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PROPELLENT FUEL ASSEMBLY

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Fig. 1

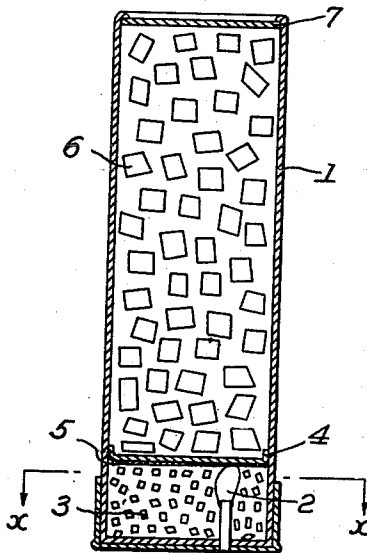
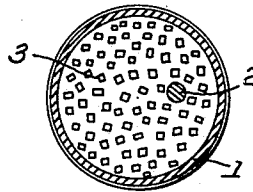


Fig. 2



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PROPELLENT FUEL ASSEMBLY

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3 Claims. (Cl. 102—39)

This invention relates to new and useful improvements in substantially solid propellant fuel cartridges and more particularly those used as the source of power for the operation of prime-movers, as for example: internal combustion engines, motor-starters, switch-closers, etc.

An object of the invention is the provision of an improved type of pressure-generating and delivering propellant fuel cartridges used for such purposes wherein the composition of the fuel charge is restricted essentially to colloidized nitrocellulose, commonly known as "single-base" type of smokeless powder. The "single-base" powders consist essentially of nitrocellulose and are nitroglycerine free. In such cartridges the problems of efficient and uniform ignition, of satisfactory and uniform acceleration of pressure and of avoidance of at least partial extinguishment or quenching of the fuel in the spaced system of the prime-mover, are greatly multiplied and made more difficult. While "double-base" types of smokeless powder have been proposed for propellant fuel cartridges as an aid to efficient and uniform ignition etc., these "double-base" powders are frequently held to be objectionable in themselves for other reasons.

In accordance with the present invention, I provide a novel structure of loading and ignition means, whereby granular "single-base" or straight colloidized nitrocellulose fuel cartridges may be rendered unusually reliable and uniform in performance in spaced prime-mover systems.

By a spaced prime-mover system, I mean any device which includes a cartridge receiving and firing chamber leading to an expansion chamber and communicating with a pressure actuated movable element, such as for example, a piston in a cylinder; the volume of the said expansion chamber being at least as great as that occupied by the fuel cartridge. In contradistinction thereto, all types of guns (including fire-arms, cannon and the like) are essentially free of any appreciable expansion space between their propellant charges and their movable elements (projectiles). Another essential difference between a gun and a prime-mover of the type to which my novel style of propellant fuel cartridge is adaptable is that the movable element (such as, for example, a reciprocating piston) is permanently associated with the latter but not with the former.

The proper functioning of a propellant fuel cartridge, when used in a spaced prime-mover system of the type described is dependent not

only upon the effective initial ignition of the fuel but also upon a careful control of the amount of pressure acceleration and flame as well as a fine balance between the two. This is necessary in order that the pressure will rise gradually and steadily and the entire fuel charge will be completely ignited and consumed. If, for example, there be a great excess of initial pressure for the amount of initial flame, the fuel is expelled so violently and quickly from the cartridge and into the expansion chamber that it is either extinguished or thrown too far out of range of the flame to be ignited, or both. This results in incomplete ignition and combustion of the charge with attending poor performance in addition to the danger of leaving accumulated unburned fuel to be later ignited by subsequent cartridges resulting in excessive and even dangerous pressures in the prime-mover system. Or, if there be a more moderate excess of initial pressure for the amount of flame, there will result an unsteady rise of pressure with attending irregularities and inefficiencies of performance.

Also, assuming that a proper balance between pressure acceleration and flame has been attained, it is essential that the amounts of these two factors be properly regulated and controlled in order that they will be adequate to do the work in overcoming the inertia of the moving parts on the one hand, but not too violent for the strength of equipment on the other hand.

It will thus be realized that one may not attain the proper balance by merely providing a suitably large volume of flame by the employment of a relatively large amount of fast burning and high pressure producing substances, which will result in too fast acceleration of pressure in the prime-mover system.

"Single-base" powders make the situation all the more difficult in that they are relatively difficult to ignite, slow burning and easily extinguished, particularly in the relatively large-sized grains necessary to properly control the rate of acceleration of pressure in such a prime-mover system.

