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R. S. MIKSCH

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VAPOR GENERATOR

Filed May 11, 1962

2 Sheets-Sheet 1

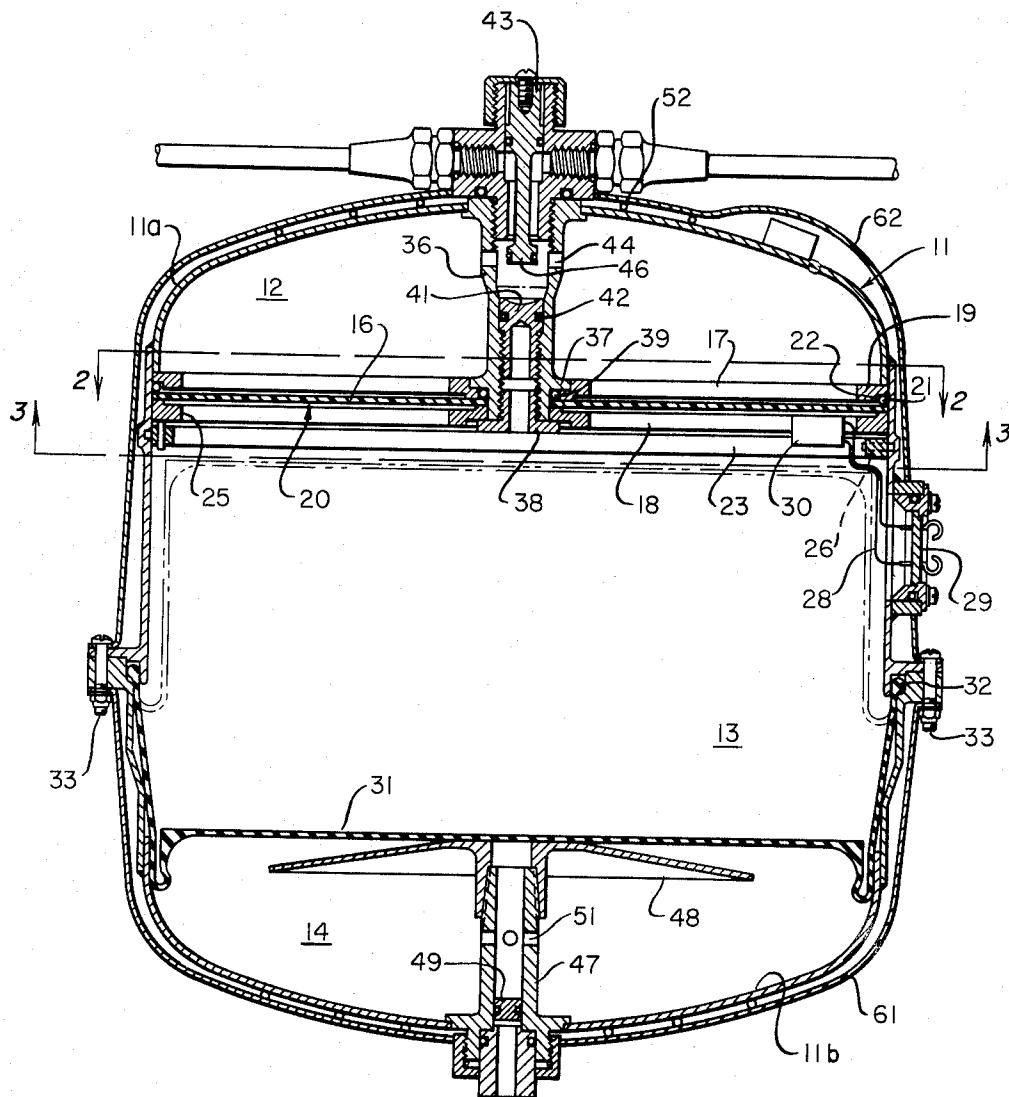


FIG. 1

RUSSELL S. MIKSCH
ROBERT E. CORRIDAN

INVENTORS

BY

BY
Lehr and Swain
 ATTORNEYS

ATTORNEYS

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FIG. 2

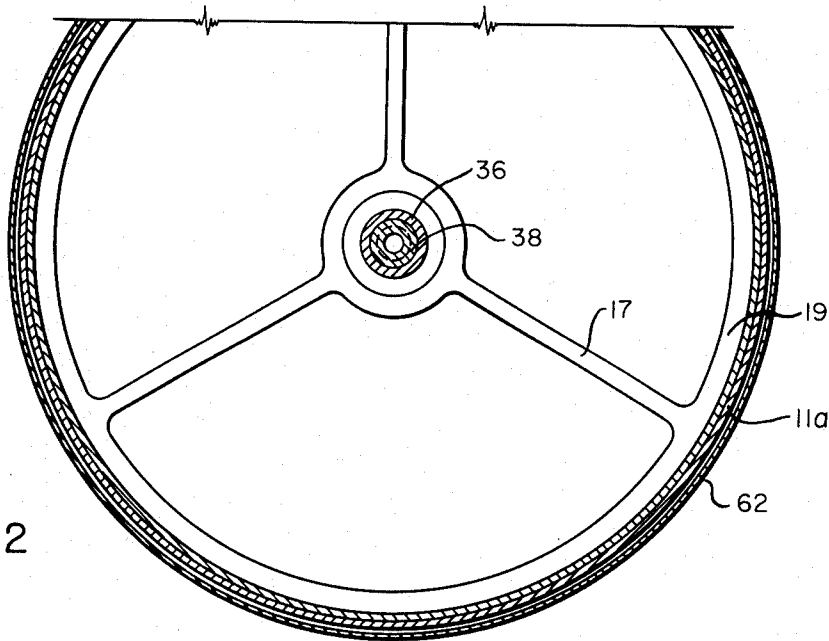
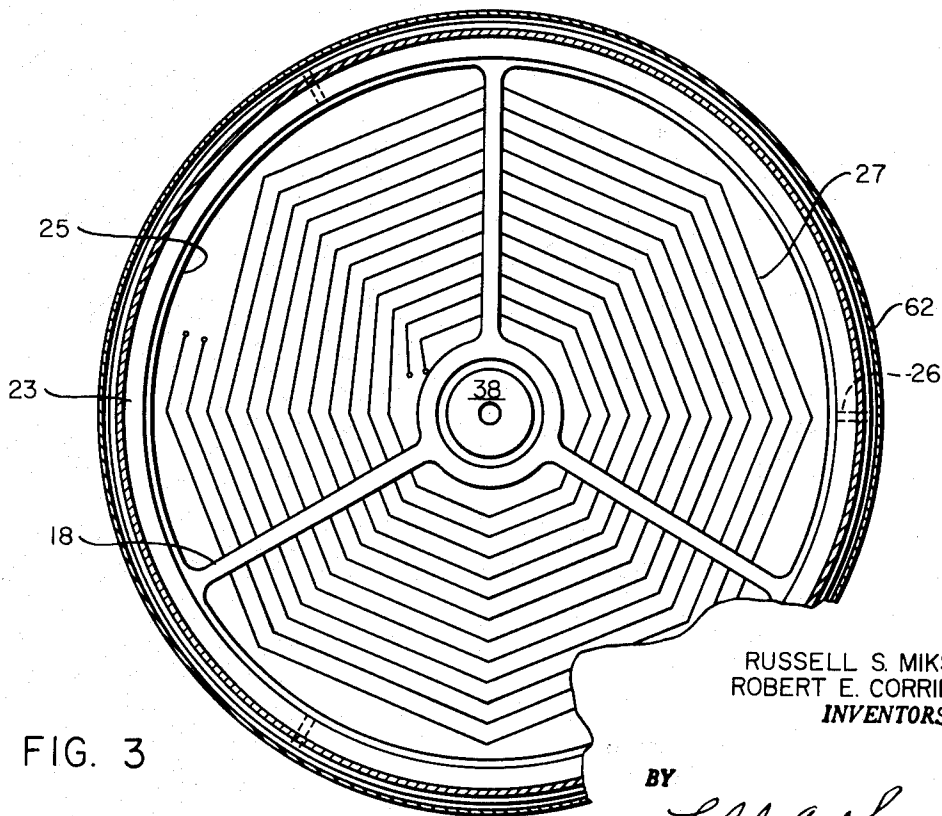


FIG. 3



RUSSELL S. MIKSCH
ROBERT E. CORRIDAN
INVENTORS

BY

Flehr and Swain
ATTORNEYS

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VAPOR GENERATOR

Russell S. Miksch, Redwood City, and Robert E. Corridan, Los Altos, Calif., assignors to American Radiator & Standard Sanitary Corporation, New York, N.Y., a corporation of Delaware

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10 Claims. (Cl. 219-271)

This invention relates generally to a vapor generator and more particularly to a vapor generator suitable for generating vapors for a jet thrust reaction guidance system.

