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MONO-FUEL

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1

This invention relates to a self-sufficient fuel adapted for use as a single liquid entity and comprising a fuel component, oxygen in combined form to support combustion of the fuel, and a flash back preventer by which to prevent burning of the self-sufficient fuel back from the point of combustion through the fuel line into the storage tank or at a "hot-spot" in the fuel system. More particularly it relates to the addition to such a self-sufficient fuel of a gas, low boiling point liquid or readily decomposable substance that possesses flame extinguishing properties, is easily vaporized or decomposed to vapor, and is relatively soluble or miscible in the self-sufficient fuel.

Much work has been done looking toward the development of a satisfactory self-sufficient fuel that safely may be used as a mono-fuel without danger of either spontaneous combustion at a "hot-spot" in the supply system or "flash-back" of the flame from the point of combustion through the supply line. A mono-fuel may be defined herein as a single liquid entity at normal temperatures and zero altitude in which a fuel and the oxygen for its combustion are intimately mixed and will burn without the necessity of supplying oxygen to the mixture from any outside source, as the atmosphere. For purposes of this invention the meaning of the term mono-fuel is broadened to include those mixtures of fuel and combined oxygen that depart from stoichiometric ratios in the sense that only some of the oxygen required for combustion is present in combined form. In such cases there is either incomplete combustion of the fuel as the oxygen becomes exhausted or additional oxygen is supplied from some source outside the mono-fuel, as for instance from the surrounding medium in which the mono-fuel is burned.

The development of a successful mono-fuel that may be transported ready mixed and fed from a single tank through a fuel system to a point of combustion has been difficult. This primarily is due to a tendency of the mono-fuel to flash back, by which is meant to burn or even detonate back through the system from the point of combustion to and into the fuel tank. Since the mono-fuel in the tank would be so proportioned as to support combustion, thermal decomposition of the fuel comparable to that in the combustion chamber might take place back from the combustion chamber into the tank even though it was otherwise closed to the outside air.

Various mechanical expedients have been tried to prevent such flash back but in so far as I am aware have been unsuccessful because

2

they could not be made to operate with a rapidity as great as the rate of flame propagation, or travel of a detonating shock wave, back through the system. The less stable such prior mono-fuels were, the greater was their tendency to flash back; this tendency was increased if the fuel was sensitive to shock. Again a mono-fuel as herein defined is liable to become ignited within the fuel system if part of the system develops a "hot-spot," due to overheating in a pump or the like, that raises the fuel to a temperature above its ignition point. Another obstacle to mono-fuel development has been encountered in attempting to arrive at a mixture that is not subject to serious decomposition over reasonable periods of time after being mixed. In some cases certain prior self-sufficient fuels are hypergolic; i. e., spontaneously combustible when mixed.

Due to the difficulties encountered in trying to prevent flash back, it has been common practice with self-sufficient fuels of this nature to maintain the fuel component and the oxygen component separate until the instant their combustion was desired. This required the provision of dual tanks and dual supply systems to maintain the fuel and oxidant separate up to the time they were actually combined for burning. In some cases such a system was further complicated by the required use of nitrogen from a third tank through a third supply line. The jet units used during the recent war to assist aircraft in taking off from airfields and carriers are examples of such systems. One example of such jet assist take off unit is illustrated in U. S. Patent No. 2,398,201, issued April 9, 1946, to Young et al. and entitled "Motor" in which, in addition to nitrogen, a self-sufficient fuel including red fuming nitric acid was employed.

The general object of the present invention is to provide a mono-fuel that is safe to handle, possesses good properties as a fuel and is not subject to a tendency to flash back or ignite prematurely. Another object of the invention is to provide a mono-fuel that may be stored in a single fuel tank, brought through a single supply line to a point of combustion and, if desired, be burned without the addition of further oxygen and without any tendency of the flame at the point of combustion to travel back through the supply line to the fuel tank. Still another object of the invention is to provide a mono-fuel including an addition agent that under certain conditions possesses flame extinguishing and heat insulating properties. Still another object is to provide a liquid mono-fuel including a constituent that easily leaves the

liquid to form a "vapor lock" at temperatures substantially below the ignition point of the fuel to insulate a hot spot in the fuel system from contact with the fuel. A still further object of the invention is to provide a flash back preventer for a mixture of oxygen in combined form and fuel that does not have appreciable undesired effect on the combustion properties of the mono-fuel when it reaches the prime mover combustion chamber.

