

April 12, 1960

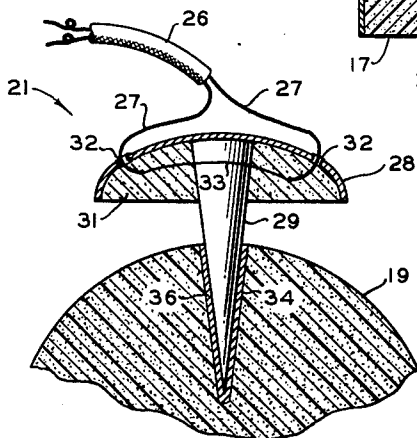
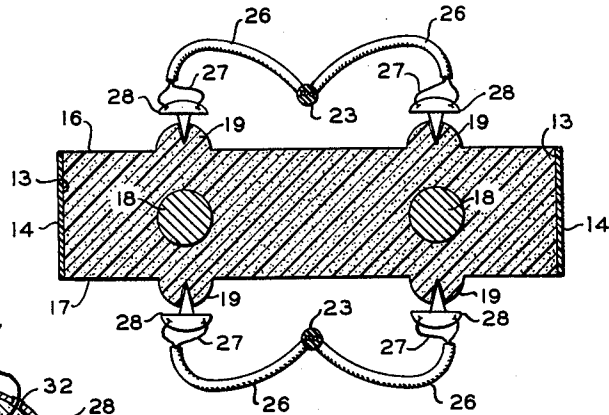
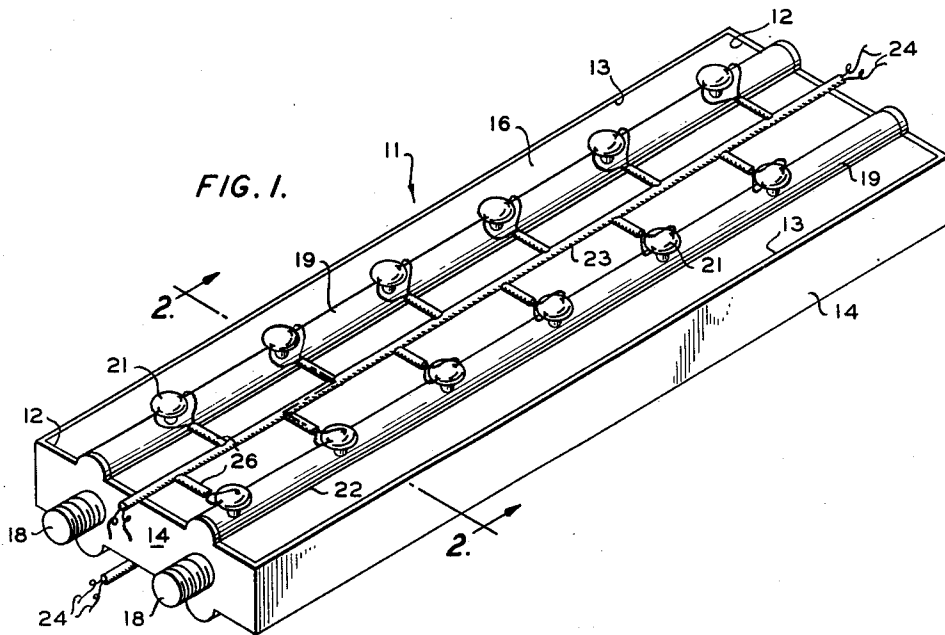
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2,932,162

