

60
39.47

Tx 6535

x 6521

Nov. 20, 1962

C. M. FREY

3,064,423

GAS-GENERATING DEVICE

Filed April 22, 1959

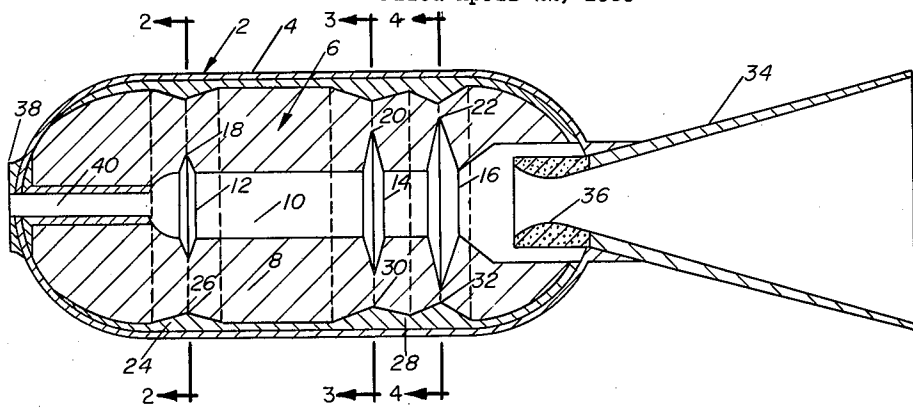


FIG. 1

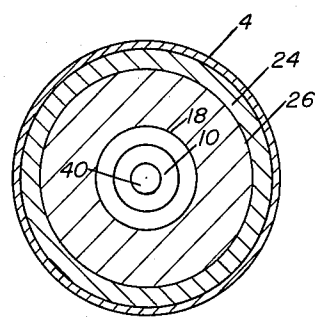


FIG. 2

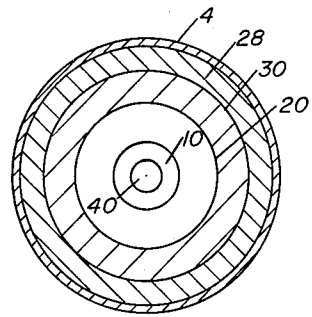


FIG. 3

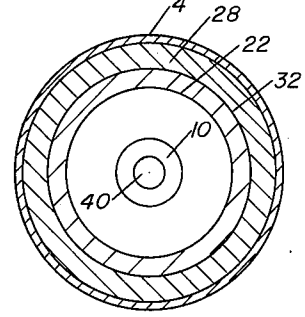


FIG. 4

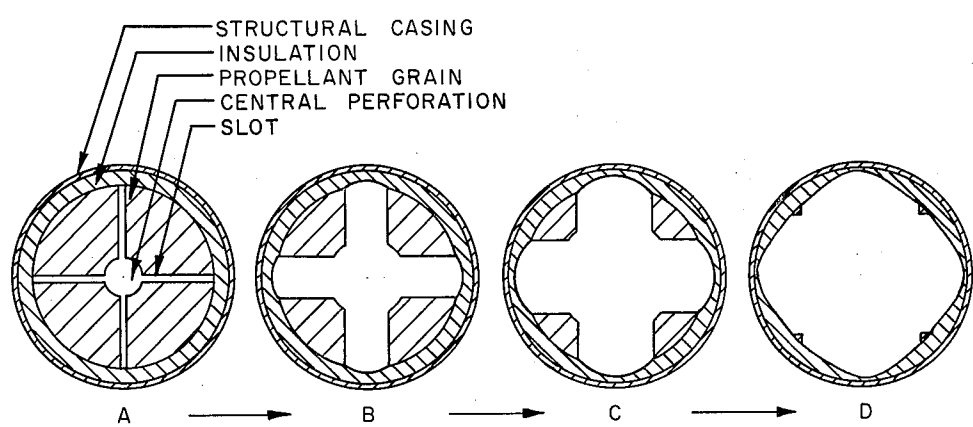


FIG. 5

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3,064,423

GAS-GENERATING DEVICE

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Filed Apr. 22, 1959, Ser. No. 808,269

5 Claims. (Cl. 60—39.47)

This invention relates to gas-generating devices and more particularly to solid propellant charges as used in rocket motors and the like.

The design of neutral long-burning rocket propellant charges was originally confined to single end "cigarette" burning charges. Although this design permits the achievement of long burning times with a high loading density, it has the distinct disadvantage that in order to obtain even a moderate thrust level, a considerable mass rate of discharge is necessary. This mass rate of discharge can be attained only by use of a large burning surface or else with a propellant charge of high burning rate. Since large surface area in single end burning charges can be accomplished only by the use of large charge diameters, flexibility in design is considerably limited. Furthermore, although the burning rate of propellant charges may be varied by formulation, the extent of practical variation of formulation still imposes certain restrictions in respect to burning rate.

