Oct. 27, 1964 R. A. McKINNON 3,154,041

MONOPROPELLANT REACTION MOTOR HAVING PERFORATED WALL PROPELLANT CONTAINER

Filed April 22, 1960 2 Sheets-Sheet 1

Fig. 1

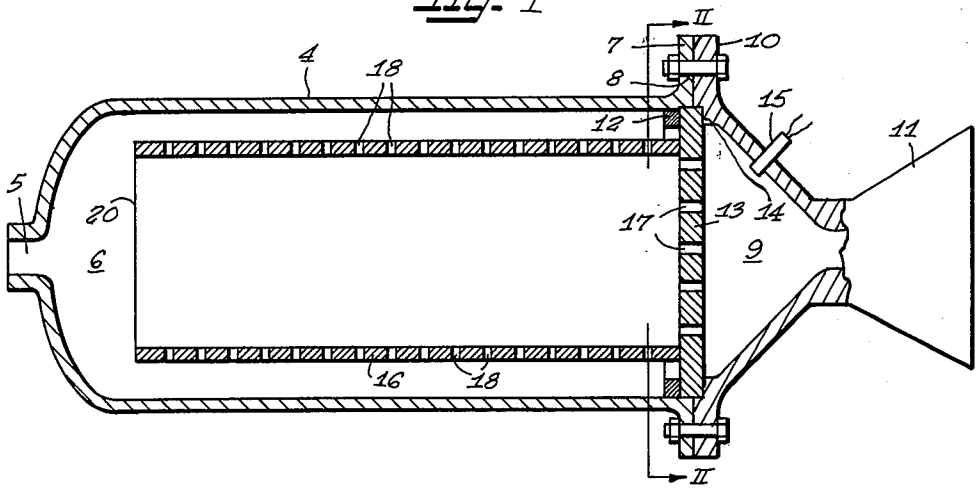
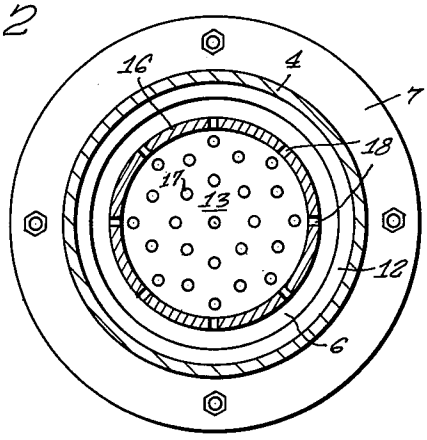