IGNITION MEANS FOR ROCKET

Filed Dec. 22, 1955

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

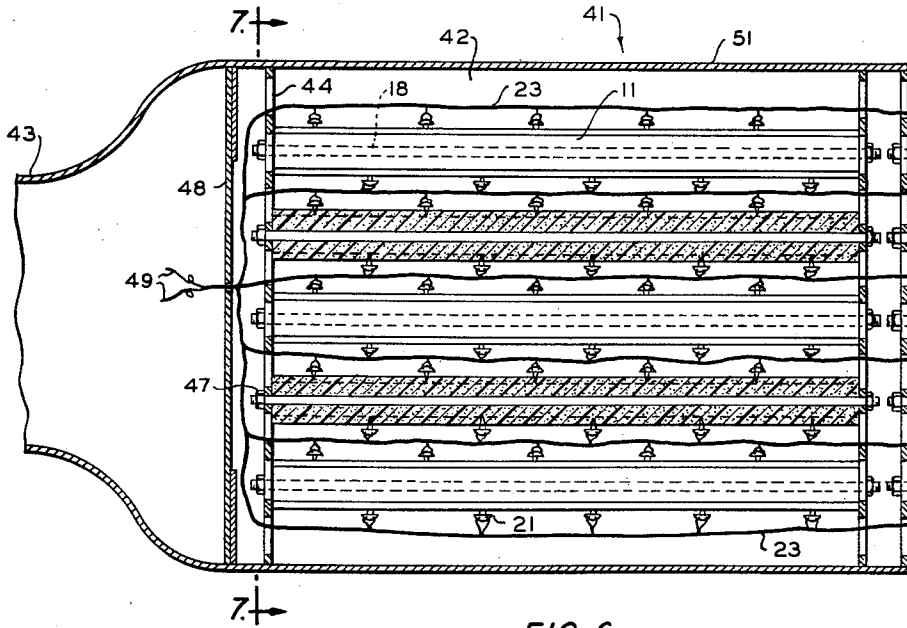


FIG. 6.

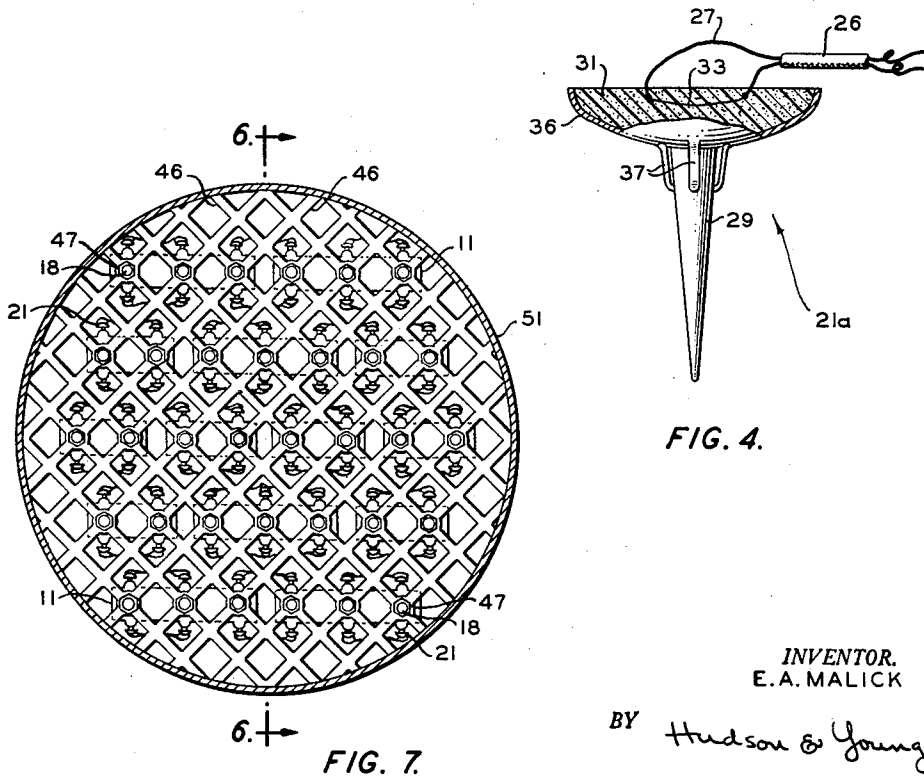


FIG. 7.

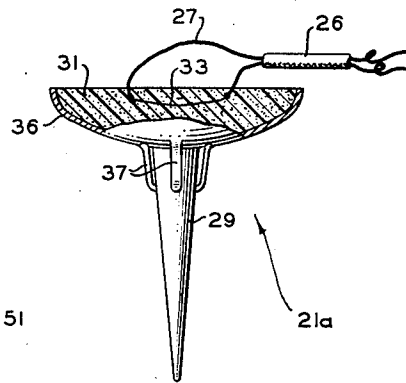


FIG. 4.