Space vehicle guidance systems are essential for the execution of many projected space missions. Their economic justification often requires a long operational lifetime. Maximum mission performance can be obtained through the avoidance of excessive weight and the employment of components of high reliability for long periods of service. The important objectives of light weight, high reliability and long lifetime are applicable to a guidance system just as for other vehicle components.

The disturbing torques on space vehicles are normally extremely small. However, in the virtual absence of natural restorative forces, the disturbing torques may eventually produce excessive deviations unless suitably counteracted by on-board equipment. If a counteractive jet impulse system is employed, the impulses must equal or exceed disturbing impulses in total magnitude to maintain the desired orientation of the vehicle. Overcorrection may result in excessive fuel and power consumption and thus adversely affect system lifetime or initial weight. The ability to consistently produce appropriately small controlled impulses is, therefore, a major objective in the design and operation of space vehicles.

In jet thrust systems of the prior art, the vapor is usually obtained from high pressure stored gas. This requires undesirably heavy tankage and complex pressure reducing components.

It is a general object of the present invention to provide a light weight, highly reliable long life jet thrust reaction guidance system for space vehicles.

It is another object of the present invention to provide a jet thrust reaction guidance system which employs a two phase liquid vapor system. Where a two phase liquid vapor system is employed, there is a problem of weightlessness in orbital flight. Liquid masses do not gravitate to one region of the containing vessel in preference to another. Further, the vapors do not necessarily move through the liquid to seek a particular free surface. Withdrawal of only the vapor phase from the two phase system requires non-gravitational means for separating the two phases.

Another problem encountered in a two phase system is that heat should be added to the system to maintain constant temperature conditions during vapor withdrawal to prevent the pressure decay that accompanies temperature decrease. A heater immersed in the body of the liquid is soon surrounded by vapor bubbles. Since these do not naturally migrate away from the heater, the heat transfer from the heater to the liquid is considerably reduced by the thermal resistance of the intervening vapor.

It is a further object of the present invention to provide a vapor generator employing a two phase vapor system which employs a nongravitational system for separating the vapor from the liquid.

It is a further object of the present invention to provide a two phase liquid vapor system in which the vapor and liquid are separated by passing the vapor through a semi-permeable member.

It is a further object of the present invention to provide a two phase liquid system employing a semi-permeable

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membrane for separating the vapor and liquid phases together with means for assuring that the liquid is in continuous contact with the membrane whereby vapors are passed through the membrane and are available for utilization.

The foregoing and other objects of the invention will become more clearly apparent from the following description when taken in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is a side elevational view in section of a vapor generator in accordance with the invention;

FIGURE 2 is a sectional view taken along the line 2-2 of FIGURE 1; and

FIGURE 3 is a view taken along the line 3-3 of FIGURE 1.

Generally, the vapor generator of the present invention includes a compartmentalized system including a plenum for the vapor phase and a reservoir for the propellant liquid with a semi-permeable membrane separating the liquid and vapor phase. Means are provided for assuring that the propellant fluid is in continuous pressure contact with the semi-permeable membrane which separates the plenum and the propellant reservoir. Such means may, according to the invention, include a third reservoir which contains a pressurizing liquid having a vapor pressure greater than the vapor pressure of the propellant fluid. One wall of said reservoir serves to drive the propellant fluid against the semi-permeable membrane.

Referring particularly to FIGURE 1, there is shown a vapor generator incorporating the present invention. The generator has a housing 11 formed of two separate members 11a and 11b. The interior of the housing is divided into three compartments: the vapor plenum 12, the propellant fluid reservoir 13, and the pressurizer fluid compartment 14.

The vapor plenum is separated from the propellant fluid reservoir by a semipermeable membrane 16, which serves to separate the vapor phase of the propellant liquid from the liquid phase. The pressure in the plenum is substantially the vapor pressure of the propellant liquid with which it is in contact through the pores of the membrane. The pressure in the reservoir is maintained at a slightly higher value by the pressurizing liquid vapor pressure. The pressure difference between the pressure in the reservoir 13 and the plenum 12 is balanced by the surface tension forces of the propellant liquid in contact with the membrane. The surface tension forces are, in general, fairly weak. Consequently, the membrane pores should be very small and the pressure differences are limited to small differences so as to prevent leakage of liquid through the membrane into the plenum. The membrane material is selected both as to type and porosity for the particular propellant liquid and pressure values being used. The essential characteristic being that the membrane pass the vapors without passing the propellant liquid.

