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PYROPHORIC COMPOSITION

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This invention relates to pyrophoric compositions suitable for fuses and starting mixtures for bombs and general explosive materials.

The design of fire bombs and explosive bombs frequently involves a complicated combination of devices to insure proper operation of the bombs. Some of these designs require a three-part system consisting of a primer or primary ignition source, such as fulminate of mercury or an azide compound. This ignited primer then initiates the combustion of a fuse mixture, and the ignition of this fuse mixture in turn establishes the proper combustion or explosive conditions for the main body of the bomb.

An important requirement of the aforementioned fuse or starting mixtures is stability during storage. They must be capable of being stored for long periods, frequently for years, under conditions of extreme cold or extreme heat, in very dry atmospheres or in exceptionally humid atmospheres. In spite of the rigors of such exposure, the fuse mixture should maintain all of its desirable combustion characteristics. Until recent years, an important ingredient of such fuse mixtures was magnesium metal powder or mixtures of magnesium and aluminum. However, an unfortunate property of the magnesium-type fuse mixtures is their relatively poor resistance to the aforementioned external storage conditions. For example, when stored in a very humid atmosphere, a magnesium fuse mixture loses all of its effectiveness in a matter of a few months and the bomb incorporating this fuse will be a dud unless the fuse mixture is replaced. The magnesium fuse mixtures suffer from still another limitation in that they cannot be compressed and therefore must be used in a relatively loose open form.

In recent years, metallic titanium powder and metallic zirconium powder, or mixtures thereof, have been found to be effective as fuse or starting mixtures without the limitations characteristic of the magnesium-type mixtures. Metallic titanium powder-type fuse mixtures in particular appear to be stable indefinitely under any of the types of climatic conditions to which a bomb may normally be subjected. These titanium-type starting mixtures cannot, however, be subjected to extreme pressure. Moreover, titanium and zirconium powders, in addition to being expensive, are dangerous to prepare and their degree of instability during preparation is such that serious losses are encountered due to premature ignition.

I have now discovered that certain titanium and zirconium alloys, when physically admixed with such elements as sulfur, selenium, or tellurium, form an extremely active pyrophoric composition which is equal or superior in activity to powdered titanium, although these alloys alone in powdered form are substantially ineffective as a pyrophoric material. Moreover, the pyrophoric mixtures of my invention are stable to a greater extent than titanium or zirconium metal powders when exposed to the types of conditions listed hereinbefore. Of still more importance, however, is the fact that when

these titanium and zirconium alloys are combined with sulfur, selenium or tellurium, they may be subjected to high compressive pressure without losing their effectiveness.

The titanium and zirconium alloys which form such effective pyrophoric mixtures with sulfur, selenium and tellurium comprise alloys of titanium or zirconium, or both, with aluminum. In general, the most useful range of compositions comprises alloys containing between 50 and 80% by weight of titanium or zirconium, or both, and the balance essentially aluminum. The zirconium base alloys are more effective than the titanium base alloys in the mixtures of my invention, and this increase in activity progresses with the zirconium content of the alloys from the level of the titanium base alloy up to the level of the zirconium base alloy. Regardless of their variation in titanium or zirconium content, the alloys may further contain from 2% to 10% by weight of either tin or silicon, or both.

The aforementioned titanium and zirconium base alloys must contain from 10% to 30% by weight of aluminum in order to impart to a mixture of the alloy with sulphur, selenium or tellurium the stability referred to hereinbefore. In such alloys wherein the total content of titanium or zirconium, or both, plus aluminum is less than 100%, the balance of the alloy will be composed of either tin or silicon, or both. Silicon in these alloys somewhat increases the pyrophoric effectiveness of the mixtures of my invention, but its primary advantage in the alloys is to increase their brittleness and thereby facilitate grinding of the alloys to powder form. Tin also somewhat increases the pyrophoric activity of the mixtures of my invention, but its presence is generally accounted for because it results from the advantageous use of tin or tin oxide during alumino-thermic production of the base alloy.