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3 Sheets-Sheet 3

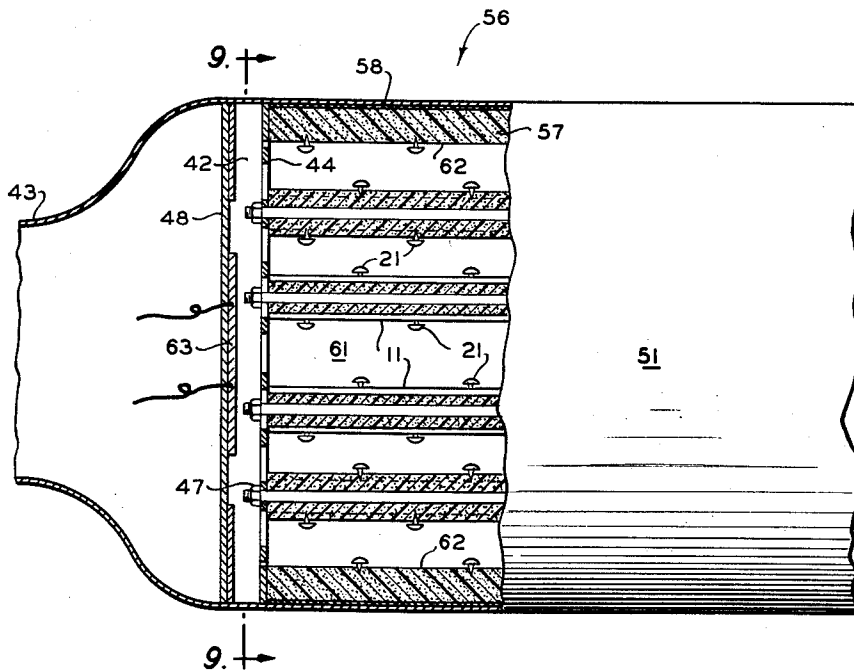


FIG. 8.

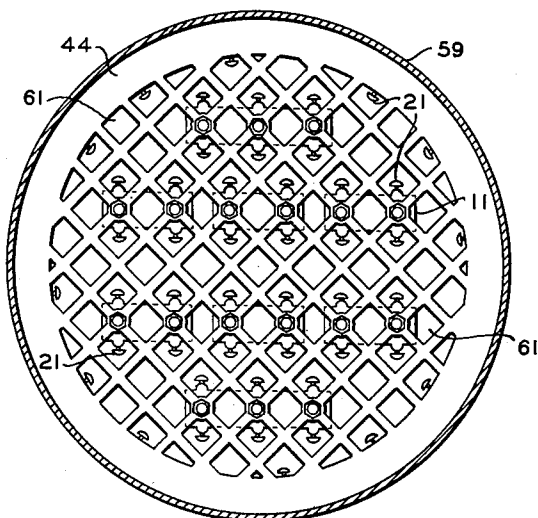


FIG. 9.

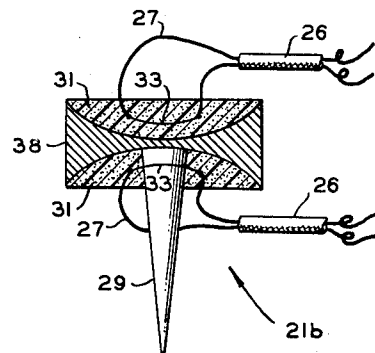


FIG. 5.

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2,932,162

IGNITION MEANS FOR ROCKET

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Application December 22, 1955, Serial No. 554,676

15 Claims. (Cl. 60—35.6)

This invention relates to rockets. In one aspect it relates to improved ignition means for igniting the propellant charge of a rocket projectile.

With recent developments in solid rocket fuels, the propellant requirements have of necessity become more exacting. As booster and large sustaining charges, for example, increased in size and efficiency, it became necessary to increase the burning surface area and utilize slower burning propellant compositions having better physical properties than earlier solid rocket fuels. In order to utilize the slower burning propellants, it became necessary to employ more complex charge configurations with larger burning surface areas. It was found with charges of this type that it was difficult to obtain uniform and simultaneous ignition, especially at low temperatures, with conventional igniters. This was due, in some instances, to the more difficultly ignitable propellant compositions and also because of the more inaccessible surfaces of the charge to which the primer flame failed to penetrate and ignite the burning surfaces uniformly and simultaneously. This non-uniformity of ignition is especially unsatisfactory when the length of burning time is critical, e.g. 2 to 60 seconds.