The membrane 16 is held between spaced grid members 17 and 18. The rim 19 of the grid 17 which supports the grid structure has its upper surface in abutment with the adjacent portion of the welded shell. The O-ring seal 21 disposed within the circumferential groove 22 provides a liquid seal whereby liquids cannot leak past the membrane.

A heater 20, to be presently described in detail, is pressed against the lower surface of the membrane by means of grid 18 which includes an outer ring 25. The grid is held by a retainer ring 23. The ring 23 is held in position by spaced pins 26 which engage the walls of the outer housing portion 11a.

The heater comprises a perforated disc, FIGURE 3, which is interwoven with a heater winding 27. Electrical connection is made to the heater winding by the leads 28 which extend through a hermetic header 29 which is sealed into the wall of the housing 11. A thermostat 30 is employed in the electrical circuit to maintain the desired temperature. In applications where waste heat is available, heat conductive heating means may be utilized to transfer heat from the source of waste heat to the propellant fluid. However, temperature control would then be more difficult than with thermostatically controlled electrical heating. Significant pressure fluctuations would be more likely to occur.

The propellant liquid or fluid reservoir is formed by the membrane 16, housing wall 11 and long stroke flexible diaphragm 31 which forms a movable wall for the liquid reservoir. The diaphragm 31 is suitably sealed to the housing by clamping the annular rim 32 between the housing portions 11a and 11b. Clamping pressure may be applied by spaced screws 33. The pressurizing fluid compartment is formed by the housing portion 11b and the flexible diaphragm 31.

The flexible long stroke diaphragm 31 which separates the liquid propellant reservoir from the pressurizing fluid compartment can travel far enough to displace the entire propellant liquid volume assuring that the entire propellant charge can be expended during a complete mission. Due to the great flexibility of the diaphragm, virtually no pressure difference prevails between the liquid propellant reservoir and the pressurizing compartment. The pressure in the pressurizing compartment is the saturated vapor pressure of the pressurizing fluid at the temperature of operation. The pressure can be selected by appropriately selecting the pressurizing fluid. Enough pressurizing fluid should be provided to assure that a two phase liquid vapor condition exists in the pressurizing chamber until all propellant has been expended by driving the diaphragm 31 against the semipermeable membrane 16. By appropriate control of temperature at various locations in the generator, or in instances where some pressure decay can be tolerated during vapor withdrawal, the pressurizing fluid may be of the same composition as the propellant fluid, thereby simplifying the selection of materials.

Means are provided for filling the propellant liquid reservoir. Such means may comprise a filler tube 36 which extends axially downwardly from the housing 11. The lower end is suitably clamped to the grids by the flange 37 and nut 38. The O-ring 39 forms a seal. Threadably received internally of the tube 36 is a plug 41. A suitable O-ring seal 42 provides a seal between the plug 41 and tube 36.

To fill the reservoir, the valve 43 and plug 41 are removed and fluid injected into the propellant reservoir 13. The valve 43 also provides means for sealing off the plenum chamber from the associated jets which communicate through the ports 44 with the plenum. The plenum can be isolated by lifting the valve 43 until the end 46 seals against the tube walls.

Extending upwardly from the lower end of the housing is a filling and purging connection 47 for supplying the pressurization fluid into the pressurizing compartment 14. A diaphragm support 48 may be provided at the upper end of the filling connection. The chamber 14 is filled by withdrawing plug 49 downwardly until the upper end of the plug 49 disengages from the bore of the filling connection 47, leaving the lower seal of plug 49 still engaged.

To purge both the propellant liquid reservoir and the pressurization liquid reservoir of air or other contaminating vapors after charging, vacuum connections are made to the vapor plenum 12 and the pressurizing compartment 14 and a vacuum is drawn until the observed pressure in each compartment corresponds to the vapor pressure of the liquid propellant or pressurization fluid in the respective compartment.

Condensation of vapors on the walls of the plenum or vapor conduit could reduce the efficiency of utilization of the propellant fluid. Controlled resistance heating elements 52 may be attached to the walls of the housing, as shown in FIGURE 1, to maintain the same at or above the condensation temperature.

