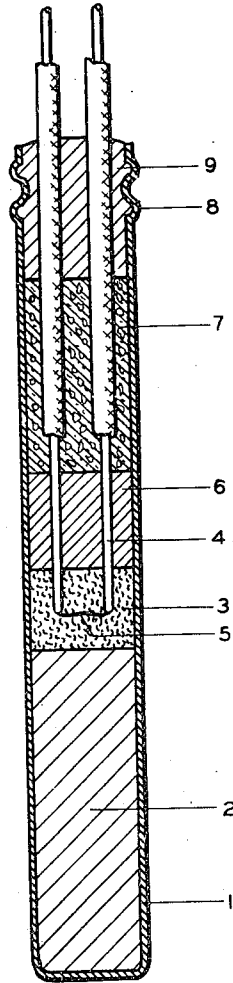


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ELECTRIC INITIATOR DEVICE
AND IGNITION COMPOSITION
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ELECTRIC INITIATOR DEVICE AND
IGNITION COMPOSITION

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This invention relates to ignition compositions and more particularly to ignition compositions for use at low temperatures.

Rocket projectiles are launched by igniting the powder in the rocket motor. For this purpose an electric squib containing a suitable flash mixture is customarily employed. However, in order that the rocket projectile may be aimed with accuracy, it is essential that the squib fire the projectile almost instantaneously; that is, the propellant powder in the rocket should be fully ignited in the order of 0.1 second or less after closing of the electric circuit which fires the squib. In the application for U. S. Letters Patent, Serial No. 449,695, now U. S. Patent No. 2,370,159, electric squibs are described which have ignition times of about 0.3 second at ordinary and elevated temperatures. However, at temperatures below about 54° C. the ignition time of these squibs increases to about 0.8 second or higher. The squibs ordinarily used for this purpose, containing a charge of about 1 gram of finely granulated black powder, meet this requirement at ordinary and elevated temperatures, but at temperatures below about 54° C. the ignition time increases, averaging around 0.3 second at -18° C. This is undesirably long, especially when the rocket projectile is to be launched at or from a rapidly moving object.

Now in accordance with this invention, electric initiators have been prepared which fire rocket projectiles instantaneously not only at elevated but also at extremely low temperatures. This has been effected by an ignition composition comprising selenium, a metal selected from the group consisting of lead and tin, a flame-producing metal and a flame-spreading agent such as an oxidizing material or a gas-producing material containing an oxidizing material. This ignition mixture is adapted for use in the standard types of both vented and ventless electric initiators.

In general, electric initiators in accordance with this invention comprise a shell, a firing assembly, and the novel ignition composition. The firing assembly includes a plug which serves as the means for spacing the lead wires and holds them in dielectric relation to each other. An electrically-resistant bridge wire connects the terminal ends of the lead wires. The initiator may be made waterproof by a layer of moisture-resistant compound such as asphalt or wax, and by a layer of sulfur or other sealing material. The ignition composition of this invention may be employed as the sole flash mixture in electric squibs. Preferably, however, it is used together

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with a base charge of flash mixture comprising a flash-producing metal and a flame-spreading agent. The ignition composition is also satisfactory as the ignition charge in electric blasting caps or igniter fuses of both instantaneous and delay types.

The nature and purpose of the invention have been generally indicated and there now follows a more detailed description of a preferred embodiment thereof with reference to the accompanying drawing. The drawing represents a cross-sectional view of an electric squib in accordance with this invention.

The squib comprises an aluminum shell 1 carrying approximately 0.8 gram of a pressed flash charge 2 of potassium nitrate and powdered magnesium. The ignition composition 3 superimposed upon the flash charge 2 comprises approximately 0.5 gram of a loose mixture of lead, selenium, magnesium, and potassium nitrate. Embedded in the ignition mixture is a pair of lead wires 4 to the terminal ends of which is affixed a bridge of electrically-resistant wire 5. The lead wires are held in position by the ignition plug 6. A layer of asphalt waterproofing compound 7 and a sulfur seal 8 held in position by crimps 8 in the shell complete the squib.

The following examples illustrate the practice of this invention.

