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REACTION MOTOR OPERABLE BY LIQUID PROPELLANTS AND METHOD OF OPERATING IT

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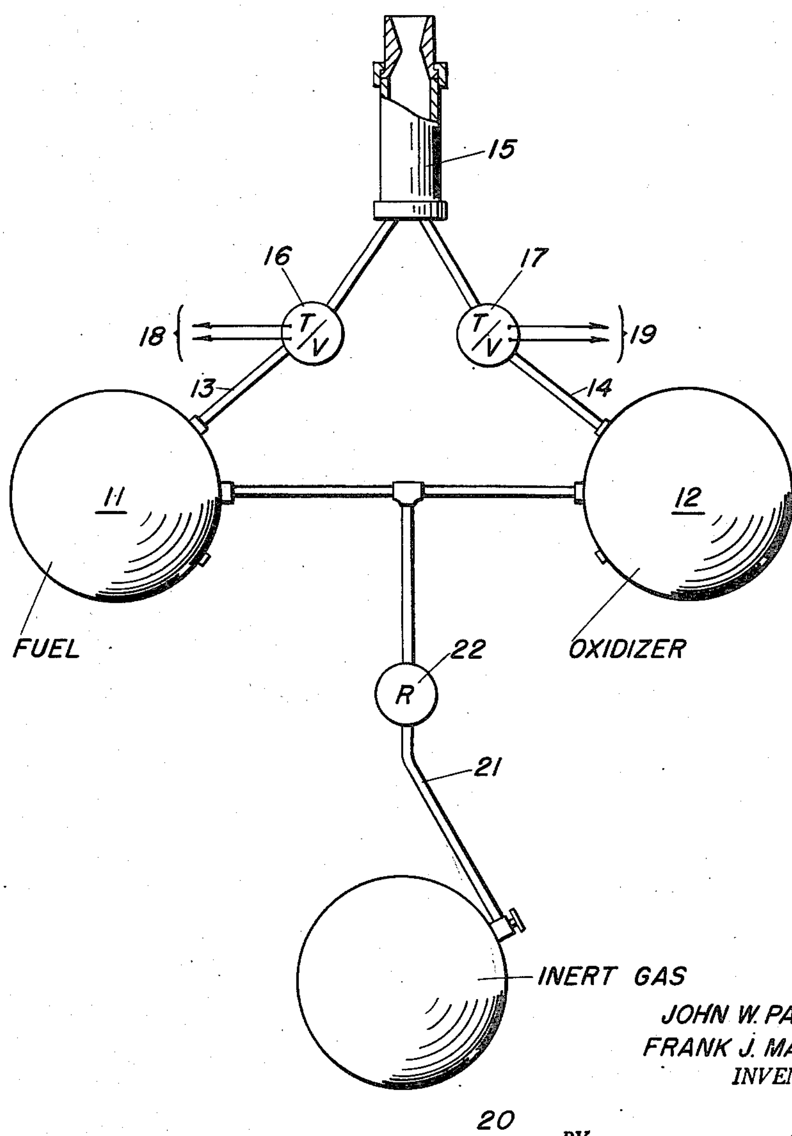

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REACTION MOTOR OPERABLE BY LIQUID PROPELLANTS AND METHOD OF OPERATING IT

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Original application May 8, 1943, Serial No. 486,236, now Patent No. 2,573,471, dated October 30, 1951. Divided and this application September 1, 1950, Serial No. 182,742

2 Claims. (Cl. 60—35.4)

Our invention relates to jet propulsion and more particularly to propellants which are useful in connection therewith.

This is a division of my copending application Serial No. 486,236, filed May 8, 1943, now U. S. Patent 2,573,471.

While our invention is capable of use in connection with the propulsion of a wide variety of different devices and vehicles, since it finds particular utility in the propulsion of aircraft, its advantages are described with relation to such use, it being understood that our invention is, however, not limited to such use.

Prior to our invention special means were always required to ignite the propellants. For example, when liquid oxygen is used as an oxidizer and gasoline is used as a fuel, some auxiliary ignition means must always be provided to initiate combustion of the propellants. This is objectionable because it requires either a spark plug or other ignitor or means for heating the walls of the combustion chamber above the ignition point of the propellant mixture making this system complex and dependent upon the operation of such ignition system.

While spontaneous combustion is obtained with our preferred combinations of propellants which is especially effective when operating in accordance with our preferred method it will be understood that the propellants we have discovered offer advantages even when operating under other conditions.

