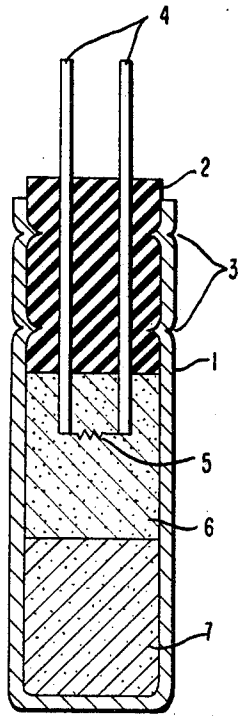
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ELECTRIC EXPLOSIVE IGNITION ASSEMBLY

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ELECTRIC EXPLOSIVE IGNITION ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

An electric explosive ignition assembly which is unaffected by exposure to one ampere of current and one watt of power for five minutes yet can be actuated reliably by five watts of power which comprises a loose charge of magnesium and tellurium dioxide.

BACKGROUND OF THE INVENTION

In recent years, electric initiators have been developed which are not subject to accidental actuation by spurious electric currents. Such initiators, known as electroexplosive devices, or "EED's" are particularly useful in an explosive train to be used in aircraft, on shipboard, or in other situations where there is the possibility of accidental actuation by static discharges or electromagnetic radiation such as is emitted by radio, TV, radar, or beacon transmitters, induction heaters, rotating electrical machinery, and the like. To preclude such accidental actuation, it is generally required that the ignition assembly of the EED not be actuated by the application of either one watt of DC power for five minutes or one ampere of DC current for five minutes. This requirement must be met without the use of external shunts. Ignition assemblies for EED's which meet these requirements are referred to as having one-watt, one-ampere, five-minute, no-fire characteristics. Additionally, the ignition assemblies should not deteriorate in any way by exposure to either extremely high or low temperatures, acceleration, shock, or static-electric discharges. The ignition assembly should however, be able to reliably initiate the EED in which it is incorporated when exposed to at least 5 amperes of current or 5 watts of power for 50 milliseconds.

Various design features previously have been used for ignition assemblies for electric initiators having the desired one-watt, one-ampere, five-minute, no-fire characteristics, such as large diameter bridgewires, special bridge resistors and/or shunts, lose ignition mixture either having high energy ignition requirements or containing heat conductive additives or heat sinks to protect the bridgewire when high-energy ignition mixtures are used. Additionally, radio frequency filters or shielding have often been provided. While these techniques have provided the desired one-ampere, one-watt, five-minute no-fire characteristics, they have done so only at the cost of one or more attendant disadvantages, such as excessively long firing times; excessively high level of current or power necessary for reliable initiation; dependence on conductive metal powders, or conductive or semiconductive shunts to dissipate one ampere of current or one watt of power; the necessity of special glass-to-metal seals or ceramic insulation; high production cost and lack of interchangeability in explosive devices.

SUMMARY OF THE INVENTION

This invention provides electric ignition assemblies having one-ampere, one-watt, five-minute, no-fire characteristics which are free of the disadvantages mentioned above and which are easily prepared by conventional assembly line apparatus and techniques.

The one-watt, one-ampere, five-minute, no-fire ignition assemblies of this invention comprise a bridgewire having a resistance of about from 0.3 to 1.0 ohm surrounded by a loose ignition composition comprising, based on the total weight of composition, (a) at least about 70% of a mixture consisting essentially of about from 10 to 90% of magnesium and about from 90 to 10% of tellurium dioxide and (b) about from 1 to 30% of an inert, dielectric, polymeric graining agent having a melting point and decomposition temperature above 250° F. Preferably, the composition further comprises up to about 5%, and especially about from 0.5 to 2.0%, of an anticaking agent, and especially an alkali metal silicoaluminate.

BRIEF DESCRIPTION OF THE DRAWING

The figure represents one particular embodiment of the ignition assembly of this invention used in a squib.