Other objects of the invention will become apparent from this specification and the novel features of the invention are defined in the appended claims.

Generally the present invention is concerned with the addition to a mono-fuel of an agent that possesses flame extinguishing properties and that is soluble or miscible, as the case may be, in the mono-fuel with which it is mixed. Such an addition agent, when dispersed in the mono-fuel, does not affect materially the fuel characteristics of the mono-fuel at the point of combustion but does act to prevent premature ignition or flash back through the mono-fuel from the point of combustion.

The addition agent by which premature ignition of the mono-fuel is avoided, whether caused by flash back or a hot spot in the fuel system, operates as a medium by which to insulate the fuel in the fuel system to prevent it from attaining its ignition temperature. In general I achieve this result in the present invention by introducing into the mono-fuel a constituent by which to establish a condition comparable to vapor lock in conventional gasoline fuel systems. In internal combustion fuel systems the fuel supply to the engine may be cut off by a condition known as vapor lock: this is the formation in the fuel line of a pocket of vaporized fuel that prevents the carburetor from being adequately supplied and causes the engine to sputter or cut off. Contrary to conventional fuel systems where vapor lock is to be avoided, my present invention makes advantageous use of this condition and in a controlled manner uses it as a medium to prevent the flash back or preignition referred to above.

The flash back constituent takes the form of a dissolved gas, liquid or solid in the mono-fuel that separates as a gas from the mono-fuel when a temperature substantially below the ignition temperature of the mono-fuel is attained. As such gas it acts to insulate the mono-fuel from that heat source that would otherwise raise its temperature to a point where it would ignite. The constituent is added to the mono-fuel in relatively small percentages as hereafter defined and it functions in the following manner.

If a hot spot develops in the fuel system, as by the overheating of a pump, the increase in temperature in the system at that point will cause vaporization of the flash back constituent in the fuel that is flowing past that point. As a result there is formed an insulating layer in gaseous form of the flash back preventer over the hot spot and this layer is constantly replenished as more mono-fuel flows to and past the spot. Due to the fact that the flash back constituent vaporizes at a temperature considerably below the ignition point of the fuel, the layer will be formed before ignition of the latter takes place. Once the layer has been formed, it, being a gas with a low coefficient of heat transfer, prevents heat from the hot spot from raising the temperature of the surrounding fuel to the ignition point. The layer of gas may be very thin because it is

constantly replenished with fresh cool gas as more mono-fuel passes over the region and thus the layer itself never attains a temperature substantially greater than that at which the vapor is formed. Although this condition is not true vapor lock I find that term well describes the formation of such an insulating layer of gas and in the following specification and the claims that is the meaning I accord to the term.

The added flash back inhibitor functions in the same manner to prevent travel of the flame from the point of combustion back through the system. If flame seeks to travel through the fuel, the fuel temperature must first be raised to the ignition point. Before this condition is reached the flash back constituent will be released as an insulating vapor or gas to form a heat insulating layer or vapor lock across the fuel system in the same manner as described in connection with the hot spot referred to above.

The constituents used in the present invention to prevent flash back possess flame extinguishing properties and may be endothermic, i. e., heat absorbent, in the sense that they involve not only vapor pressure gas liberation but also may involve low temperature decomposition. An example of such endothermic material is ammonium nitrite, which decomposes readily at low temperatures and takes on heat in so doing, below the fuel ignition point, to yield nothing but nitrogen and water. Both of the latter are diluents that are themselves incombustible and act as coolants in the mono-fuel to lower its temperature and make its premature combustion more difficult.

It may be thought from the foregoing description that a mono-fuel in which such an addition is placed would not burn at the point of combustion when desired. It has been found from experimentally derived data that in fact this is not true. At a point where controlled vapor lock is to be produced the percentage of gas vaporized at the hot spot, or elsewhere in the fuel system if flash back is involved, is, at the point of greatest heat, the predominant component of the material adjacent the hot spot and almost the only material in contact with the hot spot. On the other hand when the mono-fuel is atomized in the combustion chamber the flash back component is such a small proportion of the total which the ignitor fires that combustion at this point is not appreciably retarded. In other words, the fuel of my present invention is prevented from igniting when it is a liquid in a closed fuel supply system but may be ignited with ease when it passes from the fuel system and is vaporized in the relatively open combustion chamber.

