Dec. 22, 1959 H. M. FOX 2,917,894

OPERATION OF SOLID PROPELLANT ROCKETS

Filed March 6, 1953 2 Sheets-Sheet 1

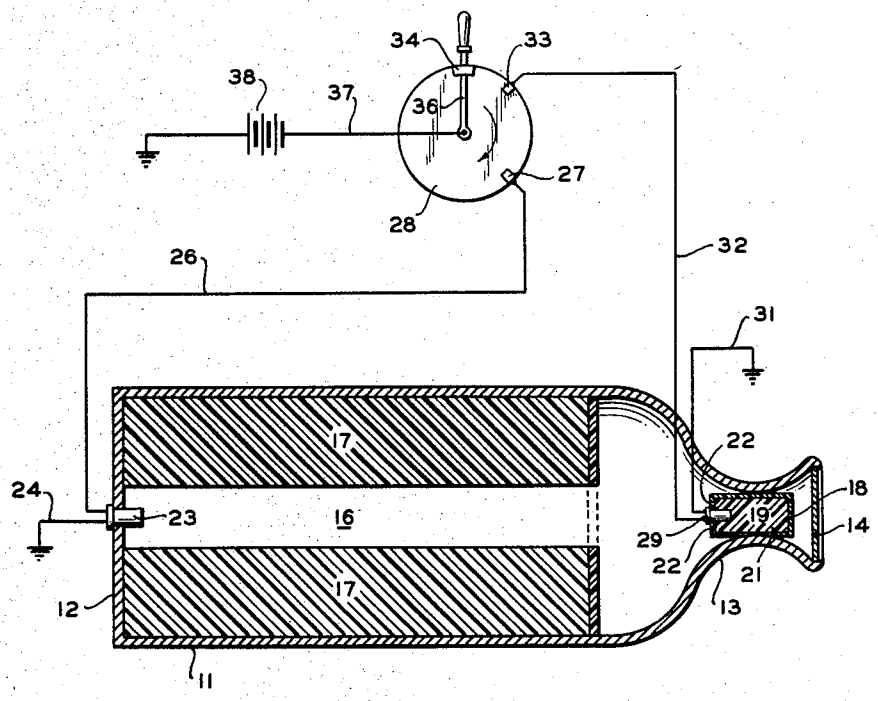


FIG. 1.

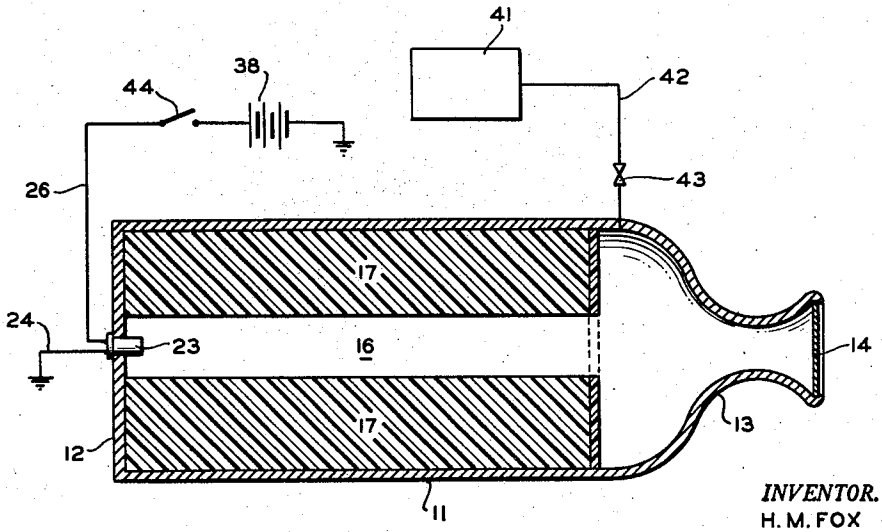


FIG. 2.

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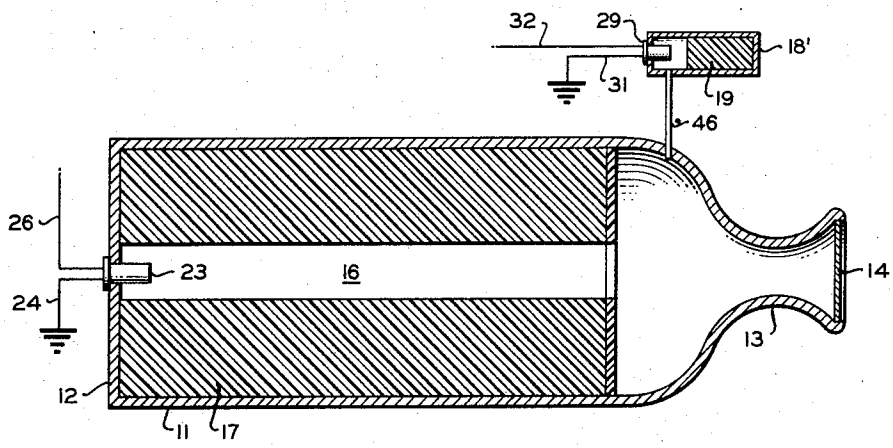


FIG. 3.

