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SOLID PROPELLANT COMPOSITIONS

Horace M. Higgins and Calvin A. Gongwer, Glendora, Calif., assignors to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

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This invention relates to solid propellants and has for its object to improve the burning rates and properties of such propellants. In particular, it relates to solid propellant compositions useful for underwater propulsion.

At the present time, the propellant compositions employed for propelling underwater projectiles are intimate mixtures of finely divided inorganic oxidizing salts, such as the chlorate, perchlorate, chromate or dichromate salts of a metal dispersed in a finely divided metal such as beryllium, aluminum or magnesium. These propellant compositions are particularly adapted for underwater military use since they do not produce non-condensable gases upon combustion. Such gases create a highly undesirable visible wake. Due to their compactness and non-gassing properties, such propellants also find valuable use in burning and cutting metal such as pipe in oil wells. Unfortunately, however, the combustion of such propellants becomes unstable at high pressures and this feature seriously limits the conditions under which these propellants may be used either for underwater propulsion or cutting purposes.

In underwater operation such propellants are burned in the presence of water and the driving thrust is created by means of evaporating the water to steam. The magnitude of the thrust is dependent upon the amount of heat available for generating steam during the time the projectile is in motion. The amount of available heat is in turn dependent upon the properties of the particular propellant being burned as well as the amount of the propellant consumed. In underwater projectiles, the burning area of a propellant is confined to a given cross section, due to space limitations inherent in the design of such projectiles. Thus, in order to increase the thrust created by burning such a propellant, it is necessary to increase the linear burning rate of the propellant.

We have now found that the pressure stability during combustion as well as the burning rate of such propellants is greatly increased and improved by incorporating finely divided metals into the propellant composition.

In accordance with the present invention, we incorporate into the propellant composition a metal or metal alloy such as finely divided cobalt, copper, ferro-vanadium, lead or tin. These metals in amounts as small as 1% by weight of the propellant substantially increase the linear burning rate of the propellants, and greatly improve their pressure stability during combustion.

The additives are incorporated into the propellant merely by mechanically mixing the finely divided ingredients, until an intimate and uniform mixture is obtained. Optimum results are achieved when the additives are employed in amounts of from about 1% to about 30% by weight of the propellant and the readily oxidizable metal and inorganic oxidizing salts are in approximately stoichiometric proportions.

The readily oxidizable metals commonly employed in the propellant composition release large quantities of heat during oxidation, have a high positive electrode potential, and are stable in the presence of air under ordinary conditions. Metals such as beryllium, aluminum, and magnesium which exhibit electrode potentials in excess of +1.6 volts at 25° C. and which liberate at least 2.4K cal./gram when reacted with perchlorates, are preferred. The oxidizing salt usually employed is a chlorate, perchlorate, chromate or dichromate salt of a metal. For reasons of convenience and weight, the alkali and alkaline earth metal salts are preferred. The perchlorate salts are preferred due to their light weight, stability and high oxygen content.

The solid propellants are prepared by mixing the finely divided metal and finely divided, inorganic oxidizing salt until an intimate, uniform mixture is obtained. The mixture is then compressed under high pressure to obtain the solid grain. The preferred formulations of the propellant compositions which have been found to be particularly useful for underwater jet propulsion are shown in Table I:

Table I

Propellant	Constituents	By Wt. Percent
A	Aluminum	34.1
	Potassium perchlorate	65.9
B	Aluminum	40.4
	Lithium perchlorate	59.6
C	Aluminum	37.0
	Sodium perchlorate	63.0
D	Beryllium	20.6
	Potassium perchlorate	79.4
E	Beryllium	25.3
	Lithium perchlorate	74.7
F	Beryllium	22.7
	Sodium perchlorate	77.3
G	Magnesium	41.2
	Potassium perchlorate	58.8
H	Magnesium	47.7
	Lithium perchlorate	52.3
I	Magnesium	44.2
	Sodium perchlorate	55.8

To illustrate the effect of the additives of this invention upon a typical propellant, the results obtained by incorporating appropriate metals into a propellant containing stoichiometric amounts of finely divided aluminum and potassium perchlorate are presented in Table II.

Table II

Catalyst	Percent by wt. added	Burning Rate—in./sec. at—		Pressure Stability
		100 p.s.i.a.	250 p.s.i.a.	
	----------	0.38	Unstable	(Unstable above 125 p.s.i.).
Cobalt	10	0.87	1.37	800 p.s.i.a.
Copper	10	0.74	Unstable	100 p.s.i.a.
Lead	13	0.90	1.50	1,100 p.s.i.a.
Tin	6	0.94	1.75	300 p.s.i.a.
Ferro-Vanadium	10	0.63	0.74	1,000 p.s.i.a.

