July 14, 1959 J. D. LEDBETTER ET AL 2,894,692

NOZZLE

Filed Jan. 25, 1957

Fig. 1

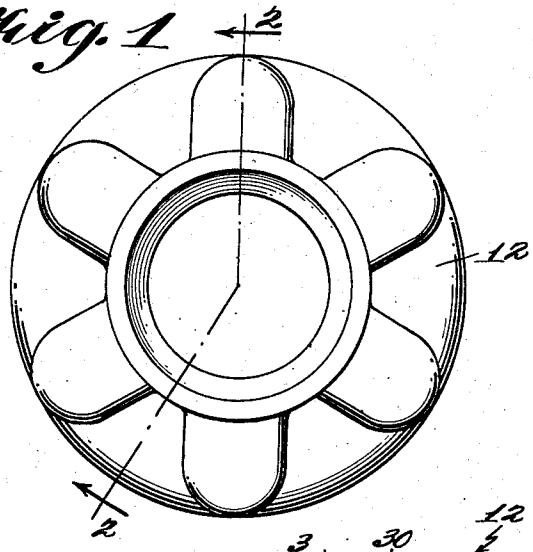


Fig. 4

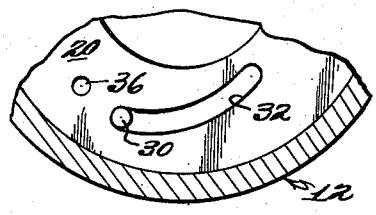


Fig. 5

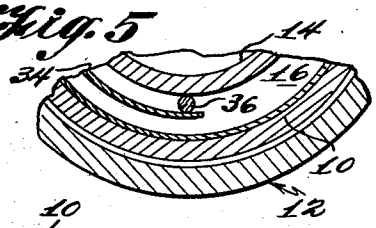


Fig. 2

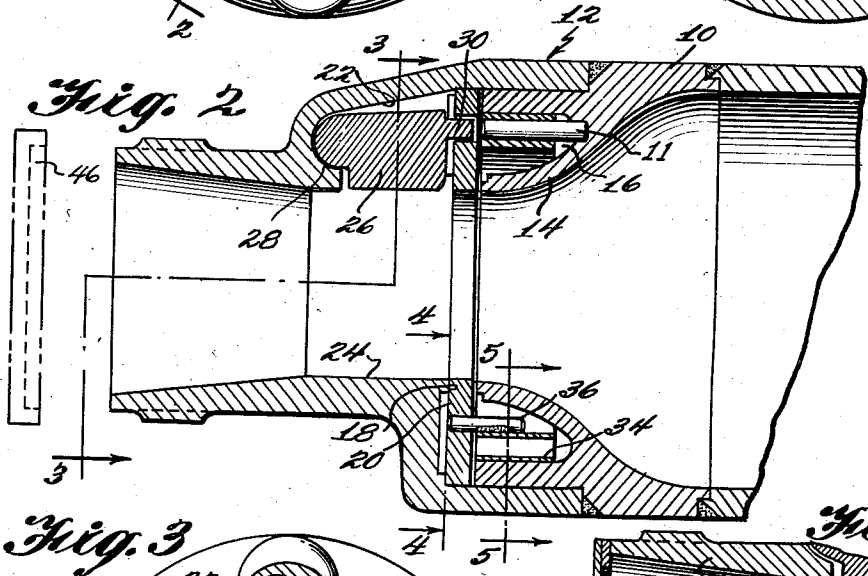


Fig. 3

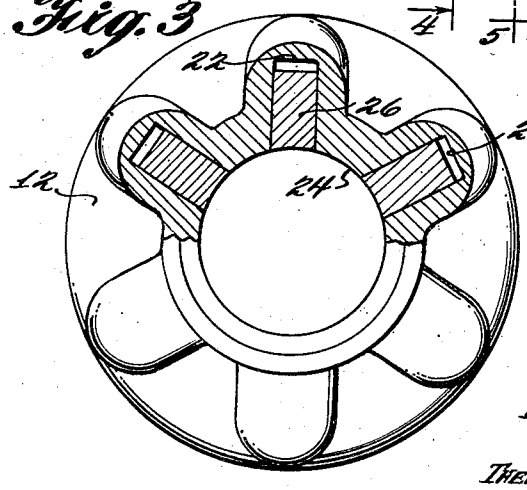
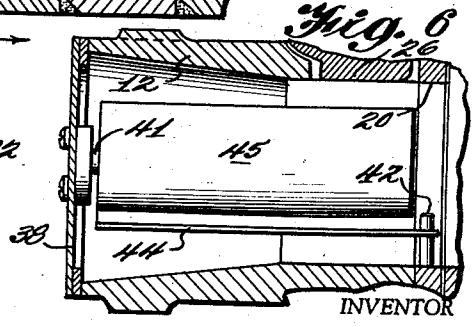


Fig. 6



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2,894,692

NOZZLE

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Application January 25, 1957, Serial No. 636,427

4 Claims. (Cl. 239—75)

This invention relates generally to rocket nozzle structures and more particularly to a variable area rocket nozzle and actuating mechanism therefor.

The use of solid propellents in rockets and propellent devices such as tank pressurization systems and jet mixing systems is well known as are some of the inherent problems connected with such use. For example, many of the solid propellents commonly used have a burning rate which varies widely with variations in temperature.

When used in short burning-time rockets, these solid propellents have the undesirable characteristic of a large increase in pressure as the burning time decreases with increasing ambient temperatures. As a result, variations in velocity are effected which in turn, affect the trajectory of the rocket, and an overly heavy motor body is required. Similarly, as the ambient temperature decreases, the burning time of the solid propellent increases so that the evolution of gas is slowed and pressures are low.

The chief object of the present invention is to provide means which will compensate for the variations in the burning rate of solid propellents so as to control the gas pressures.

Another important object of the present invention is to provide means for automatically controlling the gas pressures evolved by a burning solid propellent in accordance with temperature.

A still further important object of the present invention is to provide automatic means for compensating for the changes in solid propellent burning rates by varying the throat area of a rocket nozzle in accordance with ambient temperature.

Other objects and advantages of the present invention will become apparent during the course of the following description.