DETAILS OF THE INVENTION

The relative proportions of magnesium and tellurium dioxide in the loose ignition compositions of this invention which surround the bridgewire should be maintained within the range of 10 to 90% magnesium and 90 to 10% tellurium dioxide to assure the desired one-watt, one-ampere, five-minute, no-fire characteristics of the assembly. Within this range, 20 to 60% magnesium and 80 to 40% tellurium dioxide, and especially 40% magnesium and 60% tellurium dioxide, are particularly preferred. The presence of at least about 10% magnesium is needed to absorb heat and to sustain chemical reaction between the magnesium and tellurium dioxide. When magnesium comprises substantially greater than about 90% of the mixture of magnesium and tellurium dioxide, insufficient oxidant is present to assure reliable ignition of the composition. In general, the requisite energy to fire compositions of this invention increases with increasing magnesium content. The presence of tellurium metal in substantial proportions in the tellurium dioxide is undesirable, since tellurium melts with an endothermic reaction which may preclude reliable ignition of the composition.

The magnesium and tellurium dioxide are preferably of a maximum particle size of about 225 mesh and a minimum particle size of about 500 mesh, U.S. Standard screen, in order to insure thorough mixture with each other and dispersal with the graining agent. This particle size can be assured by screening the magnesium and tellurium dioxide separately immediately prior to mixing, then dry blending the components for at least 30 minutes to obtain an intimate mixture. This preferred particle size also facilitates the loading of the mixture in the assembly of the EED's.

The graining agent used in the instant invention is a composition which is thermally stable, i.e., not decomposed or melted by, temperatures of at least about 250° F. and preferably 300° F. The binder should also have a dielectric constant of at least about 1.0. Examples of the types of polymers which can be used are vinyl resins including fluorocarbon polymers such as polytetrafluoroethylene, polychlorotrifluoroethylene and polyvinyl fluoride, polyvinyl acetate, acrylic polymers, and vinyl chloride polymers including homopolymers and copolymers of vinyl chloride; polyesters including polyethylene terephthalate as well as styrene crosslinked maleic acid polyesters; silicone resins and rubbers including alkyl-aryl-, and alkoxy-substituted polysiloxanes; polyamides such as nylon 6, 6; polyimides; and amino- and phenol-formaldehyde resins including phenol-, urea- and melamine-formaldehyde thermosetting resins; epoxy resins;

and mixtures thereof. Preferred graining agents are polyvinyl acetate such as commercially available as "Elvacet" 1, and silicone rubber. Silicone rubber, preferably a room temperature vulcanizing silicone rubber, is particularly preferred for high temperature (>300° F.) applications. When combined with the dry blend of magnesium and tellurium dioxide, the graining agents are generally dissolved in an organic solvent, for example, alcohols such as methanol, ethanol and isopropanol, and halogenated hydrocarbons such as methylene chloride. Of these, methylene chloride is preferred. The silicone rubber is typically employed in the form of a viscous paste comprising a high molecular weight siloxane gum, e.g., polydimethyl siloxane; an inorganic filler, typically finely divided silicone dioxide; and a peroxidic or acetic acid curing or vulcanizing agent. A typical silicone rubber is RTV–112 silicone rubber adhesive/sealant commercially available from General Electric, or "Silastic" silicone rubber adhesive commercially available from Dow-Corning.

The percentage of magnesium-tellurium dioxide mixture in the ignition composition will generally range about from 70 to 99%, and preferably 80 to 97%, by weight, whereas the graining agent usually comprises about from 1 to 30% and preferably about from 3 to 20% of the composition. Usually, the minimum power required to actuate the assemblies of this invention increases as the percentage of graining agent increases.

In addition to the Mg/TeO_2 blend and graining agent, the ignition composition optionally can contain small proportions, of up to about 5% and preferably about from 0.5 to 2%, based on the total weight of the composition, of anticaking agent to tailor the flowing characteristics to particular manufacturing and loading conditions. Such additives can readily be mixed in the ignition compositions. Preferred additives are alkali and alkaline earth metal salts of silicoaluminates. One especially preferred silicoaluminate is that available commercially as "Zeolex." The addition of this additive is particularly advantageous when the EED's are to be prepared on assembly lines since their presence insures complete charging of the composition without lumping or sticking in the loading equipment.