EXAMPLE 1

Electric squibs were prepared according to standard procedures employing .25 caliber aluminum shells and electric blasting cap-type ignition assemblies, containing as the sole flash mixture various formulations of an ignition composition comprising lead, selenium, and powdered aluminum and/or magnesium. The proportions of the ingredients employed are given in Table I.

These squibs were tested in a 2.36-inch rocket held in position in a concrete block such that the gases emitted by the rocket motor were permitted to escape into the atmosphere. The sticks of smokeless powder comprising the charge for the rocket motor were inspected and weighed, then placed in position. The squib to be tested was placed in the normal position midway along the powder sticks and the end of the rocket motor tube closed with a test nozzle instead of the standard nozzle equipped with fins. The opening in the test nozzle was gauged before use and held to a tolerance of $0.410 \pm .002$ inch. The nozzles were reused until the size of the opening exceeded the tolerances or showed undue erosion. The motor tubes were used 4 times at 54° C. but

at -18°C . and -40°C . they were used until the threads showed signs of wear.

The static firing tests were conducted at -40°C ., -18°C ., and at 54°C . The rocket assemblies were allowed to remain at the temperature of the tests for about 18 hours before firing to make certain that the interiors of the sticks of smokeless powder were at the proper temperature. The temperature was held to a tolerance of $\pm 1^{\circ}\text{C}$. The round was fired within 2 minutes after removal of the rocket assembly from the conditioning temperature. In the -18°C . test, the opening in the nozzle was closed with a cardboard disk to prevent condensation of moisture in the interior of the motor. In the -18°C . test 2 strain gauges which change in resistance with the pressure were used. At 54°C . 3 ball gauges which measure the maximum pressure were used in addition to these. These gauges were connected to the interior of the motor tube through a grease channel which is formed by drilling a hole in the normally closed end of the motor tube.

A separate photographic record in duplicate was made of each shot on a strip of sensitized paper about 4 inches wide and 5 feet long, by means of a rotating drum camera. This record showed when the current was applied to the squib and the pressure at all times during the test. From this information the ignition time, pressure data, and burning time were obtained. The term "ignition time" designates the time elapsed between closing of the electric circuit which fires the squib and the time pressure first begins to build up due to burning of the smokeless powder in the rocket motor.

The images on the photographic record were formed by three mirror galvanometers. One of these vibrated at a known rate and thus placed timing lines on the record. Each of the other galvanometers was actuated by one of the strain gauges. Their degree of deflection was a measure of the change which in turn was a measure of the pressure. To obtain the actual pressure value, the deflection was compared to the deflection caused by unbalancing the galvanometers in steps of 1 ohm. The resistance value thus determined was then converted into pressure by means of a graph which was kept for each gauge. These galvanometers were caused to flicker when the current was applied to the squib. The time between this flicker and the first appearance of pressure is therefore the ignition time. The total time that the system is under pressure is the measure of the burning time.

The ignition times observed in firing these squibs are shown in Table I:

Table I

Ignition Composition	1	2	3	4	5	6
Per cent Lead.....	68	68	68	48.5	57	62.5
Per cent Selenium.....	26	26	26	45	37	31.5
Per cent Aluminum.....	3	6		6	3	3
Per cent Magnesium.....	3		6		3	3
Ignition Time (Seconds) (Average of at least 5 squibs):						
-18°C	0.74	0.85	0.9	1.04	1.11	0.82
54°C	0.29	0.22	0.24	0.24	0.24	0.3

The above results show that squibs having ignition compositions similar to that of this invention but, however, lacking a flame-spreading material fire rocket projectiles at fair ignition times at elevated temperatures but give very poor results at low temperatures.

Squibs exactly the same as the above were prepared containing as the sole flash mixture the same ignition composition modified by the addition of potassium nitrate as the flame-spreading agent. The proportions of the ingredients in the various formulations of ignition mixture employed and the firing results observed when fired as described above are given in Table II.

