March 18, 1969 L. E. BATES 3,433,437

ROCKET PROJECTILE

Filed Jan. 18, 1967 Sheet 1 of 2

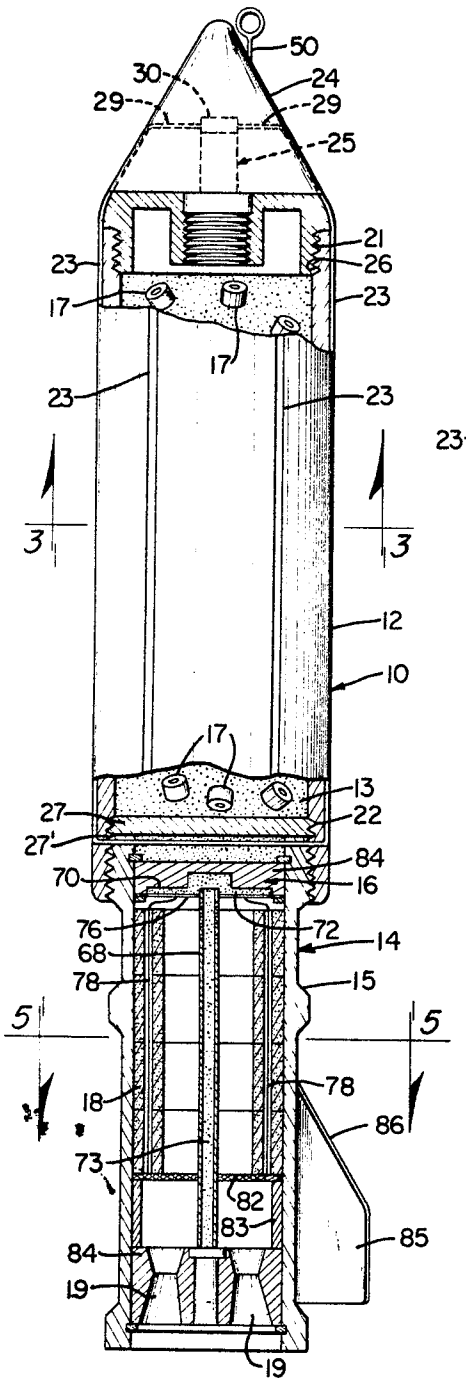

FIG. 1

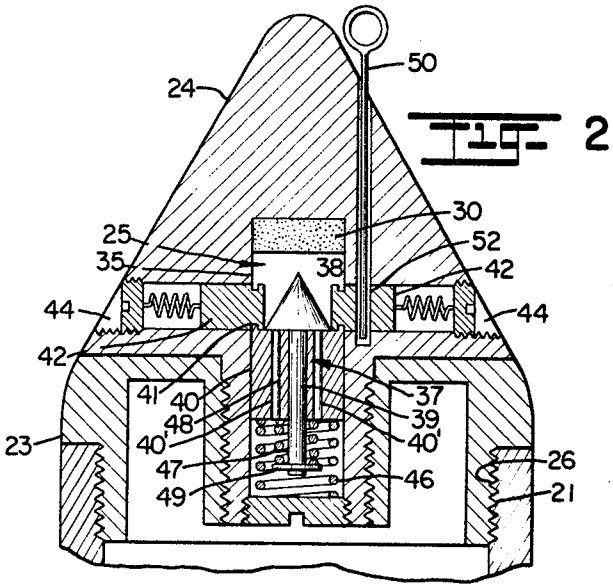

FIG. 2

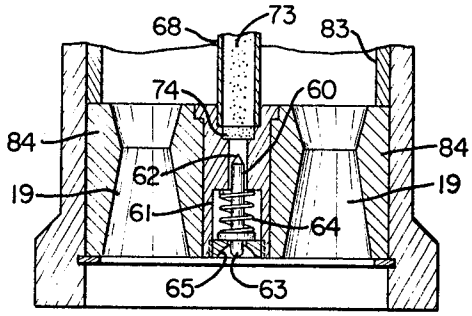

FIG. 4

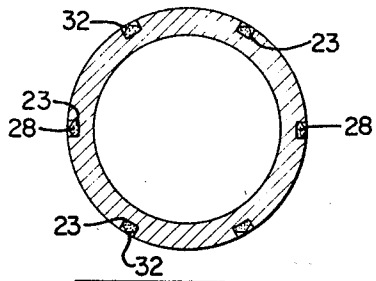

FIG. 3

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ROCKET PROJECTILE

