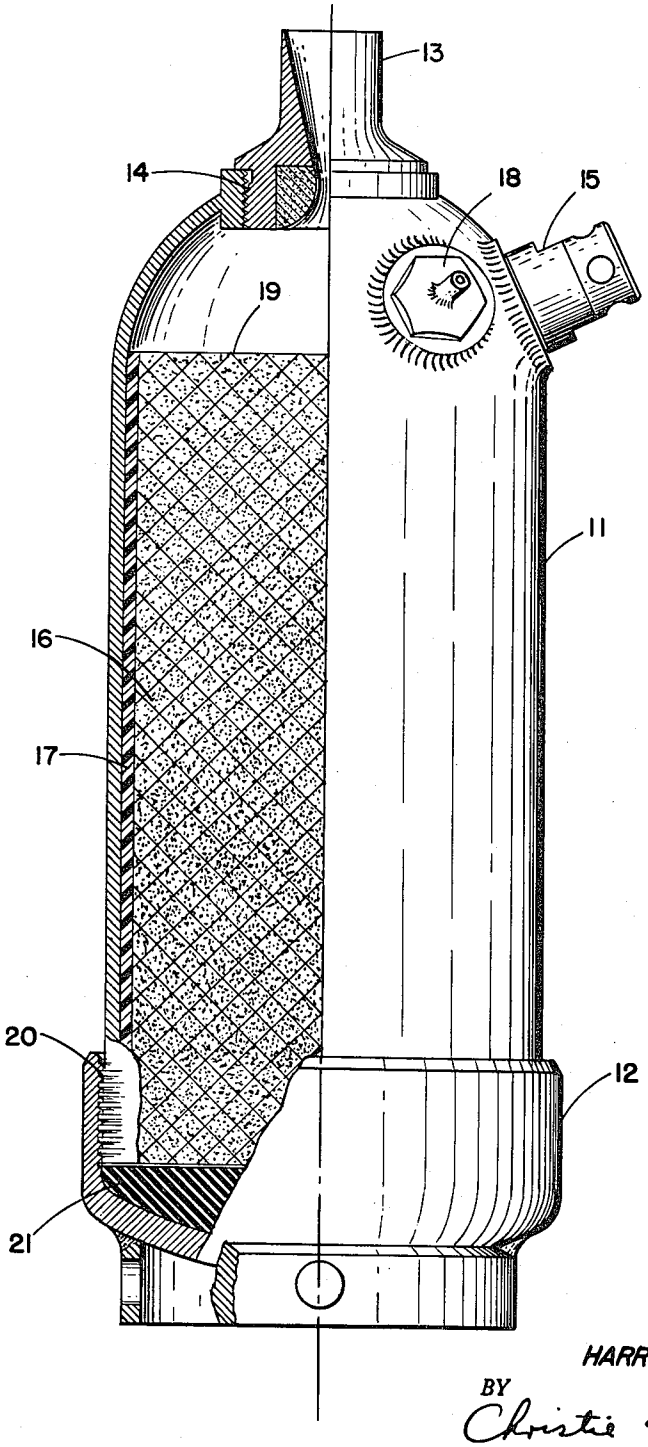
April 3, 1956 H. W. MACE 2,740,702

PROPELLANT COMPOSITION

Filed July 27, 1945



INVENTOR.
HARRY W. MACE
BY
Christie & Angus
ATTORNEYS

United States Patent Office 2,740,702 Patented Apr. 3, 1956

2,740,702

PROPELLANT COMPOSITION

Harry W. Mace, Glendale, Calif., assignor, by mesne assignments, to Aerojet-General Corporation, Cincinnati, Ohio, a corporation of Ohio

Application July 27, 1945, Serial No. 607,278

2 Claims. (Cl. 52—.5)

This invention relates to fuels adapted for use as propellants of jet propulsion motors, and provides a smokeless propellant of the so-called solid type capable of a high burning rate and particularly adapted for such use.