In the drawings we have shown two embodiments of the invention. In these showings:

Figure 1 is an end elevational view of a rocket nozzle embodying the invention;

Figure 2 is a central, longitudinal sectional view thereof taken on the line 2—2 of Figure 1;

Figure 3 is a vertical sectional view taken on the line 3—3 of Figure 2 showing some of the throat area varying restrictors, parts being shown in elevation;

Figure 4 is a fragmentary, vertical sectional view taken on the line 4—4 of Figure 2;

Figure 5 is a fragmentary, vertical sectional view taken on the line 5—5 of Figure 2; and

Figure 6 is a fragmentary, sectional view of another embodiment of the invention.

In its broadest aspects, the present invention contemplates the positioning of a thermally sensitive actuator in the region of the propellent chamber to sense the ambient propellent temperature and adjust the nozzle area before firing of the rocket to control the gas pressures when fired.

Referring to the drawings, numeral **10** designates a rocket motor body fixed at its rear end to a nozzle body **12**. The motor body includes a nozzle section **14** inwardly spaced from the motor body wall and forming therewith a chamber **16**.

The front face **18** of the nozzle body **12** is spaced from the rear edge of the nozzle section **14** to provide an annular recess therewith for the reception of a cam ring **20** which is inserted during assembly, and is also provided with a plurality of circumferentially spaced pockets **22** opening onto the recess and radially inward on the nozzle section **24** in the nozzle body **12**.

A nozzle restrictor **26** is rockably mounted in a recess **28** in each of the pockets **22** and their inner surfaces conform to the nozzle throat **24**. The forward faces of the restrictors **26** are each provided with a lug or pin **30** which projects through one of a plurality of arcuate slots **32** formed in the cam ring **20** and spaced circumferentially thereabout. Inasmuch as the radius of curvature of the slots **32** does not pass through the center of the ring **20** upon its rotation the slots act as cams on the restrictor pins **30** to pivot the restrictors **26** inwardly about their mounting recesses **28** to decrease the nozzle area.