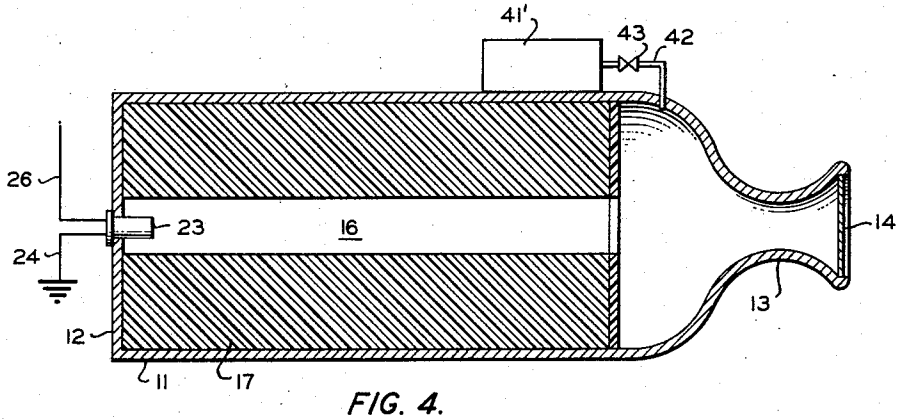


FIG. 4.

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OPERATION OF SOLID PROPELLANT ROCKETS

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5 Claims. (Cl. 60—35.6)

This invention relates to the operation of solid propellant rockets. In one of its more specific aspects, the invention relates to an improved method for burning a solid rocket propellant. In another specific aspect, the invention relates to an improved combustion apparatus for solid propellant rockets.

With rockets utilizing a solid propellant, all of the propellant to be burned is contained within the combustion chamber. Since long duration solid rocket units would require an excessively heavy and large combustion chamber, this type of propulsion unit is particularly adaptable to short duration firing. Solid propellant rocket units are most extensively used for jet-assist-take-off units and rocket bombs and projectiles. Because solid propellant rockets do not require feed systems, valves, or pumps such as there are in liquid units, the outstanding feature of these rockets is their simplicity of construction.

The solid propellant charges utilized are generally classified with reference to their burning as restricted and unrestricted burning type charges. The restricted type is the one which provides for controlled burning, and most propellants have provision for some form of restricted burning. While this invention is applicable to any solid propellant rocket, it is particularly applicable to rockets using a charge of the restricted type.

As to composition, solid propellants may be classified as the double base type and the composite type of propellant. An example of a double base propellant is "ballistite" which comprises essentially nitroglycerin and nitrocellulose. Composite type propellants are generally composed of an oxidizer, and a binder, or fuel. They may contain other materials to improve fabrication or increase ballistic performance such as a burning rate catalyst. The proportion of components will vary with the particular propellant, but in general performance requires that the oxidizer comprise the major part of the charge. Compounds which may be used as oxidizers are ammonium nitrate and perchlorates such as ammonium perchlorate and potassium perchlorate.

The rate at which solid propellant is consumed during operation is called the burning rate. It is of primary importance that the burning rate of any specific charge be uniform and in accordance with calculated limitations. Solid propellants as indicated above are fabricated into sticks, and one of the disadvantages of these charges is that they possess poor strength, tending to fracture on being subjected to the shock of ignition. Oxidizers even when combined with a very rubbery binder may result in a propellant which is brittle and which may rupture during the stresses imposed by ignition. When a charge does fracture, an increased burning surface is exposed which results in an excessively high burning rate and may cause the combustion chamber to rupture. Another disadvantage of solid propellants is poor ignitibility at atmospheric pressure. The disadvantage of poor strength, and to some extent the disadvantage of unsatisfactory ignitibility, is a result of the low oxygen

balance of the oxidizer and binder which makes it necessary to have a large concentration of oxidizer to binder. This latter statement is especially applicable when ammonium nitrate is used as the oxidizer. Because of the lower cost and greater potential availability of ammonium nitrate than other oxidizers, this invention becomes especially applicable where this compound is utilized.

The objects of the invention will be attained by the various aspects of the invention.

It is an object of the present invention to provide an improved method of burning a solid rocket propellant. It is also an object of this invention to provide an improved combustion apparatus for solid propellant rockets. It is a further object to provide a method and means of minimizing the ignition shock of solid rocket propellants. It is a still further object to provde a method and means of improving the ignitibility of solid rocket propellants.