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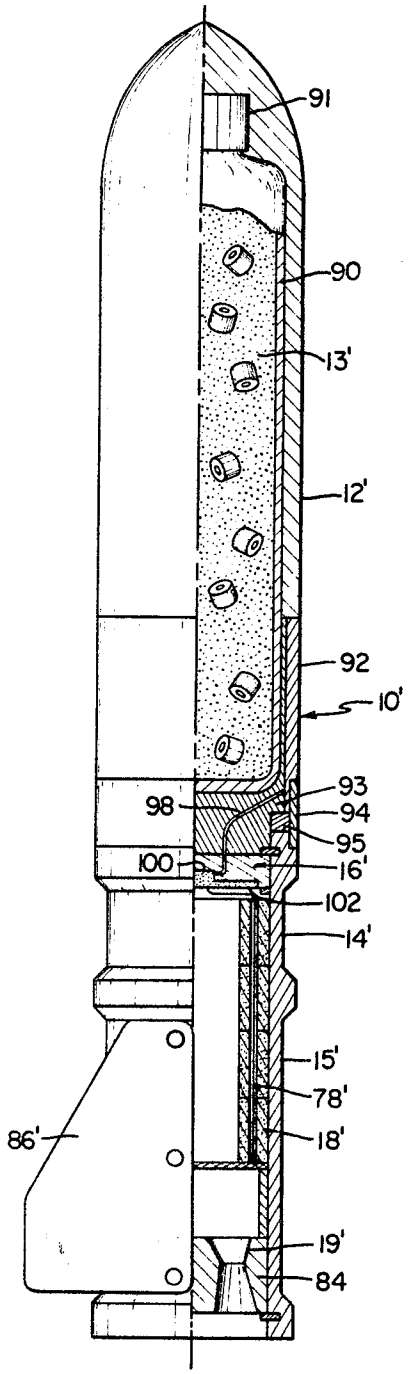

Fig. 7

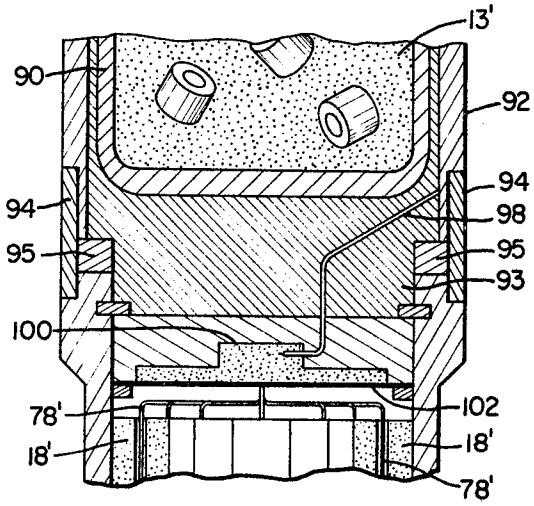

Fig. 8

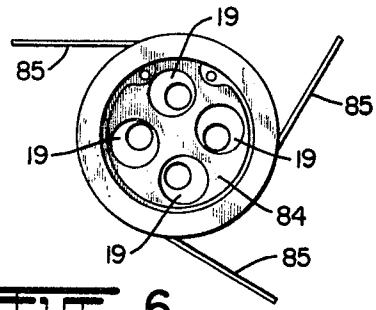

Fig. 6

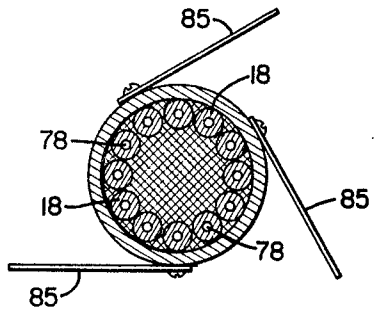

Fig. 5

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3,433,437

ROCKET PROJECTILE

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U.S. Cl. 244—3.23 13 Claims
Int. Cl. F42b 25/14, 13/14, 13/32