In order, then, to provide sufficient flame while avoiding excessive pressure acceleration, in a "single-base" fuel charge of this type, it has been found essential to effectively ignite a relatively large number of grains of such fuels by non-violent means at the start. Another object of this invention is therefore to provide a practical means for initially igniting a relatively large number of "single-base" fuel grains by non-vio-

lent means. In order to attain the necessary flame and pressure acceleration balance in a "single-base" fuel cartridge as described above, it has been found desirable to provide an ignition receiving charge consisting of about 1.5 to 4.0 grams of "single-base" fuel of relatively small grain size (with respect to the grain size or sizes of the main fuel charge). Such an ignition receiving charge, when properly ignited, serves to reinforce and to so sustain the initial flame produced by the primary and/or auxiliary igniting means as to ignite the larger granules of "single-base" fuel (slower burning and more difficult to ignite) comprising the main fuel charge. Such an ignition receiving charge also serves, when properly ignited, to provide the proper pressure acceleration, during the main fuel's ignition period, so that ignition in the main fuel charge will be properly sustained and its combustion properly completed.

I have found, however, that the nature of the primary igniting means, used with the said ignition receiving charge of "single-base" fuel, has a very important bearing upon whether or not the said ignition receiving charge properly fulfills its desired function. In other words, the speed and manner with which a large number of the grains, comprising the said ignition receiving charge, are initially ignited is important because these grains are not only of an inherently slow burning and difficultly ignitable composition (i. e. "single-base") but also are of such small grain size that they pack too close together in the cartridge to permit easy flame propagation therethrough.

Accordingly, I have found it desirable to use an igniting composition of such nature, in such an amount and so distributed and positioned with respect to the ignition receiving charge that its ignition is initially effected within the body as well as throughout a cross section of the ignition receiving charge, at essentially the same time. In accordance with the present invention this is accomplished to a most satisfactory degree by employing a primary ignition element, as an electric match or preformed fuse-head unit, projecting into the body of the said ignition receiving charge, in combination with a secondary ignition element as a highly inflammable, combustible wad. This wad is preferably treated with an ignition composition at least on its under surface and is positioned on top of the ignition receiving charge in direct flame communication with the said electric match. By this means, I not only project the flame and burning match composition of the electric match into the body of the ignition receiving charge, but I also, at the same time, subject the entire upper surface of the said charge to the flame of the burning, treated wad.

This highly inflammable wad is preferably prepared by coating a combustible wad, as for example, a nitrocellulose wad, with a flash composition, at least on the side to be exposed to the match (primary ignition element) and to the ignition receiving charge, in order to assure the desired functioning of the latter toward maintaining the proper balance between magnitude of flame and rate of pressure acceleration. This has been proven by a marked improvement in the uniformity and reliability of performance of cartridges of the type described embodying this element in prime-mover systems over a wide range of conditions, such as, for example, in se-

vere cold weather, with unusually large expansion chamber volumes, etc.

While I do not wish to be limited to these theories, I believe the above to be largely due to the following reasons:

1. The flash coating assists in quickly spreading flame entirely over a cross section of the ignition receiving fuel charge, thereby initially igniting a large number of its grains as well as causing the ignition receiving charge to burn more uniformly with respect to its cross section.

2. The ignition receiving charge is essentially ignited at the surface nearest the main charge; thus providing flame action on the main charge prior to there being sufficient pressure built up in the breech-end of the cartridge for the main charge to be blown out of range of the flame.

3. The flash coating assists in quickly consuming the separating wad, between the ignition receiving and the main charges of fuel; thereby avoiding the wad's acting as a flame barrier and permitting almost immediate access of the flame to the main fuel charge.

I have also found it to be preferable to provide a flash coating for the wad, which when ignited at one point (such as by the tip of an electric match) will quickly spread the flame across the wad surface. At the same time, there should be sufficient heat and duration to the flame to effectively ignite the fuel grains of ignition receiving charge at least in immediate contact therewith. In order to provide these features, I prefer to use a flash coating comprising both fast and slower burning components. For example, I may use a fine grained black powder, such as FFFg Sporting or 5FA Blasting powder as the fast burning, flame propagation component and I may use a fine grained nitrocellulose smokeless powder as the slower burning, flame prolonging component.

The said flash coating may be in various forms such as a paste or a powder and applied in various ways, but I prefer to apply it by first moistening the surface of the wad with a solvent or a thin lacquer and subsequently pressing the damp surface into a tray of dry flash composition. In this manner the surface may be uniformly coated and the amount of flash charge retained may be accurately controlled by varying the pressure employed, the consistency of the lacquer used, etc. While I have found various compositions and amounts of flash coatings to be suitable for my purpose, I prefer to use one part, by weight, of black powder mixed with 2 parts by weight of smokeless powder in amounts ranging from about .2 gram to about .5 gram. While various granulations may be used, I prefer to use approximately the same granulation of both types of powder, to minimize segregation and thus avoid non-uniformity from wad to wad. Also these powders are preferably of such fineness that they will essentially pass a #35 U. S. S. screen and be essentially held on a #45 U. S. S. screen.

In selecting the amount of flash coating to be used on the wads, I am partly governed by the magnitude of the main fuel charge and the performance desired in a given prime-mover system. For example, I have found that light weight fuel charges for the operation of a prime-mover system having a relatively large expansion space, requires a greater amount of flash coating than do heavier fuel charges for the operation of prime-movers having the same or somewhat smaller expansion spaces.

