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PRESSURE VESSEL

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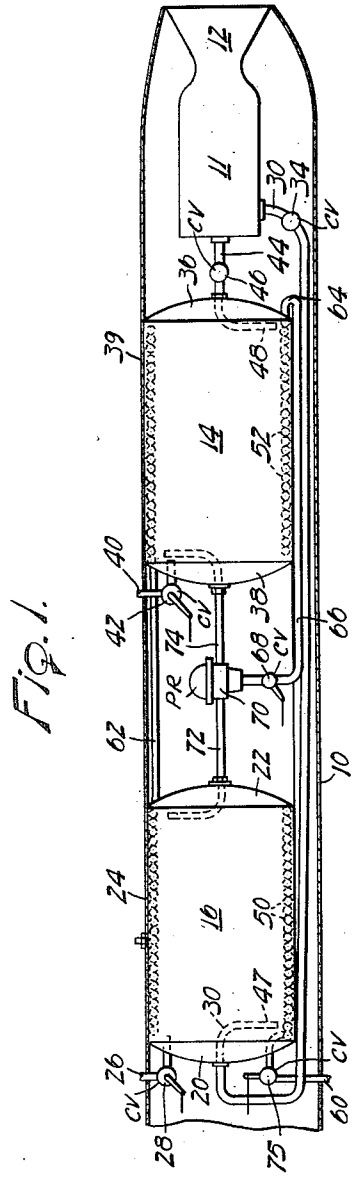


Fig. 1.

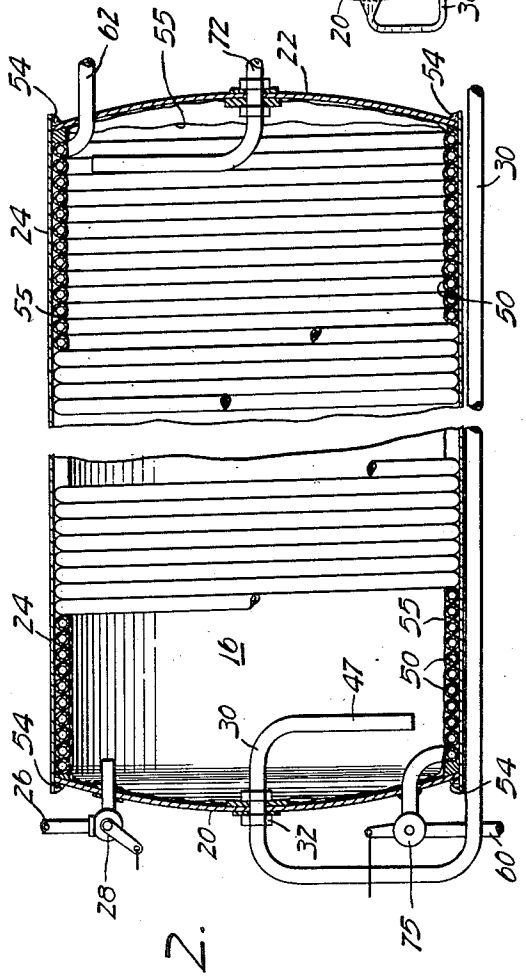


Fig. 2.

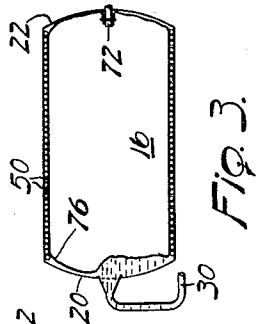


Fig. 3.

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PRESSURE VESSEL

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8 Claims. (Cl. 158—36.5)

This invention relates to high speed reaction motor propelled craft, and more particularly to improvements in propellent storage means and arrangements for supplying the propellents to the motor means thereof.

One of the objects of the invention is to provide an improved propellent storage and motor supply system in reaction motor propelled craft of high speed type.

Another object of the invention is to provide an improved high pressure liquid storage vessel such as is particularly suited to use in certain aircraft.

Another object of the invention is to provide in a reaction motor propelled craft an improved combination craft structure and high pressure storage means.

Other objects of the invention will become apparent in the following description when considered with the accompanying drawing, in which:

Fig. 1 is a fragmentary schematic longitudinal sectional view of a craft embodying the invention;

Fig. 2 is a fragmentary longitudinal section through one portion of the liquid storage and control means of the structure of Fig. 1 on a larger scale; and

Fig. 3 is a diagrammatic illustration, on a reduced scale, of a modified propellent control arrangement thereof.