ABSTRACT OF THE DISCLOSURE

The rocket projectile of the present invention contains a gelled, pyrophoric composition which can be fired or launched over distances on the order of one thousand yards with accuracy approaching a rifle bullet. The projectile is propelled by a solid propellant reaction motor to impart a relatively high muzzle velocity with no recoil; and upon impact the pyrophoric gel is released to undergo highly intense controlled burning over a relatively wire area.

The present invention relates to new and useful rocket projectiles and more particularly relates to a projectile containing a pyrophoric gel composition which upon impact with a target and exposure to air is self-igniting and, according to the properties of the composition, will undergo highly intense burning over a predetermined time interval.

Various flame-producing weapons are currently in use in modern warfare, such as for instance, flame-throwers or napalm bombs. A definite need exists for a flame-producing missile or projectile which can be fired or launched accurately by hand-held weapons over intermediate ranges. Accordingly the present invention concerns itself with the design and construction of a missile or rocket-type projectile which is particularly adapted for use in launching flame-producing substances by means of hand-held weapons whereby the projectile can be accurately propelled and delivered on target in ranges on the order of one thousand yards while being completely safe to handle by the operator.

As designed and constructed, the projectile of the present invention is readily comformable for use with various payloads, but is especially adaptable for use in launching flame-producing materials including but not limited to pyrophoric materials as well as oxidizing chemicals, such as chlorine trifluoride, or white phosphorous or finely divided sodium. Alternate payloads are high explosives, smoke, illuminating flares and chemical agents, such as, titanium tetrachloride. Moreover, the payload may contain both fragmentation and armor-piercing configurations much the same as conventional rifle grenades, but with improved range and accuracy; and in this connection the projectile can be launched or otherwise delivered in single or repeated bursts by hand-held weapons, artillery or vehicle-mounted weapon systems.

In the selection and choice of flame-producing materials, by far the most effective are pyrophoric substances, especially those of the tri-alkyl aluminum family. These compositions are characterized in that they are self-igniting upon exposure to air and will burn intensely in virtually any environment, such as, in the presence of organic materials and any non-porous, non-flammable material. Still further, these compositions possess the characteristic of reacting vigorously with moisture and with lush vegetation and thus are particularly effective in

jungle warfare. On the other hand, because of the properties of certain pyrophoric substances, such as tri-ethyl aluminum, extreme caution must be exercised in the handling, unloading and storage of the materials. In this connection it must be rendered completely safe for handling and storage when packing as a payload in a weapon system and be controlled to ignite only when delivered to the target area. For optimum performance, the burning rate of the pyrophoric substance must be controlled without reducing its heat intensity, and optimum dispersion of the substance upon impact with a target must be promoted in order to cover the widest possible target area in relation to the size of the payload.

Accordingly, desirable characteristics of the projectiles of the class described are that they can be safely handled, loaded and stored; yet when launched will upon impact be self-igniting and dispersed over a wide area while burning at a controlled rate and with a high heat intensity. Moreover that the projectile will lend itself to short or long range firing either in single or multiple shot rounds and be capable of causing maximum destruction over the widest possible area in relation to the size of the payload. It is therefore a principal object of the present invention to achieve the above and other desirable characteristics in a projectile containing a flame-producing payload which can be packaged in any selected size for launching by hand-held weapons, remote controlled weapon systems or artillery.

It is another object of the present invention to provide for a projectile which is so constructed and arranged that it can be accurately launched without danger of misfiring either in single shots or multiple shot rounds and is readily conformable for use in short, intermediate or long-range weapon systems; and more specifically to provide a projectile which can be activated to deliver a payload composed of pyrophoric gel compositions accurately on a target in a safe, dependable manner.