Reference is made to the accompanying drawing which discloses a preferred embodiment of my invention and in which:

Fig. 1 is a diagrammatic sectional view of a solid propellant fuel cartridge.

Fig. 2 is a sectional view taken on line x—x of Fig. 1.

Like numerals designate corresponding parts in both the figures of the drawing.

In the drawing 1 designates a conventional cartridge shell having a primary ignition element 2 permanently attached to the shell and in the position shown in Fig. 1. The primary ignition element preferably constitutes a pre-formed body of flash composition ignited by means of a bridge wire, spark gap, percussion cap or the like. The cartridge shell is adapted to be mounted in a breech block and the primary ignition element is so attached to the base of the cartridge shell that it may be fired by a firing pin or where electric firing is employed by the application of current to contacts on the base of the shell.

Surrounding the primary ignition element 2 and positioned at the base of the shell is the ignition receiving charge 3. Positioned closely adjacent the top of the primary ignition element and across the top of the ignition receiving charge 3 is the secondary ignition element 4 comprising the highly inflammable wad referred to above which may be coated on its under side with flash composition as indicated at 5. Located above the secondary ignition element is the main fuel charge 6 which may be held in place by an end wad 7.

Exemplary charges for such a propellant fuel assembly are as follows:

Example 1

A primary ignition charge consisting of an electric match such as that described in the Patent to Young No. 1,935,495 or such as that described in my copending application Serial No. 341,666, filed June 21, 1940; an ignition receiving charge comprising 3.5 grams of single base nitrocellulose powder of grain size .10 inch diameter by .10 inch length; a secondary ignition charge comprising a nitrocellulose wad coated with .32-.40 gram of a mixture of 1 part FFFg black powder and 2 parts of 35-45 mesh smokeless powder; and a main charge comprising 13.2 grams of single base smokeless powder of .258 inch diameter and .255 inch length.

Example 2

A primary ignition charge and an ignition receiving charge as set forth in Example 1; a secondary ignition charge comprising a nitrocellulose wad coated with from .25 to .32 gram of a mixture of 1 part FFFg black powder and 2 parts 35-45 mesh smokeless powder; and a main charge comprising 18.6 grams of single base smokeless powder of .291 inch diameter and .316 inch length.

Example 3

A primary ignition charge, a secondary ignition charge, and an ignition receiving charge as set forth in Example 2; and a main fuel charge comprising 26.5 grams of single base smokeless powder of .315 inch diameter and .310 inch length.

The propellant fuel assemblies of the above examples gave excellent performance in engine

starters even though the arrangement was such that the burning fuel and evolved gases were ejected from the cartridge into a tube of considerable volume and length which led to the pressure actuated element.

The main charge of smokeless powder can vary in grain size from about .15" diameter by about .20" length to about .35" diameter by about .35" length. It can be perforated, non-perforated and of various shapes. It can consist of one size or a mixture of sizes in various proportions and arrangements. It can be in various amounts depending on power and performance desired. The ignition receiving charge can vary from about .06" diameter by about .06" length to about .12" diameter by .12" length, but is preferably .10" diameter by .10" length. It can be in various amounts to suit the size and amount of main charge and the performance desired in the particular prime-mover system involved.

Having fully described my invention what I claim is as follows:

1. A projectile-free cartridge comprising a shell, a main charge therein consisting of relatively large grains of single base colloided nitrocellulose fuel, a relatively smaller ignition receiving charge therein consisting of relatively smaller grains of single base colloided nitrocellulose fuel, a combustible wad positioned between the said main and ignition receiving fuel charges and coated at least on the side of the wad adjacent to the said ignition receiving charge with an inflammable flash composition comprising a mixture of black powder and colloided nitrocellulose grains, and a primary ignition element permanently associated with the said shell, said primary ignition element comprising flash composition positioned to be in direct flame communication with both the said ignition receiving fuel charge and the flash coated surface of the said combustible wad; the said combustible wad preventing an intermingling of the said two types of fuel charge and assisting the said primary ignition element to initially ignite the said ignition receiving fuel charge.

2. A projectile-free cartridge as set forth in claim 1 and wherein the grain size of the main charge is within the range of about .15" diameter x .20" length to .35" diameter x .35" length and the grain size of the ignition receiving charge is within the range of about .06" diameter x .06" length to .12" diameter x .12" length.

3. A projectile-free cartridge comprising a shell, a main charge therein consisting of relatively large grains of single base colloided nitrocellulose fuel, a relatively smaller ignition receiving charge therein consisting of relatively smaller grains of single base colloided nitrocellulose fuel, a combustible wad positioned between the said main and ignition receiving charges, a coating of flash composition on the side of said wad adjacent said ignition receiving charge, and an electric matchhead permanently associated with said shell and in direct flame communication with both said ignition receiving fuel charge and said combustible wad; the said combustible wad preventing an intermingling of the said two types of charges and assisting the said electric matchhead to initially ignite the said ignition receiving fuel charge.

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