As illustrated in the drawing at Fig. 1, the invention may be embodied in a high speed craft comprising an externally streamlined body **10** for minimum aerodynamic drag; the body enclosing a jet reaction motor **11** arranged to discharge through a nozzle or tail pipe **12**. The motor supply system is shown in Fig. 1 to comprise a fuel tank **14** for containing, for example, a supply of alcohol to be employed as fuel for the motor; and a tank **16** to contain, for example, a supply of liquid oxygen to be employed as the alcohol oxidizing agent when the two materials are mixed together and ignited in the combustion chamber portion of the motor **11**.

As is understood in the rocket motored craft art, the fuel and oxidizer materials may be initially stored within tanks such as indicated generally at **14—15** and arranged to be fed therefrom to the motor apparatus by permitting a supply of pressurized nitrogen or other inert gas such as for example helium or the like, to enter the supply tanks for displacing the fuel and oxidizer contents thereof and forcing them to flow into the motor combustion chamber. It is also appreciated that in high speed craft especially of the airborne types, space and weight considerations are of prime importance; and that therefore any appreciable reduction in the space and weight requirements of the structure including the fuel and oxidizer and pressured gas supply tanks is of great importance.

In the case of the present invention the container means for the pressured nitrogen or the like is provided mainly in the form of series connected tubular reservoirs which are coiled to form the cylindrical wall portions of the fuel and oxidizer tanks **14—16**. Also, a suitable conduit system is provided for leading the pressured nitrogen to travel through a novel heat exchange path arrangement relative to the contents of the fuel and oxidizer supply tanks prior to being discharged into the tanks for displacing the fuel-oxidizer contents thereof. For example, more specifically as shown in Fig. 2, the oxidizer supply tank **16** comprises circular dlished end plates **20—22** welded to opposite ends of a relatively thin cylindrical wall sheet **24** for resisting the end bursting loads. A liquid oxygen inlet conduit **26** is fitted upon one of the tank end plates and includes a valve **28** for control of the tank loading operation. An oxygen outlet conduit **30** is also arranged in communication with the interior of

the tank **16** and is mounted upon the end plate **20** by means of a fitting **32**, and then leads to the mixing chamber portion of the motor **11**. A control valve **34** is arranged in the conduit **30** as illustrated in Fig. 1 to control delivery of oxygen to the motor. Similarly, the alcohol or other fuel tank **14** comprises end plates **36—38** which are welded to opposite ends of a thin cylindrical wall sheet **39**; and a fuel inlet conduit **40** carrying a control valve **42** is arranged for loading the fuel tank from externally of the craft, while a discharge conduit **44** carrying a control valve **46** is arranged to convey the fuel to the motor **11**. Preferably, as shown in the drawing, the propellent delivery conduits **30—44** will be formed with pick-up end portions **47—48**, respectively, interiorly of the tanks to permit only minimum dilution of the combustion producing substances with the replacement nitrogen, as will be explained more fully hereinafter.

As shown in greater detail in Fig. 2, the primary wall structure of the pressurized nitrogen container means of the system comprises a coiled tubular section designated **50** which consists of a tubular conduit helically wound in contiguously related convolutions, the coil being dimensioned according to the volumetric capacity requirements of the tank **16**. Similarly, the fuel tank **14** includes a helically coiled tube section **52** which comprises the main cylinder wall portion of the tank **14**. Thus, the coiled tube sections **50—52** are each enclosed peripherally by external fairing in the form of the cylinder walls **24—39** which are welded to the ends of the tanks as indicated at **54**, so that the coiled sections and the cylinder walls structurally cooperate to resist all of the pressure forces from within the tanks. For example, when the tanks are pressure loaded as will be explained hereinafter, the forces tending to expand the cylinder walls radially are resisted primarily by tension loadings of the coiled tubing, while the cylindrically bent wall sheets by virtue of their longitudinal strength support the end walls against relative displacement and also resist the torsional loads due to an unwinding tendency of the coils such as would otherwise permit unwinding of the coils and consequent expansion of the coil diameter dimensions in response to radially directed expansion loads thereon; thereby permitting an optimum weight-to-strength design of the overall wall structures of the tanks. In this respect it will be appreciated that the coiled tube sections provide the primary resistance to the forces tending to expand the tanks radially and are backed up by the cylindrical wall sheets **24—39**. As illustrated at **55** in Fig. 2, a gas sealing membrane of relatively thin sheet material is provided to line the interior of the coiled tubing sections so as to insure against gas escape through crevices between the tube convolutions.

