NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

June 30, 1971

MEMORANDUM

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,170,295

Corporate Source : North American Aviation

Supplementary Corporate Source :

NASA Patent Case No.: XNP-00650

Please note that this patent covers an invention made by an employee of a NASA contractor. Pursuant to §305(a) of the NAS Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of. . . ."

Gayle Parker

Enclosure:
Copy of Patent

FACILITY FORM 602

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Feb. 23, 1965 HUGH L. DRYDEN 3,170,295

DEPUTY ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPELLANT TANK PRESSURIZATION SYSTEM

Filed April 9, 1963

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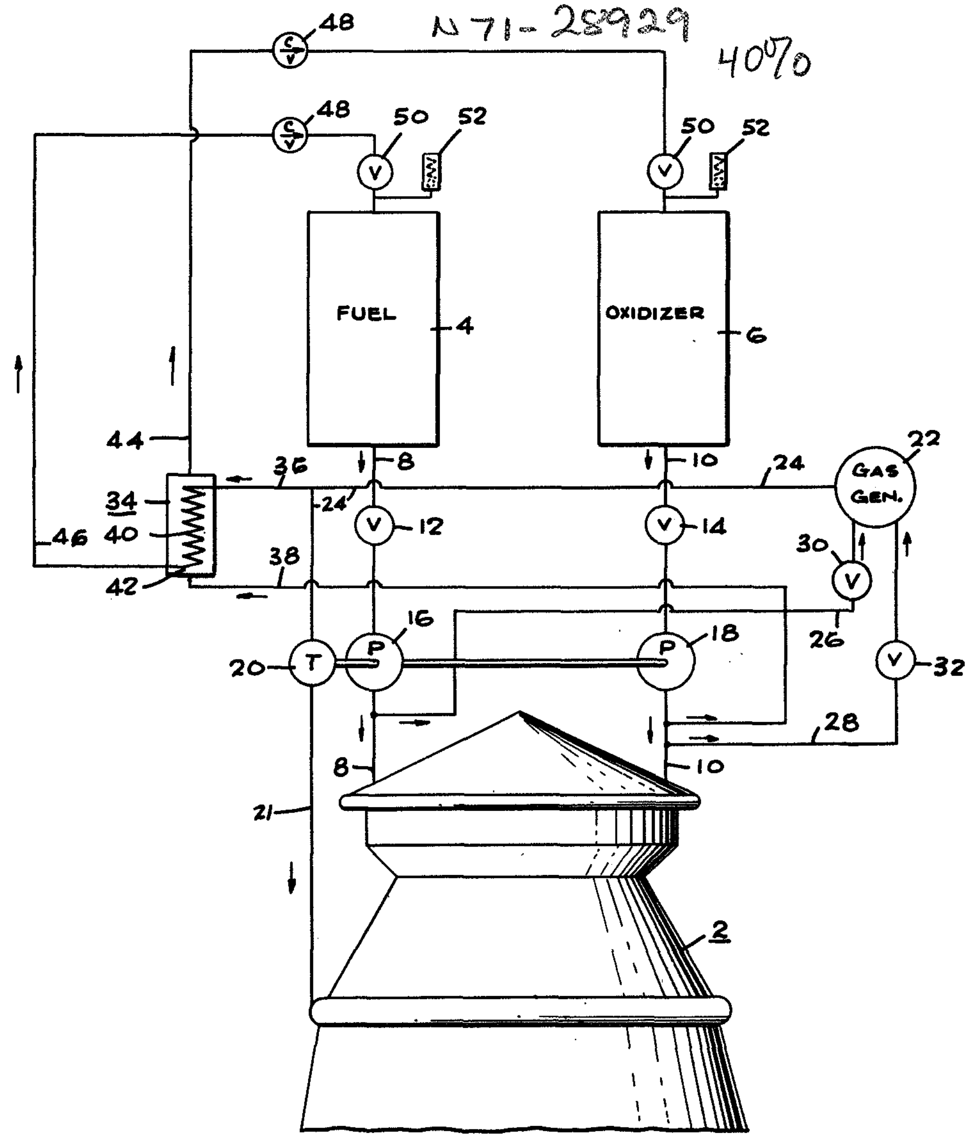

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1779

United States Patent Office

3,170,295
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3,170,295
PROPELLANT TANK PRESSURIZATION SYSTEM

Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration, with respect to an invention of Marshall A. Appel and Donald F. Weitzel

Filed Apr. 9, 1963, Ser. No. 271,823
6 Claims. (Cl. 60—39.48)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to propulsion motors. More specifically it relates to a method and apparatus for pressurizing propellant tanks used in the feed system of a propulsion motor.