If the mono-fuel is to be used in aircraft, consideration must be given to the temperatures and pressures prevailing at high altitudes. For instance, if the mono-fuel is used to drive a power plant at high altitudes it must be borne in mind that the pressure at 30,000 feet is 4.36 pounds per square inch absolute and the temperature is approximately minus 48° F. at the 40th parallel. At 60,000 feet the pressure in pounds per square inch under the same conditions is 1.04 and the temperature is approximately minus 67° F. For this reason, and to hold relatively constant the viscosity, vapor pressure and other properties of the mono-fuel, the mono-fuel system preferably should be designed to maintain pre-selected conditions of temperature and pressure irrespective of the altitude that

may be attained. This is particularly true if the mono-fuel is used in other than stoichiometric proportions and if additional oxygen is taken from the atmosphere to drive certain prime movers as gas turbines or ram-jets. The factors of altitude, pressure and temperature for the use intended all must be considered in selecting the flash back preventer constituents as well as the other mono-fuel constituents, all as hereafter set forth.

Although it is contemplated that a prime use of the mono-fuel described herein is for gas turbines it will be understood that it is susceptible to a wide variety of other uses. It may, for instance, be used in a reciprocating internal combustion engine and it may be used under a variety of circumstances as in aircraft, underwater craft, land vehicles and stationary installations. It can be used as a source of power for rockets in which both the fuel and oxygen are carried by the projectile. It also is useful in driving ram-jets, particularly at high altitudes where the rarified air offers little oxygen to support combustion and where the maintenance of a suitable flame front is difficult. It can be used in many other situations where the burning of a self-sufficient fuel as a mono-fuel is desired to make available heat energy or gas pressure due to combustion.

In general the present invention comprises a mono-fuel that includes three types of constituents. The first of these is the fuel component in the form of an organic chemical including in its composition carbon and hydrogen that are oxidized to end products as carbon dioxide and water with the generation of gas and the giving off of heat in the process. The second constituent is the oxidant that supplies to the fuel oxygen necessary for its combustion. In most cases the fuel itself includes combined oxygen so the oxidant does not need to supply all of the total amount necessary to burn the hydrogen and carbon. The third constituent of the mono-fuel is the flash back preventer and is added in the form of a soluble gas or solid or a miscible low boiling point liquid as hereafter described. This third constituent does not materially affect the combustion characteristics of the mono-fuel in an undesirable manner at the combustion chamber but does act to prevent flash back through other parts of the system with consequent decomposition of the mono-fuel.

The invention is not to be construed as limited solely to a mono-fuel consisting of the above three ingredients. It is contemplated to be within the scope of this invention to add still other ingredients to the mono-fuel to give to it other desired properties. For instance a coolant may be added to reduce the flame temperature at the point of combustion. Again, oxygen may be supplied to the mono-fuel from an outside source, such as the atmosphere, if for some reason the mono-fuel is not mixed in stoichiometric proportions.

Conversely the present invention is not to be construed as limited to a fuel in which the herein described mono-fuel is the sole fuel source. As an example percentages of the mono-fuel that is the particular subject of this invention may be added in varying proportions to other fuels that are not self-sufficient such as kerosene, gasoline and alcohol. The reason for adding a mono-fuel to such fuels is to improve the combustion characteristics of the latter for certain uses as in the operation of ram-jets at high altitudes where proper combustion cannot be obtained solely with oxygen from the outside air but where the outside air is not so rarified as to prohibit operation of a device operating on the ram-jet principle.

Various compounds such as the methyl and ethyl nitrates can be used in self-sufficient fuels of the mono-fuel type although in the present invention I prefer to use a fuel selected from the group of nitro and polynitro aliphatic hydrocarbons. An example of such a fuel component in the mono-fuel is nitromethane $CH_3(NO_2)$, that itself contains oxygen that may be used during combustion. It is contemplated that other fuels from the class of nitro and polynitro aliphatic organic liquids may be used. Examples of such fuels in addition to nitromethane are:

Nitroethane, $CH_3.CH_2.NO_2$.
1-nitropropane, $CH_3.CH_2.CH_2.NO_2$
2-nitropropane, $(CH_3)_2CH.NO_2$
1,1-dinitropropane, $C_2H_5.CH(NO_2)_2$
2,2-dinitropropane, $(CH_3)_2C(NO_2)_2$
1,2-dinitropropane, $CH_2NO_2.CHNO_2.CH_3$
1,3-dinitropropane, $CH_2NO_2.CH_2.CH_2NO_2$
1,1-dinitroethane, $CH_3.CH(NO_2)_2$
1,1,1-trinitropropane, $C(NO_2)_3.CH_2.CH_3$
1,2,3-trinitropropane, $CH_2NO_2.CHNO_2.CH_2NO_2$

Such nitro and polynitro aliphatics included as fuels, as distinguished from oxidants, within the scope of this invention include mononitromethane, dinitroethane and trinitropropane and those nitroethanes and nitropropanes below them in oxygen content but no nitroethanes or nitropropanes that are higher in oxygen content, as for instance dinitromethane.

The fuel portion of the propellant mixture preferably is limited to those nitro and polynitro aliphatics that contain not more than one nitro group for each carbon atom present. Under many conditions for most efficient use the fuel and oxidant will be combined in substantially stoichiometric proportions. Where possible this is the most economical use of the materials because after combustion there remains no appreciable amount of either unconsumed fuel or oxidant. An advantage of using nitromethane or a similar oxygen-containing fuel as listed above resides in the fact that it contains a considerable amount of oxygen that is available during combustion to burn part of the carbon or hydrogen in the fuel. This in turn does not require the inclusion in the propellant of as much oxidizing agent as would otherwise be necessary. These fuel components are non-brisant nitro and polynitro aliphatic compounds.

A propellant prepared in accord with the present invention preferably will contain a sufficient amount of oxidizing agent to provide with the oxygen of the fuel the required total amount of oxygen for its complete combustion. As indicated above the proper oxygen content can be attained by providing the constituents in direct proportion to their molecular weights and the number of molecules called for in their respective reaction equations.

The oxidizing agent that is used in the present invention is preferably selected from the group of fully nitrated aliphatic compounds that comprises tetranitromethane $C(NO_2)_4$ and hexanitroethane $C(NO_2)_3 \cdot C(NO_2)_3$. A preferred fuel-oxidant combination comprises nitromethane as a fuel and tetranitromethane as an oxidant.

When tetranitromethane is the oxidant that is used the following table indicates the percentages by weight of fuel that are to be used. In the first column the fuel is listed and in the

second column the percentage by weight if a stoichiometric mixture of the fuel and tetranitromethane is desired. In the third column is listed the range of percentages by weight of fuel that, subject to the use intended, will provide a satisfactory product when combined with tetranitromethane. In the case of both the second and third columns the amount of tetranitromethane to be used may be obtained by subtracting from 100% the percentages of the fuel indicated. This 100% does not refer to the mono-fuel but only to the fuel-oxidant proportion of the whole mono-fuel. As hereafter described the fuel-oxidant constituency of the mono-fuel is something less than 100%. This table is as follows:

Fuel	Fuel for stoichiometric mixture	Range of percentages of fuel
nitromethane	55.5	25–75
nitroethane	33.8	15–50
1-nitropropane	26.6	10–40
2-nitropropane	26.6	10–40
1,1-dinitropropane	45.8	20–65
2,2-dinitropropane	45.8	20–65
1,2-dinitropropane	45.8	20–65
1,3-dinitropropane	45.8	20–65
1,1-dinitroethane	65.5	35–90
1,1,1-trinitropropane	68.7	40–95
1,2,3-trinitropropane	68.7	40–95

If the oxidant to be used is hexanitroethane the following table governs in which again the first column is the fuel, the second column the percent by weight of fuel required for a stoichiometric mixture with hexanitroethane and the third column indicates the permissible range that may be used for a particular fuel. Again the amount of hexanitroethane to be added is obtained by substracting from 100% the indicated percentage by weight of the fuel and this 100% refers to the fuel-oxidant mixture and not to the whole of the mono-fuel.

Fuel	Fuel for stoichiometric mixture	Range of percentages of fuel
nitromethane	52.2	20–70
nitroethane	30.8	10–45
1-nitropropane	24.2	10–40
2-nitropropane	24.2	10–40
1,1-dinitropropane	42.5	20–65
2,2-dinitropropane	42.5	20–65
1,2-dinitropropane	42.5	20–65
1,3-dinitropropane	42.5	20–65
1,1-dinitroethane	62.3	30–85
1,1,1-trinitropropane	65.6	35–90
1,2,3-trinitropropane	65.6	35–90

It should be pointed out that while it will generally be the case that the fuel component will consist of only one of the above ingredients it is contemplated to be within the scope of this invention to use in the mono-fuel a fuel that contains more than one compound, as one or more of these nitro or polynitro aliphatics. In such case the proposed proportions for stoichiometric mixtures may be arrived at in accord with the molecular weights and the reaction formula for the particular combination that is contemplated. Since these calculations are within the ability of one skilled in the art they will not be given here.