Fig. 2



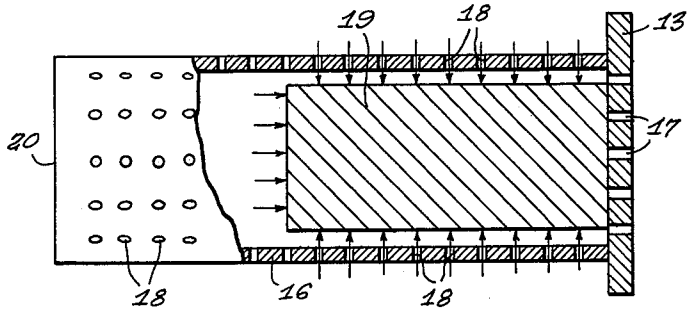


Fig. 3

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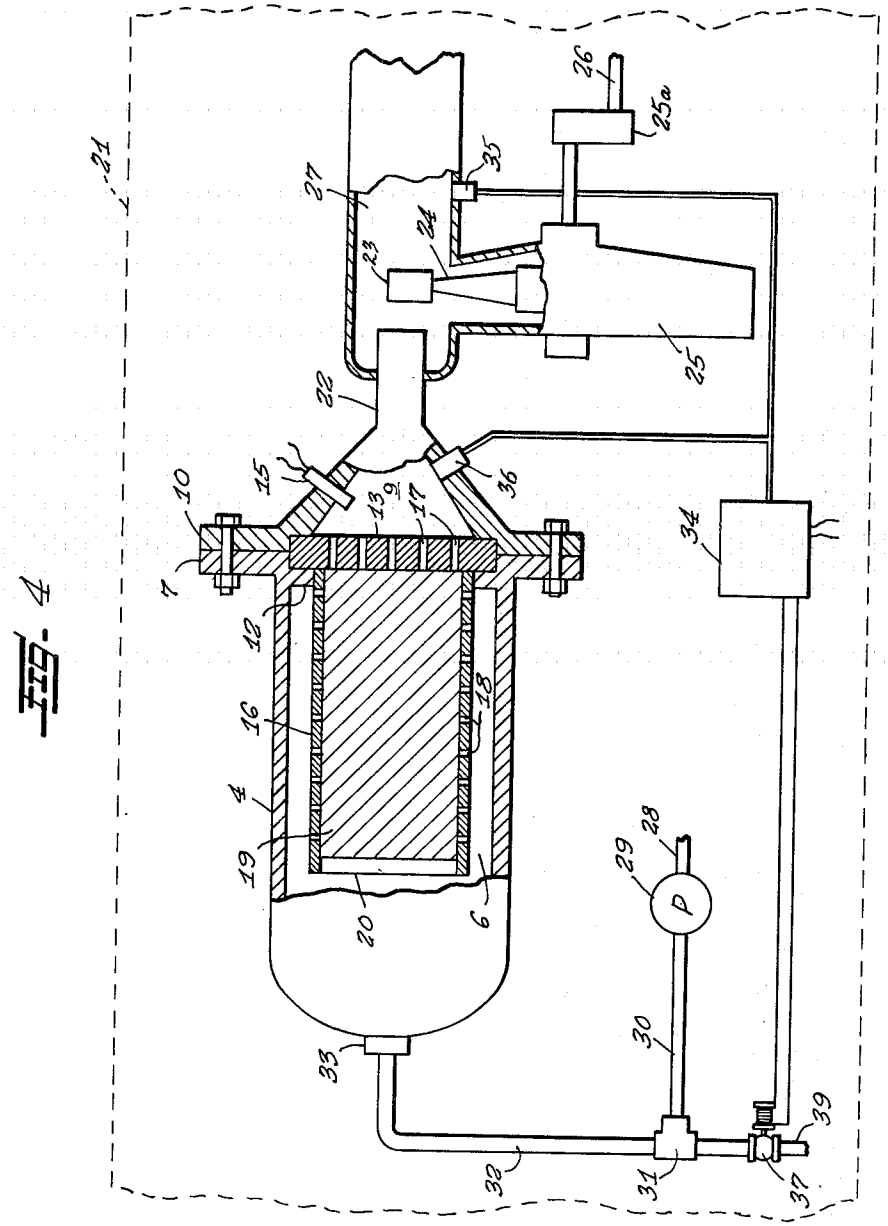


FIG. 4

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MONOPROPELLANT REACTION MOTOR HAVING PERFORATED WALL PROPELLANT CONTAINER

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This invention relates to reaction motors and is more particularly concerned with new and improved methods and means of producing thrust for rockets, guided missiles, torpedoes and the like.

It has been customary in the art to utilize liquid or solid propellants in reaction motors for generating the high energy gases which provide the thrust necessary for operation of torpedoes and to place and maintain an air or spaceborne vehicle in flight.

The design of propulsion systems employing such propellants was simplified to some extent by the fact that the materials from which propellant containers were constructed could be preformed and rigid. Furthermore, the fuel and oxidizer components of liquid propellants were readily pumped or fed under pressure to the combustion chamber, and no feed problems are associated with solid propellants.

Gel and thixotropic compositions have been recently developed for use as monopropellants in similar applications which combine the more desirable features of both liquid and solid propellants. For example, because of their plastic flow characteristics, these monopropellants may be treated as liquid propellants for pressurization purposes and, because of their cohesive properties, may be treated as solid propellants for handling, storage and transportation purposes.

However, these gel and thixotropic monopropellants present container design problems not found in solid propellant technology.

Heretofore, the light weight airborne containers employed for these monopropellants were normally constructed of flexible, plastic and heat resistant materials in bag-like form. The application of pressure to the bag-like container caused progressive collapsing of the container. The monopropellants were extruded through a flat-plate propellant flow splitter into the combustion chamber to thereafter be ignited. It will be appreciated that the application of this indirect pressurization method caused translation of the flexible container and resultant design problems within the container.

