LOW VISCOSITY MAGNETIC FLUID OBTAINED BY THE COLLOIDAL SUSPENSION OF MAGNETIC PARTICLES

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Fig. 1

Fig. 2

INVENTOR
SOLOMON S. PAPELL

BY

ATTORNEYS
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.

The present invention relates, generally, to a propellant fluid and, more particularly, to a low density and low viscosity magnetic propellant usable under zero-gravity conditions.

As the exploration and activity of man in space has enlarged, the questions associated with the behavior of rocket engine propellants, stored in space vehicle tanks and thereby utilized in a zero-gravity environment.

According to the present invention, the foregoing and other objects are obtained by the provision of a novel magnetized liquid propellant. The magnetic particles are dispersed throughout the propellant and colloidally suspended therein, by utilizing particles of submicron size, so that the surface area of each particle is extremely large in relation to its mass. Because of the small particle size and large surface area, the particles attract and hold the molecules of propellant (the dispersion medium) by surface tension and/or adsorption, thereby assuring that the magnetized particles cannot settle out of the fluid propellant. Additionally, because of the relatively small amount of magnetic material present, the propellant forms the major constituent of the colloid to provide low viscosity, easy flowability and low energy penalty due to the introduction of the noncombustible particles.

In preparing the magnetic propellant for the purposes described, various powdered magnetic materials such as nickel, cobalt, iron or various iron oxides may be used; however, the black oxide of iron, magnetite (Fe₃O₄), has been found most satisfactory in practice. The particle size of the magnetic particles preferably should be less than 0.25 micron in diameter to insure that a true colloid is formed and, advantageously, may include particles of less than 0.10 micron in diameter.

Although extremely fine particle sizes are obtainable by several known processes (e.g.: vacuum deposition, condensation, and chemical precipitation or combination), in practice grinding has been found to be a simple and satisfactory method for obtaining a colloidal suspension of the magnetized iron particles. Dispersion is accomplished by grinding commercially obtained powdered magnetite (a particle size of approximately 30 microns) in a ball mill in the presence of the propellant and a grinding agent, which prevents agglomeration or welding of the minute particles as grinding progresses. Generally, the grinding aide should comprise between 2-10 percent by weight of the metal particles and the grinding process continue until the colloid solution is composed of 0.5-10 percent by weight of suspended magnetic particles. These proportions insure that a proper particle size is obtained without agglomeration and, additionally, that the formed colloid is sufficiently magnetic for orientation by a magnetic field, and yet does not have too great an energy-penalty-loss due to the added weight of magnetic particles in the combustible propellant.

It is generally the case that the magnetic field is internal and yet must not be too strong so as to have an energy penalty due to the added weight of magnetic particles in the combustible propellant. Ideally, by the above process the formed magnetic colloidal propellant comprises 0.5 percent magnetite (by weight), with the remainder of the propellant solution formed in large part by the combustible propellant with only a small percentage present (less than 1 percent by weight) of grinding aide.

The following examples describe in greater detail the production of the novel magnetic propellant in accordance with the invention. The colloids were both formed in the same apparatus employing the following general procedure: a powdered metal slurry comprising the propellant, a surplus of powdered Fe₃O₄, and grinding agent was milled by placing the slurry in a stainless steel ball mill of one quart size, having three equally spaced internal ribs mounted on its circumference, ¼ inch in cross section and running the length of the jar. The mill was loaded with 3000 grams of stainless steel balls ½ inch in diameter and rotated at 48 r.p.m. for several days as set out below, after which, the formed colloid solution was decanted off and additional propellant and grinding agent added and milling continued. Additional charges of propellant and grinding agent were added as...
more colloid was decanted off, until the powdered mag-
netic iron remaining in slurry form in the mill was
diminished to the point where grinding was no longer
efficient.

Example 1

In this example a magnetic colloidal solution of hept-
ane, oleic acid and powdered magnetite was formed.
The mill was initially charged with 300 milliliters of
normal heptane, 30 grams of oleic acid and 200 grams
of magnetite. After 19 days of milling, the slurry
was allowed to settle and 200 milliliters of colloid solution
were decanted off. An additional charge of approxi-
mately 200 milliliters of propellant and grinding agent,
in the same proportion as above (10 milliliters of hept-
ane to 1 gram of oleic acid) was added, and grinding
continued for 6 days at which time another 200 milli-
liters of colloid were decanted off and the process of
adding additional heptane and oleic acid and then grind-
ing was repeated.

The decanted colloid was found to have a dark brown-
ish color and, as illustrated in FIG. 1, a particle size dis-
tribution of between approximately 0.06 to 0.24 micron
with the majority of the particles between 0.10-0.20
micron in size and a mean particle size of approximately
0.135 micron. This small particle size yields a true col-
loidal suspension when the amount of powdered magnetite
is limited to a maximum of approximately 10 percent by
weight of the solution. The colloidal solution then has a
density only slightly above that of heptane (0.684
gm./ml.) and essentially the same viscosity to thereby
provide low energy flow losses (e.g., pumping).

Example 2

In this example a colloidal solution of JP-1 (a common
rocket and turbojet fuel), oleic acid and powdered mag-
netite was formed.

Initially the ball mill was charged with 300 milliliters
of JP-1, 30 grams of oleic acid and 200 grams of mag-
netite; and the process of grinding and decanting off the
formed colloidal solution, as generally described, pro-
ceeded as before.