Table II

Ignition Composition	1	2
Per cent Lead.....	61.2	57.8
Per cent Selenium.....	23.4	22.1
Per cent Aluminum.....	2.7	2.55
Per cent Magnesium.....	2.7	2.55
Per cent Potassium Nitrate.....	10.0	15.0
Ignition Time (Seconds) (Average of at least 5 squibs):		
-18°C	0.019	0.003
54°C	0.005	0.002

These results show that addition of a flame-spreading agent, in this case an oxidizing material, yields an ignition mixture quite different in properties. Such a composition gives a squib which fires rocket projectiles instantaneously not only at elevated temperatures but also at temperatures as low as -18°C .

EXAMPLE 2

Squibs were prepared and tested as described in Example 1. The ignition mixtures employed contain lead, selenium, aluminum, and/or magnesium with black powder as the flame-spreading agent. Six formulations of ignition mixture were employed in the preparation of these squibs as shown in Table III. The squibs were fired in a static 2.36-inch rocket assembly at -40°C ., -18°C ., and 54°C .

Table III

Ignition Composition	1	2	3	4	5
Per cent Lead.....	59.5	57.8	51.0	61.2	61.2
Per cent Selenium.....	22.8	22.1	19.5	23.4	23.4
Per cent Aluminum.....	2.6	2.55	2.25		5.4
Per cent Magnesium.....	2.6	2.55	2.25	5.4	
Per cent Black Powder.....	12.5	15.0	25.0	10.0	10.0
Ignition Time (Seconds) (Average of at least 5 squibs):					
-18°C	0.019	0.02	0.033	0.005	0.047
-40°C		0.017		0.834	
54°C	0.009	0.017	0.022	0.003	0.033

The results show that black powder may be substituted for potassium nitrate in the ignition composition of this invention without adversely affecting the ignition time.

EXAMPLE 3

When magnesium powder is employed as an ingredient of flame-producing compositions for military use, it is sometimes coated with linseed oil to protect the magnesium against moisture and reaction with chemicals which may be in contact with it. Electric squibs were therefore prepared containing uncoated and linseed oil-coated magnesium in order to determine whether the linseed oil coating had any effect upon the ignition time. These squibs each contained 2.5 grams of the ignition composition of this invention as the sole flash mixture ignited using an electric blasting cap-type ignition assembly. The results observed after firing the squibs in a static 2.36-inch rocket assembly as described in Example 1 are given in Table IV. It is apparent that the linseed oil coating has little effect upon ignition time.

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Table IV

Ignition Composition	Uncoated Magnesium	Linseed Oil-Coated Magnesium
Per cent Lead-Selenium (72% lead 28% selenium).....	78	78
Per cent Magnesium.....	5	5
Per cent Potassium Nitrate.....	17	17
Ignition Time (Seconds) (Average of at least 5 squibs):		
-18° C.....	0.045	0.043
54° C.....	0.028	0.032

Squibs containing each of the above ignition mixtures were stored for 5 months at 50° C. in order to determine whether a larger firing current was required after storage. Those containing uncoated magnesium fired at 0.45 ampere before and after storage while those containing linseed oil-coated magnesium fired at 0.45 ampere before and at 0.55 ampere after storage.

EXAMPLE 4

Electric squibs were prepared employing 2 1/4 inch .25 caliber aluminum shells. In these shells was inserted 0.8 gram of a flash mixture containing 37% magnesium and 63% potassium nitrate which was pressed under a pressure of 500 lb./sq. in. to a height of 7/8 inch. Upon this flash mixture was placed 0.5 gram of an ignition composition containing 57.9% lead, 22.1% selenium, 7.5% magnesium, and 12.5% potassium nitrate, which was lightly pressed to a charge height of 13/64 inch by the insertion of the ignition plug containing the lead wires and the bridge wire.

Twenty of these squibs were fired in a 2.36-inch rocket as described in Example 1 at -18° C. The ignition times observed ranged between 0.042 and 0.052 second with an average of 0.049 second. The time required to burn 10% of the powder in the rocket motor was 0.072 second. When fired at 54° C., 20 squibs had an average ignition time of 0.038 second, with extremes of 0.034 and 0.040 second. One hundred of these squibs were fired in the open at -40° C. to determine whether or

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not the plugs would pop out of the shells without rupture of the shell at low temperatures. No appreciable lag in ignition time was found nor were there any signs of the shells starting off the plugs.