The area of most immediate application of the porous container of the present invention is in torpedoes where it would serve as an alternate to a piston-fed system. The piston feeding mechanism has inherent problems with piston cocking and scraping the adhesive propellant from the walls. Because indirect pressurization of the monopropellant resulted in non-uniform application of pressure forces on the container, portions of the monopropellant would adhere to the container walls, resulting in pressure differentials affecting desired thrust performance.

By employment of my invention wherein a preformed, rigid and peripherally apertured propellant container opened at both ends is positioned in the propellant chamber whereby the monopropellant may be directly pressurized and fed through a flat-plate flow splitter into the combustion chamber, I eliminate the requirement for flexible bag-like containers and/or piston feeding mechanisms, prevent adhesion of the gel and thixotropic monopropellants to the container walls and permit direct pressurization of the monopropellant for supply thereof to the combustion chamber.

It is therefore an object of the present invention to provide rockets, guided missiles, torpedoes and the like with monopropellant reaction motors having the advantages of both liquid and solid propellants in preformed and rigid propellant containers.

It is another object of the present invention to provide monopropellant gas generators for rockets, guided missiles, torpedoes and the like with propellant chambers which permit direct pressurization of the propellant.

It is still another object of the present invention to eliminate the requirement for flexible and collapsible bag-like thixotropic monopropellant containers.

A further object of this invention is to permit direct pressurization of gel-like monopropellants in the propellant chamber of reaction motors.

A still further object of this invention is to provide means for preventing adhesion of gel-like monopropellants to propellant container walls.

Another object of the present invention is to provide pre-formed and rigid containers for gel-like thixotropic monopropellants.

Still another object of the present invention is to provide a pre-formed and rigid container for gel-like thixotropic monopropellants having a plurality of peripheral apertures formed therein for permitting direct pressurization of the propellant and for preventing adhesion of the propellant to the container walls.

A further object of the present invention is to provide a gel-like monopropellant reaction motor for torpedo applications.

A further object of this invention is to provide a method of direct pressurization of gel-like propellants into a combustion chamber.

It is a further object of the present invention to provide gel-like monopropellant containers simple and compact in construction, and efficient in operation.

These and other objects, features and advantages of the present invention will become apparent upon a careful consideration of the following detailed description, when taken in conjunction with the accompanying drawings illustrating preferred embodiments of the concepts of my invention, wherein like reference characters refer to like or corresponding parts throughout the several views.

FIGURE 1 is a view in longitudinal section illustrating a preferred embodiment constructed in accordance with my invention.

FIGURE 2 is a view in cross-section taken along lines II—II of FIGURE 1.

FIGURE 3 is a view in longitudinal sectional illustrating the action of direct pressurizing forces on the monopropellant in the container of FIGURE 1.

FIGURE 4 is a view in partial elevation illustrating the device of FIGURE 1 operating as a torpedo gas drive generator.

Referring to FIGURE 1, a reaction motor propellant housing **4** of generally cylindrical construction has a closed end provided with an inlet **5** for permitting flow of pressurizing fluid, such as gas or liquid, into the propellant chamber **6** defined thereby. At its opposite open end chamber **6** is provided with an external out-turned flange **7** having peripheral mounting bores **8** to secure the propellant chamber in assembled relation with the combustion chamber **9** by a complementary out-turned and similarly apertured flange **10**. Conventional securing means, such as bolts, screws, rivets, etc. may be used to assemble the propellant chamber and combustion chamber. The combustion chamber may be provided with the usual outwardly flaring discharge nozzle **11** or, as appears in FIGURE 4, may be adapted for discharging gases produced therein against the blades of a turbine.

Inwardly of its open flanged end, the propellant chamber 4 has an annular internal flange 12 which provides a shoulder for a cylindrical flow splitter 13 which is flat in cross-section and has formed therein a plurality of concentric annularly spaced apertures 17 (FIGURE 2) to permit flow of propellant therethrough into the combustion chamber 9. Combustion chamber 9 has an annular recess 14 to hold the flow splitter 13 securely against the flange 12. Ignition means 15 of conventional construction, such as a spark plug or squib, are positioned in the combustion chamber wall to initiate and maintain combustion of the propellant.