The aforementioned alloys may be prepared by simple fusion of their constituents, or by sintering in a non-oxidizing atmosphere the powders of the metal constituents of the desired alloy at conventional sintering temperatures for these metals, or the alloys may be prepared by reduction of alkali metal double fluorides or any or all of the metals titanium, zirconium, tin and silicon with molten aluminum. However, I presently prefer, for economical reasons, to prepare the alloys in massive form by conventional alumino-thermic technique. When the alloy is produced by such alumino-thermic procedure, the yield of metal from the oxidic component of the alumino-thermic mixture may be doubled by the inclusion in the mixture of sufficient metallic tin or tin oxide to leave in the resulting alloy from 2% to 10% by weight of tin.

The titanium or zirconium alloys used in the practice of my invention are initially made in the form of massive pigs which are then crushed to roughly ¼ inch in size. The crushed alloy is subsequently ground under water, for example, in an open end or vented ball mill using iron balls, to a particle size at least fine enough so that the material will pass through a —325 mesh screen (Tyler Standard). Grinding to 400–600 mesh further increases the pyrophoric activity of the final mixture, and this range of particle size is therefore preferred for many purposes. The water is then drained from the ground alloy and the resulting powder is dried in air, advantageously at 90° C. The powdered alloy is then mixed with sulfur, selenium, or tellurium, also in powder form, but because of its availability and cost, sulfur is preferred. The amount of sulfur (or other equivalent agent as aforementioned) which is used for this purpose may range from 2 to 50% by weight of the titanium or zirconium-containing alloy, the higher the content of sulfur the more violent the pyrophoricity of the resulting

mixture. Any specific amount of sulfur (or its equivalent) results in mixtures of increasing pyrophoricity when the alloys used in making these mixtures contain increasing proportions of zirconium as described hereinbefore. A range of sulfur (or its equivalent) from 5 to 25% is preferred for a practical combination of effectiveness and economy. Mixing of the alloy and sulfur is advantageously carried out in a conventional double cone blender so that the powder is subject to as little attrition as possible.

The effectiveness of the mixtures of the present invention, compared with that of a mixture of titanium metal powder and sulfur such as that described in United States Patent No. 2,461,544, can be appreciated by a comparison of their ignition activities. These activities are indicated in the following table by the time required for each mixture to burn when packed in the form of a minus 325 mesh powder in a combustion tube having an inside diameter of 0.25 inch and a length of 10 inches:

Sample No.	Ti, percent	Zr, percent	Al, percent	Sn, percent	Si, percent	S, percent	Burning Time
1	100					30	35 sec.
2	68.6		29.5			5	40 sec.
3	68.6		29.5			20	20 sec.
4	68.6		29.5			35	6 sec.
5	52.1	17.4	27.6			5	15 sec.
6	52.1	17.4	27.6			20	7 sec.
7	52.1	17.4	27.6			35	explodes.
8		67.6	29.2			2	7 sec.
9		67.6	29.2			10	2 sec.
10	59.4		28.1	9.3		20	20 sec.
11	42.2	17.1	29.6	9.5		20	12 sec.
12	76.2		22.5		5.4	20	15 sec.
13	50.7	18.4	23.2		5.6	10	10 sec.
14	58.8		25.1	10.4	5.0	20	20 sec.
15	42.1		22.1	10.2	5.2	10	10 sec.

It will be seen that the mixtures of my invention, as represented in the foregoing table, are actively pyrophoric and that their degree of activity in this respect can be readily controlled by proportioning their constituents as previously described. All of these mixtures are furthermore stable with respect to ambient storage atmospheric conditions as well as with respect to their safe use, and they are moreover capable of being compressed (the physical condition generally preferred for fuse and starting mixtures) without danger of their premature ignition.

I claim:

1. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

2. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum, and (2) from 5 to 25% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

3. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium, 2 to 10% each of at least one metal of the group consisting of silicon and tin, and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

4. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium, 2 to 10% of silicon, and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

5. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium, 2 to 10% of tin, and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

6. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum in the amount of 10 to 30%, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

7. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of titanium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

8. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of zirconium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

9. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium, the finely divided components of the mixture having a particle size of minus 325 mesh.

10. A pyrophoric composition which comprises a mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium, the finely divided components of the mixture having a particle size within the range of 400–600 mesh.

11. A pyrophoric composition which comprises a compressed mixture of (1) a finely divided alloy composed essentially of 50 to 80% of at least one of the metals of the group consisting of titanium and zirconium and the balance essentially aluminum, and (2) from 2 to 50% by weight of a finely divided element of the group consisting of sulfur, selenium and tellurium.

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