It is a particular feature of the present invention that the pressured nitrogen containing elements thereof are designed to provide complete displacements of fuel and oxidant from their respective reservoirs through use of a reduced quantity of pressured nitrogen. This is accomplished by connecting the nitrogen supply inlet conduit **60** into the left hand end portion of the coiled tube **50** as shown in the drawings, while connecting the coils **50—52** of the tanks **14—16** in series as by means of an intercommunicating conduit **62** leading from the right hand end portion of the coil **50** and into the left hand end portion of the coil **52**. As indicated at **64** (Fig. 1) the right hand end of the coil **52** then connects into a return conduit **66** which leads through a control valve **68** into a pressure regulator **70**. The regulator **70** is provided with a pair of outlets connecting to conduits **72—74** leading through the tank end plates and into the interiors of the tanks **16—14**, respectively. A loading control valve **75** is shown in the line of the nitrogen supply conduit **60**.

Thus, it will be appreciated that the apparatus of the invention may be loaded by pumping alcohol or other fuel through the valve **42** into the tank **14** while the valve **46** is closed; and by pumping liquid oxygen or other oxidizer material through the valve **28** into the tank **16** while the valve **34** is kept closed. The nitrogen supply may then be let in through the valve **75** under great pressure so as to fill the coils **50—52** and the conduits **62—66** while the valve **68** is maintained closed. The craft is then ready for operation, and the motor **11** may be set into

operation by opening the valves 68—34—46. The pressure regulator 70 will of course be preselected and adjusted so as to deliver nitrogen through the conduits 72—74 at the prescribed pressures throughout the operational range, and it will be understood that the nitrogen will thus be permitted to enter the tanks 14—16 so as to gradually displace the fuel and oxidizer contents thereof into the motor combustion chamber.

As explained hereinabove, it is a particular feature of the arrangement of the present invention that the nitrogen flows through the coil 52 just prior to its delivery through the pressure reducer into the tanks 14—16. Therefore, although the portion of the nitrogen supply which is initially stored in the coil 50 of the liquid oxygen tank 16 becomes excessively cooled because of its heat contact relation with the oxygen, it is subsequently guided to flow helically through the coil 52 which is in heat exchange contact relation with the relatively warmer contents of the fuel tank 14, and thereby becomes heated. This increases the volumetric displacement capacity of the stored nitrogen, and correspondingly greatly reduces the volumetric dimensions requirements of the nitrogen storage coils.

As shown in Fig. 3, the propellent tanks may be furnished with suitable expansible bladders as indicated at 76, so as to avoid commingling of the propellents and the displacement gas as the latter is released to force the propellents out of the tanks and into the motor. Although only one application of the invention has been illustrated and described in detail herein, it will be apparent to those skilled in the art that the invention is not so limited but that various changes may be made therein without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a propellant storage and supply system, a first storage cylinder carrying a propellant substance of low temperature, a second storage cylinder carrying a propellant substance of higher temperature, discharge conduits leading separately from said cylinders to deliver the contents thereof to the point of use, and a compressed gas system comprising a pair of gas storage means each in the form of a coiled tube section constituting the primary structural portions of the cylinder walls of said first and second cylinders, said coiled tube sections being interconnected in series and having a gas delivery conduit connected thereto at one end of said second cylinder and leading therefrom to deliver the gas into the interiors of both of said cylinders, means lining said coiled tube sections to prevent fluid leakage outwardly between the coil convolutions thereof, and valve means controlling the flow of gas from said system into said cylinders, whereby upon release of the gas to flow into said cylinders for displacing the propellants therefrom the gas moves through the tube section of said second cylinder just prior to its passage into said cylinders.

2. In a propellant storage and supply system, a first cylindrically shaped tank carrying a propellant substance of low temperature, a second cylindrically shaped tank carrying a propellant substance of higher temperature, discharge conduits leading separately from said tanks to deliver the contents thereof to the point of use, and a compressed gas system comprising gas storage means of coiled tube form having first and second sections thereof comprising the primary structural portions of the cylinder walls of said first and second tanks, said coiled tube sections being connected in series and having a gas delivery conduit connected thereto at one end of said second tank and leading therefrom to deliver said gas into the interiors of both of said tanks, and valve means controlling the flow of gas from said system into said tanks, whereby upon release of gas to flow into said tanks for displacing the propellants therefrom the gas moves through the tube section of said second tank just prior to its passage into said tanks.