Accordingly, the art has resorted to physical methods for modifying the propellant charge in order to obtain increased versatility in respect to burning. As to physical modification, the centrally perforated grain is a common type. However, with its outer surface inhibited, the grain is, of course, decidedly progressive burning and for many applications this is undesirable. Generally, for rocket motors and the like, neutral burning of the grain or charge is desired, and to achieve this the art has resorted to longitudinal, radial slots in conjunction with the central perforation. While the slotted cylindrical grain has given high quality performance, certain difficulties are encountered which necessitate very close control to insure this high quality performance.

This may be more readily understood with reference to the accompanying drawings wherein:

FIG. 1 is a longitudinal sectional view taken along the axis of a rocket motor showing one embodiment of this invention;

FIG. 2 is a full sectional view taken along the section 2—2 of FIG. 1;

FIG. 3 is a full sectional view taken along the section 3—3 of FIG. 1;

FIG. 4 is a full sectional view taken along the section 4—4 of FIG. 1; and

FIG. 5 is a diagrammatic, transverse, sectional view of a rocket motor showing a solid, cylindrical propellant grain in which longitudinal, radial slots are provided in conjunction with the central perforation and in which diagrams A, B, C and D illustrate, sequentially, the charge prior to burning as shown by A to final consumption as shown by D.

Referring now to FIG. 5, diagram A shows the initial condition of a cylindrical, slotted propellant grain in which the central perforation and the slots run longitudinally in respect to the rocket motor and in which the structural casing and insulation are also shown. At about one-third of the burning period, the condition of the grain and insulation appears as is shown in diagram B. At about two-thirds of the burning period, the condition of the grain and insulation appears as is shown in diagram C. Here it will be noted that an appreciable loss of insulation has taken place in the four quadrants subjected to the hot gases produced by the burning of the grain. At the end of the burning period, the condition

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of the grain and insulation appears as is shown in diagram D. Here it will be noted that a considerable loss of the insulation has taken place and that the points of minimum thickness are connected by gradually thickened areas of the insulation therebetween. These thickened areas represent the amount of excess insulation which remains and deleteriously adds to the inert weight of the motor. Rocket motor manufacturers have recognized this problem and have proceeded to longitudinally pre-contour the insulation so that the thickness of the insulation is proportional to the time that it is exposed to the hot gases of the burning grain. However, it will be appreciated that this solution is expensive and in addition requires very close control to insure high quality performance since the slots in the grain and the insulation must be retained in close and accurate orientation. Moreover, as the size of the rocket motor is increased, the expense of contouring and the problem of orientation become more severe.

Now, in accordance with the present invention, the disadvantages heretofore set forth are eliminated by providing transverse slots in the rocket grain so that the combination chamber insulation in any transverse plane is exposed to the propellant gases for the same period of time and can, therefore, be consumed to a final constant thickness without having to resort to complicated longitudinal pre-contouring of the insulation and precise orientation of the grain in respect thereto. More specifically, the present invention comprises a combustion chamber having a casing therefor, a solid, cylindrical, interior burning propellant charge concentrically disposed within the combustion chamber and having at least one concentric, transverse slot therein, and an area of insulating material disposed between the casing of the combustion chamber and the solid propellant charge in transverse peripheral alignment with said transverse slot.

Referring now to FIGS. 1, 2, 3 and 4 wherein reference symbols refer to like parts wherever they occur, the rocket motor represented by 2 has a shell or casing 4 and a combustion chamber represented by 6 which contains a solid propellant grain 8 in accordance with this invention. The solid propellant grain 8 is a cylindrical, interior burning grain having a central perforation 10 extending a substantial portion of its length and having three transverse slots 12, 14 and 16 therein. Each of the slots 12, 14 and 16 has its outer periphery terminating in an apex as represented by 18, 20 and 22, respectively. An area of insulating material 24 having its apex 26 directly opposite the apex 18 of the forward slot 12 is disposed between the casing 4 and the propellant grain 8. Similarly, an area of insulating material 28 has one apex 30 directly opposite the apex 20 of the intermediate slot 14 and has another apex 32 directly opposite the apex 22 of the aft slot 16, and this area of insulating material is disposed between the casing 4 and the propellant grain 8. Thus, the apexes or critical points of the insulating material and the apexes of the slots in the propellant grain are in transverse peripheral alignment so that as the hot propellant gases contact the insulating material, the material is gradually consumed in a progressive manner from the apex and ultimately consumed to a final uniform thickness.