Rotation of the cam ring **20** in either direction as limited by the lengths of the slots **32** is effected by means of a thermostatic bimetal actuator **34** spirally arranged in the chamber **16** and having an end fixed to a cam ring pin **36** and the other end fixed to the nozzle body **12** by pin **11**. As the ambient temperature increases or decreases, the thermostatic bimetal actuator **34** deflects thereby tightening or loosening the spiral and moving pin **36** in an arcuate path to rotate the cam ring **20** and effect movement of the nozzle segments or wings **26** to vary the throat area.

The nozzle body **12** is closed at its rear by a flat closure **46** of resilient plastic such as polyethylene which is held in position by forcing it over the end of nozzle **12** as shown in Figure 2. When the rocket is fired, the gases exert pressure on the closure **46** and the cover is blown off.

It will now be readily apparent that if the ambient temperature is high, the thermostatic bimetal actuator **34** will open the nozzle area to its maximum (Figure 4) allowing, when fired, the high pressures of the rocket motor to be relieved to the nominal operating pressure desired.

Conversely, if the ambient temperature is low, the actuator **34** will reduce the nozzle area and upon firing, permit a buildup of pressure to the desired operating pressure. Thus the desired velocities and predictable trajectories may be obtained. Moreover, from a structural standpoint, the motor body weight may be decreased thereby effecting a substantial saving in material and cost per unit.

The embodiment of the invention disclosed in Figure 6 is similar to that described except for the mounting of the thermostatic bimetal actuator **45** which is positioned in and along the axis of the nozzle body **12**. The closure **38** is mounted on a central shaft **41** to which the inner end of the actuator **45** is fixed, the outer end being connected to an apertured rod **44** which is hooked over a shear pin **42**.

The nozzle area is controlled as before and when the rocket is fired, both the closure plate **38** and the actuator **45** are ejected rearwardly by the high velocity gases.

It will now be apparent that the apparatus comprising the invention will automatically compensate for the changes in the burning rates of solid propellents with temperature by regulating the nozzle throat area as a function of temperature with resultant economies in weight and cost and more predictable velocities and trajectories.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same and that various changes may be made in the shape, size and arrangement of

parts without departure from the spirit of the invention and the scope of the subjoined claims.

We claim:

1. An apparatus for varying the throat area of a nozzle body having a plurality of circumferentially spaced, axially extending recesses formed therein and opening on the throat area thereof, comprising a plurality of restrictors arranged in and filling the recesses and each having an end pivotally mounted in a recess, an annulus rotatably mounted in the nozzle body and having its inner periphery flush with and forming a part of the nozzle throat area adjacent said restrictors, said annulus having a plurality of circumferentially spaced, cam slots formed therein, and a pin formed on the other end of each of said restrictors and projecting into one each of the cam slots whereby rotation of said annulus effects pivoting of said restrictors radially into and out of the nozzle throat area.

2. An apparatus as recited in claim 1 wherein thermostatic means are connected to the nozzle body and to said annulus to rotate the latter to effect automatic adjustment of the nozzle throat area in accordance with changes in ambient temperature.

3. An apparatus as recited in claim 2 wherein a stud is fixed to and projects radially inward from said rotatable annulus, a nozzle closure including an axially extending shaft is mounted against the rear of said nozzle body, and said thermostatic means is fixed to said shaft and connected to the stud to retain the closure in position and to rotate said annulus upon expansion and contraction.

4. An apparatus as recited in claim 2 wherein the nozzle body includes an annular chamber surrounding and concentric with the nozzle throat area and open toward and closely adjacent said annulus, a stud is fixed to and projects axially from said rotatable annulus into the chamber, and said thermostatic means is positioned in the chamber and connected to the stud and to a wall of the chamber to rotate said annulus upon expansion and contraction.

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