It was decided to determine the maximum charge density at which the squibs would fire satisfactorily. Twenty-six squibs were therefore prepared in which the base flash charge was pressed at the maximum pressure (4000 lb./sq. in.) possible in the charging machine. At this pressure the shell wall bulged. Twenty of these were then fired in the open at -40° C. and 6 were fired in a dummy 2.36-inch rocket containing wooden sticks in place of the smokeless powder at the same temperature. They fired substantially instantaneously and gave complete ignition of the base charge.

Tests were conducted in order to determine whether ignition would occur if segregation of the flash mixture resulted during or following charging. Ten squibs were prepared with 0.06 gram of potassium nitrate on top of the pressed flash mixture of magnesium and potassium nitrate. Fifteen additional squibs were prepared having 0.15 gram of potassium nitrate pressed to a height of 9/64 inch placed on top of the magnesium-potassium nitrate flash mixture. These squibs were then fired in the 2.36-inch rocket. Complete ignition of the base flash mixture was obtained in each case.

EXAMPLE 5

Electric squibs were prepared in accordance with the procedure outlined in Example 4. Each of the squibs contained electric blasting cap-type plugs. The proportions of ingredients in the various formulations of ignition composition are given in Table V. These squibs were fired in a 2.36-inch rocket according to the procedure described in Example 1 and the ignition times observed recorded in Table V.

The squibs containing a magnesium-potassium nitrate base charge gave slightly better ignition times.

Table V

	Ignition Composition, Per cent by weight				Base Charge, Per cent by weight			Ignition Time, Seconds	
	Lead-Selenium ¹	Magnesium	Potassium Nitrate	Ignition Charge Weight, g.	Magnesium	Potassium Nitrate	Charge Weight	-18° C.	54° C.
1	84	6	10	2.5	None	None	None	0.078 0.086 0.082 0.070 Av. 0.079	0.068 0.094 0.076 0.069 Av. 0.076
2	76	9	15	2.5	None	None	None	0.082 0.062 0.078 0.080 0.064 Av. 0.073	0.056 0.070 0.060 0.064 0.070 Av. 0.062
3	68	12	20	2.5	None	None	None	0.096 0.054 0.090 0.060 0.038 0.088 Av. 0.071	0.060 0.064 0.100 0.078 0.052 Av. 0.071
4	60	15	25	2.5	None	None	None	0.044 0.062 0.050 0.044 0.078 Av. 0.056	0.052 0.054 0.089 0.056 0.056 Av. 0.061
5	80	7.5	12.5	0.5	37.5	62.5	0.8	0.048 0.043 0.044 0.052 0.050 Av. 0.047	0.043 0.038 0.035 0.042 0.038 Av. 0.038

¹ 72.4% lead and 27.5% selenium.

EXAMPLE 6

Electric squibs were prepared by placing 0.8 gram of an aluminum-potassium nitrate flash mixture containing 30.8% aluminum and 69.2% potassium nitrate in a .25 caliber aluminum shell. This flash mixture was lightly pressed. An ignition mixture was prepared containing 80% lead-selenium (72.4% lead, 27.6% selenium) and 20% of the same aluminum-potassium nitrate flash mixture that was employed in the base charge. Five-tenths gram of this loose ignition mixture was inserted in the shell. An electric blasting cap-type ignition assembly was inserted in such a manner that the bridge wire was embedded in the ignition mixture. The shell was sealed by a layer of waterproofing compound and by a layer of sulfur held in the shell by crimps.

These squibs were fired in a 2.36-inch dummy socket assembly as described in Example 4. They fired substantially instantaneously. In each case part of the base charge was recovered in an unburned condition.

