a new slug of water. At the same time, this under-pressure draws a new charge of fuel-air mixture into the combustion chamber from the carburetor. Combustion of this new charge then forces another slug of water rearwardly through the duct, like the preceding slug. The successive accelerations of these masses of water develop the propulsive thrust for the device.

A feature of the flap valve according to this invention resides in its hinged arrangement and rigid construction which enhances the separation of the gases in the combustion region from the water flowing through the duct. A related feature of the valve resides in the provision on the downstream edge of a sharp corner which shears the water as the valve opens and forms a smooth walled cavity providing for the formation of a well-defined gas bubble in the water duct without substantial spray, thus permitting the gases to expand in a more efficient manner against the water while forcing the water through the tail pipe.

A further feature resides in the provision of an expansion chamber immediately adjoining the combustion chamber which has a cross section that resembles an ellipse or circle having a flattened side. This outline is roughly the same as the outline that is assumed by the gas bubble as it expands in the water. This minimizes turbulence and other operating difficulties.

The shape of the duct downstream from this position reverts to the cylindrical form of tail pipe. The bubble substantially fills the casing cross section and effectively displaces the water rearwardly in an orderly manner.

The foregoing and other features of my invention will be better understood from the following drawings and detailed description in which:

Fig. 1 is a longitudinal view partly in cross section showing a jet propulsion device according to this invention;

Fig. 1*a* is an enlarged view of the combustion chamber outlet and flap valve;

Fig. 2 is a cross sectional view taken on the line **2—2** of Fig. 1 showing the shape of the duct adjoining the combustion chamber;

Fig. 3 is an enlarged view showing the manner in which the flap valve covers the combustion chamber outlet;

Fig. 4 is a schematic view showing a motor similar to the one in Fig. 1 using an electrical system for timing the explosions;

Fig. 5 is an isometric view of a valve blade used at the forward end of the device of Fig. 1;

Fig. 6 is a schematic view partially broken and looking down from above to illustrate the manner in which the valve blade covers the valve channel;

Fig. 7 is an end plan view partly in cross-section showing one of the valve blades interleaved between two valve channels;

Fig. 8 is a cross section view of a valve assembly taken on the line **8—8** of Fig. 1;

Fig. 9 is a top plan view showing the complete inlet valve which controls the flow of carburetted mixture from the carburetor to the combustion chamber;

Fig. 10 is a cross section view taken on the line **10—10** of Fig. 9;

Fig. 11 is a plan view of the lower member of the inlet valve assembly; and

Fig. 12 is a cross section view taken on the line **12—12** of Fig. 9 and showing the valve assembly from another angle.

Referring to the drawings the jet motor comprises a duct **10** having an inlet opening or mouth **11** at the front end and an exhaust opening or nozzle **12** located at the

rear end. Within the inlet opening **11** there is located a valve assembly **13**. A combustion chamber **14** is located above the duct at a position downstream from said valve.

At the forward end, where valve **13** is located, a cross section of the duct would be for convenience approximately square or rectangular, as shown in Figs. 1 and 8. Starting at the rear end of the valve, the duct tapers at point **15** to a different cross section and assumes at this point the approximate form of an ellipse or circle flattened on one side forming an expansion chamber. From this shape it gradually undergoes a transition and reduction to a circle until it reaches region **16** at which it is circular. An elongated pipe **17** of approximately the same diameter as **16** extends rearwardly to the exhaust opening **12**. Preferably, the length of the pipe **17** should be approximately five times its diameter.

The fuel mixture is introduced into chamber **14** through a conduit **18**. The upper end of combustion chamber **14** is provided with a flange **19** which attaches to a reed valve assembly **20**. The opposite end **21** of the valve assembly is attached to the conduit **18** covering the fuel air carburetor **22**.

