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TWO-STEP ROCKET PROPELLANT INJECTION SYSTEM

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FIG. 1

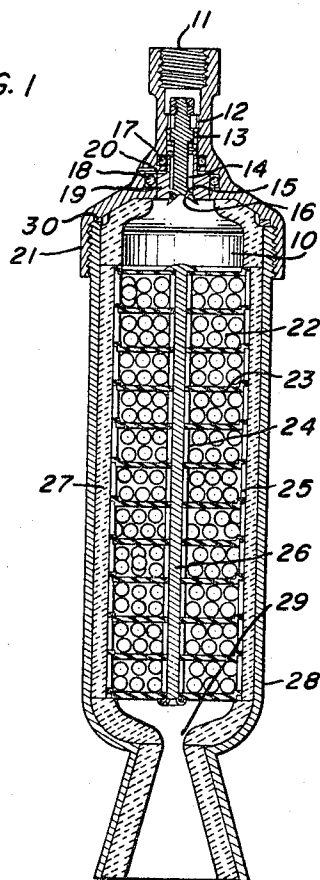
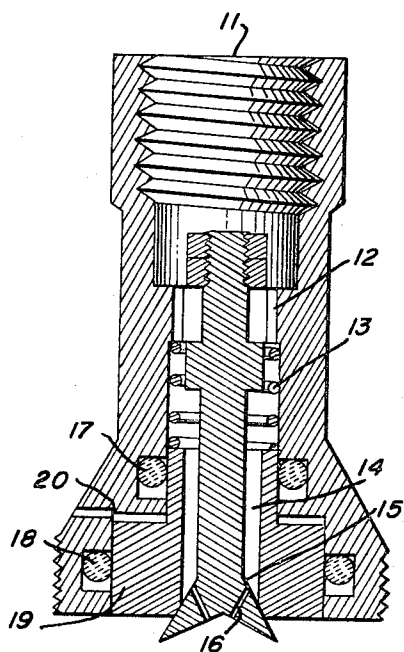


FIG. 2



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TWO-STEP ROCKET PROPELLANT INJECTION SYSTEM

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1 Claim

ABSTRACT OF THE DISCLOSURE

The invention consists of a combination monopropellant injector and catalyst bed system which initially restricts the monopropellant flow to the catalyst bed chamber allowing a gradual build up of temperature and pressure due to decomposition of the monopropellant. Once adequate pressure is generated an annular valve piston is actuated which permits normal rated flow to the chamber.

The present invention relates broadly to decomposition of monopropellant fuels suitable for rocket propulsion and gas generation, and is more particularly concerned with injection of propellant into a chamber employing a decomposition catalyst without damaging the catalyst bed at start up.

It is the primary aim of the present invention to provide an injection system which automatically limits the amount of propellant introduced into the catalyst bed at start up, thereby preventing flooding of the catalyst bed with propellant before the catalyst bed reaches an operable temperature.

Another objective of the invention is to provide an improved method of holding the catalyst particles in place for more effective and uniform decomposition of the propellant and better resistance to shock and vibration.

A further objective of the invention is provision of an insulating lining material of low heat capacity to reduce the amount of heat conduction from the rocket chamber body to the propellant injector, especially after shut down of the rocket motor.

Other objects and advantages of the present invention will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawing.

In the drawing wherein like numerals are employed to designate like parts throughout the same:

FIGURE 1 is a fragmentary perspective view of one form of rocket or gas generator chamber which may be employed in the practice of the method of the invention.

FIGURE 2 is a detail of the propellant injector of this invention.

Applicant's invention lies in the discovery that a mechanical arrangement can be devised for limiting the amount of fuel introduced into the catalyst bed until adequate pressure is generated to actuate the injector in such a manner as to allow full flow of the propellant. Numerous starts with commercially available catalysts, especially those using carriers composed of pressed alumina pellets with large internal surfaces, have shown that injection of the full rated flow of propellant into the catalyst bed frequently results in flooding of the bed with consequent failure to start immediate decomposition. A secondary effect of this failure is that after shut down of the fuel subsequent to failure to start, the catalyst gradually generates adequate heat to explosively decompose the residual propellant in the chamber and crush the alumina carrier. Crushing of the bed results in blockage of the flow of gaseous decomposition products and renders the catalyst bed unusable and dangerous.

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The utilization of a two-step injection system allows a slow rate of propellant injection until the catalyst bed temperature is increased to the point where it is adequately reactive to admit full propellant flow. When propellant is injected onto the catalyst bed and the temperature of the bed rises due to propellant decomposition, there is also a rise in chamber pressure. The present invention of a two-step injection system is based on utilization of the accompanying pressure rise.

