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MANUFACTURE OF FUSE POWDER
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The present invention relates to new or improved fuse compositions of the kind comprising mixtures of pulverulent inorganic oxidising and reducing agents, and to improved delay elements, for instance fuses for blasting or military purposes, containing the new fuse compositions.

Fuses made from black powder are liable to considerable variation in their burning properties according to the prevailing atmospheric pressure, which frequently causes inconvenience in blasting at high altitudes and in the production of military fuses. Mixtures of oxidising and reducing agents that react together with the formation of little or no gaseous products are free from this objection, and it has been proposed to employ as fuse compositions mixtures consisting of red lead and silicon. The reaction may be represented by the equation



Unfortunately the range of fuse speeds that can be obtained in mixtures of red lead and silicon by variation in the relative proportions of two ingredients is very limited, and the burning speed at atmospheric pressure of fuses made from even the slowest burning mixtures composed of red lead and silicon is substantially faster than that of ordinary black powder fuse.

It is known that mixtures of silicon and potassium nitrate are capable of reacting exothermically when they are strongly heated, but they cannot be used as fuse compositions since they are incapable of propagating the reaction progressively through a train of small cross sectional area. This reaction proceeds with the evolution of gas and the formation of a glowing residue, and may be represented as follows:



I have now found that by using potassium nitrate and red lead together as oxidising agents for silicon fuse compositions, fuses capable of burning vigorously at a wide range of burning speeds are obtained, and more particularly the production of fuses burning vigorously at lower speeds than those that can be obtained by the use of mixtures of red lead and silicon alone, is facilitated.

According to the present invention fuse compositions comprise a pulverulent mixture of potassium nitrate, red lead and silicon.

The amounts of potassium nitrate, red lead and silicon can lie between 50-15%, 30-60% and 10-40%, respectively, and preferably between 40-20%, 40-50% and 20-30%, respectively.

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The burning speeds of the resulting fuse powders depend both on the relative amounts of potassium nitrate and red lead present in the oxidising component of the mixture, and on the silicon content of the composition. The minimum fuse speeds that can be attained become progressively slower as the potassium nitrate content of the oxidising component is increased towards the limit that can be tolerated without rendering the composition incapable of propagating the reaction along the fuse. Up to a point the effect of excess of silicon over the stoichiometric proportion, calculated from the foregoing equations, is to increase the fuse speeds; but as the excess of silicon is progressively increased the resulting fuse speeds approach a maximum, and may become slower before sufficient silicon has been included in the composition to render the fuse incapable of burning steadily.

For any particular proportion of potassium nitrate in the oxidising component it is preferable to employ a composition containing the less of any two excesses of silicon that will give a fuse of the desired speed, since the resulting fuse composition will be the more vigorously burning of the two.

But the presence of progressively increasing proportions of potassium nitrate renders it possible to include progressively higher amounts of excess silicon in the mixture.

When the ratio of the amount of potassium nitrate to that of red lead is low, no excess of silicon over the stoichiometric proportion need be employed, or it may even be permissible that there should be a slight deficiency of silicon, but as the potassium nitrate content of the oxidising component is increased it becomes necessary to employ a progressively increasing excess of silicon to render the fuse powder capable of propagating the reaction. The maximum excess of silicon that can be used without rendering the fuse incapable of propagating the reaction also increases.

The fuse compositions produced according to the present invention yield a certain amount of gas amongst the products of their combustion, thus providing for "end spit," a characteristic absolutely indispensable in non-detonating fuse in order that it may be operative to set off a detonator into which it may be crimped. But, by means of the invention, it is possible to obtain fuse compositions burning at speeds comparable with those obtained from black powder fuse compositions, that are substantially less liable to variation in their burning properties with variation in the atmospheric pressure. This is be-

cause, in the new fuse compositions, the gaseous component of the products of combustion can be so much smaller in proportion to the total amount of said products than is the case with black powder fuse.

In putting the invention into effect the pulverulent ingredients may be mixed together in any order but preferably the pulverulent mixture is produced by first admixing potassium nitrate and red lead and thereafter admixing this mixture with silicon. The fuses may be made with a core of the pulverulent fuse composition in powder or rod form containing a binding agent, or preferably with corned granules containing gum, nitrocellulose or an artificial resin, in the customary fashion; but the composition may also be made into an imporous mass by means of a thermoplastic binding agent, for instance a gelatinised nitrocellulose composition, so that it can be extruded at a suitably raised temperature to form a core around which an envelope is applied. It will be understood that the burning speed of the fuse so produced may differ considerably from that of fuse having a core of the powder or corned fuse composition.

For the purpose of study and comparison of the burning speeds of these compositions, a testing method known as the "lead fuse test" may be used. In this test, lead tubes of specified size and weight are filled with the fuse powder to be tested, and are sealed and drawn through dies until they have been reduced to a specified standard diameter. Measured lengths are then cut from the middle portion of the filled and drawn tube, and the speed of burning of these lengths is then measured at any desired pressure.

Since the lead sheath is melted by the heat of combustion of the fuse powder, the gaseous combustion products are substantially unconfined and the burning takes place under the prevailing barometric pressure.

The burning speeds of the fuse made in accordance with the present invention may be somewhat increased by embedding in the core a soft metal wire, for instance of 20 to 40 standard wire gauge diameter.