It is a further object of the present invention to provide in a projectile for a rocket or thrust producing system that can be selectively activated to accurately propel a payload over considerable distances and to maintain the projectile in proper alignment for detonation and dispersion of the payload upon impact at the target area.

It is a still further object of the present invention to incorporate a payload in a projectile which is composed of a gelled or thickened pyrophoric composition which will afford maximum fire power and destruction for the size of the payload and is capable of dispersion and ignition immediately upon impact at the target area and of burning with a high heat intensity and at a controlled rate; and in addition to provide a rocket projectile containing payloads of the type herein described which is safe to handle and load without danger of misfiring and can be accurately launched and propelled with maximum stability over considerable distances.

The above and other objects, advantages and features of the present invention will become more readily understood and appreciated from a consideration of the following preferred and alternate forms of the present invention when taken together with the accompanying drawings, in which:

FIGURE 1 is a view partially in section of a preferred form of rocket projectile, in accordance with the present invention.

FIGURE 2 is an enlarged sectional view in detail of

one form of arming device for the rocket projectile of the present invention.

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 1.

FIGURE 4 is an enlarged view in section of the aft portion of the rocket or thrust section of the preferred form of invention shown in FIGURE 1.

FIGURE 5 is a sectional view taken about line 5—5 of FIGURE 1.

FIGURE 6 is an end view of the aft portion of the thrust section of the projectile shown in FIGURE 1.

FIGURE 7 is a view partially in section of a modified form of rocket projectile in accordance with the present invention; and

FIGURE 8 is an enlarged view in section of the ignition system for the modified form of invention shown in FIGURE 7.

The present invention is best exemplified by illustrating preferred and alternate rocket projectiles which are designed for firing by hand-held weapons or launcher systems. Nevertheless, for purposes of the present invention, this weapon system is merely representative and it will be apparent from the following that preferred and alternate forms of projectiles herein described are readily conformable for manufacture and use in different sizes for launching in other weapon systems.

In the preferred form of invention shown in FIGURES 1 to 6, a projectile **10** comprises an outer shell **12** containing a payload designated at **13**. A rear thrust section **14** of the reaction type includes an outer case **15** for an ignition system **16**, a solid rocket propellant **18** and circumferentially spaced reaction nozzles **19**.

The outer shell **12** is in the form of a thin-walled tube and is preferably composed of a lightweight material, such as, aluminum. The shell is internally threaded at opposite ends as designated at **21** and **22** and is further provided with external, longitudinally extending grooves **23** at equally spaced, circumferential intervals. The front end of the shell is closed by a bullet-nosed cap **24** containing a conventional arming device **25**, and the cap **24** has an externally threaded extension **26** to threadedly engage the end **21** of the shell. The opposite end of the shell is closed by a disk **27** which makes threaded engagement with the end portion **22** and together with the nose forms a hermetically sealed container for the payload composition. Linear, flexible, shaped charges **28** are inserted in each of the external grooves **23** as best seen from FIGURE 3 and which charges run the entire length of the shell and continue forwardly through limited bores **29** in the cap **24** and terminate in a detonator **30**, the latter forming part of the arming device. The shaped charges are suitably covered with an outer lead sheath **32** for the purpose of sealing in place and preventing exposure to the elements. The charge employed may be of any suitable composition and for example may be of the type manufactured and sold by Du Pont de Nemours Company designated A67. It is important that the charges be set deeply enough within the body of the shell whereupon detonation by the arming device the charges will simultaneously explode with sufficient force to sever the shell along the grooves and to separate the shell from the nose thereby exposing the payload composition to air.