My invention provides a method and means of raising the pressure of a rocket combustion chamber without shocks to the propellant. In the conventional ignition of solid rocket propellants, extremely high pressures are developed in a few milliseconds. Because of the shock development of pressure during ignition, impact of the shock waves against the propellant and/or extreme pressure differentials may exist which will result in propellant failure. By this invention a gas is supplied to the combustion chamber prior to the ignition of the propellant until the pressure of the combustion chamber is substantially lower, and preferably from about 100 to 200 pounds per square inch lower, than the operating pressure of the combustion chamber. The pressure of the combustion chamber is thus raised without shock to the propellant, and when the propellant is subsequently ignited, the shock of ignition is substantially eliminated. And by the initial raising of the combustion chamber pressure, the ignitibility of the propellant is automatically improved.

For a better understanding of the invention, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described preferred embodiments of my invention.

In the drawing:

Figure 1 is a cross-sectional view of a solid propellant rocket, illustrating one embodiment of the invention.

Figure 2 is a cross-sectional view of a solid propellant rocket, illustrating another embodiment of the invention.

Figure 3 is a cross sectional view illustrating a modification of the solid propellant rocket of Figure 1.

Figure 4 is a cross-sectional view illustrating a modification of the solid propellant rocket of Figure 2.

Referring in detail to Figure 1, an elongated container **11**, which may be cylindrical in shape, is closed at its upstream end by closure member **12**. A nozzle **13** provided with pressure diaphragm **14** is connected to the downstream end of container **11**. Pressure diaphragm **14** is designed to blow out at some small increment of pressure less than the operating pressure of the rocket as will be discussed hereinafter. Container **11** encloses main combustion chamber **16** in which is positioned solid rocket propellant **17**. As illustrated, a single hollow charge is being utilized, but it is not intended to limit the invention to this type of charge, and it is contemplated that either the restricted or unrestricted type of burning unit may be used. Enclosed container **18**, positioned within the throat of nozzle **13** contains auxiliary combustion chamber **19** in which is disposed a solid rocket propellant **21**. Orifices **22** in the upstream face of container **18** communicate auxiliary combustion chamber **19** with main combustion chamber **16**. The igniter for the main combustion chamber comprises powder container **23** with a hot wire contained therein in contact

with a powder charge, and leads 24 and 26 connected to the hot wire. Other arrangements of the igniter are possible than the one illustrated. For example, the igniter may be held within the solid propellant, or it may be built into the chamber wall. Lead 24 is grounded while lead 26 is connected to a contact 27 mounted on disc 28 which is made of a non-conducting material. The igniter for the auxiliary combustion chamber comprises powder container 29 with a hot wire contained therein in contact with a powder charge, and leads 31 and 32. Lead 31 is grounded while lead 32 is connected to contact 33 mounted on disc 28. Contact 34, attached to and rotatable with handle 36, is connected through handle 36 to the positive terminal of battery 38 which has its other side grounded.

Referring in detail to Figure 2, parts corresponding to those described in relation to Figure 1 are designated by identical numerals. A source 41 of inert gas is connected to combustion chamber 16 by means of line 42 which is provided with a pressure regulating valve 43. Lead 26 is connected to the positive terminal of battery 38 through switch 44.

In the operation of the rocket illustrated in Figure 1, handle 36 is rotated in a clockwise direction. When contact 34 meets contact 33 current flows through line 32 heating the hot wire positioned within powder container 29. Contact 34 is shown as a segment in order to allow sufficient time for the powder within container 29 to ignite. The powder upon ignition burns with a hot flame and ignites solid rocket propellant 21 disposed within auxiliary combustion chamber 19. Any of the solid rocket propellants previously discussed may be utilized in the auxiliary combustion chamber, but it is preferred to use "ballistite." Upon ignition of the solid propellant within auxiliary combustion chamber 19, the products of combustion escape through orifices 22 and enter main combustion chamber 16, thereby raising the pressure of this latter chamber to a predetermined amount. Pressure diaphragm 14 is designed to blow out of nozzle 13 at some pressure less than the rocket operating pressure, but greater than the initial pressure to which the main combustion chamber is subjected. Upon continued rotation of handle 36 in a clockwise direction, contact 34 meets contact 27, causing current to flow in lead 26 so as to heat the hot wire positioned within powder container 23 and ignite the powder contained therein. The hot flame of the ignited powder ignites solid rocket propellant 17 disposed within main combustion chamber 16. The products of combustion of the burning propellant raise the pressure of main combustion chamber 16 to operating pressure and are ejected through nozzle 13, thus imparting the desired thrust to the rocket. When the products of combustion are ejected through the nozzle, pressure diaphragm 14 and container 18 are blown out of the rocket.