To prevent heat exchange between the vapor generator and the surrounds, it may be advantageous to shield the entire vapor generator from the surrounds by a highly reflectant radiation shield such as a gold plated shield. A shield of this type is shown at 61 and 62 in FIGURE 1.

A vapor generator in accordance with the foregoing was constructed and operated. The membrane was porous Teflon having a maximum pore size of 10 microns. The membrane was maintained at approximately 120° F. by the heating element. The propellant was water. At the above temperature, the vapor pressure of the propellant was approximately 1.7 p.s.i.a. The pressurization liquid was propyl acetate which has a vapor pressure of 2.05 p.s.i.a. at the foregoing temperature. The flexible diaphragm 31 was formed of butylrubber.

It is apparent that other types of propellants having the desired vapor pressure, low latent heat of vaporization, absence of toxicity and minimum corrosive effect can be found. Preferably, the liquid should have high values of specific impulse, surface tension, specific gravity and specific heat. An increase in specific impulse permits a reduction in total propellant weight to satisfy a given impulse requirement. Reduction in the heat of vaporization decreases the power needed for vaporization of liquid to continuously maintain a constant thrust level and thereby reduces the weight of necessary related equipment.

We claim:

1. A vapor generator including a liquid reservoir for storing a liquid having a vapor phase, a vapor plenum for storing the vapor phase of said liquid in communication with said liquid reservoir, a semipermeable membrane separating the vapor plenum and the liquid reservoir, said semipermeable membrane serving to pass only the vapor phase of said liquid whereby vapor is transferred into said vapor plenum from said liquid reservoir, and means for continuously urging the liquid in said reservoir against the semipermeable membrane.

2. A vapor generator as in claim 1 wherein there is provided means for heating the liquid contained in said liquid reservoir.

3. A vapor generator including a liquid reservoir for storing a liquid having a vapor phase, a vapor plenum for storing the vapor phase of said liquid in communication with said liquid reservoir, a semipermeable membrane separating the vapor plenum and the liquid reservoir, said semipermeable membrane serving to pass only the vapor phase of said liquid whereby vapor is transferred into said vapor plenum from said liquid reservoir, a portion of the wall of said liquid reservoir being movable to continuously urge the liquid in said reservoir against the semipermeable membrane, and means for moving said wall portion.

4. A vapor generator as in claim 3 including a pressurizing chamber a portion of whose wall is formed by said movable wall portion, and a pressurizing fluid having a predetermined vapor pressure disposed in said pressurizing chamber to thereby urge the movable wall against the liquid in the reservoir.

5. A vapor generator including a liquid reservoir for storing a liquid having a vapor phase of predetermined vapor pressure, a vapor plenum for storing the vapor phase of said liquid, a semipermeable membrane forming a common wall portion for said plenum and said liquid reservoir, said membrane being semipermeable whereby it passes the vapor phase and blocks the liquid phase of said stored liquid, a portion of the wall of said liquid reservoir being movable and forming a portion of the wall of a pressurizing chamber, and a pressurizing liquid disposed in said pressurizing chamber having a vapor and liquid phase, the vapor pressure of said pressurizing liquid

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being greater than said predetermined vapor pressure whereby it urges the movable wall against the liquid in said reservoir to maintain the liquid in said reservoir in contact with the semipermeable membrane.

6. A vapor generator as in claim 5 wherein heating means are disposed in cooperative relationship with the semipermeable membrane to heat the liquid in contact with the membrane.

7. In a vapor generator, a housing, a semipermeable membrane disposed in said housing and cooperating with a first portion of said housing to define a vapor plenum, a propellant fluid reservoir for storing a liquid having a vapor and a liquid phase, said liquid reservoir being defined by a movable wall, a second portion of the housing and the semipermeable membrane, said semipermeable membrane serving to pass the vapor phase of said propellant fluid and block passage of the liquid phase, said movable wall also cooperating with a third housing portion to define a pressurizing chamber for storing a pressurizing fluid having a vapor and a liquid phase, said pres-

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surizing fluid serving to urge the movable wall against the propellant fluid to urge the propellant fluid against the semipermeable membrane.

8. A vapor generator as in claim 7 including means for heating at least the portion of said housing which defines in part said plenum.

9. A vapor generator as in claim 8 in which a radiation shield is disposed about said housing.

10. A vapor generator as in claim 7 including heating means disposed in said propellant fluid reservoir in cooperative relationship with said semipermeable membrane.

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20 ANTHONY BARTIS, *Examiner*.