Various means may be devised or utilized for detonating the shaped charges, such as, conventional point detonating or super-quick fuses. In the preferred form, the arming device **25** is a setback device which is broadly comprised of a central chamber **35** being formed in the cap **24** for placement of the detonator **30** and of a firing pin **37**, the latter including an enlarged tapered end **38** and a rearwardly directed stem **39**. The device is normally disarmed by retaining the pin in spaced relation behind the detonator through use of a sleeve **40** vented at **40'** which is slidably disposed in the chamber and has a stop **41** insertable in external grooves at the leading end of diametrically opposed keepers **42**. The keepers **42** are spring-loaded to be biased inwardly into the chamber through laterally extending bores **44** formed in the nose cap section. Similarly, the sleeve element **40** is normally biased forwardly to make connection between the stop **41** and keepers **42** by an outer concentric, coiled spring **46**, and an inner spring **47** is coiled about the trailing end of the stem **39** between the sleeve **40** and a backing ring **49** mounted on the stem. A safety wire **50** extends through the cap and through a lateral bore **52** in one of the keepers **42** whereby to normally lock one of the keepers in position and prevent accidental forward release of the firing pin toward the percussion cap.

Immediately prior to firing in a manner to be described, the safety wire is released to arm the projectile. Upon firing, the keeps are movable in response to spinning or centrifugal force of the projectile laterally and away from the central chamber; at the same time the forward momentum of the projectile is sufficient to overcome the force of the spring **46** to retract the firing pin rearwardly through the chamber. In response to impact or sudden deceleration of the projectile the pin is thrown forwardly to strike the detonator **30** and to detonate the charges **28**.

The payload **13** is preferably composed of a liquid pyrophoric substance combined with a combustible thickening agent and solid particles **17** uniformly distributed throughout the mixture. Preferably, the pyrophoric substance is composed of triethyl aluminum in its liquid state. The thickener may comprise a mixture of natural or synthetic rubber in a suitable solvent together with a magnesium powder, the rubber solution acting as a combustible thickener to inhibit or retard the burning rate of the aluminum substance and encourage the gel to stick to objects upon striking, and the magnesium powder serving to raise the temperature or heat intensity of the mixture. The solid particles **17** may be incorporated as part of the gel and may take the form of chunks of rubber or rubber-like particles, such as, latex or gum rubber which have the capacity of absorbing the liquid aluminum material and upon impact will form burning chunks of incendiary material. Further the particles will cooperate in reducing the burning rate and affording wider dispersion upon impact. The solvent also encourages the rubber particles to absorb the tri-ethyl aluminum thereby to cause the particles to swell or expand. In determining the relative proportions of the ingredients, the tri-ethyl aluminum is present in the optimum range of seventy-five to ninety-five percent and the balance being comprised of the thickener made up of equal parts by weight of magnesium and of the rubber solution. In mixing, the objective is to provide a controlled burning rate at the highest possible temperature as well as to provide optimum dispersion upon impact in the form of tiny particles, as opposed to a vapor, and further wherein the gelled or thickened mixture has the characteristic of being sticky or glue-like in consistency so as to adhere on contacting an object until each of the particles is entirely burned. In this connection, it is essential that the ingredients be mixed and loaded into the shell in an oxygen-free chamber to prevent combustion of the pyrophoric material and that the payload be hermetically sealed within the shell. Accordingly, in loading the gel into the shell, both the nose portion **24** and disk **27** should be threaded into sealed relation at opposite ends of the shell with the aid of sealant compounds.

The thrust or rocket section **14** is so constructed as to achieve maximum acceleration and to the extent that the propellant will have completely expended itself while providing the necessary momentum by the time the projectile is released from the end of the launcher barrel thereby eliminating flash-back when fired. Of course the size and thrust of the motor section will vary according to size of payload and maximum range desired. In the preferred form, the motor case **15** is of reduced diameter and relatively thick-walled in relation to the thick-