After an initial grinding period of 15 days, the slurry
was allowed to settle and 180 milliliters of colloidal
solution was decanted off. Approximately 180 milliliters
of JP-1 and oleic acid (10 milliliters of JP-1 to 1 gram
of oleic acid) were added and grinding continued for 6
days. The magnetic propellant was again decanted off
and the process repeated. Again the colloid was found
to be a dark brown color with a density and viscosity
closely approaching that of the particle carrier, JP-1.

Each of these colloidal solutions (Examples 1 and 2)
exhibited strong magnetic properties and was easily
oriented by the imposition of a magnetic field. Further,
samples of the heptane and JP-1 magnetic propellants
were found, upon dilution, to exhibit strong magnetic
properties with as low as 0.5 percent powdered mag-
netite. Thus, a satisfactory magnetic propellant was
obtained having a low energy penalty and a minimum
amount of oleic acid present, i.e., approximately 0.24
percent oleic acid based on the weight of heptane or JP-1
in the diluted solution. The oleic acid constituent
may be further minimized by utilizing a minimum of 2
percent oleic acid as the grinding aide in the slurry
charged in the ball mill. This substantially increases the
required grinding time (approximately twice as long),
but a true colloidal solution is still obtainable with a
particle size distribution similar to that illus-
trated in FIG. 1.

It should be apparent that higher percentages of oleic
acid may also be utilized to decrease grinding time, per-
centages as high as 10 percent having been successfully
utilized in practice. Additionally, other grinding agents
such as stearic acid and cetyl alcohol may be utilized
in the production of a magnetic propellant and other
long chain hydrocarbons having similarly high surface
tensions; such as: benzene, ethane, hydrazine, and gaso-
toline may be utilized as the partic. I.e carr' rer and major
constituent of the magnetic propellant.

In FIG. 2 is illustrated one apparatus which may ad-
vantageously utilize the novel magnetic propellant. The
propellant is stored in a tank 1 having a discharge line
12 adjacent to which a magnet, such as a permanent
magnet 14 and pump 16 is disposed. Under zero-gravity
conditions, the magnet orients and attracts the col-
loidally suspended magnetized particles towards the dis-
charge line 12. The hydrocarbon fuel molecules (e.g.,
heptane molecules) which are held to these particles
by high surface tension and/or adsorption move with
the magnetized particles and displace any propellant
vapor in this area; the pump 16 is actuated and the mag-
netized propellant moves through discharge line 12
and is ignited in nozzle 18.

Obviously many modifications and variations of the
present invention are possible in light of the above teachings.
It is, therefore, to be understood that within
the scope of the appended claims, the invention may be
practiced other than as specifically described.

What is claimed is:

1. A fluid rocket propellant for use in a zero-gravity
environment comprising a colloidal solution of a fuel
and magnetizable particles of a size less than 0.25 micron
in diameter whereby said propellant may be oriented and
attracted by the imposition of a magnetic field.

2. A magnetizable fluid for use as a rocket propell-
ant, said fluid including finely divided iron particles of
a size less than 0.25 micron and with an average parti-
cle size between 0.10 and 0.20 micron colloidal
suspended in a liquid propellant, said iron particles com-
prising between 0.5-10 percent by weight of the liquid
propellant.

3. The magnetizable fluid set forth in claim 2 wherein
the liquid propellant is a long chain hydrocarbon fuel.

4. A propellant fluid for use in a rocket engine com-
prising a long chain hydrocarbon fuel and magnetizable
particles colloidal suspended in said fuel, said mag-
netizable particles being less than 0.25 micron in diam-
eter and comprising 0.5-10 percent by weight of the fuel.

5. A magnetizable fluid for use as a rocket propellant,
said fluid consisting of finely divided submicron mag-
netite particles having a particle size distribution between
0.06 and 0.24 micron and a mean particle size of
approximately 0.135 micron, said particles being colloidal
suspended in a solution of a long chain hydrocarbon
propellant and oleic acid, said magnetite particles com-
prising between 0.5-10 percent based on the weight of
the solution, said oleic acid comprising between 0.1-10
percent based on the weight of the propellant.

6. The magnetizable fluid set out in claim 5 wherein
the range of size of the magnetite particles falls within
0.050 micron and 0.24 micron.

7. The magnetizable fluid set out in claim 6 wherein
the propellant is normal heptane.

8. A magnetizable fluid for use as a rocket propellant
comprising finely divided magnetizable particles of
a size less than 0.25 micron colloidal suspended in a
liquid propellant, said magnetizable particles comprising
less than 10 percent by weight based on the weight of
the liquid propellant.

9. The magnetizable fluid set forth in claim 8 wherein
the liquid propellant is a long chain hydrocarbon.

10. The magnetizable fluid set forth in claim 9 where-
wherein the liquid propellant is heptane.

11. In a fluid for use as a rocket propellant, the im-
provement comprising a plurality of particles of mag-
netic material of a size less than 0.25 micron disposed in
colloidal suspension in said fluid whereby said fluid
may be oriented and attracted by means of a magnetic field.

References Cited by the Examiner

| UNITED STATES PATENTS | | | |
|-----------------------|------------------|------------------|
| 2,809,661 10/57 Gillespie | 3,119,412 1/64 Kraft | 3,119,412 1/64 Kraft |
| 2,890,108 6/59 Toulmin | 3,122,429 2/64 Toulmin | 3,122,429 2/64 Toulmin |
| 2,986,456 5/61 Toulmin | | |
| 3,019,145 1/62 Whitby | | |


CARL D. QUARFORTH, Primary Examiner.

BENJAMIN R. PADGETT, Examiner.