It is a common practice to use in the combustion chambers of jet propulsion motors solid or plastic propellant mixtures which are burned to produce gaseous combustion products which in turn are exhausted through a nozzle at high velocity, thereby producing a thrust. The burning rate of the propellants placed in the jet motors affects the amount of thrust that can be obtained in a unit of given cross section because the thrust developed is dependent upon the volume of gases liberated per unit time. It is desirable in many instances to have a propellant of this type which is smokeless, but difficulty has been encountered heretofore in formulating a smokeless propellant that will burn at a sufficient rate to insure the creation of enough gas per unit time to produce the required thrust.

A propellant composed principally of ammonium perchlorate mixed with an asphalt base fuel, for example, will burn with relative freedom from smoke but will not develop as much thrust as other known propellants. Substances have heretofore been added to accelerate the burning rate of these so-called smokeless propellants, but the increases in burning rate of such compositions have been small in comparison to the rate increases obtained when this invention is employed. A common procedure has been to add certain substances which while increasing the burning rate somewhat, incidentally make the propellant composition sensitive to shock, thereby creating an explosion hazard. Another expedient proposed heretofore involves use of motors of large dimensions so as to insure a sufficient burning surface to produce the required amount of gas per unit time. Both expedients have undesirable disadvantages.

I have discovered that the low burning rate at which ammonium perchlorate base propellants ordinarily burn may be increased by the addition of suitable catalytic materials to the mixtures. In fact, the propellants compounded according to my invention have a burning rate that is comparable to that of the fastest burning so-called smokeless propellants if these are burned at a pressure of 2000 lbs./in.^{2}. These catalysts may be added to the propellant formula at the time that the solid propellant is made.

I carry out my invention by incorporating in an ammonium perchlorate-asphalt type of propellant suitable amounts of metal oxides which I have found accelerate the combustiton rate of ammonium perchlorate-asphalt mixtures. Examples of such metal oxides are chromium sesquioxide and ferrosoferric oxide.

I have also found that a mixture of chromium sesquioxide with an oxide taken from the group of metal oxides consisting of ZnO, Fe_3O_4, TiO_2, SnO_2, Al_2O_3 and CuO also exhibit catalytic properties. These metal oxides may be added to the chromium sesquioxide in percentages varying from a trace to 50% of the mixture of oxides by weight. However, in some cases it has been found desirable to use these oxides, particularly Fe_3O_4 alone. These

mixtures do not increase the burning rate the same amount that chromium sesquioxide alone is capable of doing.

A mixture of chromium sesquioxide and an acid-activated aluminum silicate available on the market under the trade name of "Filtrol" has also been found to possess catalytic properties. The choice of a particular oxide, or one of the mixtures of oxides, is dependent on the degree of activity and economy required of the catalyst, for example, it has been found that Fe_3O_4 used by itself (although not quite as effective as chromium sesquioxide) exerts a catalytic effect that is comparable to any of the mixtures of chromium sesquioxide and the named metal oxides. The compositions of the catalytic mixtures of oxides which have been found next most satisfactory to chromium sesquioxide alone are a mixture of Cr_2O_3 and Fe_3O_4, mixtures of chromium sesquioxide with SnO_2, and mixtures of Fe_3O_4 and TiO_2. These mixtures are enumerated in the relative order of activity.

The above-described catalysts may be added to the propellants in amounts varying from 1% to 4% by weight, it having been found that 1% increases the burning rate of the propellant approximately ⅛ of an inch per second. When more than 4% by weight of the catalyst is employed, there is a decrease rather than an increase in burning rate. This is probably caused by the diluting effect of the catalyst on the active ingredients of the propellant.