ness of the shell **12** with the leading end of the case being externally threaded for threaded connection to the trailing end **22** of the shell **12**. As shown in FIGURE 4, the motor section is armed with a mechanical firing pin **60** which is centered in a chamber **61** within the nozzle section **19** and has a tapered leading end **62** and a trailing end **63** biased by spring element **64** to project into a cup-shaped recess area **65** at the aft end of the motor section. A central tube **68** defines a forward continuation of the chamber **61** to extend the length of the motor section and terminate at its leading end within a cavity **70** filled with a secondary ignitor material **72**. The tube may be loosely filled with a finely ground black powder or other suitable primary ignitor **73'**, and a percussion cap **74** at the trailing end or entrance to the tube **68** is positioned in the path of travel of the firing pin **60**. A cloth screen **76** may serve as a temporary retainer for the ignitor **72**, and a series of fuse trains **78** leads outwardly from the ignitor and rearwardly through central openings formed in solid propellant sticks **18**, the fuse trains extending through the entire length of the propellant sticks. In turn the sticks **18** are placed circumferentially in contacting relation to one another around the inner surface of the case as shown in FIGURE 5 and are interposed between a cap **80** at the forward end of the case and a wire screen or disk **82** located just forwardly of the reaction nozzles; a spacer sleeve **83** retains the screen in spaced relation away from the reaction nozzles. In this manner, when the firing pin is engaged and driven forwardly through its chamber to detonate the cap **74** the primary ignitor in the tube **68** will provide the necessary spark for the ignitor **72** to simultaneously activate each of the fuse trains **78** and to ignite the external surfaces of the solid propellant thereby to initiate simultaneous burning of the propellant sticks both internally and externally; and, although burning of the propellant is to some extent progressive in nature it occurs almost instantaneously. Furthermore the screen **82** will temporarily contain the fire and gases formed within the propellant section for a sufficient time interval to permit complete burning and conversion into gas under high pressure prior to release and discharge through the reaction nozzle section **19**.

A series of four reaction thrust nozzles, as shown in FIGURE 6, are formed out of a solid cylinder **84** and are arranged at equally spaced circumferential intervals about the aft end of the motor section each including a venturi throat and rearwardly divergent exhaust to develop maximum thrust in response to high pressure ignition and release of the propellant gases. Further the nozzles are canted at a low angle to the longitudinal axis of the projectile or line of flight, as shown in FIGURE 6, to impart a spin to the projectile as it is discharged from the barrel thereby affording maximum stability and accuracy in flight. The spin moment imparted will further aid in releasing the keepers **42** in the arming device whereby to free the firing pin for forward travel through its chamber to strike the detonating member **30**. In addition, flexible or collapsible fin members **85** are tangentially connected to the external surface of the case, there being a series of three fins mounted at equally spaced circumferential intervals about the aft end of the projectile or case. Most desirably, the fins are composed of spring steel or other resilient material so that when inserted into a launcher will be free to collapse against the case, and it will be noted that the fins are each formed with rearwardly divergent edges **86** which when propelled through the barrel will cooperate with the reaction nozzles to lend an increased spin force to the projectile; and when released from the barrel will spring out to materially increase the stability and greatly minimize any tendency of the projectile in flight to tumble or deviate from its course. The fins are located toward the aft end in order to displace the center of pressure of the rocket motor rearwardly of the center of gravity of the projectile and contribute to greatly increased stability in flight.

As described in said co-pending application, the projectiles may be loaded in a magazine and successively advanced into alignment with the barrel of the launcher, in which position the firing pin is aligned with the hammer of a cocking mechanism. Prior to loading, or just prior to firing, the safety wire **50** is removed to prepare the arming device for detonation of the shell. When fired, the energy of propulsion developed by the solid propellant sticks will have expended itself in accelerating and spinning the projectile through the barrel for discharge at a high rate of speed. The spin is initiated by the reaction nozzles and, once released from the barrel, the fin members are free to spring away from the case to increase both the accuracy and stability of the projectile in flight. Again the forward momentum of the projectile will retract the firing pin **38**, and the spin force developed will urge the keepers **42** outwardly and away from the chamber **25**. Under sudden deceleration or impact the detonator will ignite the explosive charges in the shell. Resultant sectioning or severance of the shell is almost instantaneous upon impact thereby causing the pyrophoric gel composition, or payload **13**, to be dispersed and scattered over a wide area. Again, the use of solid particles in the gel composition serves to increase dispersion and to inhibit the burning rate of the gel.