To illustrate further the operation of Figure 1, it is assumed that main combustion chamber 16 operates at 1000 pounds per square inch chamber pressure. Pressure diaphragm 14 is designed to blow out of nozzle 13 at 900 pounds per square inch so that it is apparent that a pressure up to at least this amount can be built up within the rocket before any gases are ejected through nozzle 13. Auxiliary combustion chamber 19 contains a small quantity of a well known superior solid propellant as ballistite, having a mass sufficient so that when completely burned the pressure in main combustion chamber 16 will be raised to approximately 800 pounds per square inch or a pressure somewhat less than the blow-out pressure of pressure diaphragm 14. Upon ignition of the charge within auxiliary combustion chamber 19, main combustion chamber 16 is initially pressurized comparatively slowly to a pressure of approximately 800 p.s.i. By pressurizing the chamber relatively s'owly in this manner, no excessive pressure forces are exerted on the solid propellant during this stage. When the solid propellant is ignited a short time later, it will be necessary to raise the pressure of the main combustion chamber only about 200 p.s.i. In this manner the shock of ignition and concomitant fracture of propellant, which might result if the chamber pressure were suddenly raised to 1000 p.s.i. without a preliminary pressurizing of the chamber, is substantially eliminated. Furthermore, since ignition is improved with increased pressure and since under pressure the flame will move more rapidly over the surface to be ignited, ballistic performance in general will be improved by operating a solid propellant rocket in accordance with this invention.

In the operation of the rocket of Figure 2, which illustrates another embodiment of the invention, a pressurized inert gas, as nitrogen or carbon dioxide, is utilized to pressurize combustion chamber 16. Air or oxygen, which will also affect the burning characteristics of the solid rocket propellant, may also be used. When valve 43 is opened the gas at the desired pressure is supplied from source 41 to combustion chamber 16 through line 42. After combustion chamber 16 has been pressurized, valve 43 is closed and switch 44 is closed thus causing solid propellant 17 to be ignited in the same manner as described above in conjunction with Figure 1. Pressure diaphragm 14 is provided here as well as in Figure 1 to permit the initial pressure to build up within combustion chamber 16, and will be ejected along with the products of combustion through nozzle 13.

Although I have described my invention with a certain degree of particularity, it is to be understood that numerous alterations in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention. For instance, referring to Figure 1, it is within the contemplation of the invention to place auxiliary combustion chamber 21 in other positions than that illustrated, as for example, outside of and adjacent to the rocket. This modification of the invention is illustrated in Figure 3 which shows enclosed container 18' encompassing the auxiliary combustion chamber as being positioned outside of and adjacent elongated container 11. Line 46 communicates the auxiliary combustion chamber with main combustion chamber 16. It is also within the contemplation of the invention, referring to Figure 2, to utilize a pressurized gas source which is attached to the rocket itself. Figure 4 of the drawing illustrates this latter modification of the invention. In this figure, a source 41' of pressurized gas is shown as being attached directly to elongated container 11. In Figures 3 and 4, elements corresponding to those described with relation to Figures 1 and 2 are designated by identical reference numerals. Various modifications of the invention will become apparent to those skilled in the art, and the illustrative details disclosed are not to be construed as imposing unnecessary limitations upon the invention.

I claim:

1. An improved combustion apparatus for solid propellant rockets which comprises an elongated container enclosed at one end only and encompassing a main combustion chamber; a nozzle connected to the open end of said container and communicating with said main combustion chamber; a pressure diaphragm positioned in said nozzle; a second container encompassing an auxiliary combustion chamber, said auxiliary chamber communicating with said main combustion chamber; means for igniting a solid propellant charge disposed within said main combustion chamber, and means for igniting a solid propellant charge disposed within said auxiliary chamber.

2. An improved combustion apparatus for solid propellant rockets which comprises an elongated container enclosed at one end only and encompassing a main combustion chamber; an ignition means positioned within said main combustion chamber; a nozzle connected to the open end of said container and communicating with said main combustion zone, the downstream of said

nozzle being closed with a pressure diaphragm; a second container encompassing an auxiliary combustion chamber, said auxiliary chamber communicating with said main combustion chamber; and an ignition means positioned within said auxiliary combustion chamber.

3. An improved combustion apparatus for solid propellant rockets which comprises an elongated container enclosed at one end only and encompassing a combustion chamber; an ignition means positioned within said combustion chamber; a nozzle connected to the open end of said container and communicating with said combustion chamber, said nozzle being closed with a pressure diaphragm; gas inlet means adapted to inject an inert gas into said combustion chamber; and a source of pressurized inert gas connected to said gas inlet means.

4. The combustion apparatus of claim 2 in which said auxiliary container is disposed within the throat of said nozzle.

5. The combustion apparatus of claim 2 in which said auxiliary container is disposed outside of and adjacent said elongated container and conduit means communicate said auxiliary chamber with said main combustion chamber.

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