A cylindrical and porous propellant container 16 may be mounted on the flow splitter 13 as by brazing, welding, etc. and is positioned in the propellant chamber to permit communication between the injection apertures 17 formed in the flow splitter and the interior of the container. The container may be constructed of suitable material such as bronze, stainless steel, a reinforced wire cloth having controlled permeability, etc. The container is provided with a sufficient number of a plurality of annular circumferential apertures 18 to permit pressurizing fluid flow therethrough whereby the gel-like monopropellant in the container will be urged away from the walls during operation to obtain optimum thrust performance. The opposite end 20 of the container is open to permit uniform application of pressure against the entire end surface area of the propellant to thereby force the propellant through the flow splitter and into the combustion chamber.

The pressure inlet 5 is adapted for attachment to a pressure flow line leading to a pressurization fluid source (not shown).

The monopropellant 19 should possess certain requisite physical characteristics. For example, it should be sufficiently cohesive to retain its shape for an appreciable length of time when extruded. Preferably also, its cohesive strength should be sufficiently high to withstand fragmentation under the given conditions in the combustion chamber. The degree of cohesive strength desired is determined, to some extent, by the particular stress forces developed in a particular use and the particular burning conditions involved as, for example, the unsupported length of the extruding, burning mass. Since cohesive strength is closely related to the tensile strength of the material, the mono-propellant material should preferably have a minimum tensile strength of about 0.01 lb./sq. in., preferably about 0.03 p.s.i. or higher, to obtain the desired shape-retentivity.

The monopropellant should be extrudable at ambient temperatures, namely, should be capable of continuous flow, preferably under relatively moderate pressure differentials. In general, it is desirable to employ a material which flows at a maximum shear stress of about 10 p.s.i. at the wall of the tube or orifice to which it is being extruded.

Substantially any monopropellant composition having the requisite physical characteristics, as for example, gelled liquid monopropellants such as hydrazine nitrate, nitromethane, or ethylene oxide containing a suitable gelling agent may be employed.

Double-base propellant compositions including nitrocellulose gelatinized with nitroglycerin with, or without, an inert, non-volatile plasticizer such as triacetin, diethyl phthalate, dibutyl phthalate or dibutyl sebacate, to reduce impact sensitivity, in proportions producing a soft gel having the requisite shape retentiveness and flow characteristics are suitable for use.

In general, gel compositions comprising about 3% to 25% nitrocellulose dissolved in nitrogylcerin, desirably diluted with at least about 10%, preferably at least 20 to 30% by weight, based on total liquid, of an inert plasticizer solvent to reduce sensitivity, possess the requisite physical characteristics. Such soft gel compositions also have the advantage of being admixable with finely divided

insoluble solid oxidizers such as the ammonium, sodium and potassium perchlorates and nitrates, to provide for combustion of the inert plasticizer, while retaining the desired shape-retentative extrudible characteristics.

Other highly active propellant liquids, such as pentaerythritol trinitrate, 1,2,4-butanetriol trinitrate, and diethylene-glycol dinitrate, which normally are too sensitive for use as mobile liquid monopropellants, can also be gelatinized with nitrocellulose, with or without inert plasticizer diluents and with or without finely divided solid insoluble oxidizers, to provide monopropellants of substantially higher density than presently usable mobile liquid monopropellants.

The monopropellants may be any composition, preferably a soft gel, possessing the characteristics of non-Newtonian liquids, namely, yielding to flow only under a finite stress. Such monopropellants are usually comprised of a liquid oxidizable fuel which is preferably high boiling, substantially non-volatile and free flowing at ordinary temperatures and which is substantially inert or insensitive to shock or impact. For special applications, the inert fuel component may be mixed with another liquid fuel containing releasable oxygen such as nitroglycerin, and diethylene glycol dinitrate.

The inert liquid is preferably an inorganic liquid which, in addition to carbon and hydrogen, may contain other elements such as oxygen, hydrogen, sulphur, phosphorous or silicon and which meets the aforedescribed requirements in terms of the desired physical and chemical properties. Such liquid fuels include hydrocarbons, e.g., triethyl benzene, dodecane and the like; compounds containing some oxygen linked to a carbon atom, such as the esters, e.g., dimethyl maleate, dibutyl oxalate, etc.; alcohols, e.g. benzyl alcohol, diethylene glycol, triethylene glycol, etc.; ethers, e.g., methyl o-naphthyl ether; ketones, e.g., benzyl methyl ketone, isophorone; etc., acids, e.g., caproic acid, N-heptylic acid, etc., aldehydes, e.g., cinnamaldehyde; nitrogen-containing organic compounds such as amines, e.g., N-ethylphenylamine, tri-n-butylamine, etc.; phosphorous-containing compounds e.g., triethyl phosphate; sulphur containing compounds, e.g., diethyl sulfate; viscous liquid polymers, such as polyisobutylene and many others.