Prior art igniters such as cloth bags, plastic cups or other containers filled with black powder have been found unsatisfactory for ignition of inaccessible burning surfaces. These igniters require a comparatively large quantity of black powder which sets up excessively high pressures within the rocket combustion chamber upon ignition, especially when these igniters are used for the ignition of the large, dense propellant charges recently developed. The resulting high pressures cause an excessive burning rate of the pressure sensitive propellant and have a tendency to break up the charge within the chamber, thereby seriously affecting the ballistic pattern of the rocket projectile. Moreover, these igniters, which were primarily applicable for the ignition of small propellant surfaces and rapid burning solid rocket fuels, have generally been found unsuitable for the ignition of large booster and sustaining type charges. For example, uniform and simultaneous ignition is difficult to attain because the direction of flow of hot gases liberated from the black powder is generally axially of the combustion chamber, thus minimizing the propagation of the flash over all of the propellant surfaces desired to be ignited.

Broadly contemplated, I propose to provide by this invention improved means for igniting the burning surfaces of large, heavy propellant charges, such as the booster and sustaining type having normally inaccessible igniting surfaces. In general, my improved igniter means comprises a piercing member surmounted by a cavity-forming head, said head cavity being filled with an igniter

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composition capable of readily igniting propellant materials, such as rubbery copolymer-oxidizer compositions, in proximity with said ignition means. My ignition means are so oriented that the entire burning surface area of the propellant in proximity therewith is covered with flame and ignited uniformly and simultaneously when the said igniters are set off by a primary ignition means. The latter may be electrical, temperature increasing and/or pressure increasing in function, and can be located in a convenient location which may be remote with respect to the burning surface of the propellant. In one embodiment of my invention, the igniter material is pressure and/or temperature sensitive and is set off by primary ignition means which develop an effective pressure and/or temperature within the combustion chamber of the rocket motor.

Accordingly, an object of this invention is to provide improved ignition means to ignite the burning surface area of a solid rocket propellant, such as large booster and sustaining type charges.

Another object is to provide an improved igniter to uniformly and simultaneously ignite a propellant charge of a rocket projectile comprising for example, a plurality of spatially aligned, double web grains.

Another object is to provide an improved igniter for the ignition of normally inaccessible igniting surfaces of solid rocket propellants.

A further object is to provide improved ignition means utilizing substantially less igniter material than other forms of igniters used heretofore for the ignition of large booster and sustaining type rocket propellants.

A still further object is to provide an improved rocket motor in which are loaded large booster or sustaining type propellant charges of such configuration that there are normally present inaccessible igniting surfaces.

Other objects and advantages of my invention will become apparent to those skilled in the art from the accompanying specification, appended claims, and the drawings in which:

Figure 1 is an isometric view of a propellant grain provided with one embodiment of the igniter assembly of my invention;

Figure 2 is a cross-section view of the propellant grain of Figure 1 taken along the plane 2—2;

Figures 3, 4 and 5 are detailed views of several embodiments of my improved igniter;

Figures 6 and 8 are side elevational views in partial cross-section of two rocket motors each provided with a propellant charge having associated therewith various embodiments of the igniter assembly of my invention; and

Figures 7 and 9 are cross-sectional views of Figures 7 and 9 respectively taken along the planes 7—7 and 9—9.

Referring to the drawings now in detail, and to Figure 1 in particular, there is shown a restricted solid rocket grain 11 which is similar in some respects to that disclosed and claimed in the U.S. application of B. R. Adelman, Serial No. 453,772, filed September 2, 1954. This type of rocket grain, particularly applicable in those rocket motors utilizing large booster or sustaining type charges, is characterized by an extremely short burning time which may be controlled by varying the web thickness of the grain. The rocket grain 11 has a rectangular parallelepiped configuration with its ends 12 and its sides 13 covered by burning restricted material 14 while its upper surface 16 and its lower surface 17, Figure 2, are ex-

posed or unrestricted to permit burning of the propellant material. Longitudinal internal support members or rods 18 (preferably made of metal) protrude from the restricted ends 12 of rocket grain 11. The exposed or unrestricted surfaces 16, 17 are provided with longitudinal protuberances or ribs 19 which are likewise unrestricted and form part of said surfaces 16, 17. The total surface area of ribs 19 is equal to or slightly greater than the surface area of the perforation in the propellant material of rocket grain 11 provided for support members 18. The igniter assembly of this invention comprises a plurality of piercing instruments generally designated 21 which are inserted in the propellant surfaces 16, 17 along the ribs 19. Igniters 21 are preferentially oriented along the tops of the ribs in an alternate manner as shown in Figure 1 so that the normally inaccessible igniting surfaces, such as at 22, are in close proximity to the igniters 21. A cable 23 longitudinally extends between the ribs 19 and is provided with electric lead wires 24. The several igniters 21 are electrically connected in parallel with the lead wires 24 by laterally extending cables 26 having a single hot wire 27 looped through the head 28, Figure 2, of the igniter 21.