Propellant tanks have been pressurized in a number of ways. One way has been to take liquid oygen from the oxygen tank, vaporize it, and use it to pressurize both the oxygen and fuel tanks. Some of the vaporized oxygen is fed to the oxygen tank. The remainder of the vaporized oxygen is used to inflate a bag carried in the fuel tank. As the vaporized oxygen inflates the bag, it forces fuel out of the fuel tank.

There are a number of disadvantages in the above system. It is dangerous. Oxygen might escape from the inflatable bag into the fuel tank. Many propellants are hypergolic—will ignite on contact. Also, an inflatable bag is bulky, and takes up room in the fuel tank.

Another approach to pressurizing propellant tanks, has been to use a separate gas generator to provide hot combustion gases. These gases are mixed with an inert gas to cool them, and they are then fed to both the oxidizer and fuel tanks to pressurize them.

This system also has disadvantages. It is heavy. Fuel necessary for the gas generator, the inert gas, and the container for the inert gas, all add weight to the system. Further, since the same mixture is fed to the oxidizer and fuel tanks, it is necessary that it be compatible with both oxidizer and fuel. It is also necessary that the products do not contanminate the propellants. This is also very important where the propellants are hypergolic.

In this invention, hot combustion products and vaporized oxidizer are used to individually pressurize the propellant tanks. The combustion products pressurize the fuel tank, and the vaporized oxidizer pressurizes the oxidizer tank. Fuel and oxidizer are obtained from the propellant tanks and are combined in a fuel-rich mixture. They are then combusted to completely consume the oxidizer and form hot combustion products. The hot combustion products are then fed to a heat exchanger. Additional oxidizer is then bled from the oxidizer propellant tank and passed through the heat exchanger where it is vaporized by the hot combustion products. The oxidizer in turn, cools the hot combustion products to a temperature that is compatible with the fuel to be pressurized.

The vaporized oxidizer is then fed back to the oxidizer propellant tank to pressurize it. And, the combustion products are fed to the fuel propellant tank to pressurize this tank.

It is, therefore, an object of this invention to use the propellants themselves to pressurize the propellant tanks, thereby eliminating the need for extra pressurant containers and accompanying equipment.

It is also an object of this invention to directly pressurize propellant tanks with products that are completely compatible with the contents of each individual tank and that can be fed directly to the tanks.

Other objectives and advantages will appear from the specification and claims taken in connection with the drawing wherein in the single figure there is illustrated the propellant tank pressurization system in one type of propulsion system.

A preferred embodiment of the invention is shown in the figure. There is provided propulsion motor **2** and propellant tanks **4** and **6** containing propellant for the motor. Propellant tank **4** contains fuel such as RP–1 (kerosene-base fuel) or similar propellant. Propellant tank **6** contains oxidizer such as liquid oxygen or similar propellant.

Generally, depending on conditions to be encountered, either a gravity flow or positive feed means are used to feed the propellant from the tanks to the propulsion motor. In the embodiment disclosed, a positive propellant feed means is illustrated.

The propellant feed means includes: ducts **8**, **10** connected to tanks **4** and **6**; valves **12**, **14** in the ducts; propellant pumps **16**, **18** to feed the propellant; and gas turbine **20** to operate the propellant pumps. The output of turbine **20** passes through duct **21** to thrust chamber **2**.

To initially start the flow of propellant to the propulsion motor, it is necessary to first start the turbine operating so it will in turn operate the propellant pumps. To start the turbine initially, a combustor means or gas generator **22** is used. The gas generator is made with a starting supply of a liquid or solid propellant (not shown). The combustion products from the generator are fed through duct **24** to turbine **20**.

The hot combustion products from the gas generator operate the turbine and it in turn operates propellant pumps **16**, **18** to feed fuel and oxidizer through ducts **8**, **10** to propulsion motor **2**. Once the propellant pumps start operating, they will take over and also feed fuel and oxidizer to gas generator **22** through ducts **26**, **28** and valves **30**, **32**.

Valves **30**, **32** in ducts **26**, **28** are adjusted so the propellants are fed to the gas generator in a fuel-rich mixture. The reason for this will be explained below. It is pointed out that once the system is started, it sustains itself to the depletion of the propellants.

The propellant tank pressurization system will now be explained.

A heat transfer means **34** is provided, in the form of a heat exchanger. A small quantity of hot combustion products is fed to heat transfer means **34** by means in the form of bleed duct **36** connected to duct **24** upstream of turbine **20**. Also, a small quantity of oxidizer is fed to heat transfer means **34** by means in the form of bleed duct **38** connected to duct **10**.