EXAMPLE 7

Electric squibs were prepared using .25 caliber aluminum shells containing as the sole flash mixture 1 gram of an ignition composition comprising 58% lead, 28.3% selenium, 18% powdered zinc, and 5% barium nitrate. These squibs proved very superior to ordinary squibs containing diazodinitrophenol-potassium chlorate and diazodinitrophenol-potassium chlorate-charcoal-nitrostarch flash mixtures. In the ignition of potassium chlorate-trinitro-toluene explosive pellets, they gave 17 more ignitions out of 100 tests. Also, the squibs ignited "C" granulation black powder in the open air at a distance 4 inches from the ignition mixture without failure in successive trials. The air cavity in delay-type initiators is usually less than 1 inch long. Thus, the ignition composition was shown to be satisfactory in delay initiators. Twenty-five squibs in series showed a critical firing current of 0.6 ampere. The critical firing current for 25 squibs with diazodinitrophenol-potassium chlorate ignition mixture in series is 0.8 ampere. These firing currents and the ability to ignite "C" granulation black powder were not appreciably changed by storage of the squibs for 5 months at 50° C.

EXAMPLE 8

Electric squibs containing 1 gram of a loose flash charge comprising 77% of a mixture of lead and selenium (72.4% lead and 27.6% selenium), 20% powdered zinc, and 3% potassium chlorate were tested for minimum firing current and for flame-throwing ability before and after 5 months hot storage at 50° C. The shells were sealed by an asphalt waterproofing compound and a layer of sulfur crimped in the shell. The electric blasting cap-type ignition plugs in each case were fitted with platinum bridge wire on 0.142 inch terminal centers. The lead wire terminals protruded $\frac{3}{4}$ inch from the face of the plug. Aluminum, bronze, and zinc closed shells (0.267 caliber) were employed. The minimum firing current was found to be 0.50 ampere before and after storage, regardless of which type of shell was used.

The squibs were placed 4 inches from "C" granulation black powder in wire baskets and fired. No failures to ignite the powder were noted. The flash mixture when fired in aluminum or bronze shells broke open the side of the shell with not too much violence. When the mixture was fired in zinc shells, the entire bottom portion of the

shell was usually disintegrated, thereby giving a large flash with no indication of violence.

The ignition flash mixture in accordance with this invention contains as essential ingredients a mixture of powdered selenium and either lead or tin, a flash-producing metal such as powdered magnesium or aluminum, and a flame-spreading material such as potassium nitrate or black powder. This ignition mixture may be employed in squibs, igniter fuses, blasting caps, or other electric firing devices. In electric squibs and igniter fuses it may serve as the sole flash mixture, or, preferably, it may be used together with a mixture of a flash-producing metal, such as magnesium, and a flame-spreading material, such as potassium nitrate or a gas-producing mixture containing an oxidizing agent such as black powder.

The ignition composition in accordance with this invention, as illustrated by the examples, contains a mixture of powdered selenium and either powdered lead or powdered tin, preferably in stoichiometrically equivalent proportions. Such a chemically equivalent mixture contains, by weight 27.6% selenium and 72.4% lead or 40% selenium and 60% tin. However, it has been found that mixtures containing between 64% and 80% lead and between 20% and 36% selenium are satisfactory. Similarly, mixtures containing between 46% and 69% tin and between 31% and 54% selenium have given good results. In general, ratios containing the smaller quantities of lead and the larger quantities of selenium give the smallest firing time. Between about 57% and about 84% of the lead-selenium mixture by weight of the total ignition composition is customarily employed. However, between 55% and about 90% by weight of the ignition mixture has given satisfactory results.

As the flash-producing metal, powdered magnesium or aluminum are preferred. Of these, magnesium gives somewhat better results. Aluminum on certain occasions shows an undesirable difficulty in ignition. The function of the flash-producing ingredient is to ignite the smokeless powder or other explosives present. Between about 3% and about 40% flash-producing metal, by weight of the ignition mixture, may be employed. When magnesium and aluminum are used, they should preferably comprise between 5% and 20% by weight of the ignition mixture. This quantity gives the optimum flash with the greatest economy in material. Other metals which may be employed as the flash-producing ingredient in quantities stoichiometrically equivalent to magnesium within the above ranges include zinc in an amount between 17% and 37% by weight, and, under certain circumstances, tin. Metals other than magnesium or aluminum, however, may fail to give nearly instantaneous, complete ignition of propellant rocket powder at low temperatures. Mixtures of two or more flash-producing ingredients, such as mixtures of magnesium and aluminum, may also be employed. It is desirable under certain conditions to coat the flash-producing ingredient with linseed oil in order to protect it from reaction with the explosives with which it may be mixed or from reaction with the atmosphere.