Referring now to the igniter embodiment shown in Figure 3, igniter 21 comprises a piercing member 29 which may be integral with the head member 28. The top surface of head member 28 is convex in shape and igniter material 31 is secured to the underside of the head member 28. The latter may be provided with small openings 32 to receive the loop of hot wire 27 in which is connected filament portion 33 which is in intimate contact with the igniter composition 31. The tapered piercing member 29 is adapted to be inserted into a cavity 34 formed within the top portion of propellant rib 19 and is adhesively secured thereto by a suitable bonding agent 36. Because of the downwardly directed configuration of the head member 28, the flame and hot combustion gases formed by the ignition of the igniter material 31 will be directed downwardly so as to envelope that portion of the propellant material in proximity therewith.

In the igniter embodiment 21a shown in Figure 4, in which like characters have been used to designate like parts, the head member 36 is removable from the piercing member 29, the top portion of which it may be rigidly secured by means of the clasp arms 37 extending from the under side of head member 36. The top surface of the head member 36 is concave in shape forming a cavity in which is placed igniter composition 31. The piercing member 29 of igniter 21a is also adapted to be inserted into the surface of a propellant grain in a manner similar to that described in the discussion of the igniter 21 of Figure 3. Upon the ignition of the igniter material 31 of igniter 21a the resulting flame and hot combustion gases are primarily directed away from the propellant surface to which the igniter 21a is secured, for which purpose it will be hereinafter set forth in detail.

Referring to the igniter embodiment 21b shown in Figure 5, the head member 38, which may be made integral with the piercing member 29, is provided with top and bottom concave surfaces thereby forming cavities in which are placed igniter compositions 31. Upon the ignition of the two igniter compositions 31, the resulting flame and hot combustion gases are directed both toward and away from the propellant surface to which the igniter 21b is secured in the manner hereinbefore described.

It is to be understood that I do not wish to limit the orientation of the igniters 21 to that described herein and illustrated in the drawings. For example, for some charge configurations it may be desirable to orient a portion of the igniters 21 along the restricted sides or ends of the rocket grain. The igniter orientation desirable for a particular charge configuration will be dictated in the main by the normally inaccessible igniting burning surfaces, etc.

Since double web type propellant grains such as shown in Figure 1, burn on the upper and lower surfaces simultaneously, each grain must be mounted in a rocket motor combustion chamber in spaced relationship with respect to other grains in order that this burning can occur. In Figure 6, there is shown a schematic way, a side elevation of a rocket motor generally designated 41 having a cylindrical combustion chamber 42, the rear end of which is shaped to define a nozzle or venturi 43 for the discharge of combustion gases at a high velocity. Obviously, a separate nozzle portion could be substituted for the integral construction shown. Disposed in chamber 42 are a plurality of the plank shaped, double web grains 11 of Figure 1. Rocket grain frame 44 comprises a support grid made of crossing members or bars 46, shown more clearly in Figure 7, in which frame a plurality of grains 11 are supported in spaced relation with respect to one another. The threaded ends of the rod like supporting members 18 of grains 11 extend through the holes formed at the intersection of bars 46 and are secured thereto by a nut 47 mounted within the chamber 42. A blow-out type sealing disc 48 is provided across the forward end of the nozzle portion 43. The burning surfaces of the grains 11 are shown provided with the igniters 21 of my invention, said igniters 21 being positioned so as to envelope the maximum amount of propellant burning surface area with flame and combustion gases produced upon the ignition of the igniter material of igniters 21. In the igniter assembly shown the several electrical cables 23 are connected to common electrical cables 49 which may pass out through the nozzle portion 43 to suitable contacts of a power source exterior to the rocket motor 41.

In the igniter assembly of Figure 6 those igniters 21 adjacent to the casing 51 of rocket motor 41 preferably have head members which direct the flame and combustion gases of the igniter material produced during combustion downward toward the propellant surfaces to which these igniters 21 are secured. Those igniters 21 positioned on the propellant surfaces of different rocket grains parallel spaced from one another preferably have head members which direct the flame and combustion gases of the igniter material away from the propellant surfaces to which the igniters 21 are secured and toward the adjacent propellant surfaces of the other parallel-spaced grain. Alternatively, those igniters 21 provided between parallel-spaced grains 11 may have head members which both direct the flame and combustion gases of the igniter material toward and away from the propellant surface to which the igniters 21 are secured.