To complete the rocket motor, a nozzle assembly 34 is suitably affixed to the aft portion of casing 4 in which the throat section 36 thereof extends into the combustion chamber 6 and is unsupported therein throughout a substantial portion of its length. A forward adapter ring 38 is suitably affixed to the forward portion of casing 4. The adapter ring provides for attachment to or with other devices as, for example, a pay-load. An aperture 40 extends through the adapter ring 38 and the forward end of the propellant grain 8 for accommodation of a reson-

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ance suppressor (not shown). The central perforation 10 of the grain 8 accommodates an ignition assembly (not shown). The design and detail of suitable resonance suppressors and suitable ignition assemblies are well understood in the art. Accordingly, they are not illustrated and further described here.

To more specifically illustrate the invention, the following example is given.

A grain similar to that depicted in FIG. 1 was made of cast aluminized double-base propellant having three transverse slots and a six-inch diameter central perforation. When fired, the grain produced a thrust at sea-level of 350 pounds for 20 seconds. The chamber pressure was essentially constant throughout the burning period. The chamber was insulated with a silica loaded Buna N rubber being 0.34 inch thick at the most critical points. The chamber was fabricated of helically wound fiberglass roving imbedded in a matrix of epoxy resin. The nozzle was a composite structure consisting of plastic and graphite and was of the type disclosed in pending application Serial No. 801,962 filed March 25, 1959.

The advantages of this invention are multifold in that a facile method for the reduction in inert weight is provided as well as freedom in grain design. Usually the grain designer is faced with the problem of designing the grain which has a constant surface throughout the burning period. The present invention provides the designer with another configuration from which to choose, and prior to this invention designers were limited to grain configurations such as the star, longitudinally slotted tube, iota, rod and shell, multiperforated, etc.

From the foregoing, it is evident that this invention may be carried out by the use of various modifications and changes without departing from its spirit and scope. For example, although the embodiment given herein utilized a cast aluminized double-base solid propellant grain, other solid propellant systems may be utilized in which binder and fuel materials such as polyurethane, petrin acrylate, plastisol polyvinyl chloride and thiokol are used in conjunction with other suitable oxidants such as ammonium nitrate, ammonium perchlorate and potassium perchlorate. Furthermore, other insulating materials which may be utilized include phenolic-asbestos, phenolic-glass, epoxy-zirconia, and various rubbers. Other casing materials which may be utilized include steel, titanium and aluminum. Additionally, although the diagrammatic drawing of the invention as presented herein shows insulation throughout a substantial portion of the combustion chamber, in certain instances, the insulation need be provided only in the critical areas opposite the transverse slots. Thus, it is intended that all matter presented in the description, and shown in the accompanying drawing relative to this invention, shall be interpreted as illustrative with only such limitations placed thereon as are imposed by the scope of the appended claims.

What I claim and desire to protect by Letters Patent is:

1. In a gas-generating device, the improvement which comprises in combination a combustion chamber having a casing therefor, a solid, cylindrical, interior burning

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pellant charge concentrically disposed within the combustion chamber and having at least one concentric, transverse slot therein, and an area of thickened insulating material disposed between the casing of the combustion chamber and the solid propellant charge in transverse peripheral alignment with said transverse slot and said area of thickened insulating material having its thickest portion opposite the said transverse slot.

2. In a gas-generating device, the improvement which comprises in combination a combustion chamber having a casing therefor, a solid, cylindrical, interior burning propellant charge concentrically disposed within the combustion chamber and having a plurality of concentric, transverse slots therein, and a plurality of areas of thickened insulating material disposed between the casing of the combustion chamber and the solid propellant charge in transverse peripheral alignment with each of said transverse slots and each of said areas of thickened insulating material having its thickest portion opposite each of the said transverse slots.

3. In a gas-generating device, the improvement which comprises in combination a combustion chamber having a casing therefor, a solid, cylindrical, interior burning propellant charge concentrically disposed within the combustion chamber and having at least one concentric, transverse slot therein, and the outer periphery of which terminates in an apex, and an area of insulating material disposed between the casing of the combustion chamber and the solid propellant charge in transverse peripheral alignment with said transverse slot in which the inner periphery of the insulating material terminates in an apex which is in substantial transverse peripheral alignment with the apex of the transverse slot in the propellant charge.

4. In a gas-generating device, the improvement which comprises in combination a combustion chamber having a casing therefor, a solid, cylindrical, interior burning propellant charge concentrically disposed within the combustion chamber and having a plurality of concentric, transverse slots therein and in which the outer periphery of each of said slots terminates in an apex, and a plurality of areas of insulating material disposed between the casing of the combustion chamber and the solid propellant charge in transverse peripheral alignment with each of said transverse slots in which the inner periphery of each of said areas terminates in an apex which is in substantial transverse peripheral alignment with the apex of each of the transverse slots in the propellant charge.

5. The gas-generating device according to claim 4 wherein the insulating material is contiguous throughout a substantial portion of the length of the combustion chamber and is gradually thickened in each area to form each insulation apex.

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