In assembling EED's having the ignition assemblies of the instant invention, the grained mixture of magnesium and tellurium dioxide is loaded into the shell above the base charge of a squib or priming charge of a detonator and pressed in place by the sealing plug which supports the bridgewire. Compression of this charge contributes to uniformity and reliability of response to a firing impulse. In general compositions pressed into place with compression forces of about from 20 to 30 lb. of force are less sensitive to actuation to mild firing stimuli than those which are not only mildly compacted.

The bridgewire is an additional important factor in achieving a satisfactory one-ampere, one-watt, five-minute, no-fire ignition assembly. The resistance of the bridgewire should be about from 0.3 to 1 ohm. A particularly preferred bridgewire has 0.5 to 0.77 ohm resistance which range provides an operating spread of 1.65 amperes between a maximum no-fire current of 1.68 amperes and a minimum all-fire current of 3.33 amperes. Bridgewire metals can include, for example, metals of Groups VI*a* and VIII and alloys thereof and alloys with Group I*b* metals of the "Periodic Table" appearing in Webster's New Collegiate Dictionary, page 626 (1953). Iron and nickel alloys, particularly those containing 50% or more of nickel or noble metal such as the Ni-Cr, and noble metal alloys (e.g., Pd-Au) are preferred. Specific examples of bridgewire materials are 0.00225 to 0.0035 inch diameter "Kanthal" alloy (5% Al, 22% Cr, 0.5% Co, 72.5% Fe), 0.003-inch diameter "Nichrome" (80% nickel, 20% chromium) bridgewire, and the 7294 alloy of 49.5% by weight gold, 40.5% by weight palladium, and 10% by weight iron (commercially available from Baker Division of Engelhard Industries) of 0.004 or 0.0045 inch diameter. Of these, the "Kanthal" and No. 7294 alloys are particularly suitable since they are particularly resistant to change on prolonged exposure to currents approaching the one watt level (ca. 1.5 amperes). The diameter of the bridgewire should be at least about 2 mils (0.002 inch) to preclude fusing during passage of current therethrough. Naturally the bridgewire should be affixed to the lead wires or other elements of the internal EED firing circuit by a thermally-stable, high-strength juncture, such as, for example, by soldering, brazing, sonic bonding, etc.

The assemblies of this invention can be incorporated in a wide variety of EED's including squibs, electric instantaneous and delay blasting caps as well as other detonators. In such applications, the assemblies are connected in the internal EED firing circuit, usually by lead wires. Such lead wires usually pass through a dielectric plug, e.g., of natural or synthetic rubber, or of a synthetic resin potting composition. In any event, the assemblies are juxtaposed to at least one explosive charge ignitible thereby. The ignition assembly, the remainder of the internal firing circuit and the other EED charges are usually all disposed in a metal shell having one open end into which the plug and embedded lead wires fit.

One such EED is illustrated in the figure, wherein **1** is a tubular shell, e.g., of commercial bronze or aluminum, **2** is a dielectric sealing plug, e.g., of natural or synthetic rubber, retained by peripheral crimps **3**. Charge **7** is an exothermic burning squib charge such as black powder; a mixture of barium peroxide, magnesium and selenium; smokeless powder; the complex of lead nitrate and the bis-basic lead salt of 4,6-dinitro-o-cresol (i.e., lead nitrato-bis-basic-lead-4,6-dinitro-o-cresylate, hereinafter "lead salt"), lead azide or a mixture of, by weight, 50% smokeless powder, 25% lead salt, and 25% potassium chlorate. Extending into the shell **1** through dielectric sealing plug **2** are lead or "leg" wires **4** whose internal terminals, i.e., extremities, are connected by bridgewire **5** having a resistance within a range of about 0.3 to 1.0 ohm, the other extremities of the lead wires being connected in an external firing circuit (not shown) comprising a power source. Bridgewire **5** is surrounded by a loose ignition charge **6** comprising (a) 70 to 99% by weight of an intimate blend of 10 to 90% by weight magnesium, 90 to 10% by weight of tellurium dioxide, and (b) 1 to 30% by weight of the total composition of a silicone resin graining agent.