The solid oxidizer may be any suitable, active oxidizing agent which yields oxygen readily for combustion of the fuel mixture and which is insoluble in the liquid fuel. Suitable oxidizers include the inorganic oxidizing salts, such as ammonium, sodium, potassium and lithium perchlorates or nitrates, and methyl peroxides such as barium peroxide. The solid oxidizer should be in finely divided form, preferably with a maximum particle size of about 300 to 600 microns, to insure stable, uniform dispersion of the oxidizer despite the storage, although somewhat larger particles can be maintained in gelled compositions without separation.

The amount of liquid fuel employed in the composition is critical only insofar as an adequate amount must be present to provide a continuous matrix in which the solid phase is dispersed. This, of course, will vary with the particular solids involved, and their shape and degree of subdivision may be readily determined by routine test formulation. The minimum amount of liquid required generally is about 8%, usually about 10% by weight.

Beyond the requsite minimum, any desired proportion of liquid fuel to dispersed solid oxidizer may be employed, depending on the desired combustion characteristics, particularly since the desired cohesive, shape-retentive properties may be obtained by employment of additives such as gelling agents.

Where the requisite cohesiveness and plasticity are obtained by proper size distribution of the finely divided solid oxidizer, without the addition of a gelling agent, the amount of solid oxidizer incorporated should be sufficient to provide the consistency essential for shape-retentiveness. This, of course, will vary with the particular liquid

fuel vehicle employed, the particular solid oxidizer used and its size distribution and may be readily determined by routine testing.

The agents employed to form gels with any particular liquid fuel must possess the desired dispersion stability, cohesiveness, shape retentiveness and flow characteristics desired. Examples of compatible gelling agents include natural and synthetic polymers such as polyvinyl chloride; polyvinyl acetate; cellulose esters, e.g., cellulose acetate and cellulose acetate butyrate; cellulose ethers, e.g., ethyl cellulose and carboxymethyl cellulose; metal salts of higher fatty acids such as the sodium, magnesium and aluminum stearates, palmitates and the like; salts of napthenic acid; casein; karaya gum; gelatin; bentonite clays and amine-treated bentonite clays; etc. I prefer to utilize organic gelling agents because of their characteristic ability to serve as fuel. The amount of gelling agent employed is largely determined by the particular liquid fuel, the particular gelling agent, the amount of dispersed solid oxidizer, and the specific physical and chemical properties desired.

Finely divided solid metal powders, such as aluminum, magnesium, zirconium, boron, beryllium, titanium, silicon, or the like, may be incorporated in the monopropellant compositions as an additional fuel component along with the liquids used for the purposes of increasing the density of the fuel and improving the specific impulse of the monopropellant by acting as flame propagators. These metal particles should preferably be within a size range of from 0.25 to 50 microns and the amounts of such metals added to the fuel is not critical if above a certain minimum (13 percent aluminum for example) but is determined largely by the specific use and the requisite physical characteristics of the composition as aforedescribed. For example, the metal powders should not be incorporated in the matrix in such large amounts as to cause textural granulation of the matrix. Experience indicated that the maximum amount of metal powders which may be introduced into the matrix while still maintaining the desired physical characteristics of the composition and an adequate amount of solid oxidizer is about 45% by weight, and depends upon the density of the metal and its chemical valence or oxidant requirement for combustion.

Thixotropic, plastic, shape-retentive compositions having the desired characteristics may be prepared by incorporating sufficient finely divided solid, insoluble oxidizer into the liquid fuel to make an extrudable mass, the particles of which are so distributed that the minimum ratio of size of the largest to the smallest is about 2:1 and preferably about 10:1. At least 90% of the oxidizer particles by weight should preferably have a minimum size of about 300 microns and above this percentage a small proportion by weight of oversize particles up to about 600 microns may be tolerated.