The present invention relates to fuels, and oxidizers and their combination as propellants and their method of injection into a jet motor. Among the objects of our invention are: to provide more efficient and effective propellants for jet propulsion systems; to provide an oxidizing agent which is easily combustible with a suitable fuel and which has a large amount of oxygen available for burning a fuel; to provide propellants, that is, fuels and oxidizers, which are spontaneously combustible; to provide a method for utilizing such propellants to give smooth combustion and to eliminate danger of explosion; to obviate the difficulties attendant upon the use of liquified gases; to eliminate the need of an auxiliary ignition system to ignite the propellants.

Oxidizers

As a result of a thorough investigation of the various oxidizing agents which may be used as propellants we prefer to employ nitric acid. Since water tends to retard combustion of the acid with any fuel, the nitric acid should be substantially free of water. Thus, white fuming nitric acid, which normally contains less than about 2% of water by weight, is to be preferred to weaker solutions of nitric acid. However, we have found that more dilute solutions of nitric acid may be utilized provided that nitrogen dioxide is dissolved in the nitric acid; which is a way of increasing the concentration of an otherwise more dilute solution. Preferably the nitric acid should contain at least about 5% NO_2 but preferably at least about 15 to 20% NO_2. Such a solution of nitrogen dioxide is known as red fuming nitric acid and almost all red fuming nitric acid which is commercially available in this country contains between about 5% and 20% nitrogen dioxide by weight and less than about 5% water by weight. Specifications for nitric acid, obtainable commercially as red fuming nitric acid, are as follows:

Chemical composition:	
HNO_3	90.5% by wt. min.
Water	2.5% by wt. max.
NO_2	7.25% by wt. max.—6.50% by wt. min.
Physical properties:	
Density	1.5 min.—1.55 max. @ 70° F.
Melting point	—50° F. max.
Color, etc	Orange to dark red—fumes vigorously when exposed to air.

Specifications for nitric acid, obtainable commercially as white fuming nitric acid, are as follows:

Chemical composition:	
Nitric acid	97.5% by wt. min.
Water	2.0% by wt. max.
NO_2 content	0.5% by wt. max.
Physical properties:	
Density	1.46 min.—1.52 max. @ 68° F.
Melting point	—45° F.
Color, etc	Straw yellow to water white; fumes vigorously when exposed to air.

The term "white fuming nitric acid" as used herein means a nitric acid containing a maximum of about 2% water by weight.

The term "red fuming nitric acid" as used herein means a nitric acid containing at least about 5% NO_2 and a maximum of about 5% water, by weight.

Nitric acid of all types containing at least 80% HNO_3 is useful as an oxidizer. We have also found that liquid nitrogen dioxide is a very satisfactory oxidizer.

To eliminate the requirement for providing the jet motor with special igniting means, we employ nitric acid, and preferably red fuming nitric acid, substantially free of water, as an oxidizer.

Fuels

We have discovered a family of fuels which are spontaneously combustible with the oxidizing agents hereinabove mentioned and which are satisfactory for jet propulsion provided that the propellants are supplied to the combustion chamber under suitable operating conditions. These operating conditions are discussed more in detail hereinbelow.

We have found that the four groups of compounds listed below may be utilized as fuels. These groups are listed in the order of their effectiveness.

Group I.—Liquid organic compounds containing at least one amine radical, such as,

A. Aniline, orthotoluidine, and methylamine.

B. Liquid hydrocarbons, containing large percentages of such amine substituted organic compounds.

Group II.—Highly unsaturated hydrocarbons: Liquid hydrocarbons of the acetylene type and containing a large fraction of unsaturated (double and triple) carbon bonds, or both, for example, divinyl acetylene, dipropargyl, and propargyl alcohol.

Group III.—Liquid substances containing the elements having the properties of lithium (Li), beryllium (Be), boron (B), aluminum (Al), magnesium (Mg), phosphorus (P), potassium (K), and sodium (Na). With the exception of phosphorus all of the foregoing elements are particularly useful in fuels because they generate large amounts of heat during combustion, and phosphorus is particularly useful because it has a low ignition temperature.

A. Liquid hydrides of those elements.

B. Liquid organo-metallic compounds containing one or more of such elements.

C. Liquid fuels containing one or more such elements.

D. Liquid fuels containing one or more such elements in suspension.

Group IV.—Organic compounds having the properties of:

1. Pyrole
2. Pyridine
3. Pinene
4. Terpene
5. Pinole
6. Terpinol
7. Hydrazine
8. Ozonides
9. Carbon disulphide containing phosphorus.

All the above identified substances are spontaneously combustible with the oxidizers hereinbefore discussed and are independently useful with other oxidizers where means for ignition is provided.

Of all of these fuels we prefer to employ the amine substituted hydrocarbons. Aniline, for example, not only has the advantage of being spontaneously combustible with the oxidizers hereinbefore mentioned but is less hazardous than gasoline in the presence of air. While aniline is toxic it has the great advantage of being relatively inexpensive, even though more expensive than gasoline, and of being commercially available in large quantities.

