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SOLID FUEL ROCKET WITH SEPARATE FIRING RATE CHARGE PORTIONS

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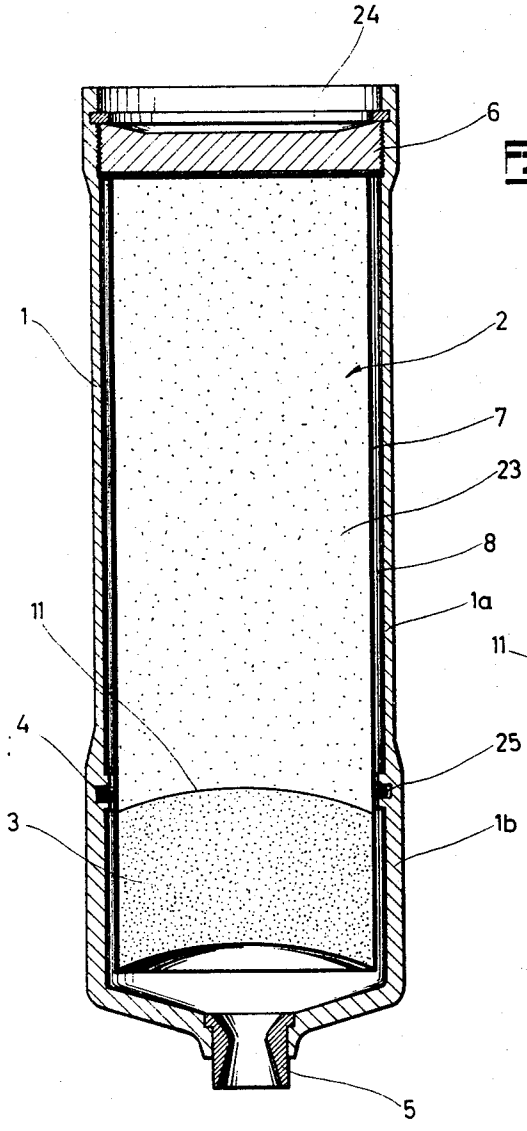


FIG. 1

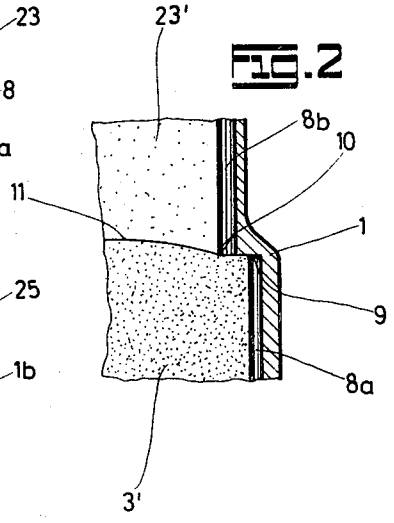


FIG. 2

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SOLID FUEL ROCKET WITH SEPARATE FIRING RATE CHARGE PORTIONS

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ABSTRACT OF THE DISCLOSURE

The solid fuel rocket propulsion engine of the invention includes a cylindrical housing or container having a narrow nozzle section discharge at one end. A solid fuel having charge portions which burn at different rates is mounted in the combustion chamber so that it is spaced inwardly from the interior walls and leaves an empty gas chamber slot around its periphery. The charge advantageously includes a starting or ignition charge portion at the end adjacent the nozzle which will burn off first and a cruising charge portion at the inner end of the combustion chamber.

In accordance with the invention, means are provided for holding the charge in a position such that it is spaced from the interior walls of the combustion chamber, and there is a seal dividing the surrounding slot chamber at a location adjacent the juncture of the individual charge portions. The seal thus divides the surrounding slot chamber into two separate sealed chambers so that each charge portion may ignite and burn in its own sealed chamber while the remaining portion of the combustion chamber is separated therefrom and sealed therefrom so that there will be no return or inward flow of the thrust gases until the charge portion is consumed and the next adjacent charge portion in ignited.

This invention relates, in general, to thrust engine construction and, in particular, to a new and useful solid fuel rocket propulsion unit having means for programming the firing of charges at different propulsion or thrust rates and to means for sealing off the remaining portions of the combustion chamber during the firing of the respective charges.

If a missile which is driven by a solid fuel rocket propulsion unit is to perform certain flight maneuvers, or to continue to fly at constant speeds following one or several acceleration phases, then the thrust output or thrust development which will be generated by the propulsion unit must be adapted to the individual flight conditions. A varying thrust output or programmed thrust development for predetermined flight periods can be achieved in a conventional manner by using several multi-stage rocket engines which are fired at the desired times. Multi-stage rocket engines have the disadvantage, particularly in respect to small missiles, that the combustion chambers of the burnt out stages are either dragged along or must be ejected from the missile by means of special severing devices. The equipment for a multi-stage propulsion unit with a severing device has the disadvantage that they require additional technical equipment and are greater in overall weight. In addition, such systems tend to malfunction and this cannot easily be prevented. Since it is not always possible to eject propulsion unit stages, the range of application of these propulsion units is greatly limited. Such problems and difficulties are also encountered in respect to an arrangement where the starting and the cruising units are separate units.