Under certain condtions of use fuels from the mono nitro aliphatics are preferred. It is to be noted that mono nitro aliphatics are referred to herein simply as nitro aliphatics and that the prefix "mono" is not used—as for example mono nitromethane is referred to simply as nitromethane. On the other hand in the case of poly nitro aliphatics the prefixes, as "di" "tri" and "tetra" are used. These mono nitro aliphatic compounds include the following:

Nitromethane, $CH_3(NO_2)$
Nitroethane, $CH_3.CH_2.NO_2$
1-nitropropane, $CH_3.CH_2.CH_2NO_2$
2-nitropropane, $(CH_3)_2CH.NO_2$

This group of fuels may be used individually or they may be used in admixture with each other. An example of the latter is the fortuitous mixture of these compounds that results from the reaction of propane and nitric acid in the vapor or gas phase. Such a mixture may be used with an oxidant in stoichiometric proportions, in which case the fuel of this fortuitous mixture is mixed with tetranitromethane in approximately the folowing proportions by weight to provide the fuel-oxidant proportion of the mono-fuel:

	Per cent by weight
Tetranitromethane	65
Fortuitous fuel mixture	35

Again if the oxidant is hexanitroethane the corresponding mixture will be approximately as follows:

	Per cent by weight
Hexanitroethane	70
Fortuitous fuel mixture	30

In each case the percentages of nitromethane, nitroethane, 1-nitropropane and 2-nitropropane are assumed to be present in proportions according to the reaction equation for propane and nitric acid. Considerable latitude in propellant composition is permissible within the scope of the invention particularly when the fuel is such a fortuitous mixture as discussed above. Thus, if the oxidant is tetranitromethane the components of the fuel-oxidant part of the complete mono-fuel that lie within the following percentages by weight are deemed to be within the present invention:

	Per cent by weight
Fortuitous fuel mixture	15–50
Tetranitromethane	85–50

Again the fuel-oxidant proportion of the mono-fuel using hexanitroethane as the oxidant and a fortuitous fuel mixture, if mixed in approximately the following ranges of percentage by weight, fall within the scope of this invention:

	Per cent by weight
Hexanitroethane	90–55
Fortuitous fuel mixture	10–45

As indicated above, in the present invention an addition agent in the form of a flash back preventer or suppressor is added to the above defined fuel-oxidant mixtures to improve their qualities as true mono-fuels. Such an addition agent will be a soluble solid, soluble inert gas or a low boiling point liquid that is miscible with the balance of the mono-fuel and will have a much higher vapor pressure. It is a material which, at a temperature substantially below the ignition point of the fuel, develops considerable volumes of gas. This may be accomplished by using a material with much higher vapor pressure or partial pressure than the main fuel constituent or a material which is easily decomposed at low temperatures. The gas developed should be relatively chemically inert and should act to dilute any mono-fuel vapor present to a point below the combustible limit. In addition to these re-

quirements it may be desirable for the additive to act as a coolant, either due to its latent heat of vaporization or to endothermic reaction at the place where the vapor lock is to be established. It is also desirable, but not essential, that the material possess positive flame extinguishing properties.

These are the mechanisms by which the gaseous mixture derived from the fuel and the flash back suppressor is held below the combustible limit of the fuel; that is to say that at some point below the ignition temperature of the fuel the partial pressure of the flash back preventer will be very much greater than the partial pressure of the fuel. However in spite of its action in a fuel system as described above the flash back preventer, constituting a small percentage of the total mass or volume of the mono-fuel, will have very little effect on the ultimate combustion characteristics of the mono-fuel when the entire bulk of the latter is vaporized in the combustion chamber. In other words, its only important effect is when it is in equilibrium with liquid fuel at temperatures well below the ignition temperature of the latter.