In the modified form of invention shown in FIGURES 7 and 8, like or similar parts are correspondingly designated with prime numerals. Broadly it will be seen that the projectile **10'** is comprised of a shell **12'** encasing a pyrophoric gel composition or payload **13'**, and the necessary thrust is again developed by a solid rocket motor section **14'** including an electrical ignition system **16'**. In the modified form, however, the arming device is eliminated; instead the shell **12'** is in the form of a frangible, bullet-nosed container of one-piece construction and, for example, may be composed of a thin-walled glass or brittle plastic material which will readily rupture or break upon impact so as to expose the pyrophoric gel composition to air for self-combustion. In this relation, the gel composition is sealed in a separate glass container **90** having a front stopper portion **91**; in turn, the outer frangible shell may be formed by pouring or casting a curable synthetic resinous material in surrounding relation to the container. The rearward end of the container **90** is enclosed by an aluminum sleeve **92** forming a rearward continuation of the shell **12'**, and a fast curing synthetic resin material, such as, polysulfide rubber is cast around and behind the container to define a cushion or impact absorbing member **93**.

In the motor section, the basic construction and arrangement of parts is the same as that of the preferred form but is activated by an electrical ignition system **16'**. In assembly, the leading end of the motor case is connected to the shell portion by a threaded connector sleeve **94** with a spacer ring **95** interposed between adjacent ends of the motor case **15** and sleeve **93**, the spacer ring together with the leading end of the motor case defining a cavity in front of the propellant section for insertion of the electrical ignition system.

In the ignition system, a contact wire **98** leads from the sleeve **93** into an ignitor cup **100** filled with primary and secondary ignitor substances with a combustible cloth screen **102** retaining the ignitor in the cup portion. The ignition or contact wire **98** will when energized cause sparking across the ignitor cup and ignition of the primary then secondary ignitor materials to burn the ignitor fuses **78'** for the propellant sticks **18'**. In firing the projectile, it will be apparent that the launcher requires a modified trigger system which for example may take the form of a battery-powered capacitor-transformer spark system which can operate off the primary trigger to selectively energize the contact wire **98**. In this relation, one side of the contact sleeve would be positive and the op-

posite side negative, or at ground, to develop the necessary spark in the gap or space across the ignitor cup.

In practice, a six-ounce charge of a gel composition composed of tri-ethyl aluminum, rubber solution, magnesium powder and latex rubber particles in the proportions described developed a flame ranging from ten feet by ten feet on ninety degree impact to three feet by thirty feet at less than five degree impact. Terrain and target conditions will obviously influence the flame size and pattern. However on a non-porous, non-flammable surface the duration of the flame is twenty-five to thirty-five seconds and would of course increase with more porous surfaces. Each individual round weighed on the order of one pound and accuracy was demonstrated to be within eight mils in bench rest tests. Ignition was by spark gap in a primary ignitor composed of one-half gram of black powder which in turn ignited two grams of secondary ignitor mix and thirteen rapid fuse trains leading to the propellant sticks. A disk or screen bearing one-tenth gram of ignitor mix was located at the aft end of the propeller charge to assist in complete ignition. In each case, the size and weight of the projectile will vary with different sized payloads as will the size and capacity of the various component elements of the projectile.

It will be apparent that component parts of the preferred and modified forms of invention may be readily interchanged, such as, the shell and payload construction or the ignition systems described. Moreover, by virtue of the safety afforded in handling, accuracy and reliability in launching and firing, projectiles devised according to the present invention are adaptable for use with virtually any type of payload or warhead. Accordingly, while preferred and alternate forms of the present invention are herein set forth, illustrated and described it is to be understood that various other modifications and changes may be made in the particular construction and arrangement of parts without departing from the spirit of the present invention.

What is claimed is:

1. A projectile comprising thrust producing means for launching and propelling said projectile, an outer thin-walled shell, and a payload composed of an admixture of a major amount of a liquid pyrophoric substance, and minor amounts of a combustible thickening agent to modify the burning rate of said pyrophoric substance hermetically sealed within said shell, said payload being capable of self-combustion upon release from said shell and exposure to air.

