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METHOD OF OPERATING JET PROPULSION
MOTORS

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This application relates to jet-propulsion motors and particularly to propellants for such motors.

Jet-propulsion motors may be defined, for the purposes of this invention, as motors which derive their driving power from the escape through a jet or nozzle, of the relatively large volume of products resulting from the combustion of a fuel by means of an oxidizing agent. The jet may be exhausted into the open air as in the rocket type of motor, or it may be trained on a movable piece of machinery such as the blades of a fan as in the turbine type of motor.

The primary requisites of auxiliary jet-propulsion motors such as described above, are simplicity of fabrication and efficiency of operation. The motors should be light in weight, small in size, and simple to construct and operate; and the propellants should be safe to handle, stable in storage, should ignite readily and positively, and burn rapidly and smoothly, with a maximum volume of products of combustion. It is an object of this invention to supply novel propellants, i. e. a novel oxidizer and novel fuels for such motors, whereby their simplicity of construction and efficiency of operation is increased.

As a specific example of the process of this invention methyl nitrite may be charged into the feed tank of a jet-propulsion motor and pressured with nitrogen to a pressure of about 1,500 pounds per square inch. The pressuring may be accomplished by release of nitrogen or other inert gas contained in a second tank under high pressure, through suitable lines and a pressure reducing control valve. The methyl nitrite may then be released from the fuel tank and fed through suitable lines and control valves to a combustion chamber equipped with an igniting device, such as a spark plug, and allowed to burn or decompose in the absence of any added oxidizer.

As an example of the operation of a similar motor in which a separate fuel and oxidizer are employed, a fuel may be prepared by blending about 10% by weight of isopropyl nitrite in about 90% of a paraffinic crude gasoline fraction, the gasoline fraction having a boiling range of about 100° F. to 400° F. and containing less than about 10% of aromatic type hydrocarbons. This fuel may be charged into one feed tank of a jet-propulsion motor and pressured with nitrogen as above. A second feed tank may be charged with fuming nitric acid and similarly pressured with nitrogen. The fuel and the nitric acid oxidizer may then be released from the fuel tanks and

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fed to a combustion chamber where they are allowed to react. This reaction is an oxidation reaction or combustion and the hot gaseous products of the combustion are utilized as above to provide the driving force. The rates of introduction into the combustion chamber may be about two and one-half pounds and three and one-half pounds for the fuel and oxidizer, respectively, for a combustion chamber of about the above size. The effect of the isopropyl nitrite in the above fuel is to lower the ignition temperature and to make the burning smooth and non-explosive, thus providing a smooth thrust during the entire period of operation rather than a single explosion or a series of explosive bursts. Similar effects are obtained with the other fuels or additives of this invention.

It is clear that the invention is not limited to the particular conditions of the above examples, since different pressures, up to several thousand pounds, different rates of introduction of propellants, generally increasing with the pressure and the size of the motor, and different sizes and styles of equipment may be employed, some of which are referred to below. The propellants of this invention are particularly effective in any such jet-propulsion motor, to increase the certainty, the smoothness, and the efficiency of the combustion. Regarding the methyl nitrite of this invention it may be noted that this material is a gas at ordinary temperatures, but is readily liquefied, the liquid having a vapor pressure at about 40° C. of about 70 pounds per square inch gage. Its heat of combustion at 25° C. in calories per mol is over 180,000 and its heat of decomposition to form carbon dioxide, water, carbon and nitrogen is 99 calories per mol. These show that it is especially valuable as a fuel or as a monopropellant, the term "monopropellant" as used herein referring to a propellant which is a single material rather than a mixture of a fuel and an oxidizer. Methyl nitrite is very easily prepared by the reaction of methanol and sodium nitrite in the presence of sulfuric acid. Homologs of methyl nitrite containing less than about four carbon atoms, such as ethyl nitrite and propyl nitrite may also be used as monopropellants, but when higher homologs containing more than about four carbon atoms are employed, such as octyl nitrite, benzyl nitrite, phenyl nitrite, cyclohexyl nitrite, and the like, it is preferred that some oxidizer be employed also. These materials may be used without dilution as straight fuels, or they may be employed as additives for hydrocarbon fuels, those homologs con-

taining less than about four carbon atoms being preferred for the latter use. The nitrites, especially methyl nitrite, are preferred but the nitrates are also very valuable. The nitrates, especially the lower ones, containing less than about four carbon atoms, such as methyl, ethyl and propyl may also be employed as monopropellants since they have an even larger proportion of oxygen than do the nitrites. For use with oxidizers the nitrates and nitrites which contain more than about four carbon atoms are preferred, especially those having between about six and about sixteen carbon atoms. The organic radicals may be paraffinic, naphthenic, aromatic or olefinic in character, as indicated above.