If the flash back preventer is added in the form of a gas, carbon dioxide is preferred because it has excellent flame extinguishing properties and is quite soluble under pressure in mono-fuels of the type described herein. An advantage to the use of a soluble gas arises from the fact that a pressurized fuel system can result as hereafter described. The group of polychlorofluoromethanes are examples of low boiling point liquids that may be used in the present invention as flash back preventers. These are respectively known as dichlorodifluoromethane, trichloromonofluoromethane, and dichloromonofluoromethane, and, with dichlorotetrafluoroethane, they bear the respective chemical formulae of CCl_2F_2, CCl_3F_1, $CHCl_2F$ and $C_2Cl_2F_4$. Each of these freons and carbon dioxide has different boiling points, molecular weight, density, specific heat and latent heat of vaporization as indicated by the following table and the specific material to be used under certain conditions will be selected accordingly.

	CO_2	CCl_2F_2	CCl_3F	$CHCl_2F$	$C_2Cl_2F_4$
Boiling point, degrees F		−21.7	74.67	48.0	38.4
Molecular weight	44	120.9	137.3	102.9	170.9
Density		1.445	1.568	1.446	1.570
Specific heat of constant pressure	.2025	.1476	.147	.18	
Latent heat of vaporization in B.t.u.'s.	256.3	71.95	78.8	101.8	58.3

A soluble solid that may be used as the flash back preventer is ammonium nitrite NH_4NO_2, which is subject to spontaneous decomposition at ordinary temperatures by an endothermic reaction whose end products are nitrogen and water. The use of a material subject to endothermic decomposition results in the removal of heat at the location of the hot spot or vapor lock and tends further to reduce the likelihood of raising the mono-fuel to temperatures near the ignition point. A further advantage in the use of such material is the fact that the end products, such as nitrogen and water, possess properties as diluents that tend to prevent ignition of the mono-fuel.

It is not necessary to add very much flash back preventer to the mono-fuels described herein. Amounts of such preventer will vary, within the scope of this invention, from a trace to a maximum of 10% by weight of the mono-fuel. The particular flash back preventer that is used will be dependent upon the conditions under which it is used, taking into account the permissible boiling point of the material, its density, latent heat of vaporization, molecular weight and specific heat. In addition to these factors the choice between solid, liquid or gas may depend on whether or not a pressurized system is required and whether or not decomposition of the flash back preventer is desired. As a matter of fact certain of the materials may be in different physical states under different conditions of use. For example, $CHCl_2F$ is a gas above 48° F. and a liquid below. If such materials are used as liquids their latent heat of vaporization gives a heat extraction result analogous to the endothermic decomposition of ammonium nitrite. If the flash back preventer decomposes, its products of decomposition act as the gas to form the vapor-lock as distinguished from carbon dioxide where it is the gas itself that so functions or the freon where the liquid vaporizes to perform its function. Any of these three methods of establishing a vapor-lock are deemed to be within the scope of the present invention.

The flame extinguishing constituent of the mono-fuel is added to the fuel-oxidant mixture to form a complete product. In many cases this product comprises only fuel, oxidant and flame extinguisher constituents and will be burned as such. On the other hand it is contemplated that in some cases a relatively small proportion of the mono-fuel may be added to other fuels to improve their combustion properties. As an example of this a mixture of approximately 90% of gasoline and 10% of a mono-fuel, said mono-fuel including fuel, oxidant and flash back preventer in proportions as described herein, may be mixed to form a propellant fuel. Again other constituents may be added to the mono-fuel described herein to give it other properties. An example of this is the addition of very small amounts of tetraphenyl tin, approximately 1% by weight, to act as a flame inhibitor.

A pressurized fuel system results when the flame extinguishing constituent is a soluble gas such as carbon dioxide. This is of advantage in certain fuel systems where it is desired to do away with as much auxiliary equipment in the form of pumps and the like as possible, particularly to effect a reduction in overall weight. Under such circumstances the pressure exerted by the gas in the liquid mixture may be utilized to force the liquid from the fuel tank to the combustion chamber. This action is in effect a controlled decomposition of the mono-fuel resulting in a release of pressure that acts as a driving force to propel the liquid components. In such circumstances the mono-fuel as a complete entity is retained within the storage tank and its controlled decomposition is only begun after it leaves the tank. Furthermore the rate of decomposition and the extent to which it is allowed to progress must be limited to the extent that the flash back preventive properties of the gas must

e at least partially maintained. In an ideal system the decomposition would be so controlled that he inert gas has all been removed from the fuel y the time it reaches the point of entry into he combustion chamber. Between the fuel tank nd the point of entry there will be a controlled lecomposition in which the inert soluble gas is radually removed from the other constituents of he mono-fuel.

