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STABLE ELECTRICALLY IGNITABLE EXPLOSIVE CHARGES

Filed March 11, 1968

Fig. 1

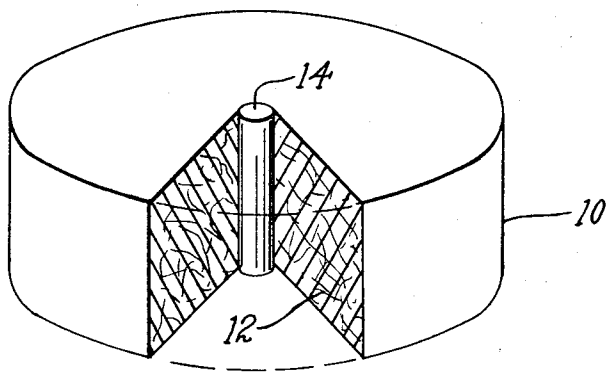


Fig. 2

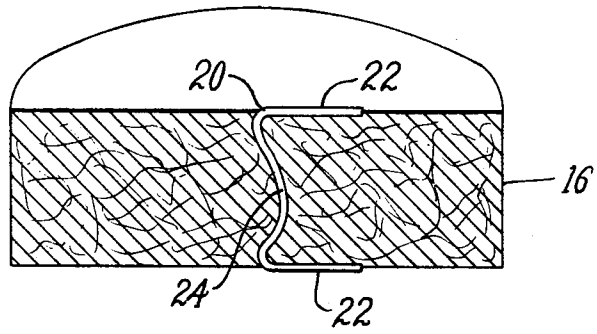


Fig. 3

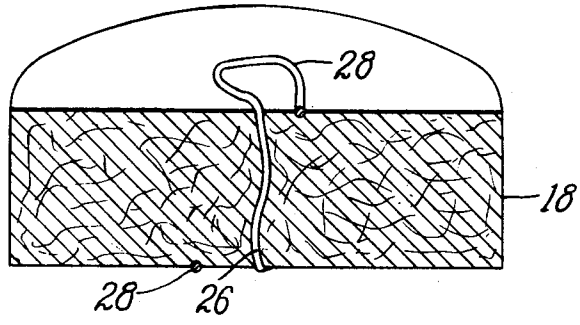
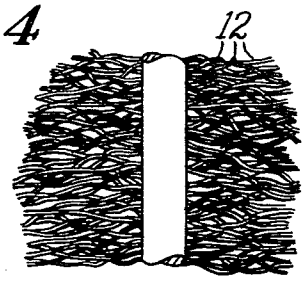


Fig. 4



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3,518,943

STABLE ELECTRICALLY IGNITABLE EXPLOSIVE CHARGES

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U.S. Cl. 102—70.2 8 Claims

A solid deflagrating charge of fibrous nitrocellulose has continuous burning surfaces defined by interconnected interstitial air spaces and includes firing means desirably in the form of an appropriate central electrical heating element leaving little or no residue on combusion. The element is illustrated as of fine metal wire or graphite which, on carrying electrical energy, initiates ignition of the charge. The charge will have been compacted to disc shape or other predetermined configuration suitable for sealing its firing chamber. The cartridge, though contemplated for use in explosively actuated stud driving tools or the like, is not limited to this field.

RELATION TO OTHER CASES

A copending application Ser. No. 524,168, filed Feb. 1, 1966, in the name of Robert C. Kvavle, and having the same assignee, now Pat. 3,372,643, issued Mar. 12, 1968, relates to a solid, low explosive consisting solely, exclusively of possible diluents and additives, of fibrous nitrocellulose compacted to a density of less than 1.66 gms./cc. As therein disclosed certain configurations of explosive pellets of this type are particularly well adapted to being ignited without the aid of a primer or diesel effect merely by physical impact, for instance that deliverable by a cocked firing pin.

BACKGROUND OF THE INVENTION

This invention relates to solid, primerless low explosive formed charges. More particularly it is concerned with the provision of a stable, electrical igniter. One application of this invention is as a power source in a fastener driving tool, a tool which could be simpler, perhaps less heavy, and probably less costly than the corresponding construction tool employing an impact ignitable charge of the type referred to in the copending application above mentioned. It is further recognized that the convenience of electrical ignition when coupled to relatively non-sensitive propellent fuel as herein disclosed finds utility in a broad range of applications including, but not limited to, propellants, pyrotechnic devices, primers, underwater forming or cutting devices, initiators etc.

While reliability of impact-type ignition, as disclosed for example in U.S. Letters Patent No. 3,283,657, issued in the name of Robert C. Kvavle on Nov. 8, 1966, has been found to be high, it requires that mechanical or potential firing energy, perhaps on the order of 0.6–2 joules, be provided as by manually cocking a spring for acting on a firing pin. In many situations a workman prefers to avoid such inconveniences and desires, especially where repeat fire is practiced or environment is adverse, more easily and quickly to attain ignition by merely actuating a switch to energize a circuit capable of initiating deflagration and consequent detonation of a propellant charge. Electro-explosives hitherto known have incorporated sensitive, high explosive and various more or less complicated hot wire ignition means. The particular combinations of low explosive propellant and incorporated electrical igniting means herein taught are considered to afford improved performance and safety at reduced cost.