With the above described igniter assemblies, it is evident that not only the normally accessible ignitable surfaces of the propellant material will be uniformly and simultaneously ignited, but also those normally inaccessible igniting surfaces which heretofore have been difficult to ignite with the conventional igniters of the prior art.

In the rocket motor 56 shown in Figures 8 and 9 similar reference characters have been used to designate like parts. The propellant charge of rocket motor 56 comprises in part a cylindrical perforated grain 57. The liner 58 binds the grain 57 to the casing wall 59. Said liner 58 is made of a material which may readily adhere to the casing wall 51 and to the grain 57 and is preferably of a thermoplastic nature which is more plastic than the grain 57 itself so as to reduce any tendency of the grain 57 to fracture when subjected to shock or thermal stress. Said liner 58 is preferably made of an oxidizer-free thermoplastic material. Within the perforation 61 of grain 57 is spatially aligned a plurality of plank type grains 11 of Figure 1 in a manner similar to that shown in Figures 6 and 7. The inside surface 62 of the perforated grain 57 is provided with a plurality of igniters 21. Those igniters 21 inserted in the propellant burning surfaces of grains 11 which are in proximity to the inside

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surface 62 of the perforated grain 57 preferably have head members which direct the flame and hot combustion gases of the igniter material both toward the burning surfaces of the grains 11 to which they are secured and also toward the portions of the burning surface 62 in proximity thereto.

It will be appreciated that while the several igniter modifications shown in Figures 3-5 may be so employed in the rocket motors 41 and 56 so as to insure the maximum ignition of the propellant burning surfaces, especially those normally inaccessible ignitable surfaces which have heretofore been difficultly ignited, I do not wish to limit the practice of my invention to those igniter assemblies described and shown in the drawings.

In the rocket motor 56 the igniters 21 can be set off by any conventional means, such as an electrically initiated primer igniter 63 mounted within the chamber 42 adjacent to the blow-out type sealing disc 48 which is provided across the forward end of the venturi 43. The electrical lead wires connected to the primary igniter 63 may extend through the nozzle portion 43 to contacts of a power source exterior to the rocket motor 56. The igniter material of igniters 21 are set off after the primary igniter 63 is ignited due to the propagation of flame and hot combustion gases from the latter axially downward the length of the combustion chamber 42. The temperature and/or pressure of the flame and combustion gases produced by the ignition of the primary igniter 63 set off the igniter material of igniter 21 since the igniter material is made of a temperature and/or pressure sensitive composition.

In order to provide a more specific disclosure of my invention, examples will be given for two relatively important forms of rocket motors namely the 4-second 240,000 lb. thrust booster and the 60-second 17,000 lb. thrust sustainer. The design of these two rocket embodiments are similar in that both deliver a total impulse of approximately 1,000,000 lb.-seconds and require approximately 6,000 lbs. of basically similar propellant. However, the booster propellant will differ in oxidizer composition and will require some ammonium perchlorate to attain a burning rate of 0.25 inch per second. The sustainer propellant which requires an average burning rate of approximately 0.15 inch per second can be prepared from ammonium nitrate, copolymer binder and milori blue.

The following are typical formulations for the preparation of propellant material and it is to be understood that they are set forth for illustrative purposes only and do not unduly limit my invention.

Table I

Ingredient	Booster		Sustainer	
	Parts per 100 parts of rubber	Parts, weight percent	Parts per 100 parts of rubber	Parts, weight percent
Binder		17.5		17.5
Butadiene/methylvinylpyridine (80/10)	100		100	
Carbon Black	10-30		10-30	
TP-90B ¹	10-30		10-30	
Flexamine ²	0-5		0-5	
Aerosol-OT ³	0-2		0-2	
Sulfur	0-2		0-2	
SA-113 ⁴	0-2		0-2	
Zinc Oxide	0-5		0-5	
Oxidizer		82.5		82.5
Ammonium nitrate (70.1-78.4)				
Ammonium perchlorate (4.1-12.4)				
Catalyst: Milori blue ⁵		1.0-2.0		0.0-2.0

¹ Dibutyl carbitol formal.