Method of operation

The above mentioned oxidizers and fuels may be used together as pairs of spontaneously combustible propellants at atmospheric temperature and pressure. However, if desired these oxidizers and fuels may be used with other fuels (such as gasoline) or other oxidizers (such as liquid oxygen) respectively.

So far as we know we are the first to achieve spontaneous combustion in jet propulsion systems at the temperature and pressure of the medium surrounding the jet motor and while other fuels and oxidizers might be utilized to accomplish such spontaneous combustion we prefer to use the fuels and oxidizers hereinbefore mentioned.

Certain difficulties are encountered when utilizing these propellants for propulsion Unless the propellants are supplied to the jet motor under the proper conditions the motor is liable to fail completely, to pulsate in its operation, or to explode, even though the propellants are supplied at uniform rates.

These difficulties may be eliminated and certainly smoothness of operation secured by so relating the rates of injection of fuel and oxidizer to the size of the jet chamber and the inherent ignition properties of the mixture that explosion of the combustible mixture is avoided during the initial combustion, and subsequent injection occurs at rates conducive to the combustion of the continuously supplied propellants so as to avoid the accumulation in the jet chamber of any substantial amount of the unburned propellants. To achieve this result, we initially inject propellants into the combustion chamber at rates such that the amount of propellants injected prior to the initiation of combustion is less than about 20% of the volume of the combustion chamber.

After combustion has been initiated, the propellants may be injected at a greater rate than they are injected initially inasmuch as the time interval between their injection and combustion is reduced because of the higher temperature and pressure of the mixture resulting from prior combustion and the heating of the walls of the combustion chamber by the products of combustion.

In the drawing the figure shows a jet motor system including tanks and conduits for supplying propellants to the motor.

The fuels and oxidizers hereinbefore described are advantageously employed in the propulsion of an aircraft by providing the fuel and oxidizer in separate containers **11** and **12** respectively connected in any suitable manner as by pipes **13** and **14** to a jet or combustion chamber. Throttle valves **16** and **17** energized by electrical circuits **18** and **19** are provided in said pipes to control the rates of supply of the fuel and oxidizer respectively to the combustion chamber **15**. A receptacle **20** is connected by a conduit **21** having a pressure regulator **22** therein to the receptacles **11** and **12** and is provided with a gas under pressure, preferably a gas inert with respect to either propellant. Preferably the container for the fuel and the container for the oxidizer are connected to a source of pressure adapted to force the contents of such containers into the jet or combustion chamber at controlled rates determined by the degree of opening of the valves in said pipes.

The practice of the method of our invention contemplates so relating the rates of injection of the oxidizer and of the fuel to the combustion or jet chamber to their inherent combustion properties and the size and temperature of the chamber that smooth non-explosive combustion occurs initially and throughout the entire operation while providing the desired quantity of propulsive power. Our invention is particularly advantageous when the combustion chamber is initially at atmospheric temperature, or at the temperature of any other medium in which the motor is to operate, as we are able to achieve combustion initially without auxiliary ignition or preheating of the chamber or the propellants.

If the propellants are supplied at such initial rates, then, when the propellants are initially injected into the jet motor, the initially burned propellants soon fill the combustion chamber with high temperature gases and vapors which heat the incoming propellants thereby vaporizing them and reducing the ignition time lag. Then the subsequently injected propellants burn spontaneously without any substantial accumulation of propellants in the liquid phase.

As an example, applied to a combustion chamber having a length of about 10 inches and a cross sectional area of about 7 square inches, highly concentrated nitric acid and aniline operate very satisfactorily when they are injected into the combustion chamber initially and prior to combustion at the rates of 3.6 lbs. per second and 2.4 lbs. per second respectively.

While these propellants and method of use and the apparatus for their use in propelling aircraft or other devices, which are hereinbefore described, are fully capable of providing the advantages primarily stated, it will be recognized by those skilled in the art that various modifications and alterations may be made therein while still providing such advantages, and our invention is therefore to be understood as not limited to the specific embodiments hereinbefore described but as including all modifications and variations thereof coming within the scope of the claims which follow.

We claim as our invention:

1. The method of developing thrust which comprises ejecting from a reaction chamber the gaseous products produced by the spontaneous combustion of a compound selected from the group consisting of hydrazine and carbon disulphide containing phosphorus, and acid selected from the group consisting of red fuming nitric acid and white fuming nitric acid.

2. The method of developing thrust which comprises ejecting from a reaction chamber the gaseous products produced by the spontaneous combustion of hydrazine and acid from the group consisting of red fuming nitric acid and white fuming nitric acid.

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