An essential ingredient of the ignition composition is a flame-spreading material such as oxidizing compound, or a gas-producing mixture containing an oxidizing compound such as black powder, preferably in an amount such that the

ignition composition has a zero or slightly positive oxygen balance. However, under certain circumstances a small negative oxygen balance not lower than approximately -5 may be tolerated. Higher negative oxygen balances tend to produce hangfires. On the other hand, positive oxygen balances assist in reducing the ignition time to a minimum. In fact, in one instance where the ignition composition had a positive oxygen balance of 2, the ignition time was only 0.003 second. Where potassium nitrate is the oxidizing compound, it is employed in an amount between 5% and 30% by weight of the ignition mixture, preferably between 10% and 25% by weight. Other oxidizing compounds, such as potassium chlorate, barium nitrate, sodium nitrate, sodium chlorate, barium peroxide, and lead dioxide may be employed in amounts stoichiometrically equivalent to potassium nitrate within the ranges given above and within the limitations of oxygen balance of the composition. Preferably, potassium nitrate is used with magnesium or aluminum.

The importance of each of the essential ingredients in the ignition mixture may readily be demonstrated. If a mixture of lead or selenium, magnesium, and potassium chlorate or nitrate were used, ignition of the mixture employing a bridge wire would be impossible. If a stoichiometrically equivalent mixture of lead and selenium containing 72% lead and 27% selenium were employed, good low current ignition could be obtained, but it would fail to create a flash sufficient to ignite black or smokeless powder which may be present. A mixture containing lead, selenium, and potassium chlorate or nitrate or lead, selenium, and magnesium will ignite the explosives. However, mixtures of lead, selenium, and potassium chlorate or nitrate give a poor flash while mixtures containing lead, selenium, and magnesium give only a mild flash. The addition of a small amount of a flame-spreading material, such as an oxidizing agent, to the mixture of lead, selenium, and magnesium causes the flame to spit out and scatter over a wider area in a more desirable manner, and makes possible the ignition of rocket powder substantially instantaneously at low temperatures. The importance of a flame-spreading material in the ignition mixture is further emphasized by the results shown in Example 1, comparing tests with ignition mixtures containing and lacking such an agent. However, materials which are not themselves oxidizing agents will give this effect. Black powder, which is a good reducing agent but which contains an oxidizing agent and during burning gives off large quantities of gas, has proved itself almost the equal of potassium nitrate in causing the flame to scatter in a desirable manner. It appears that any materials containing oxidizing compounds which liberate large quantities of gases will serve the same function. Such gas-producing materials may be employed in amounts such that the oxidizing compound is present within the ranges given for potassium nitrate, above.

The particle size of the ingredients employed must be carefully regulated in order to prevent segregation. While segregation does not necessarily produce failure, it should be avoided. The lead, tin, and selenium should be of a particle size comparable to the flash-producing metal. The flame-spreading material and the flame-producing agent should be of approximately the

same mesh size. Satisfactory particle sizes for potassium nitrate have been found to be between 30 and 150 mesh, and for magnesium about 80 mesh. Potassium nitrate which passes through a U. S. Standard #35 sieve but is held on a #120 sieve gives an excellent mixture with magnesium which passes through a U. S. Standard #200 sieve.

The ignition mixture may itself serve as the flash mixture since when it is employed in squibs, it will effectively ignite the smokeless powder in rockets and the like, and when it is employed in blasting caps, it will ignite the priming charge. However, when employed in squibs, an even shorter ignition time has been obtained by employing in addition to the ignition mixture of this invention a flash mixture comprising a flash-producing metal and a flame-spreading material, preferably the same flash-producing metal and the same flame-spreading material that are employed in the ignition mixture itself. A mixture of magnesium and potassium nitrate has given best results, and is preferred. However, mixtures of aluminum, zinc, or tin and potassium nitrate or mixtures of flash-producing metals with other flame-spreading materials may be employed. Stoichiometrically equivalent amounts of flash-producing metals and flame-spreading agents are preferable. However, between 37% and 50% magnesium and between 50% and 63% potassium nitrate have been found operable. Stoichiometrically equivalent quantities of flash-producing ingredients and other oxidizing agents may be substituted for magnesium and potassium nitrate within these ranges.