In heat transfer means **34**, the combustion gases are at a high temperature and contain excess heat. The heat transfer means is constructed so that the hot combustion gases will be cooled by the oxidizer, to a temperature that is compatible with the fuel being pressurized, and the overall system. The excess heat from the combustion gases in turn is used to vaporize the oxidizer and raise its temperature to enable it to be used as a pressurant gas.

Heat transfer means **34** is constructed so the hot combustion gases from duct **36** pass through tubing **40**. The relatively cold oxidizer is circulated on the outside **42** of tubing **40**. This is done so the oxidizer will act as a shield to protect contiguous parts of the system from the heat of the combustion gases.

The vaporized oxidizer and cooled combustion products are then fed from the heat transfer means to their respective tanks **4**, **6**. The vaporized oxidizer is fed by means in the form of duct **44** to tank **6**. The cooled combustion products are fed by means in the form of duct **46** to its respective tank **4**. To control the flow of the propellants, each duct 44, 46 contains a check valve 48, adjustable orifice valve 50 and relief valve 52.

A fuel-rich mixture is used in gas generator 22 to insure that the oxidizer will be completely consumed in the combustion process. This is to eliminate any danger of oxidizer being fed to the fuel propellant tank with the combustion products and contaminating the fuel. Also, as mentioned previously, if the propellants are hypergolic, the fuel would ignite on contact with any unconsumed oxidizer. The desired ratio of oxidizer to fuel feed can be obtained by adjusting valves 30 and 32 in ducts 26, 28.

The system does not require separate tanks or storage of pressurant gas.

Operation

To initially start turbine 20 operating, gas may be generated in gas generator 22 by either a solid fuel (not shown) or from propellant (not shown) first obtained from the propellant tanks 4, 6.

The high temperature, high pressure combustion products from gas generator 22, then flow through duct 24 to gas turbine 20 which operates propellant pumps 16, 18. Simultaneously, propellant pumps 16, 18 start to build up pressure. As pressure increases, propellant valves 12, 14 open to feed fuel and oxidizer through ducts 8, 10 into thrust chamber 2.

In a boot strap type of operation, fuel and oxidizer are then fed to gas generator 22 from propellant tanks 4, 6; through conduits 8, 10; propellant pumps 16, 18; conduits 26, 28; and valves 32, 36. The propellants are combusted in gas generator 22 at high temperature and pressure and hot combustion products fed through duct 24 to turbine 20.

The pressurants are fed to heat transfer means 34 from bleed ducts 36, 38. Bleed duct 36 is connected to hot gas duct 24 just up stream of the turbine 20 and directs a flow of a small quantity of hot gases to heat transfer means 34, and bleed duct 38 is connected in feed line 10 to feed oxidizer to be vaporized to heat transfer means 34.

As oxidizer passes through heat transfer means 34 it adsorbs heat from the hot combustion gases and is vaporized. The oxidizers' temperature is raised to the degree required for use. The temperature of the hot gases is in turn lowered to a usable temperature.

After passing through heat transfer means 34, the pressurants pass through their respective ducts 44, 46, check valves 48, valves 50 that are made adjustable to provide a variable restriction in the line, and then into their respective tanks 4, 6. Relief valves 52 are adjusted to maintain a selected pressure in the system.

The following is an example of some of the temperatures that may be encountered in a system using RP–1 as fuel, and liquid oxygen as an oxidizer. The temperature of the hot combustion gases in duct 24 going into the heat exchanger would be about 1700° F. The temperature of the liquid oxygen in duct 38 going into the heat exchanger would be around −292° F. Leaving the heat exchanger, both pressurization gases will be at approximately +575° F.

The specific design of the heat exchanger is dependent upon a number of factors. For example, the propellants used, and exit temperatures of the pressurants required.

If the heat available in the combustion gases is higher than required to pressurize the fuel tank, additional cooling of the combustion gases may be attempted through a second heat exchanger in the oxidizer feed line 38, or even in the oxidizer tank itself.

Conversely, when required, additional heating of the vaporized oxidizer may be obtained. A second heat exchanger may be placed in duct 21 leading from turbine 20 to thrust chamber 2; or through the use of additional hot gases obtained directly from thrust chamber 2.

Although but a single embodiment out of the present invention has been illustrated and described, it will be apparent to one skilled in the art that various changes and

modifications may be made therein without departing from the invention as defined in the appended claims.