The disadvantage of the multi-stage units can be eliminated by using a single chamber multi-thrust propulsion unit which includes propelling charges of different firing and thrust generation rates and which are arranged in a combustion chamber having a single nozzle or jet discharge. The propelling charge is arranged within the combustion chamber in a free standing manner spaced inwardly from the interior periphery of the chamber wall. This arrangement is generally provided where the propulsion units must be ready for use at any time and at varying ambient temperatures. The combustion chamber wall must be designed over its entire length for maximum anticipated pressures that can be produced by each part of the propelling charge. This is due to the fact that there is a uniform pressure distribution in the annular slot between the periphery of the propelling charge and the interior of the combustion chamber wall.

Since the maximum pressure of an acceleration propelling charge, for example, is only effective for a relatively short time period, this has the disadvantage in the known single chamber multi-thrust propulsion unit that the entire combustion chamber is loaded during the combustion phase of each propelling charge portion. This produces a lower pressure with an excessive weight and material expenditure. A propulsion unit designed in this way has such an unfavorable weight per horse power that it cannot achieve the power of a multi-stage propulsion unit or of rocket engines which include separate starting and cruising units of comparable size, for example. This is particularly true for propulsion units which operate with a relatively short acceleration phase and a high combustion chamber pressure initially followed by long cruising phase having a lower combustion chamber pressure.

In accordance with the present invention, the above mentioned disadvantages are overcome by using a single chamber and single nozzle multi-thrust rate propulsion unit which is improved in weight per horse power without any substantial technical expenditure and corresponds to that of a multi-chamber propulsion unit or of a multi-stage solid fuel propulsion unit.

In accordance with the invention, the propulsion unit includes a substantially cylindrical chamber in which is positioned the propulsion charge which is made up of a plurality of charge units of varying thrust gas capacity per unit of time and which is provided with sealing means for sealing the annular space between the charge and the combustion chamber at the location of the border areas between the charges of different thrust generation characteristics. By such an arrangement, a separate sealed combustion chamber is provided for each section of the propelling charge and it is limited by the duration of the production of the thrust gases for the particular charge during the burning thereof. The thrust provided during the burning of each charge portion will remain constant for the period of time in which the charge portion remains ignited. The firing combustion chamber is sealed off from the remaining portions of the propelling charge and of the remaining portion of the combustion chamber by effective sealing means between the charge portions so that the non-firing portion of the combustion chamber is relieved of any radial compressive stresses which may be produced by the pressure of the combustion gases in the firing section of the propelling charge. Such a pressure relief has the advantage that the part of the combustion chamber inwardly of the portion of the charge which is ignited and discharging thrust gases through the rear nozzle need only be made to withstand smaller compressive forces and may be made of less wall thickness and lighter weight and of a strength which corresponds only to the pressure produced by the portion of the propelling charge arranged therein. The sealing of the annular slot between the propelling charge portions and the combustion chamber insures that at least a part of the retarding layer which is included in the charge construction is not exposed to

stress of the hot combustion gases during the entire combustion time of the propelling charge. The present invention does not provide for a mere sealing within the combustion chamber between portions of the charge, but between portions of a charge which have varying combustion rates for the purpose of permitting the firing portions of the charge to operate separately from the remaining portions and to seal the non-operating portions off from the operating portion.

In accordance with one embodiment of the invention, the border area between explosive charge portions of different characteristics is provided with an annular resilient seal at the location of the border area between the charge parts within the combustion chamber.

In accordance with still a further embodiment of the invention, the combustion chamber is provided with a light construction at the location of a change of charge characteristics of an explosive charge within the combustion chamber which provides an interior ledge sealing the outermost charge portion from the innermost so that the outermost will burn independently and that the portion of the combustion chamber associated with the innermost charge will not be subjected to annular pressures during the combustion phase of the outermost charge.

The sealing of the interior of the combustion chamber may be accomplished by means of an annular slot having a collar sleeve provided therein which cooperates with the corresponding surface of the junction of the two portions of the propelling charge. Such a design has the advantage that the sealed off portion of the combustion chamber will be relieved not only of compressor stresses but also axial stresses. The further feature of the invention is that the wall thickness of the combustion chamber may be reduced without any reduction in thrust capabilities. This results in optimum savings in weight of the combustion chamber.

Accordingly, it is an object of the invention to provide a thrust gas engine having a single nozzle or jet discharge and with a combustion chamber interior wall which is spaced from an explosive charge having a plurality of portions of different firing rate and thrust capabilities and with means sealing the space in the combustion chamber between the explosive charge and the interior wall of the combustion chamber and adjacent the location of the juncture of the charge portions of different characteristics.

A further object of the invention is to provide a sealing means for a combustion chamber having a single nozzle discharge for thrust gases and with an explosive charge with a plurality of different characteristics thrust charge portions in the chamber and wherein the sealing means are provided between the charge portions which includes an inwardly directed annular resilient seal or a ledge formation formed by the walls of the combustion chamber or a combination thereof.