The functioning of the devices shown in the figure is basically the same as conventional EED's. Passage of electric current of one ampere or power of one watt through the bridgewire is insufficient to heat one bridgewire to a degree sufficient to ignite the composition surrounding it. However, the passage of current of at least 5 amperes or power level of at least 5 watts is sufficient to ignite the ignition composition within 50 milliseconds. Ignition of this composition causes charge **4** to be ignited, as is conventional in EED's.

In the following examples, which further illustrate the instant invention, parts and percentages are by weight unless otherwise indicated.

Example 1

Ignition compositions are prepared for EED's of the type shown in FIGURE 1. Powdered magnesium and tellurium dioxide are screened separately through a 325 and 400 mesh screen, respectively. The powders that pass the screen are dry blended in proportions as shown in Table I in a Fisher-Kendall mixer for at least 30 minutes. The blended dry powders are then mixed with a solution comprising about 125 parts silicone resin in about 700 parts methylene chloride for every 1000 parts of dry powder. The damp blend is grained through a 28 or 34 mesh screen, dried at 120° F. for at least 16 hours, then screened through a 44 mesh screen. The compositions comprise 11% silicone resin graining agent and 89%

Mg/TeO_2 mixture. To improve flowability 1% of sodium silicoaluminate is blended into the grained mix.

Thirteen EED's are assembled, loading a small quantity of the loose grained blend on top of a load of pressed lead azide and compressing with 20 lb. force by a sealing plug supporting a bridgewire ignition assembly. The bridgewire is of 0.0035 inch diameter "Kanthal" alloy A having a resistance of 0.50Ω. The units are tested by connecting them in the firing circuit of a balance panel comprising a 30 volt DC power source, means for continuously varying the current over a range of 1 to 10 amperes, and means to set a variable resistor equal to the bridge circuit. Timing tests are made using a balance panel, an electronic counter-timer, and a photocell and amplifier. Application of firing current from the balance panel to the test unit triggers the counter-timer and fires the test unit. Firing time is recorded by the counter-timer on receipt of the gating signal produced in the photocell-amplifier by the flash from the initiated test unit or collapse of a special "target" circuit. Three to six tests are made at each current level. Results of the test are given in Table I.

Example 2

Ignition assemblies are prepared as in Example 1 except that the weight ratio of magnesium to tellurium dioxide is maintained at 40/60 and the percentage of silicone graining agent is varied as set forth in Table II, in which the results are tabulated.

Example 3

Ignition assemblies are prepared as described in Example 1 using an ignition composition comprising 86% of a blend of 40% magnesium and 60% tellurium dioxide grained with 14% silicone and compressed at about 20 lb. When the composition was used in conjunction with bridgewires of the resistances specified in Table II, firing times as set forth in that table are obtained.

TABLE III

Current (amps)	Avg. functioning time in milliseconds at specified bridgewire diameter and resistance			
	0.00225 (in.)	0.00275 (in.)	0.0031 (in.)	0.0035 (in.)
	0.77 (ohms)	0.72 (ohms)	0.56 (ohms)	0.50 (ohms)
1.6	ND			
1.7	160	ND		
1.8	80	115		
1.9	65	76		
2.0	46	56	ND	
2.2	29	35	190	ND
2.4	22	27	82	130
2.8	15	18	36	55
3.0	13	15	27	42
3.4	10	12	21	28
4.0	7	9	15	21

I claim:

1. A one-watt, one-ampere, five-minute, no-fire ignition assembly comprising a bridgewire having a resistance of about from 0.3 to 1.0 ohm surrounded by a loose ignition composition comprising, based on the total weight of the composition, (a) at least about 70% of a mixture consisting essentially of about from 10 to 90% of magnesium and about from 90 to 10% of tellurium dioxide and (b) about from 1 to 30% of an inert, dielectric polymeric graining agent having a melting point and decomposition temperature above 250° C.