Pressure stability refers to the pressures below which combustion is stable.

As shown by the data presented in Table II, the additives of this invention more than doubled the burning rate of the propellant in most cases, permitting more fuel to be burned during a given period of time, hence creating greater thrust. In addition, a substantial increase in pressure stability permitting a broader range of operating conditions was attained. We have also found that two or more metals may be used to obtain any particular balance of pressure stability and burning rate desired.

It is apparent from the above discussion that by incorporating the additives of this invention into propellant compositions containing finely divided magnesium, beryl-

lium and aluminum and inorganic oxidizing salts propellant compositions are produced which provide greater thrust when used for underwater propulsion. In addition, these propellants may be used under a wide range of pressures, thus greatly increasing their usefulness both for underwater propulsion and for burning and cutting operations in oil wells. The improved propellants of this invention are particularly suited for use in underwater propulsion plants of the type disclosed in assignee's copending application Serial No. 428,698, filed May 10, 1954, now abandoned.

We claim:

1. In a solid propellant composition consisting essentially of an intimate mixture of a metal having an electrode potential above 1.6 volts at 25° C. and an inorganic oxidizing salt of a metal in substantially stoichiometric proportions; the improvement which comprises incorporating a burning rate acceleration additive selected from the group of metals consisting of cobalt, copper, ferro-vanadium, lead and tin.

2. In a solid propellant composition consisting essentially of an intimate mixture of a readily oxidizable metal selected from the group consisting of beryllium, aluminum and magnesium and an inorganic oxidizing salt selected from the group consisting of a chlorate, perchlorate, chromate and dichromate of a metal in substantially stoichiometric proportions; the improvement which comprises incorporating a burning rate acceleration additive selected from the group consisting of cobalt, copper, ferro-vanadium, lead and tin.

3. A solid propellant composition consisting essentially of an intimate mixture of a readily oxidizable metal selected from the group consisting of beryllium, aluminum and magnesium in about stoichiometric proportions with an inorganic oxidizing salt selected from the group consisting of a chlorate, perchlorate, chromate and dichromate of a metal in substantially stoichiometric proportions; and a burning rate acceleration additive selected from the group consisting of cobalt, copper, ferro-vanadium, lead and tin.

4. A solid propellant composition consisting essentially of an intimate mixture of a readily oxidizable metal selected from the group consisting of beryllium, aluminum, and magnesium and an inorganic oxidizing salt selected from the group consisting of a chlorate, perchlorate, chromate and dichromate of a metal in substantially stoichiometric proportions; and a burning rate acceleration additive selected from the group of metals consisting of cobalt, copper, ferro-vanadium, lead and tin in amounts of from about 1% to about 30% by weight of the total propellant composition.

5. A solid propellant composition comprising an intimate mixture of aluminum metal, an alkali metal perchlorate and cobalt metal in an amount of from about 1% to about 30% by weight of the total propellant composition.

6. A solid propellant composition comprising an intimate mixture of aluminum metal, an alkali metal perchlorate and ferro-vanadium metal in amounts of from about 1% to about 30% by weight of the total propellant composition.

7. A solid propellant composition comprising an intimate mixture of aluminum metal, an alkali metal perchlorate and ferro-vanadium metal of from about 1% to about 30% by weight of the total propellant composition.

8. A solid propellant composition comprising an intimate mixture of aluminum metal, an alkali metal perchlorate and lead metal in amounts of from about 1% to about 30% by weight of the total propellant composition.

9. A solid propellant composition comprising an intimate mixture of aluminum metal, an alkali metal perchlorate and tin metal in amounts of from about 1% to about 30% by weight of the total propellant composition.

10. A solid propellant composition comprising an intimate mixture of aluminum metal and an alkali metal perchlorate in about stoichiometric proportions and finely divided cobalt metal in an amout of about 10% by weight of the total propellant composition.

11. A solid propellant composition comprising an intimate mixture of aluminum metal and an alkali metal perchlorate in about stoichiometric proportions and finely divided copper metal in an amount of about 10% by weight of the total propellant composition.

12. A solid propellant composition comprising an intimate mixture of aluminum metal and an alkali metal perchlorate in about stoichiometric proportions and finely divided ferro-vanadium metal in an amount of about 10% by weight of the total propellant composition.

13. A solid propellant composition comprising an intimate mixture of aluminum metal and an alkali metal perchlorate in about stoichiometric proportions and finely divided lead in an amount of about 13% by weight of the total propellant composition.

14. A solid propellant composition comprising an intimate mixture of aluminum metal and an alkali metal perchlorate in about stoichiometric proportions and finely divided tin in an amount of about 6% by weight of the total propellant composition.

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