The manner in which my propellant may be used in a jet propulsion device is illustrated in the accompanying drawing which shows a jet motor partly in cross section. This comprises a cylindrical body **11** closed at one end by a threaded cap **12** when screwed in place on threads **20** of the cylindrical body **11** and provided with an exhaust nozzle **13** at the opposite end. The nozzle **13** is fitted into the open end of the cylindrical shell **11** and is held in the open end by threads **14**. Cylindrical shell **11** is provided with a safety plug **15**. A propellant charge **16** composed of a modified ammonium perchlorate-asphalt mixture, as later described, and a catalyst are placed inside the motor shell **11**. The charge is separated from the outer wall of the shell **11** by a suitable liner **17** and supported at the cap end by a cushion **21** of resilient material such as rubber. The charge is ignited by igniter **18** when the motor is to be put into operation. When the igniter **18** is fired by suitable electrical contacts (not shown) the entire burning surface **19** of propellant charge **16** will burn at one time causing gases to form. The escape of these gases through the exhaust nozzle **13** provides the thrust.

The improvement in the burning rate of a smokeless propellant charge containing catalytic material in accordance with the invention is illustrated by the following:

Example

As an example the following basic propellant mixture which contains:

A. 8% of an asphalt produced in the region of Port Neches, Texas, and airblown until it possesses the following properties:

1. Penetration with 100 gr. wt. for 5 sec. at 77° F. 12–20
2. Softening point ..... 230–240° F.

(This asphalt is of a slightly aromatic nature and an equivalent may be purchased on the market under the designation of Texaco 18 Asphalt.)

	Per cent
B. Cetyl acetamid	3
C. Dibutyl sebacate	5½
D. Castor oil modified glycerol sebacate	3
E. Ammonium perchlorate (finely ground)	73
F. Chromium sesquioxide	2½

When such a mixture is burned without any catalyst, its approximate burning rate, measured in depth through the layer, is .25 of an inch per second at 700 p. s. i.

The same mixture containing 2½% chromium oxide by weight when burned at 2000 p. s. i., chamber pressure burns approximately at the rate of .75 of an inch per second. When the pressure is dropped to 1000 p. s. i., the burning rate is .65 of an inch per second.

The metal oxide or oxide mixtures may be introduced into the propellant mixture by incorporating the finely divided oxide with the ammonium perchlorate before it is blended with the fuel, or by mixing the catalyst with the entire mass after the fuel and oxidizer are blended together.

The accelerating effect due to the metal oxides is due apparently to a catalytic action on the ammonia of the ammonium perchlorate types of propellant, perhaps by the acceleration of the otherwise slow oxidation rate of the ammonia to the oxides of nitrogen by the perchlorate.

The instant invention permits the use of such types of propellant in cases in which high burning rates are essential. Up to the present, the use of ammonium perchlorate types of propellant has been limited to applications where low burning rates were required.

Moreover, the addition of metal oxides to ammonium perchlorate type propellants does not result in propellant mixtures which are more sensitive to shock than those which do not have the metal oxides and therefore makes

available a propellant of the smokeless type which is comparable for application to operations where, heretofore, potassium perchlorate-asphalt type of propellants have been employed.

A further advantage is that the smokeless propellants, compounded according to my invention, are capable of burning, when the chamber pressure is 2000 lbs. at a rate that is as rapid as other smokeless propellants and actually exceeds the burning rate of the commonly known smokeless type of propellants such as nitrocellulose.

I claim:

1. An ammonium perchlorate-asphalt base propellant for jet propulsion motors containing about 1% to 4% by weight of a catalytic compound composed of chromium sesquixoide and a metal oxide selected from the group consisting of ZnO, Fe_3O_4, SnO_2, TiO_2, Al_2O_3 and CuO, the amount of the metal oxide being up to about 50% by weight of the mixture.

2. A propellant consisting principally of ammonium perchlorate mixed with plastic asphalt fuel and having incorporated therein about 1% to 4% by weight of a mixture of finely divided chromium sesquioxide and a metal oxide taken from the group consisting of ZnO, Fe_3O_4, TiO_2, SnO_2, Al_2O_3 and CuO.

References Cited in the file of this patent

UNITED STATES PATENTS

1,966,652 Tanner ---------- July 17, 1934