² A physical mixture containing 65% of a complex diarylamineketone reaction product and 35% of N,N'-diphenyl-p-phenylenediamine.

³ Dioctyl ester of sodium sulfosuccinic acid.

⁴ N,N-dimethyl-S-tertiary butyl sulfonyl diethiocarbamate.

⁵ A pigment, similar to Prussian blue, prepared by the oxidation of a paste of potassium ferrocyanide and ferrous sulfate.

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Suitable igniter materials for use in the practice of my invention may be formed from the following ingredients, but it should be understood that they are set forth for purposes of illustration only and do not limit the practice of my invention.

Table II

Ingredient	Parts by Weight	Parts, weight percent
Igniting Composition		98
Zirconium/nickel ¹ (50/50)	30-60	
Potassium perchlorate ² (0-40)	30-70	
Barium nitrate ³ (10-70)		
Aluminum ⁴	0-7	
Black powder ⁴	0-3	
Binder: Ethocel ⁵		2

¹ 90% through 325-mesh.

² Through 325-mesh.

³ 250-325-mesh.

⁴ Eastman's.

⁵ Ethylcellulose supplied by Dow Chemical Co.

The layer of burning restricting material can be made from any of the slow-burning materials used for this purpose in the rocket art, such as cellulose acetate, ethyl cellulose, butadiene-methylvinylpyridine copolymer, GRS, and the like. Also, metal plates can be secured to the sides and/or ends of the grain by plastic or rubber cements or these materials may be bonded by curing.

Suitable bonding agents for securing the piercing members of the igniters of this invention to the propellant grain include Thiokol Bonding Agent, supplied by Thiokol Company; Bostik 1075, supplied by B. B. Chemical Company; SWE-1692-3 and SWB-72-23, supplied by Angiers Products Inc.; Loxite 7003, supplied by Xylos Rubber Company; and the like.

Since many possible variations and modifications may be made of this invention by those skilled in the art without departing from the scope thereof, it is to be understood that all the matter set forth in the discussion and examples or shown in the accompanying drawings are merely illustrative and do not unduly limit my invention.

I claim:

1. An igniter assembly for use in combination with a propellant charge having exposed burning surfaces, comprising, in combination a plurality of igniter members, each of said members comprising a support member adapted to pierce the external surface of said charge and be mounted thereon in proximity to said exposed burning surfaces, a head member surmounting said support member, and an igniter composition affixed to said head member and adapted to be held thereby out of contact with said charge.

2. An igniter assembly for use in combination with a propellant charge having exposed burning surfaces, comprising, in combination a plurality of igniter members, each of said members comprising a piercing member adapted to be mounted on said charge in proximity to said surfaces, a head member surmounting said piercing member and having at least one cavity therein, and an igniter composition affixed to said head member and filling said cavity, said igniter members so oriented over said surfaces of said charge so as to ignite said surfaces when said composition is ignited.

3. The combination of claim 2 wherein said cavity is defined by a head member having a convex top surface.

4. The combination of claim 2 wherein said cavity is defined by a head member having a concave top surface.

5. The combination of claim 2 wherein said head member has top and bottom concave surfaces, thereby defining two cavities.

6. The combination of claim 2 wherein said head member has clasp arms on the underside thereof adapted to secure said head member to said piercing member.

7. In combination, a solid propellant charge having exposed burning surfaces, and an igniter assembly com-

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prising a plurality of igniter members oriented over said surfaces, each of said members comprising a support member piercing the external surface of said charge and mounted thereon in proximity to said exposed burning surfaces, a head member surmounting said support member, and an igniter composition affixed to said head member and out of contact with said charge.

8. In combination, a solid propellant charge comprising a plurality of grains supported in spaced relation and having exposed burning surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter members comprising, in combination, a piercing member having a tapered end adapted to be embedded in said surfaces, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniter composition affixed to said head member and filling said cavity, said igniter members so oriented over said surfaces so as to ignite the same when said igniter composition is ignited.

9. In combination, a solid propellant charge comprising a plurality of grains in spaced relation, each of said grains having at least one centrally-disposed, longitudinally-extending perforation, and a rod-like supporting member in said perforation, the upper and lower surfaces of said grain having an outwardly-protruding longitudinally extending rib in alignment with said perforation, the total surface area of said upper and lower ribs being substantially the same as that of said perforation, said grain being restricted on its ends and sides and being unrestricted on said upper and lower surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter members comprising, in combination, a piercing member having a tapered end adapted to be inserted in said rib, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniter composition affixed to said head member and filling said cavity, said igniter members so oriented in said ribs so as to ignite exposed surfaces of said grain when said igniter composition is ignited.