At the place where the combustion chamber enters the duct there is provided a rigid flap valve **23** which rests against a seat **24** in duct **10** and is hinged at its forward end **25**. The valve is thinner at the edges and fits into a recess with a close ground fit as shown in Fig. 1*a*. The flap valve **23** is preferably of metal, since that will provide the desired rigidity, although it will be understood that other material which is similarly rigid and strong enough could be used. Furthermore, the free edge **26** of the flap is made with a sharp lower corner so as to enable it to shear the water cleanly as it moves through it. Thus the smooth surface of the bubble is generated in a manner similar to the smooth surface of a jet flowing over a sharp edged weir. This particular arrangement and construction of the flap valve have been found to be of great importance in improving the efficiency and performance of the device. A spring **27** holds this metal flap seated against the opening from the combustion chamber as long as the pressure within the combustion chamber remains below the pressure existing within the duct. This flap valve is normally closed and prevents the flow of any water into the combustion chamber. In this manner the ignition device **28**, which is ordinarily a spark plug or hot spot, is never wetted by the water and the danger of drowning the ignitor is avoided. Whenever the pressure in the combustion chamber exceeds the pressure within the duct and spring load combined, the flap valve **23** opens. Each time the valve **23** opens it is capable of swinging through a 90° arc, as indicated by the dotted line **23***a* in Fig. 1.

The fuel-air reed valve **20** is preferably of the feather type and consists of two members, an upper member **29**, (Fig. 10) which is provided with a plurality of through slots **30**, and a lower member **31**, which is provided with a plurality of through slots **32**. Slots **32** are positioned to fall between the slots **30** in the upper member **29**. Lower member **31** is also provided with a plurality of grooves **33** (Fig. 12) which do not extend through the member and are positioned to correspond to the slots **30** in the upper member **29**. A plurality of flat reeds **34** are seated in the grooves **33** and are held tightly against the opening **30** when the valve is assembled by a corresponding number of weak back-up springs **35**. This makes the fluid entering the opening **30** of the valve **20** travel in an S-shaped path in order to exist through the openings **32** whenever the reed **34** is not seated against the opening **30** in upper member **29**. This valve arrangement provides a well-distributed influx of fuel-air mixture into the combustion chamber and uniformly displaces the residual burnt gases with a minimum of intermixing. The carburetor **22** may be of any common type, preferably one suitable for use on an internal combustion engine.

A suitable construction of water inlet valve **13**, usually located at the entrance of the duct, is shown in detail in Figs. 5, 6, 7 and 8. The valve is essentially of the reed and plate type and is built up of an assembly of alternating flexible blades **38** and rigid channel members **39**. Each channel member **39** comprises a rectangular plate **40**, the upper surface of which is provided with a series of partition members **41**, which are preferably integral with the plate **40** and are parallel to each other as shown. These partitions **41** form a series of channels **42**, preferably tapering in depth and are deeper at the leading edge **43** and diminish to nothing at the rear end **44** to coincide with the thickness of the rear edge of blade **38**.

In assembling the valve unit **13**, several flexible blades **38** are alternately interleaved between the several channel members **39** and are generally held on the upper surface near their leading edge **45** by the channel plate **40** of the channel member above and on the lower surface by the upper edge **46** of the partitions **41** of the next adjacent channel member.

These valves and channel members are securely held together in a valve housing **47** by bolts **48** which pass through holes **49** provided in both the flexible blade **38** and the rigid channel member **39** as shown in Figs. 5 and 8. The central span of the valve assembly is placed under compression by a series of bolts **50** which bear against plate **51**. Valve **13** is made rectangular for convenience only and may be of any other shape.

When a series of these valves and channel members are assembled in the housing **47** they form the complete valve assembly **13**, and fill the cross sectional entrance to the duct. For purpose of assembly, the valve **13** slides into housing **47** and is bolted in position by the bolts **48**, compression bolts **50** and a pair of retainers **52** which are attached to opposite sides of the duct opening **11**.

Figs. 6 and 7 are views illustrating means by which one of the blades is held between two channel members. Fig. 6 shows a cutaway view looking into the channel **42** and showing its relationship to the valve blade **38**. The arrangement is such that each flexible plate is free to vibrate, the lower face **53** of the blade **38** alternately contacting and moving away from the top edge **45** of partitions **41**. This creates the valve action placing the valve in a closed position whenever the pressure on the downstream side of the valve exceeds that of the upstream side; and placing the valve in an open position, by pushing the blade away from the top of channel partition **41** whenever the downstream pressure becomes less than the upstream pressure.