3. In a propellant storage and supply system, a first storage cylinder carrying a propellant substance of low temperature, a second storage cylinder carrying a propellant substance of higher temperature, discharge conduits leading separately from said cylinders to deliver the contents thereof to the point of use, and a compressed gas system comprising a pair of gas storage means each in the form of a coiled tube section constituting the primary structural portions of the cylinder walls of said first and second cylinders, said coiled tube sections being interconnected in series and having a gas delivery conduit connected thereto at one end of said second cylinder and leading therefrom through a pressure regulator to deliver the gas into the interiors of both of said cylinders, means lining each of said coiled tube sections to prevent fluid leakage outwardly through the coil convolutions thereof, and valve means controlling the flow of propellants from said cylinders and of gas from said system into said cylinders, whereby upon release of the gas to flow into said cylinders for displacing the propellants therefrom the gas moves through the tube section of said second cylinder just prior to its passage into said cylinders while the propellants are displaced and fed to the point of use.

4. In a propellant storage and supply system, a first cylindrically shaped tank carrying a propellant substance of low temperature, a second cylindrically shaped tank carrying a propellant substance of higher temperature, discharge conduits leading separately from said tanks to deliver the contents thereof to the point of use, and a compressed gas system comprising gas storage means of coiled tube form having first and second sections thereof comprising the primary structural portions of the cylinder walls of said first and second tanks, said coiled tube sections being connected in series and having a gas delivery conduit connected thereto at one end of said second tank and leading therefrom through a pressure regulator to deliver said gas into the interiors of both of said tanks, and valve means controlling the flow of propellants to said point of use and of gas from said system into said tanks, whereby upon release of gas to flow into said tanks for displacing the propellants therefrom the gas moves through the tube section of said second tank just prior to its passage into said tanks.

5. In a propellant storage and supply system, a first storage cylinder carrying a propellant substance of low temperature, a second storage cylinder carrying a propellant substance of higher temperature, discharge conduits leading separately from said cylinders to deliver the contents thereof to the point of use, and a compressed gas system comprising a pair of gas storage means each in the form of a coiled tube section constituting the primary structural portions of the cylinder walls of said first and second cylinders, a membrane interiorly of each of said coiled tube sections for sealing the latter against leakages between adjacent tube convolutions, a flexible bladder interiorly of each of said cylinders, said coiled tube sections being interconnected in series and having a gas delivery conduit connected thereto at one end of said second cylinder and leading therefrom to deliver the gas into the interiors of both of said bladders, and valve means controlling the flow of gas from said system into said bladders whereby upon release of the gas to flow into said cylinders for displacing the propellants therefrom the gas moves through the tube section of said second cylinder just prior to its passage into said bladders.

6. In a propellant storage and supply system, a first cylindrically shaped tank carrying a propellant substance of low temperature, a second cylindrically shaped tank carrying a propellant substance of higher temperature, discharge conduits leading separately from said tanks to deliver the contents thereof to the point of use, and a compressed gas system comprising gas storage means of coiled tube form having first and second sections thereof comprising the primary structural portions of the cylinder walls of said first and second tanks, said coiled tube sections being connected in series and having a gas delivery conduit connected thereto at one end of said second tank and leading therefrom to deliver said gas through pressure regulating means into the interiors of both of said tanks, a fluid sealing member lining each of said coiled tube sections to prevent leakages through spaces between coil convolutions of said sections, a streamlined shell member enclosing each of said coiled tube sections, and valve means controlling the flow of gas from said system into said tanks whereby upon release of gas to flow into said tanks for displacing the propellants therefrom the gas moves through the tube section of said second tank just prior to its passage into said tanks.

7. In combination, a pressure storage tank of cylindrical form and a higher pressure gas storage system, said system including a coil of helically wound tubular structure formed to comprise the primary cylinder wall structure of said tank, a membrane fitted interiorly of said tubular structure to seal the latter against leakage through

the spaces between the convolutions of said coil, said tank structure also including end wall members and an outer cylindrical shell, said shell being fixed to said end wall members whereby the end thrust loads on said tank are taken by said shell and the radial expansion loads are taken by said coil and the unwinding tendency of said coil is resisted by said shell.

8. In combination, a pressure storage tank of cylindrical form and a higher pressure gas storage system for displacing the contents of said tank, said system including a coiled tubular member formed to comprise the primary cylinder wall structure of said tank as well as the primary storage space for the gas, means sealing the tubular member against leakage through spaces between adjacent coil convolutions, said tank structure also including end wall plates and a cylindrical shell disposed outside of said tubular member, said shell being fixed to said end wall plates whereby the end thrust loads on said tank are taken by said shell and radial loads are taken by said coiled tubular member.

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