10. In combination, a solid propellant charge comprising a first cylindrical grain having an axial perforation defined by an inner burning surface, said first grain being restricted on its ends and outer surface, a plurality of second grains disposed in said axial perforation in spaced relation, each of said second grains having at least one centrally-disposed, longitudinally-extending second perforation, and a rod-like supporting member in said second perforation, the upper and lower surfaces of said second grain having an outwardly-protruding, longitudinally extending rib in alignment with said second perforation, the total surface area of said upper and lower ribs being substantially the same as that of said second perforation, said second grain being restricted on its ends and sides and being unrestricted on said upper and lower surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter member comprising, in combination, a piercing member having a tapered end adapted to be inserted in said rib and said inner burning surface, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniting composition affixed to said head member and filling said cavity, said igniter members so oriented in said ribs and said inner burning surface so as to ignite exposed surfaces of said first and second grains when said igniting composition is ignited.

11. In a jet-propelled device having a combustion chamber terminating at one end in an axially disposed exhaust nozzle, and a primary igniting means, the combination of a solid propellant charge having exposed burning surfaces, and an igniter assembly comprising a plurality of igniter members oriented over said surfaces, each of said members comprising a support member piercing the external surface of said charge and mounted thereon in proximity to said exposed burning surfaces, a head member surmounting said support member, and an igniting

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composition affixed to said head member and out of contact with said charge.

12. In a jet-propelled device having a combustion chamber terminating at one end in an axially disposed exhaust nozzle, and a primary igniting means, the combination of a solid propellant charge comprising a plurality of grains supported in spaced relation and having exposed burning surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter members comprising, in combination, a piercing member having a tapered end adapted to be embedded in said surfaces, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniting composition affixed to said head member and filling said cavity, said igniter members so oriented over said surfaces so as to ignite the same when said igniting composition is ignited by said primary igniting means.

13. In a jet-propelled device having a combustion chamber terminating at one end in an axially disposed exhaust nozzle, and a primary igniting means, the combination of a solid propellant charge comprising a plurality of grains in spaced relation, each of said grains having at least one centrally-disposed, longitudinally-extending perforation, and a rod-like supporting member in said perforation, the upper and lower surfaces of said grain having an outwardly-protruding, longitudinally extending rib in alignment with said perforation, the total surface area of said upper and lower ribs being substantially the same as that of said perforation, said grain being restricted on its ends and sides and being unrestricted on said upper and lower surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter members comprising, in combination, a piercing member having a tapered end adapted to be inserted in said rib, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniting composition affixed to said head member and filling said cavity, said igniter members so oriented in said ribs so as to ignite exposed surfaces of said grain when said igniting composition is ignited by said primary igniting means.

14. In a jet-propelled device having a combustion chamber defined by a motor casing and terminating at one end in an axially disposed exhaust nozzle, and a primary igniting means, the combination of a solid propellant charge comprising a first cylindrical grain having an axial perforation defined by an inner burning surface, said first grain being restricted on its ends and outer surface, a plurality of second grains disposed in said axial perforation in spaced relation, each of said second grains having at least one centrally-disposed, longitudinally-extending second perforation, and a rod-like supporting member in said second perforation, the upper and lower surfaces of said second grain having an outwardly-protruding, longitudinally extending rib in alignment with said second perforation, the total surface area of said upper and lower ribs being substantially the same as that of said second perforation, said second grain being restricted on its ends and sides and being unrestricted on said upper and lower surfaces, and an igniter assembly comprising a plurality of igniter members, each of said igniter members comprising, in combination, a piercing member having a tapered end adapted to be inserted in said rib and said inner burning surface, a head member surmounting said piercing member and having at least one cavity formed therein, and an igniting composition affixed to said head member and filling said cavity, said igniter members so oriented in said ribs and said inner burning surface so as to ignite exposed surfaces of said first and second grains when said igniting composition is ignited by said primary igniting means.

15. An igniter assembly for use in combination with a propellant charge having an exposed burning surface,

comprising a support adapted to pierce the external surface of said charge and be mounted thereon in proximity to said exposed burning surface, a head member surmounting said support member, and an igniter composition supported by said head member.

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