Referring now to FIGURES 1 and 2, there is shown a rocket chamber designated by the numeral 10 and employing a two-step propellant injector with catalyst bed and fused silica liner.

A pressurized monopropellant is fed through an appropriately attached line to inlet 11, passes through planetary holes 12 across spring 13 into annulus 14 around pintle 15 and through small holes 16 and into the decomposition chamber. Propellant seals 17 and 18 prevent propellant or generated gases from passing around injector seat 19. Any small leakage which occurs is vented through the port 20 in the injector head causing 21. Fuel is sprayed through the small holes onto catalyst bed 22 which consists of segmented compartments composed of separator 23, supports 24 and 25 and retention pin 26. Separator 23 is perforated so that the propellant and decomposed gases may pass through and around the pellets in the catalyst bed. Upon contacting pellets the propellant decomposes thereby heating up the catalyst bed and building up pressure in the chamber. As the pressure builds up it exerts a force against the injector seat 19 greater than the force exerted by the fuel on the opposite end which has only a small area in contact with the propellant. Upon the injector seat being moved away from the pintle, the full flow rate of the propellant is allowed and the rocket is operating at rated conditions. The fused silica liner which must be made in multiple sections before being place in the rocket chamber shell 28 serves as a low heat capacity insulator to prevent the shell 28 from heating up rapidly. The thickness of the liner 27 will, of course, determine the length of time before the chamber shell 28 heats up. By thus preventing the rapid heating up of the shell 28, the amount of heat available for conduction to the injector head 21 is reduced and the danger of explosively decomposing the residual fuel left in the head after shut down can be reduced or eliminated. By utilizing the segmented compartments for retention of the catalyst particles, maximum control over placement of the particles is maintained. This is important to the functioning of the chamber for the following reasons:

(1) The distance from the point of propellant admission to the catalyst bed should remain constant for uniform performance. The compartmented arrangement helps to do this.

(2) With a large compartment, catalyst pellets move a larger distance and acquire greater momentum during high amplitude vibrations thus incurring greater damage to the pellets.

(3) For chambers with the centerline in a horizontal position relative to the earth's gravitational field, it is possible to bypass the catalyst bed in the void between the catalyst bed and the shell with a loosely filled compartment. With the arrangement shown the statistical chances of bypassing the catalyst bed in the above manner are lessened.

(4) Chances of packing the catalyst bed due to explosion are greatly lessened due to the fact that pressure exerted on one end of the catalyst bed would not necessarily be transmitted to the entire bed due to the supports 24 and 25.

Gases generated by decomposition of the propellant are exhausted through the nozzle throat 29. Gases are prevented from escaping at the junction of the injector head 21 and chamber shell 28 by means of copper gasket 30. The injector head 21 is held to the chamber shell 28 by means of threads which offer a convenient means of assembly and disassembly of the rocket chamber. The catalyst bed assembly is held in place by segments of the fused silica liner 27. The conical section of silica liner downstream of the throat 29 is held in place by crimping the shell 28 around the cone exit. Upon shut down of the rocket motor, pintle seat 19 resumes its closed position due to the pressure exerted by spring 13.

Example rocket chamber

The compartments of the catalyst bed 22 are filled with .10 pounds of commercially procured catalyst pellets $\frac{1}{8}$ -inch diameter by $\frac{1}{8}$ -inch long. The catalyst pellets are equally distributed among the 11 compartments of the catalyst bed. Anhydrous hydrazine, the monopropellant fuel, is spray-injected through the injector head at a rate of .2 to 2 pounds per minute. As the pressure increases in the chamber the pintle seat 19 is forced away from the pintle 15 and the full rated flow of approximately 2 pounds per minute is allowed. The chamber pressure is approximately 180 pounds per square inch gauge and the throat diameter is approximately .168 inch. The approximate thrust of the rocket at this flow rate is 5 pounds.

The foregoing quantities have not been tested in the generator shown in FIGURE 1 but were computed on the basis of previous work, some of which is cited in the reference.

5 I claim as my invention:

1. A monopropellant rocket motor comprising a reaction chamber containing a catalyst bed, means for injecting monopropellant into said catalyst bed, and a thrust nozzle, said injection means comprising a fixed pintle 10 extending toward said bed and having a flared end, said end having at least one aperture for injecting monopropellant, for starting said motor, an annular valve piston biased toward said flared end and forming therewith a 15 second aperture for injecting monopropellant for normal operation of said motor, said valve piston being responsive to reaction chamber pressure to open said second aperture.

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