

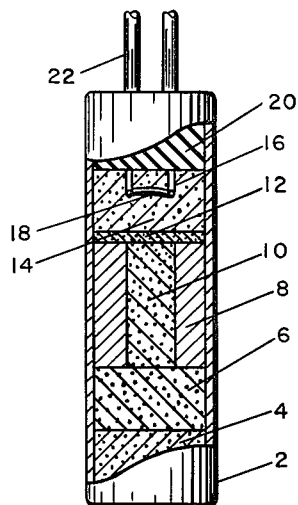
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FIRING DEVICE

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3,009,418

FIRING DEVICE

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This invention relates to improved firing devices and more particularly to delay electric initiators or blasting caps of novel construction which give improved firing characteristics.

Blasting cap charges comprise generally a base charge of a detonating explosive such as pentaerythritol tetranitrate, a heat-sensitive primer charge such as diazodinitrophenol superimposed on the base charge, and an ignition system for firing the primer charge. In some instances where, for example, the primer charge is difficult to ignite as in the case of lead azide, a readily ignitable ignition charge capable of firing the primer charge by the heat generated is additionally provided. However, in the case of delay caps, an additional slow burning composition or delay fuse is generally included between the ignition and primer charges and exhibits such a predetermined rate of burning that a specified time interval elapses between the application of the firing current and the explosion of the primer charge. The present invention is concerned with a novel improvement in conjunction with such blasting cap charges and particularly as utilized in delay electric blasting caps.

Accordingly, one object of this invention is to provide an improved blasting device which is superior in performance to presently available blasting devices when fired under high voltage conditions. Another object is to provide delay electric blasting caps which are capable of firing when employing a variety of ignition compositions heretofore deemed inoperable because of relatively low temperatures produced but, otherwise, known as having desirable characteristics as ignition compositions. Still another object is to provide delay electric blasting devices capable of utilizing ignition compositions heretofore deemed inoperable but, in addition, to render such compositions more accurate in burning.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Generally described, the present invention comprises a firing device which utilizes an intermediate charge between an ignition charge and a fuse charge. This intermediate charge is readily compressible, is readily ignitable by heat from the ignition charge, and is substantially nongaseous when ignited. The intermediate charge when compressed is considerably reduced in thickness resembling a wafer and is hereinafter referred to as "wafer charge." More specifically, the present invention is concerned with a firing device having in combination at least an ignition charge and a fuse charge in which the improvement comprises a compressed wafer charge of substantially gasless burning composition essentially containing a nonferrous metal powder, said wafer charge being interposed between the ignition charge and the fuse charge.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawing wherein the single

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figure is a part elevational and part sectional view of a delay electric blasting cap utilizing the principle of this invention.

With reference to the drawing, a shell 2 has a base charge 4 pressed in the bottom thereof. A priming charge 6 is placed over the base charge 4 and a fuse charge 8 is inserted into the shell 2 and pressed upon the priming charge 6. The fuse charge 8 consists of a lead tube having a fuse composition 10 therein. A gasless burning material is then loosely placed over the fuse charge 8 and is then highly compressed to form the wafer charge 12. A loose ignition charge 14 is then placed over the wafer charge 12 and an ignition assembly is pressed down on the ignition charge 12. The ignition assembly comprises a pair of leg wires 16 connected by a bridge wire 18 in which the leg wires 16 are supported by a plug member 20 having a pair of lead wires 22 extending therefrom for connection to a suitable electrical source.

To further exemplify the invention, a mixture of solder power-selenium in stoichiometric ratio is superimposed over the delay element or fuse charge 8 and it is compressed at a pressure of at least about 2,000 lbs. per sq. in. or more in which the upper limit is actually dictated by practical consideration. This highly compressed mixture then becomes the wafer charge 12. A loose ignition mixture or charge 14, such as lead-selenium-silicon, lead-tellurium, or combinations of these compositions or similar compositions, which are essentially gaseous, is then superimposed over the wafer charge 12.

By utilizing a dual system of ignition, that is, the wafer charge 12 in conjunction with the ignition charge 14, it has been found that the high voltage characteristics of delay caps, which are otherwise conventional, are significantly improved.

The term "nonferrous metal powder" as used herein means a nonferrous metal or mixture of nonferrous metals in finely divided form such that substantially all will pass through a 200-mesh screen and at least 80% through a 325-mesh screen, said metal being characterized by having a melting point of not more than 700° F. Such metals include lead, tin, bismuth, cadmium and mixtures thereof wherein the mixtures are commonly referred to as fusible alloys and in the case of mixtures of lead and tin are also referred to as common solders. The term "solder powder" as used herein means a finely divided lead-tin alloy in the respective proportions of from about 60/40 to about 90/10. Throughout the specification the ratios and amounts given refer to percent by weight unless otherwise indicated, and conventional blasting caps and blasting cap components were used for purposes of comparison with the invention as set forth in the following examples and tables.