The invention is illustrated by the following examples, in which the parts are parts by weight:

Example 1

The fuse powder is made by mixing red lead powder as used in paints with potassium nitrate screened to pass a 100 British Standard Specification sieve and silicon sieved to pass a 200 British Standard Specification sieve. In the oxidising component the red lead and the potassium nitrate are present in the proportions 78.5:21.5 and the silicon in various proportions from stoichiometric upwards. The lead fuse speeds of the resulting fuse powders at one atmosphere pressure are approximately as follows:

Percentage Silicon Excess	Seconds Per Yard
0	111
8	86
12	62
20	41
30	33
40	26
60	27
80	30
100	34

Example 2

The ingredients used are the same as in Example 1, but the red lead and potassium nitrate

are used in the proportions 71.4:28.6. The lead fuse speeds of the resulting fuse powders at one atmosphere pressure are approximately as follows:

Percentage Silicon Excess	Seconds Per Yard
4	120
6	114
8	111
12	104
20	85
30	68
40	53
50	45
60	42
80	41
100	43
120	44
140	50
160	60

In the absence of an excess of silicon the lead fuse fails to propagate.

Example 3

The ingredients used are the same as in Example 1 but the red lead and potassium nitrate are used in the proportions of 55.5:44.5. The lead fuse speeds of the resulting fuse powders at one atmosphere pressure are approximately as follows:

Percentage Silicon Excess	Seconds Per Yard
26	Fails
30	162
40	98
50	92
60	87
70	83
80	79
90	72
100	73
120	72
160	70

The corresponding lead fuse speeds of fuse compositions made with red lead and silicon alone range from about 57 seconds per yard with no excess silicon to about 14 seconds per yard with 35 per cent excess silicon, the diameter in all cases being approximately .08 inch.

The compositions of Example 1 containing from 0 to 40 per cent excess silicon, the compositions of Example 2 containing up to 60 per cent excess silicon, and those of Example 3 containing up to 100 per cent excess silicon give fuses of excellent quality when the compositions corned with gum are provided with water-proofed textile envelopes after the fashion customarily employed for the manufacture of safety fuse from black powder. The minimum excess of silicon that can be included is lower than in the case of lead fuse. Thus, when the ratio of red lead to potassium nitrate is 55.5:44.5 a fuse burning steadily at about 450 seconds per yard can be obtained by use of a 3% excess of silicon.

Example 4

The ingredients of the fuse core consist of a thermoplastic nitrocellulose binding agent composed of half-second industrial nitrocellulose of 12% nitrogen content gelatinised with its own weight of dibutylphthalate, with which the red lead, potassium nitrate and silicon are incorporated at raised temperature so as to form a core that can be extruded at a temperature of about

100° C. The red lead and the potassium nitrate are present in the proportions 55.5:44.5. The ratio of the amounts of powder to binding agent is 70:20, and the approximate diameter of the extruded fuse core is 0.06 inch. In the pulverulent ingredients the silicon is present in an excess of 12.5 per cent over the theoretical. The extruded core composition is coated with a textile covering spun around it and the envelope is waterproofed. The resulting fuse has a speed of about 320 seconds per yard at one atmosphere pressure.

Example 5

The procedure is the same as in Example 4, but the diameter of the extruded core is .08 inch. The relative proportions of red lead and potassium nitrate and the ratio of powder to binding agent are the same as in Example 4, but the excess of silicon is 8 per cent. The burning speed of the resulting fuse is about 475 seconds per yard at one atmosphere pressure.

Example 6

The procedure is the same as in Example 4. The diameter of the core is .08 inch and the proportions of red lead to potassium nitrate and of powder to binding agent are the same as in Example 4, but the excess of silicon is 4 per cent. The burning speed of the resulting fuse is about 660 seconds per yard.

Example 7

The procedure is the same as in Example 4, except that the core is extruded around a 30 standard wire gauge copper wire passing centrally through the die. The diameter of the core is .05 inch, the red lead and the potassium nitrate are present in the ratio 71.4:28.6 and the silicon is present in an excess of 23 per cent. The ratio of powder to binding agent is 75:20. The resulting fuse has a speed of approximately 33 seconds per yard at atmospheric pressure and 38 seconds per yard at one third of an atmosphere pressure.

I claim:

1. Fuse compositions comprising a pulverulent mixture of potassium nitrate, red lead and silicon, wherein the proportions by weight of the ingredients in the order named lie between 50-15%, 30-60% and 10-40%, respectively.

2. Fuse compositions as claimed in claim 1 wherein the amounts of potassium nitrate, red

lead and silicon lie between 40-20%, 40-50% and 20-30%, respectively.

3. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is in the form of corned granules containing a binding agent.

4. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is bound together in rod form by means of a binding agent.

5. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is in homogeneous admixture with a sufficient quantity of a thermoplastic binding agent to form an imporous plastic mass capable of extrusion.

6. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is in the form of corned granules containing a binding agent, and the proportions of potassium nitrate, red lead and silicon lie between 40-20%, 40-50% and 20-30%, respectively.

7. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is bound together in rod form by means of a binding agent, and the proportions of potassium nitrate, red lead and silicon lie between 40-20%, 40-50% and 20-30%, respectively.

8. Fuse compositions as claimed in claim 1 wherein the said pulverulent mixture is in homogeneous admixture with a sufficient quantity of a thermoplastic binding agent to form an imporous plastic mass capable of extrusion, and the proportions of potassium nitrate, red lead and silicon lie between 40-20%, 40-50% and 20-30%, respectively.

9. Non-detonating fuse containing the fuse composition set forth in claim 1.

10. Non-detonating fuse containing the fuse composition set forth in claim 1, wherein the proportions of potassium nitrate, red lead and silicon lie between 40-20%, 40-50% and 20-30%, respectively.

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