2. An ignition assembly of claim 1 wherein the ignition composition further comprises about from 0.5 to 5.0% of anticaking agent.

3. An ignition assembly of claim 2 wherein the anticaking agent is selected from alkali metal and alkaline earth metal silicoaluminates.

4. An ignition assembly of claim 1 wherein the mixture consists essentially of magnesium and tellurium dioxide in a ratio, in parts by weight, of about 10 to 90.

5. An ignition assembly of claim 1 wherein the mixture consists essentially of magnesium and tellurium dioxide in a ratio, in parts by weight, of about 20 to 80.

TABLE I

Current (amps)	Calculated minimum power (watts)	Calculated maximum power (watts)	Avg. functioning time in milliseconds of various Mg/TeO_2 ratios					
			10/90	20/80	25/75	40/60	60/40	80/20
1.5	0.95	1.17	[1]ND	ND	ND			
1.6	1.08	1.33	420	500	400			
1.7	1.22	1.50	230	280	200			
1.8	1.38	1.68	170	190	140	ND		
1.9	1.52	1.88	150	150	105	220		
2.0	1.68	2.08	135	125	85	155	ND	
2.2	2.04	2.52	115	80	60	100	150	
2.4	2.42	3.00	96	60	47	74	100	ND
2.8	3.30	4.07	80	38	32	35	52	250
3.0	3.78	4.68	76	32	27	30	42	230
3.5	5.00	6.20	68	22	20	22	25	200
4.0	6.73	8.30	64	18	15	16	18	195
5.0			60	11	11	11	11	190

[1] ND—No detonation.

TABLE II

Current (amps)	Calculated minimum power (watts)	Calculated maximum power (watts)	Average functioning time in milliseconds with 40/60 Mg/TeO_2 mixes having varying amounts of silicone		
			3%	7%	11%
1.5	0.95	1.17	ND	ND	ND
1.6	1.08	1.33	ND	ND	ND
1.7	1.22	1.50	ND	ND	ND
1.8	1.38	1.68	290	380	ND
1.9	1.52	1.88	190	260	280
2.0	1.68	2.08	145	200	210
2.1	1.85	2.29	105	140	170
2.2	2.04	2.52	80	110	130
2.4	2.42	3.00	58	70	90
2.8	3.30	4.07	32	39	54
3.0	3.78	4.68	26	32	35
3.2	4.30	5.30	21	26	30
4.0	6.73	8.30	13	15	16

6. An ignition assembly of claim 1 wherein the mixture consists essentially of magnesium and tellurim dioxide in a ratio, in parts by weight, of about 40 to 60.

7. An ignition assembly of claim 1 wherein the mixture consists essentially of magnesium and tellurium dioxide in a ratio, in parts by weight, of about 60 to 40.

8. An ignition assembly of claim 1 wherein the mixture consists essentially of magnesium and tellurium dioxide in a ratio, in parts by weight, of about 80 to 20.

9. An ignition assembly of claim 1 wherein the graining agent is thermally stable at temperatures of at least about 300° F.

10. An ignition assembly of claim 9 wherein the graining agent is a silicone rubber.

11. An ignition assembly of claim 1 wherein the maxi-

mum agent particle size of the magnesium-tellurium dioxide mixture is such that the mixture will pass a 225 mesh screen.

12. A one-watt, one-ampere, five-minute, no-fire ignition assembly comprising a bridgewire of Group VIII metal alloy having a resistance of 0.35–0.45 ohm and a diameter of at least about 3 mils surrounded by a loose ignition composition comprising, based on the total weight of the composition, (a) at least about 70% of a mixture consisting essentially of about from 20 to 60% magnesium and about from 20 to 40% of tellurium dioxide and (b) about from 1 to 30% of a silicone rubber graining agent having a melting point and decomposition temperature above 300° C.

References Cited

UNITED STATES PATENTS

2,761,386	9/1956	Zebree	102—28
3,366,054	1/1968	Gruber	102—28

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149—37