An example of the effectiveness of the dual ignition which utilizes nonferrous metal powder and specifically solder powder-selenium as the wafer charge and loose ignition mixtures comprising lead-selenium/silicon, lead-tellurium and lead-tellurium/magnesium is given in Table I which summarizes parallel firing results at 220 volts A.C. In the tests summarized in Table I, the ignition compositions were evaluated in 10th period delay electric blasting caps containing a fuse powder mixture (delay charge) of barium peroxide-tellurium-selenium in the approximate ratio of 40/40/20.

Table I

Fuse powder	Wafer charge ¹	Ignition mixture ²	Number tested	Percent failed
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Se/Si, 98/2-----	300	0.67
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Te-----	300	0.33
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Te/Mg, 98/2-----	300	0
BaO ₂ /Te/Se, 40/40/20-----	None-----	Pb-Se/Si, 98/2-----	190	21.1

¹ PbSn, 85/15. ² Pb-Se, 72.4-27.6; Pb-Te, 61.9-38.1.

Another example of the utility and advantages of this invention is demonstrated in Table II. In this example a comparison is made between various ignition mixtures, some of which generate a small amount of heat, in combination with a wafer charge and without a wafer charge, both at room temperature and at -65° F. storage for a period of 4 hours. In all tests the systems were evaluated in 10th period delay electric blasting caps using the same fuse powder mixture (delay charge) as was used in Table I. The caps were fired individually at 110 volts D.C., 2 amperes.

flow of current and to the burning ignition powder, the shell wall in this vicinity is often ruptured. As a result, rapid escape of heat and pressure occurs. Since the delay fuse element is sealed over by the mass of the residue formed from the compressed wafer charge, the powder in the fuse train is not appreciably affected by the sudden change of conditions internally. Consequently, fuse failures are essentially eliminated. Without the use of the compressed wafer, a very high percentage of failures results. These are due, for the most part, to the rupture of the shell wall in the vicinity of the

Table II

Fuse powder	Wafer charge ¹	Ignition mixture ²	Heat of reaction (cal./g.)	Number tested each condition	Results	
					Rm. temp.	-65° F.
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Te-----	65	25	A.S.-----	A.S.
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Te/Mg, 98/2-----	73	25	A.S.-----	A.S.
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Se-----	85	25	A.S.-----	A.S.
BaO ₂ /Te/Se, 40/40/20-----	None-----	Pb-Te-----	65	25	1 F*-----	25 F*
BaO ₂ /Te/Se, 40/40/20-----	None-----	Pb-Te/Mg, 98/2-----	73	25	A.S.-----	2 F*
BaO ₂ /Te/Se, 40/40/20-----	None-----	Pb-Se-----	85	25	A.S.-----	A.S.

¹ PbSn, 85/15. PbSn-Se, 72-28 generates 86 cal./g.

² Pb-Te, 61.9-38.1. Pb-Se, 72.4-27.6.

NOTE.—A.S.—All Shot; F.—Failed; *Ignition mixture burned but failed to light the fuse powder.

From the foregoing tests, it will be readily seen that ignition mixtures which generate a small amount of heat, such as Pb—Te and Pb—Te/Mg, are materially benefited by employing the wafer charge of this invention as shown by the absence of failures under low temperature firing conditions.

Still another example of the utility and advantages of this invention is demonstrated in Table III. Here, the firing characteristics of 10th period delay electric blasting caps utilizing lead-tellurium ignition mixture with a wafer charge of solder powder-selenium are compared with the same mixture without the wafer charge.

ignition assembly which, due to the rapid escape of heat and pressure, causes the fuse train to be extinguished.

From the foregoing it is evident that there are several factors which will influence conditions for the most satisfactory operation of the invention, the actual requirements of which are determined by the starting materials and the finished products desired. For example, in addition to the use of solder powder-selenium, other highly compressible, substantially gasless compositions may be used, such as lead-selenium/silicon, tin-selenium, or combination of solder powder-selenium-tellurium, and the like. In addition, it is also possible to use mixtures of

Table III

Fuse powder	Wafer charge ¹	Ignition mixture ²	Timing data			
			Number timed	Average (sec.)	Spread (sec.)	Standard deviation
BaO ₂ /Te/Se, 40/40/20-----	PbSn-Se, 72-28-----	Pb-Te-----	10	9.5	0.69	0.23
BaO ₂ /Te/Se, 40/40/20-----	None-----	Pb-Te-----	10	9.7	1.80	0.60

¹ PbSn, 85/15. ² Pb-Te, 61.9-38.1.