A further object of the invention is to provide an explosive charge which is simple in design, rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

In the drawings:

FIG. 1 is a longitudinal sectional view of a single chamber multi-thrust propulsion unit constructed in accordance with the invention; and

FIG. 2 is a partial enlarged sectional view of another embodiment of the invention.

Referring to the drawings, in particular, the invention as embodied in FIG. 1 includes a single chamber double thrust characteristic propulsion unit having a substantially cylindrical casing defining a substantially cylindrical combustion chamber **1** in which there is located a substantially cylindrical propelling charge generally designated **2**.

In accordance with the invention, the propelling charge **2** includes a starting propelling charge portion **3** and a cruising propelling charge portion **23**. The cruising propelling charge portion **23** and the starting propelling charge portion **3** are connected together in a single substantially cylindrical formation or charge **2** by an adhesive layer **11**. The entire exterior surface of the charge **2** is provided with a retarding layer or coating **7** around the exterior periphery. The charge **2** is held in position within the combination chamber in a manner such as that an annular space or slot is left between its cylindrical periphery and the interior wall of the combustion chamber. It is advantageously secured on the combustion chamber cover **6** by a screw joint (not shown). A retaining ring **24** holds the cover **6** in position after it has been applied. The thrust gases generated by ignition of the charge **2** are directed out through a nozzle **5**.

In accordance with a feature of the invention, sealing means are disposed to seal the annular slot **8** at a location adjacent the juncture of the charges of different thrust-rate characteristics, that is, between the propelling charge **23** and the starting charge **3**.

In the construction of FIG. 1, the sealing means include a wall reinforcement or ledge **4** which includes an annular groove in which is positioned a resilient sealing member or O-ring **25**. Additional reinforcement may be placed behind the ledge **4**, that is, toward the cover **6** from the charge **3** in accordance with the pressure conditions which must be withstood. The wall portion **1***a* alongside the cruising charge portion **23** may be reduced from the wall portion **1***b* alongside the firing charge portion **3** because of the lower operating pressures generated by the burning of the cruising propelling charge **23**. The sealing ring **25** may be of a material that can withstand the thermal stress of the combustion starting propelling charge **3** during the period of operation of this charge. This ring **25** is burned gradually during the combusion of the cruising propelling charge **23**.

In the embodiment of FIG. 2, the sealing means includes a ledge formation **9** which is formed at the junction of a cruising charge portion **23'** and a starting charge portion **3'** adjacent the adhesive layer **11**. The ledge or collar **9** seals off the annular space **8***a* from the annular space **8***b*. In this embodiment, the sealing charge **3'** is made to a greater diameter than the sealing charge **23'** in order to form a ledge or surface **10** which extends outwardly from the charge **23'** under the ledge portion **9** and aids in providing a seal of the space **8***a* at such location. In some instances, an additional gasket is provided directly over the surface **10** at the location of annular slot **8***b*.

It should be appreciated that instead of a propelling charge **2** composed of different types of powders a propelling charge may comprise a single type of powder whose combustion surface is designed geometrically with geometric portions having different combustion characteristics for providing separate starting and cruising phases.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A solid fuel rocket propulsion unit comprising a casing defining a combustion chamber having a thrust nozzle opening at one end for discharging thrust gases, a propulsion charge within the casing spaced inwardly from the interior wall of the casing and defining with the wall an empty slot defining a gas chamber around said propulsion charge, said propulsion charge comprising charge portions having different thrust gas generation characteristics, and means for sealing the combustion chamber

across the empty slot surrounding the propulsion charge adjacent the juncture of the individual charge portions to divide the gas chamber, whereby to permit each charge portion to ignite and burn while the remaining portion of the combustion chamber is separated therefrom by said sealing means.

2. A solid fuel rocket, according to claim 1, wherein said sealing means include an encompassing sealing member in said combustion chamber disposed around said propulsion charge adjacent the borders of said adjacent charge portions.

3. A solid fuel rocket propulsion unit, according to claim 1, wherein said sealing means includes a ledge formed within said combustion chamber, said ledge overlying one of said charge portions and sealing the annular space between the one of said charge portions and the interior wall of the combustion chamber from the remaining annular space.

4. A solid fuel rocket propulsion unit, according to claim 1, wherein said charge includes a cruising charge portion and a starting charge portion, said portions being adhesively connected together.

5. A solid fuel rocket propulsion unit, according to claim 1, wherein said combustion chamber includes a first cylindrical wall portion of relatively thin thickness

adjacent of said charge portions and a second cylindrical wall portion thicker than said first portion.

6. A solid fuel rocket propulsion unit according to claim 1, wherein said sealing means includes an annular member having a groove adjacent the juncture of said charge portions and an O-ring member disposed in said groove and sealing said combustion chamber between said charge and the interior wall thereof.

7. A solid fuel rocket, according to claim 6, including means adjacent said annular member reinforcing said member.

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