Electric blasting caps containing the ignition mixture of this invention may contain the customary base explosives such as pentaerythritol tetranitrate, tetryl, cyclonite, mannitol hexanitrate, trinitrotoluene, nitrolactose, nitrosucrose, etc. The blasting caps, squibs, and igniter fuse shells may be formed of copper, aluminum, lead, and other metals, cellulose acetate, ethyl cellulose, phenol-formaldehyde resin, and other plastic materials. The plugs may be formed of the standard materials including sulfur, rubber, polystyrene, phenol-formaldehyde resin, ethyl cellulose, etc. If desired, the plugs may be sealed and the shells made waterproof by using a sealing compound such as asphalt, sulfur, wax, or other waterproofing adhesive material. The lead wires may be copper or iron wire, plain, tinned, or enameled, insulated in desirable manner using cotton or plastic materials. The bridge wire connecting the terminal ends of the lead wires may be electrically-resistant wire composed of noble or base metals or alloys thereof such as platinum, Nichrome, copper-nickel, etc.

Delay electric igniters and blasting caps have been prepared using electric blasting cap-type plugs. The loose ignition composition may be placed in a capsule of Celluloid or other inflammable material, where an air space is provided, and thereby held in position about the bridge wire, or may be placed upon the delay fuse, where an air space is not needed. The ignition mixture has satisfactorily ignited delay fuses having cores of black powder, barium peroxide-selenium, and other standard delay powders.

The improved squibs in accordance with this invention have been found particularly useful for insuring the ignition of smokeless powder of the type used in rockets in an extremely low ignition time. They may be used in rockets of all sizes. When used in 4.5-inch or larger rockets, it may

be advisable to insert the squib in a bayonet igniter—a long narrow tube filled with a flash mixture, such as black powder. The squib ignites the flash mixture, which then provides a greater scattering effect the full length of the rocket motor.

These squibs show an improved rapid ignition time at low and high temperatures, from -40°C . to 54°C . and above. They have shown substantial reductions in critical firing current when fired in series.

This application is a continuation-in-part of my application for U. S. Letters Patent, Serial No. 449,695, now Patent No. 2,370,159, filed July 3, 1942.

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

1. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of a flame-producing material based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

2. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of magnesium based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

3. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of zinc based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

4. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of aluminum based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

5. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of magnesium based on the weight of the ignition composition; and 5–30% of potassium nitrate based on the weight of the ignition composition.

6. An ignition composition comprising selenium and a material of the group consisting of

lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of zinc based on the weight of the ignition composition; and an amount of potassium chlorate which is stoichiometrically equivalent to 5–30% of potassium nitrate based on the weight of the ignition composition.

7. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of zinc based on the weight of the ignition composition; and an amount of barium nitrate which is stoichiometrically equivalent to 5–30% of potassium nitrate based on the weight of the ignition composition.

8. An ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of aluminum based on the weight of the ignition composition; and between 5–30% of potassium nitrate based on the weight of the ignition composition.

9. An electric initiating device comprising a shell, a firing assembly and a flame-producing mixture comprising an ignition composition consisting of selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of a flame-producing metal; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

10. An electric initiating device comprising a shell, a firing assembly and a flame-producing mixture comprising an ignition composition consisting of selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of magnesium based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

11. An electric initiating device comprising a shell, a firing assembly and an ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin proportion is 31–54% selenium to 46–69% tin by weight; from 3–40% of zinc based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5–30% potassium nitrate based on the weight of the ignition composition.

12. An electric initiating device comprising a shell, a firing assembly and an ignition composition comprising selenium and a material of the group consisting of lead and tin in which the selenium to lead proportion is 20–36% selenium to 64–80% lead and the selenium to tin propor-

tion is 31-54% selenium to 46-69% tin by weight; from 3-40% of aluminum based on the weight of the ignition composition; and an amount of a flame-spreading material comprising an oxygen-yielding salt stoichiometrically equivalent to 5-30% potassium nitrate based on the weight of the ignition composition.

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