A thixotropic, monopropellant having the foregoing characteristics is indicated generally by the reference character 19 in the drawings.

In operation, a fluid under pressure will be introduced from a pressure supply source into the chamber 6 through pressure inlet 5. It will be appreciated that when the desired pressure operating level has been reached, pressure forces are acting uniformly on the open end surface of the propllant to thereby extrude the propellant through the flow splitter 13. Simultaneously, pressure forces are acting through the plurality of apertures formed around the periphery of the propellant container and thereby uniformly urge the propellant away from the walls of the container towards the longitudinal axis of the propellant mass, as shown in FIGURE 3.

Thus direct pressurization means employing a preformed and rigid propellant container are provided for positively overcoming the disadvantageous characteristics of the propellant to adhere to the container walls, while the propellant is extruding through the flow splitter into the combustion chamber.

As appears in FIGURE 4, a reaction motor constructed in accordance with my invention may be employed as the prime mover for turbine driven torpedoes. Those parts corresponding to like or identical parts in FIGURE 1 have been marked with the same reference numeral.

The reaction motor is appropriately mounted in the torpedo 21 and the combustion chamber outlet communicates with an elongated cylinder 22 for discharging the gases of combustion against the blades 23 of a turbine 24 appropriately mounted in turbine housing 25 for driving auxiliary components of the torpedo or reduction gearing 25a which drives propeller shaft 26. The gases are then discharged through a conduit or pipe 27 by a suitable pumping system to a discharge point at the rear of the torpedo from which the gases may be discharged to aid in propulsion.

A suitable medium for direct pressurization of the gel or thixotropic monopropellant and one conveniently available is sea water. The sea water may be drawn into the pressurization system through a conduit 28 by conventional pump means 29 from which the water flows through a conduit 30 connected as by a T fitting 31 to conduit 32 which supplies the sea water to chamber 6. Conduit 32 may be suitably connected to propellant chamber inlet 5 by a suitable fitting 33.

It will be appreciated that the turbine 23 operates at optimum efficiency when a fixed pressure ratio exists thereacross. However, the turbine back pressure will vary with the depth of the torpedo and consequently means must be provided to maintain this fixed ratio at variable torpedo depths. Preferably I employ a pressure switch 34 to maintain the desired turbine operating pressure ratio. A conventional pressure sensor 35 is positioned downstream of the turbine to feed back turbine back pressure to the control device 34, and, I similarly provide a pressure sensor 36 to "feed back" turbine inlet pressure to the control device 34. If turbine inlet and outlet pressures are equal, the control device 34 is in an inoperative position and no signal is fed to the bleed valve 37 which may be a conventional solenoid valve controlling flow out bypass conduit 39. If a difference exists between turbine inlet and back pressure, either greater or less than the desired fixed ratio, the control device is energized to open or close the valve and thereby increase or decrease the pressure forces acting in the propellant chamber.

For example if the guidance system (not shown) of the torpedo causes a rise of the torpedo to a higher level in the water, the turbine back pressure decreases as a function of torpedo rise. Accordingly as the back pressure decreases, the ratio of inlet to back pressure increases above the desired ratio. This difference is fed through the pressure sensors to the control device 34 and an error signal is sent to the solenoid bleed valve to open the valve thereby bypassing water through conduit 39 and therefore less pressurizing water is fed to the propellant chamber. Thus less propellant is forced into the combustion chamber through the fuel splitter. The lesser propellant flow rate therefore will automatically produce less gas pressure and, for a constant volume combustion chamber, a resultant lower chamber or turbine inlet presusre. Thus the ratio of the lower inlet pressure to the lower back pressure is controlled to approach the desired fixed pressure ratio across the turbine.

On the other hand if the torpedo is guided in the opposite direction to a lower level in the water, the above pressure variation is reversed and the bleed valve will be closed by the control means to permit greater pressurizing fluid flow into the propellant chamber.

Thus the pressurizing sea water is pumped into the propellant chamber and the monopropellant fuel is extruded through the fuel splitter into the combustion cham-

ber where it is ignited and the resulting gases discharged into the turbine chamber to drive the turbine and propeller. As long as the fixed predetermined pressure ratio exists across the turbine, the pressure in the propellant chamber will be substantially constant. However, once a pressure difference other than the desired pressure exists between the turbine inlet and back pressures the control means 34 will cause opening or closing of the bleed valve thereby regulating the amount of sea water permitted entry into the propellant chamber. It will be seen, therefore, that means are provided to maintain the turbine inlet and back pressures at a predetermined level, thus assuring proper thrust performance and operation of the turbine at variable torpedo depths.