The timing and firing are controlled by an electrical system which periodically energizes spark plug **28**. Since such systems are well-known, there is no necessity for describing it in detail. A schematic representation of such a system is shown in Fig. 4 and consists of a timing device **55** placed in series with a vibrator **56** and a coil **57**. The timer, vibrator, and coil are located between the spark plug **28** and a source of electrical energy **58** such as, for example, a battery. The timer **55** may be of any suitable type such as a rotary member making one or more contacts during a revolution, such that the voltage across the battery is periodically applied at the terminal of the vibrator when the timer contacts are touching each other. When the vibrator is in series between the voltage source and the coil, a high tension alternating voltage will be developed at the spark plug **28** while the vibrator is vibrating. Both the spark plug **28** and the negative terminal of the battery **59** are grounded to complete the circuit.

Operation of the device takes place in the following manner: When a rearward moving flow of water causes the pressure within the duct and combustion chamber **14** to drop below atmospheric pressure, the flap valve **23** will be opened and at the same time the feather type fuel inlet valve **20** will open allowing air and fuel to flow from the carburetor **22**, filling the combustion chamber

with a combustible mixture in the ordinary manner. This passes through the feather type valve **20**, into the combustion chamber **14**, displacing the residual gases which are in the combustion chamber and substantially fills the chamber **14** with unexploded combustible mixture simultaneously relieving the subatmospheric pressure in chamber **14**. This charge is then ignited and the flap valve **23** is blown open by the force of the explosion, the gases expand in the duct and the bubble of gas formed normally expands substantially to fill the outline of the duct. At this portion the reduction of pressure within the duct **10** simultaneously causes water to be drawn through the valve **13** in much the same manner as the fuel-air mixture is drawn in through the carburetor, thereby scavenging the duct and refilling it with water from the surrounding medium. When the pressure in chamber **14** rises to approximately atmospheric, the pressure exerted by the spring **27** will close flap valve **23** and the feather valve **20**. The feather valve **20** is designed to permit the reeds to open the ports whenever the pressure within the duct drops slightly below atmospheric pressure.

The flap valve **23** serves to form a water-gas interface for the expanding gas bubbles which are formed in the combustion chamber and discharged into the duct. Bubbles are formed successively which force water slugs out the exhaust opening **12** and thereby permit a corresponding intermittent entry of water into the duct through the inlet valve **13**. Each time that an explosion occurs within the combustion chamber, a bubble of gas under pressure is formed which forces open the lightly loaded valve **23** and permits the gas bubble to act against the water in the duct.

As soon as the pressure within the combustion chamber **14** drops below the pressure exerted by spring **27** against valve **23**, the flap valve closes. The successive acceleration of a number of these water masses develops the necessary thrust to propel the device. When each bubble has expanded to the ambient pressure, the momentum of the water in the tail pipe and the simultaneous cooling effect on the over-extended, cooled bubble causes an under-pressure of approximately one-half an atmosphere to develop in the bubble. This under-pressure opens the valves and draws a new charge of gas-air mixture into the chamber from the carburetor and also draws in fresh water into the main duct replacing the portion of water which has been exhausted through the nozzle.

The foregoing description of the construction and operation of the specific devices disclosed in this application provide a significant improvement in jet propelled devices for operation in water.

The device according to this invention is capable of developing high efficiency and greater thrust than heretofore. Furthermore, the inclusion of the hinge metal flap valve greatly increases the life of the unit, which is simple in construction and operation and requires no large amount of upkeep.

The elliptical or circular with a flattened side outline of the expansion chamber is important in producing high efficiency since this corresponds to the outline assumed by the gas bubble after it has started to expand in the clean cut cavity formed by the knife edged valve after leaving the combustion chamber and entering the expansion chamber. The bubble will, therefore, substantially fill the expansion chamber moving all of the water ahead of it and substantially avoiding turbulence.

The invention is not limited to the particular specific embodiments illustrated and described. These embodiments are for purposes of illustration rather than of limitation; and the invention is not limited except in accordance with the scope of the appended claims.