2. A projectile according to claim 1, said payload further including solid particles distributed throughout the mixture.

3. A projectile according to claim 1, said payload being composed of a major proportion of tri-ethyl aluminum in the liquid state and minor amounts of a rubber solution and magnesium powder.

4. A projectile according to claim 1, said outer shell having a generally cylindrical container and a nose cap closing one end thereof, explosive charges in said shell, and an arming device in said nose portion being operative upon launching to detonate said charges and sever said shell for release of said payload.

5. A projectile according to claim 4, said explosive charges being in the form of linear, shaped charges extending through longitudinal grooves at spaced circumferential intervals about said shell, and said arming device being operative upon impact to detonate said charges.

6. A projectile according to claim 1, said outer shell being composed of a frangible material defining a generally cylindrical container and a nose portion closing one end of said shell, said thrust producing means being connected to the opposite end of said shell with an interface isolating said payload from said thrust producing means.

7. A projectile having an outer shell containing a payload composed of an admixture of a major amount of a liquid pyrophoric substance, and minor amounts of a combustible thickening agent to modify the burning rate of said pyrophoric substance; a reaction motor connected to the rearward end of said shell comprising an outer casing, a propellant enclosed within said casing, an ignition system within said casing being operative to ignite said propellant, a series of reaction nozzles at uniformly spaced circumferential intervals about the trailing end of said casing rearwardly of said propellant, said reaction motor further including a series of collapsible fins tangentially mounted at equally spaced circumferential intervals about the external surface of the casing.

8. In a projectile according to claim 7, said reaction nozzles being canted about axes in relation to the longitudinal axis of said projectile to impart a spinning moment of force to said projectile about its longitudinal axis upon ignition and discharge of the propellant gases through said reaction nozzles.

9. A projectile according to claim 7, said propellant mixture being in the form of solid propellant sticks arranged about the inner wall of said case and in parallel to the longitudinal axis of said case, and said ignition system being located forwardly of said case including a fuse train extending rearwardly from the ignition system with a fuse extending longitudinally through each of said elongated propellant sticks, and a screen interposed between said propellant sticks and said reaction nozzles.

10. In a projectile according to claim 7, said ignition system further including a tubular member extending rearwardly through said casing and terminating at the trailing end thereof, a primary ignitor within said tubular member including a percussion cap at the trailing end thereof, and a firing pin at the rearward end of said case being selectively engageable to strike said percussion cap.

11. In a projectile according to claim 7, said ignition system comprising electrical contact elements, ignition material contained within a recess forwardly of said propellant section and ignition wires leading from said electrical contacts into the recess being energized to discharge a spark across the recess to ignite the ignition material, and a fuse leading from said ignition material into said propellant section.

12. A projectile adapted for launching from a hand-held weapon comprising in combination a stream-lined frangible shell, a pyrophoric gel composition hermetically sealed within said shell, said pyrophoric gel being composed of a major amount of a triethyl aluminum and minor amounts of a combustible thickener to modify the burning rate of the triethyl aluminum upon exposure to air, and solid rubber or rubber-like particles interspersed throughout said gel; and a thrust reaction motor connected to the trailing end of said shell including rearwardly disposed thrust reaction nozzles canted in a direction to promote spinning of said projectile through the barrel upon energizing said motor, and a series of tangentially extending, collapsible stabilizers arranged at equally spaced circumferential intervals about the external surface of said motor case.

13. A projectile adapted for launching from a hand-held weapon comprising in combination a streamlined frangible shell, a pyrophoric gel composition hermetically sealed within said shell, said pyrophoric gel composition being disposed in a liner, and said frangible shell being composed of a curable synthetic resin material cast into surrounding relation to said liner; a thrust reaction motor connected to the trailing end of said shell including rearwardly disposed thrust reaction nozzles canted in a direction to promote spinning of said projectile through the barrel upon energizing said motor, and a series of tangentially extending, collapsible stabilizers arranged at equally spaced circumferential intervals about the external surface of said motor case.

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U.S. Cl. X.R.

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