Thus the stationary, preformed and rigid propellant container is directly pressurized by sea water to prevent adhesion of the propellant to the walls of the container thereby assuring positive thrust performance in the combustion chamber.

Although various minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim:

1. A pressurizable gel monopropellant gas generator feed device comprising: a peripherally apertured monopropellant container opened at one end, a closure means mounted at the other end, and said closure means provided with a plurality of extrusion apertures communicating with the interior of said monopropellant container.

2. A pressurizable gel monopropellant gas generator feed device comprisng: a peripherally porous monopropellant container opened at one end, a plate mounted at the other end of said container, and said plate provided with a plurality of extrusion apertures communicating with the interior of said monopropellant container.

3. A pressurizable gel monopropellant gas generator feed device comprising: a peripherally apertured cylinder open at one end, a plate mounted at the other end and provided with a plurality of extrusion apertures communicating with the interior of said cylinder.

4. A pressurizable gel monopropellant gas generator feed device comprising: a peripherally apertured cylindrical monopropellant container having two open ends and an apertured plate closing one of said ends, the apertures of said plate registering with the interior of said monopropellant cylinder.

5. In a gel monopropellant reaction motor including a combustion chamber, means for igniting a monopropellant in said combustion chamber and a gas discharge outlet in communication with said combustion chamber, a device for supplying gel monopropellant to said combustion chamber comprising: a peripherally apertured monopropellant container open at one end and mounting at the other end an extrusion plate provided with a plurality of apertures communicating with the interior of said container and said combustion chamber.

6. In a gel monopropellant reaction motor including a combustion chamber, means for igniting a monopropellant in said combustion chamber and a gas discharge outlet in communication with said combustion chamber, a device for supplying gel monopropellant to said combustion chamber comprising: a peripherally apertured cylindrical monopropellant container open at one end and mounting at the other end an extrusion plate provided with a plurality of apertures communicating with the interior of said cylinder and with said combustion chamber, whereby pressurizing forces acting on said cylinder feed said monopropellant through said plate apertures while urging said monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to the container.

7. In a gel monopropellant reaction motor including a combustion chamber, means for igniting a monopropellant in said combustion chamber, a gas discharge outlet in communication with said combustion chamber and a pressurizable chamber, a pressurizable device in said pressurizable chamber for supplying gel monopropellant to said combustion chamber comprising: a peripherally apertured cylindrical monopropellant container having two open ends, and an apertured extrusion plate closing one end of said container, the apertures of said plate registering with the interior of said cylinder and wtih said combustion chamber, whereby pressurization of said pressurizable chamber causes pressure forces to act on said monopropellant in said container and to feed said monopropellant through said plate apertures into said combustion chamber while urging said monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls.

8. A gel monopropellant reaction motor comprising a combustion chamber, means for igniting a monopropellant in said combustion chamber, a gas discharge outlet in communication with said combustion chamber, a pressurizable chamber, a peripherally apertured monopropellant container positioned in said pressurizable chamber, said container having two open ends, and apertured means in communication with the interior of said container for extrusion of monopropellant from said container into said combustion chamber, whereby pressurization of said pressurizable chamber causes pressure forces to act on monopropellant in said container to thereby supply said monopropellant through said extrusion means into said combustion chamber while urging said monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls.

9. A gel monopropellant reaction engine comprising: a combustion chamber; means for igniting a monopropellant in said combustion chamber; an outwardly flaring gas discharge nozzle in communication with said combustion chamber; a chamber; a peripherally apertured cylindrical monopropellant container open at one end positioned in said chamber, apertured means for extrusion of monopropellant from said container into said combustion chamber, and means for pressurizing said chamber, whereby pressurization of said chamber causes pressure forces to act on monopropellant in said container to thereby supply said monopropellant through said extrusion means into said combustion chamber while urging said monopropellant from contact with the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls.