I claim:

1. A jet propulsion device adapted for operation through water, comprising a duct having an inlet opening and an exhaust opening, an automatic pressure-operable inlet valve located within the duct for intermittently passing water entering the duct through the inlet opening in a downstream direction only, a fuel-air mixing carburetor having an outlet leading into a combustion chamber, an opening in the wall of the duct between said combustion chamber and the duct, a recess in the inner wall of the duct adjacent said opening in the wall, a flap valve positioned at the last-mentioned opening and being hinged to the wall of the duct at the upstream end of the flap valve so that the downstream part of the flap valve moves into the duct when the valve opens, said flap valve when closed lying in continuity with the inside wall of the duct recess, and being capable of opening and admitting the products of combustion into the duct when the pressure within the chamber is greater than the pressure in the duct, and closing to prevent water from entering said combustion chamber from the duct when the pressure within the chamber is lower than the pressure within said duct, firing means located within said combustion chamber for igniting said fuel-air mixture, said duct constituting an expansion chamber in the region adjoining said flap valve, the energizing of said firing means causing pressurized gases to escape through the said flap valve into the said expansion chamber and forcing the mass of water within the duct towards the exhaust opening.

2. A jet propulsion device according to claim 1 in which the expansion chamber portion of the duct immediately adjoining the flap valve is substantially elliptical in shape having one side thereof flattened.

3. A jet propulsion device according to claim 1 in which the expansion chamber portion of the duct immediately adjoining the flap valve is substantially circular in shape having one side thereof flattened.

4. A jet propulsion device according to claim 3 in which the flap valve is rigid.

5. A jet propulsion device according to claim 4 in which the unhinged edge of said flap valve has a sharp edged corner, thereby hinging the flap valve to shear the water cleanly when it opens into the duct.

6. A jet propulsion device adapted for operation through water, comprising a duct having an inlet opening and an exhaust opening, an automatic pressure-operable inlet valve located within the duct for intermittently passing water entering the duct through the inlet opening in a downstream direction only, a fuel-air mixing carburetor having an outlet leading into a combustion chamber, an opening in the wall of the duct between said combustion chamber and the duct, a recess in the inner wall of the duct adjacent said opening in the wall, a flap valve positioned at the opening in the wall and being hinged to the wall of the duct at the upstream end of the flap valve so that the downstream part of the flap valve moves into the duct when the valve opens, said flap valve when closed lying in continuity with the inside wall of the duct and seated within said recess, and being capable of opening and admitting the products of combustion into the duct when the pressure within the chamber is greater than the pressure in the duct, and closing to prevent water from entering said combustion chamber from the duct when the pressure within the chamber is lower than the pressure within said duct, firing means located within said combustion chamber for igniting said fuel-air mixture, said duct constituting an expansion chamber in the region adjoining said flap valve, said expansion chamber being substantially circular in shape and having one side thereof flattened, the energizing of said firing means causing pressurized gases to escape through the said flap valve into the said expansion chamber and forcing the mass of water within the duct towards the exhaust opening.

7. A jet propulsion device adapted for operation through water, comprising a duct having an inlet opening and an exhaust opening, an automatic pressure-operable in-

let valve located within the duct for intermittently passing water entering the duct through the inlet opening in a downstream direction only, a fuel-air mixing carburetor having an outlet leading into a combustion chamber, an opening in the wall of the duct between said combustion chamber and the duct, a recess in the inner wall of the duct adjacent said opening in the wall, a flap valve positioned at the opening in the wall and being hinged to the wall of the duct at the upstream end of the flap valve so that the downstream part of the flap valve moves into the duct when the valve opens, said flap valve when closed lying in continuity with the inside wall of the duct and seated within said recess, and being capable of opening and admitting the products of combustion into the duct when the pressure within the chamber is greater than the pressure in the duct, and closing to prevent water from entering said combustion chamber from the duct when the pressure within the chamber is lower than the

pressure within said duct, firing means located within said combustion chamber for igniting said fuel-air mixture, the energizing of said firing means causing pressurized gases to escape through the said flap valve into the said duct and forcing the mass of water within the duct towards the exhaust opening.

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