A further advantage to the use of the above lash back preventers in the mono-fuels of the resent invention is that they may be used to a ertain degree to control the conditions of burning within the combustion chamber. While it s possible to so prepare the mono-fuel that the lash back preventer will have substantially no effect at the point of combustion it also is possible to use this constituent to decrease the flame emperature and the rate of flame propagation nd in general to alter somewhat the combustion conditions beyond those if only fuel and oxidant were burned. The addition of the flash back preventer only affects burning at the combustion chamber to a small degree because as the mono-fuel is passed through a nozzle the whole is vaporized and then the vaporized flash back addition is only a small fraction of a vaporized mass as distinguished from its vapor lock condition within the fuel supply system where it only is vaporized and all or substantially all of the balance of the mono-fuel remains liquid.

Although a preferred use of the present invention is in the form of a mono-fuel in which a single liquid entity is stored, transported and fed to the point of combustion this is not necessary. In certain cases it is desirable to maintain the constituents separate from each other until they are brought together at the point of combustion. Such a procedure would be desirable if the combustion characteristics of the self-sufficient fuel were to be altered during use by altering the percentages in which the constituents are mixed at the point of combustion.

The propellant that is the subject of this invention may be used for various purposes and in various ways. Its use in a gas turbine or other prime mover has been emphasized here but it is not to be limited to such use. It may be used in any apparatus and environment where combustion of a fuel is employed as for instance a source of gas under pressure as by confined combustion of the propellant and retention of the products of combustion.

I claim:

1. A self-sufficient fuel which, although non-hypergolic, has a tendency to burn in a closed system comprising a liquid nitroparaffin having not more than one nitro group for each carbon atom in the paraffin skeleton, said nitroparaffin being selected from the group consisting of nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane and 1,2,3-trinitropropane; an oxidant; and, dispersed in the fuel in an amount greater than a trace but not greater than 10% by weight of the fuel, a flash-back suppressor selected from the group consisting of ammonium nitrite, carbon dioxide, and the polychlorofluoromethanes.

2. A self-sufficient fuel which, although non-hypergolic, has a tendency to burn in a closed system comprising a liquid nitroparaffin having not more than one nitro group for each carbon atom in the paraffin skeleton, said nitroparaffin being selected from the group consisting of nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane and 1,2,3-trinitropropane; tetranitromethane as an oxidant; and, dispersed in the fuel in an amount greater than a trace but not greater than 10% by weight of the fuel, a flash-back suppressor selected from the group consisting of ammonium nitrite, carbon dioxide and the polychlorofluoromethanes.

3. A self-sufficient fuel which, although non-hypergolic, has a tendency to burn in a closed system comprising a liquid nitroparaffin having not more than one nitro group for each carbon atom in the paraffin skeleton, said nitroparaffin being selected from the group consisting of nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane and 1,2,3-trinitropropane; an oxidant; and, dispersed in the fuel in an amount greater than a trace but not greater than 10% by weight of the fuel, ammonium nitrite as a flash-back suppressor.

4. A self-sufficient fuel which, although non-hypergolic, has a tendency to burn in a closed system comprising a liquid nitroparaffin having not more than one nitro group for each carbon atom in the paraffin skeleton, said nitroparaffin being selected from the group consisting of nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane and 1,2,3-trinitropropane; an oxidant; and, dissolved in the fuel in an amount greater than a trace but not greater than 10% by weight of the fuel, carbon dioxide as a flash-back suppressor.

5. A self-sufficient fuel which, although non-hypergolic, has a tendency to burn in a closed system comprising a liquid nitroparaffin having not more than one nitro group for each carbon atom in the paraffin skeleton, said nitroparaffin being selected from the group consisting of nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1,1-dinitropropane, 2,2-dinitropropane, 1,2-dinitropropane, 1,3-dinitropropane, 1,1-dinitroethane, 1,1,1-trinitropropane and 1,2,3-trinitropropane; an oxidant; and, dissolved in the fuel in an amount greater than a trace but not greater than 10% by weight of the fuel, a polychlorofluoromethane as a flash-back suppressor.

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