10. A gel monopropellant reaction engine comprising: a combustion chamber; means for igniting a monopropellant in said combustion chamber; an outwardly flaring gas discharge nozzle in communication with said combustion chamber; a pressurizable chamber; a peripherally apertured cylindrical container open at one end positioned in said pressurizable chamber; a flow splitter having a plurality of apertures communicating with the interior of said container and said combustion chamber, and means for pressurizing said pressurizable chamber, whereby pressurization of said pressurizable chamber causes pressure forces to act on monopropellant in said container to thereby supply said monopropellant through said flow splitter into said combustion chamber while urging the monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls.

11. The method of supplying a gel monopropellant from a pressurizable chamber through extrusion means into a combustion chamber comprising: placing said gel monopropellant in a preformed container having open ends and a plurality of peripheral apertures; positioning the container in said pressurizable chamber with one of said open ends in registry with said extrusion means, and pressurizing said pressurizable chamber whereby the

monopropellant is supplied through said extrusion means into said combustion chamber while pressure forces acting on said monopropellant through said apertures prevent substantial adhesion of the monopropellant to the walls of the container.

12. The method of supplying a gel monopropellant from a pressurizable chamber through extrusion means into a combustion chamber comprising: positioning in said pressurizable chamber a gel monopropellant-carrying, cylindrical and preformed container having open ends and a plurality of circumferentially spaced apertures, one open end of said container being in registry with said extrusion means, and pressurizing said pressurizable chamber, whereby the monopropellant is supplied through said extrusion means into said combustion chamber while pressure forces acting on said monopropellant through said apertures prevent substantial adhesion of the monopropellant to the walls of the container.

13. In a gel monopropellant propulsion system for turbine driven torpedoes including: a combustion chamber, a torpedo propeller, a turbine connected to drive said torpedo propeller, said combustion chamber having a gas discharge outlet for supplying gas against the blades of the turbine; means for igniting monopropellant in said combustion chamber the improvement comprising: a pressurizable propellant chamber; a peripherally apertured cylindrical container in said pressurizable chamber and having two open ends; an apertured extrusion plate closing one end of said container, the apertures of said plate registering with the interior of said cylindrical container and with said combustion chamber; means for pressurizing said propellant chamber whereby pressure forces acting on monopropellant in said container feeds said monopropellant through said plate apertures into said combustion chamber while urging said monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls, and pressure responsive means for controlling operation of said pressurization means.

14. In a gel monopropellant propulsion system for turbine driven torpedoes including: a combustion chamber, a torpedo propeller, a turbine connected to drive said torpedo propeller, said combustion chamber having a discharge outlet for supplying gas against the blades of the turbine; means for igniting monopropellant in said combustion chamber the improvement comprising; a pressurizable chamber; a pressurizable peripherally apertured container in said pressurizable chamber; apertured means in communication with the interior of said container for extrusion of monopropellant from said container into said combustion chamber; means for pressurizing said propellant chamber whereby pressure forces act on said monopropellant in said container to thereby supply said monopropellant through said extrusion means into said combustion chamber while urging said monopropellant from the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls, and pressure actuatable means operatively responsive for controlling pressurization of said pressurizable chamber.

15. In a gel monopropellant propulsion system for turbine driven torpedoes including the improvement comprising: a combustion chamber, a torpedo propeller, a turbine connected to drive said torpedo propeller, said combustion chamber having a gas discharge outlet for supplying gas against the blades of the turbine adapted for driving the torpedo propeller; means for igniting monopropellant in said combustion chamber the improvement comprising: a pressurizable propellant chamber; a peripherally apertured cylindrical container open at one end positioned in said pressurizable chamber; apertured means for extrusion of monopropellant from said container into said combustion chamber; means for pressurizing said pressurizable chamber with sea water, whereby pressurization of said pressurizable chamber causes pressure forces to act on monopropellant in said container to thereby supply said monopropellant through said extrusion means into said combustion chamber while urging said monopropellant from contact with the walls of said container to thereby prevent substantial adhesion of the monopropellant to said walls, and means for controlling pressurization of said pressurizable chamber including a pair of pressure sensors for sensing turbine chamber inlet and back pressures respectively, said pressure sensor communicating with a pressure responsive device operatively responsive to said pressures for opening and closing a bleed valve adapted to by-pass sea water from said pressurizable chamber.

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