What is claimed is:

1. In a propulsion system a method of pressurizing propellant tanks, wherein one of said tanks contains oxidizer and one of said tanks contains fuel, comprising the steps of:
   - providing a portion of oxidizer and a portion of fuel in a fuel-rich mixture from said propellant tanks;
   - combusting said mixture to completely consume said oxidizer and produce hot combustion products;
   - providing additional oxidizer from said oxidizer propellant tank;
   - transferring heat from said hot combustion products to said additional oxidizer to vaporize said oxidizer and lower the temperature of said combustion products;
   - feeding said vaporized oxidizer back to said oxidizer propellant tank to increase the pressure in said tank; and
   - feeding said relatively cooled combustion products to said fuel propellant tank to increase the pressure in said tank.

2. In a propulsion system a method of pressurizing propellant tanks wherein one of said tanks contains oxidizer and one of said tanks contains fuel, comprising the steps of:
   - providing a portion of oxidizer and a portion of fuel in a fuel-rich mixture from said propellant tanks;
   - combusting said mixture to completely consume said oxidizer and produce hot combustion products;
   - providing additional oxidizer from said oxidizer propellant tank;
   - surrounding said hot combustion products with said additional oxidizer propellant to act as a heat shield and to also transfer heat from said hot combustion products to said additional oxidizer to vaporize said additional oxidizer and lower the temperature of said combustion products;
   - feeding said vaporized oxidizer back to said oxidizer propellant tank to increase the pressure in said tank; and
   - feeding said relatively cooled combustion products to said fuel propellant tank to increase the pressure in said tank.

3. In a propulsion system, a construction for pressurizing propellant tanks, wherein one of said tanks contains oxidizer and one of said tanks contains fuel, the combination comprising:
   - means to provide a portion of oxidizer and a portion of fuel in a fuel-rich mixture from said propellant tanks;
   - means to combust said mixture to completely consume said oxidizer and produce hot combustion products;
   - means to provide additional oxidizer from said oxidizer propellant tank;
   - heat transfer means to transfer heat from said hot combustion products to said additional oxidizer to vaporize said oxidizer and lower the temperature of said combustion products;
   - means to feed said vaporized oxidizer from said heat transfer means back to said oxidizer propellant tank to increase the pressure in said tank; and
   - means to feed said relatively cooled combustion products from said heat transfer means to said fuel propellant tank to increase the pressure in said tank.

4. In a propulsion system a construction for pressurizing propellant tanks, wherein one of said tanks contains oxidizer and one of said tanks contains fuel, the combination comprising:
   - a gas generator;
   - means to bleed a portion of oxidizer and a portion of fuel in a fuel-rich mixture from said propellant tanks to said gas generator, said gas generator combusting said mixture to completely consume said

oxidizer and produce hot combustion products;

heat transfer means;

means to feed oxidizer from said oxidizer tank to said heat transfer means;

means to feed said hot combustion products from said gas generator to said heat transfer means in sufficient quantities to vaporize said oxidizer and to lower the temperature of said combustion products;

means to feed said vaporized oxidizer to said oxidizer propellant tank to increase the pressure in said tank; and

means to feed said relatively cooled combustion products to said fuel propellant tank to increase the pressure in said tank.

5. In a propulsion system a construction for pressurizing propellant tanks wherein one of said tanks contains fuel and one of said tanks contains oxidizer, the combination comprising:

first and second propellant pumps;

duct means connecting said oxidizer tank to the inlet of said first propellant pump;

duct means connecting said fuel tank to the inlet of said second propellant pump;

a turbine connected to drive said propellant pumps;

a gas generator;

individual duct means connecting the outlets of said first and second propellant pumps to the inlet of said gas generator;

valve means to adjust the feeds of said oxidizer and said fuel to said gas generator to provide a fuel-rich mixture;

duct means connecting the outlet of said gas generator

to said turbine to feed combustion products from said gas generator to said turbine;

heat transfer means;

bleed duct means to feed oxidizer from said first propellant pump to said heat transfer means;

bleed duct means upstream of said turbine to feed hot combustion products from said gas generator to said heat transfer means;

means to adjust the feeds of said oxidizer and hot combustion products to said heat transfer means in an amount sufficient to vaporize said oxidizer and lower the temperature of said hot combustion products;

duct means to feed vaporized oxidizer from said heat transfer means to said oxidizer propellant tank to increase the presesure in said tank; and

duct means to feed said combustion products from said heat transfer means to said fuel tank to increase the pressure in said fuel tank.

6. A device as set forth in claim 5 wherein said heat transfer means is a heat exchanger, and said heat exchanger is constructed with tubing through which the hot combustion products pass, and the oxidizer is circulated on the outside of said tubing to act as a heat shield.

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