The above data clearly demonstrate the improvement obtained in respect to standard deviation when the principle of this invention is employed.

Although it is not intended that the invention shall be limited to any particular theory of operation, it appears that the improvement in performance at high voltages, that is, 220 volts A.C. or higher, of the devices utilizing the dual ignition system in Table I above is made possible by the unique action of the wafer charge upon ignition. For instance, after the delay cap with the dual ignition system is ignited, the hot burning wafer charge immediately solidifies and adheres to the fuse element with which it is in intimate contact. This immediately seals over the ignited fuse train. As the internal pressure and heat in the ignition chamber is increased due to continued

red lead-manganese boride, barium peroxide-selenium and similar gasless mixtures in combination with the nonferrous metal powders. In fact, most any combination of solid, gasless, heat-sensitive mixtures can be used in conjunction with the nonferrous metal powders which can be readily compressed over delay fuse elements, such as those used in delay electric initiating devices generally. In this respect, particularly efficacious heat-sensitive mixtures suitable for this purpose are those disclosed in my copending application Serial No. 631,468, now U.S. Patent No. 2,892,695. The compositions in my copending application contain an alloy of lead and tin in admixture with barium peroxide and a fuel such as selenium, tellurium and sulfur.

Although the advantages of the invention have been

demonstrated more particularly in respect to delay electric blasting caps, it will be appreciated that the invention may be utilized with other devices requiring reliable delay characteristics, such as explosive actuators, motors, squibs, primers, detonators, gas generators, boosters and the like. Consequently, the base charge and priming charge or main charge, as the case may be, can be any material recognized in the art as suitable for activation of these devices. Also, the ignition charge and the fuse charge may be any of numerous materials recognized in the art as suitable for these purposes. Additionally, and in particular respect to blasting caps, the shell bodies may be metal or plastic, since the effect of a shell wall rupture as heretofore pointed out is of less consequence when employing the principle of this invention.

With respect to the concentration of the nonferrous metal powder in the wafer charge of this invention, the metal powder is used in an amount of from about 65 to about 80% by weight and preferably at substantially stoichiometric proportions with a fuel, such as selenium and the like. Additional materials such as silicon and magnesium may be added to the wafer charge to modify its burning characteristics; however, these materials ordinarily will be used in an amount of less than 5% by weight. All ingredients used for the wafer charge are in the form of finely divided powders such that the overall particle size of the wafer charge composition is from about 1 to about 75 microns and the wafer charge after compression is from about 0.02 to about 0.20 inch in thickness and preferably about 0.05 inch in thickness. The preferred material for the wafer charge of this invention is solder powder-selenium in stoichiometric proportion. Other preferable materials in approximately stoichiometric proportion include lead-selenium/silicon, 98/2, tin-selenium, and mixtures thereof.

It will be seen, therefore, that this invention may be carried out with the objects heretofore set forth accomplished by the use of various modifications and changes without departing from its spirit, with only such limitations placed thereon as imposed by the scope of the appended claims.

This application is a continuation-in-part of applica-

tion Serial No. 631,468, filed December 31, 1956, now U.S. Patent No. 2,892,695, patented June 30, 1959.

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

1. In a firing device having in combination at least an ignition charge and a fuse charge, the improvement which comprises a compressed wafer charge of substantially gasless burning composition essentially consisting of a nonferrous metal powder having a melting point of not more than 700° F., said wafer charge compressed at a pressure of at least about 2,000 pounds per square inch and interposed between and in contact with the ignition charge and the fuse charge.

2. In a firing device having in combination at least an ignition charge and a fuse charge, the improvement which comprises a compressed wafer charge of substantially gasless burning composition essentially consisting of from about 65 to about 80% by weight of a nonferrous metal powder having a melting point of not more than 700° F., and the remainder fuel, said wafer charge compressed at a pressure of at least about 2,000 pounds per square inch and interposed between and in contact with the ignition charge and the fuse charge.

3. The firing device of claim 2 in which the metal powder is an alloy of lead and tin in the respective proportions of from about 60/40 to about 90/10 by weight.

4. The firing device of claim 2 in which the metal powder is lead.

5. The firing device of claim 2 in which the metal powder is tin.

6. The firing device of claim 2 in which the metal powder is bismuth.

7. The firing device of claim 2 in which the metal powder is cadmium.

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