Although only the mono nitrites and nitrates have been specifically discussed above, the nitrates and nitrites of this invention also include those compounds containing more than one such polar group in the molecule, such as the dinitrites, dinitrates, nitrite-nitrates, trinitrites and the like. As with the mono substituted compounds, those compounds which contain fewer than about 4 carbon atoms for each polar group (or each nitrogen atom) are preferred as mono-propellants or as additives for hydrocarbon fuels, while the higher homologs are preferred as straight fuels. Examples of these materials are: cyclohexane-1, 1-dinitrate; benzene-1, 2-dinitrite; isobutane nitrite-nitrates; and ethylene glycol dinitrate.

Where oxidizers are employed with the above fuels these oxidizers may be nitric acid, oxygen, and nitrous oxide (these three being preferred) or air, ozone, hydroperoxides, metal peroxides, metal manganates, permanganates, chlorates, perchlorates, hypochlorites, persulfates, chromites, chromates, bichromates and the like as well as sulfur, the halogens such as fluorine, chlorine, bromine and iodine and their compounds with oxygen, nitrogen and sulfur. The nitric acid is preferably fuming nitric acid containing less than about 5% by weight of water. White fuming nitric acid containing less than about 2% of water and substantially no nitrogen dioxide is very suitable and red fuming nitric acid containing up to about 20% by weight of nitrogen dioxide and less than 5% of water is also excellent, although as indicated fuming nitric acid of greater than 95% concentration is preferred. Any nitric acid having a concentration greater than about 80% may be employed. Liquid nitrogen dioxide may also be employed as well as other oxides of nitrogen.

Where both the fuel and the oxidizer are fluids, that is, liquids or gases or stable suspensions of solids in liquids, or gases, the method of operation described in the specific example may be followed, that is the fuel and oxidizer may be kept in separate compartments until the time of combustion and pressured with a piston gas, such as nitrogen or other inert gas, to force them into the combustion chamber. The combustion chamber may be provided with an igniting device such as a spark plug or a detonating device where necessary, although in certain instances the contact of the fuel with the oxidizer produces spontaneous combustion. Where the fuel is a monopropellant only one storage chamber is necessary and an igniting device must always be employed. Where both the fuel and the oxidizer are non-fluids, that is, are solids which are not readily transferred from the storage compartment to the combustion chamber, and the mixture of the fuel and the oxidizer will not spontaneously ignite under storage conditions, the fuel and the oxidizer may be blended or intimately mixed and positioned in

the combustion chamber itself in such a position that there is no danger of its obstructing the jet. Thus, a mixture of asphalt and potassium perchlorate, for example, may be heated sufficiently to allow it to be poured into the combustion chamber so that it will solidify at the opposite end of the combustion chamber from the jet. It is desirable that when such a mixture is burned it will burn smoothly at the surface of the charge and not burn in a series of explosions. The additives of this invention aid materially in making the combustion of fuel more smooth and in permitting ignition at lower temperatures. Where either the fuel or the oxidizer is a solid and the other component of the propellant is a fluid the solid material may be positioned in the combustion chamber as described above and the fluid material charged to the combustion chamber as described previously. The proportion of the oxidizer, compared to the fuel in the propellant employed is preferably somewhat less than the amount theoretically required for complete combustion. Generally, proportions between about 50% and about 90% oxidizer by weight are satisfactory, although higher or lower proportions may be necessary in some instances.

Modifications of this invention which would occur to one skilled in the art are to be included in the invention as defined in the following claims.

We claim:

1. In a method of operating a jet-propulsion motor, wherein a fuel is burned in a combustion chamber in the absence of separate oxidizer, and the products of combustion are allowed to escape through a jet, thereby producing a driving force, the improvement which comprises injecting into the chamber a fuel consisting essentially of a nitrogen and oxygen containing organic compound of the class consisting of organic nitrites and nitrates containing not more than four carbon atoms for each nitrogen atom, and igniting the fuel therein.

2. In a method of operating a jet propulsion motor, wherein a fuel is burned in a combustion chamber, and the products of combustion are allowed to escape through a jet, thereby producing a driving force, the improvement which comprises injecting into the chamber a fuel consisting essentially of an organic nitrite having not more than four carbon atoms for each nitrogen atom, and igniting the fuel therein.

3. A method according to claim 2 in which the organic nitrite is methyl nitrite.

4. A method according to claim 1 in which the nitrogen and oxygen containing organic compound is an organic nitrate.

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