SUMMARY OF THE INVENTION

In view of the foregoing it is a main object of this invention to provide an improved electrically ignitable solid, low explosive charge. As herein shown the charge comprises, in combination, a body of compacted nitrocellulose fibres having a density less than that of nitrocellulose per se (and preferably for peak efficiency on the order of about 0.9 gram per cc.) and a conductor or heating element extending therethrough. The hot wire, so called, for carrying electric current to initiate ignition desirably extends centrally through a formed pellet of the fuel, and preferably axially of a disc-shaped charge. The wire may be of metal such as that available under the trade name Nichrome (a nickel, chrome alloy), or be of graphite, or other suitable conductor having a heat developing resistance, and yet decomposable during the explosive reaction by reason of its dimensions without leaving any appreciable residue. Although the preferred configuration of nitrocellulose pellet disclosed in the application 524,168 cited above facilitates impact ignition when the locality of impact is at a thin or recessed and reduced portion of the charge, the electrically ignitable formed charge herein disclosed need not be recessed or reduced, and hence greater power may be expected therefrom in a firing chamber of substantially the same size.

Instead of using a current surge of a magnitude to detonate a wire and thus provide explosion heat with shock wave as hitherto employed in the so-called exploding wire technique, less energy and in the form of mere heat due merely to electrical resistance of a wire is provided, as for instance to cause the wire to glow, and suffices to initiate ignition and explosion of our non-sensitive caseless charge.

DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the invention will now be described with greater particularity, and with reference to selected illustrative explosive charges and the accompanying drawings thereof, wherein:

FIG. 1 is a perspective view of a pellet having a sector removed to reveal a central, axial igniting conductor, of graphite for instance;

FIG. 2 is a perspective of one-half of an explosive disc embodying our invention wherein a hot wire conductor has its terminal portions radially disposed and embedded in opposed faces of the disc;

FIG. 3 is a view corresponding to FIG. 2 but showing a conductive wire with at least partly circular terminals abutting opposed faces of the charge, and

FIG. 4 is an enlarged detail view illustrating the interconnected, interstitial air spaces providing continuous burning surfaces on the flat, ribbon-like nitrocellulose fibres employed in the charges of FIGS. 1–3, and showing a portion of the central heating element.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 illustrates a disc-like charge or cartridge **10** of compacted nitrocellulose fibres **12** having a density in the range of from 0.6–1.6 gms./cc. Axially extending centrally between opposed planar end faces of the charge **10** is an electric, heat generating conductor in the form of a slender rod of graphite **14**. It will be apparent that the charge **10** shown in FIG. 1, as well as those of FIGS. 2 and 3 to be described, may be compacted to a self-sustaining form which is non-circular in section if desired, the disc-like shape usually being preferred to enable substantially closed sealing of a cylindrical firing chamber which is to receive it. For effecting electrical ignition of the charge **10** the current conductor **14** will have its opposite ends, while the charge is confined in a substantial-

ly closed chamber, contacted by the electrodes of a circuit (not shown) connected to a suitable source of electric energy, for instance a suitable battery or a capacitor discharge circuit.

The cartridge of FIG. 1 may be made in quantity from an elongated cylindrical form, an entire length of graphite being axially disposed in the fibres of nitrocellulose as they are compacted from a slurry. Numerous individual charges **10** of the desired degree of power (corresponding approximately to their selected individual axial lengths) may then be transversely severed from the full length prior to final drying and hardening, as by a jet of cutting fluid, for instance water.

The pellets **16** (FIG. 2) and **18** (FIG. 3) next to be described, may be assumed to have their main body portions of compacted fibrous nitrocellulose in the manner of the cartridge **10**. In the pellet **16** a hot or bridge wire **20** may, for example, be of Nichrome (75% Ni, 12% Fe, 11% Cr, 2% Mn) or stainless steel having a diameter of about .003". The wire need not be of a single strand but its melting point is preferably above that of copper which is 1082° C. Its radial terminal portions **22, 22** (or at least one of them) are preferably lying exposed but partly embedded in opposite flat faces, respectively. These portions are accordingly protected to some extent from being broken off, but are readily contactable by suitable electrodes of an ignition circuit. An intermediate portion **24** of the wire **20** preferably extends axially through a central portion of the pellet **16** and may be somewhat bowed as a consequence of angularly deflecting the terminal portions at the time of wire insertion, or as a result of pellet compaction. While in preferred form the conductor normally extends through a pellet, as above indicated, the electrodes of an ignition circuit for the pellet need not necessarily be disposed to contact opposite extremities of the conductor, but may be disposed in a firing chamber for contact with operatively spaced localities of the conductor lying in or on an external surface portion of the pellet, for instance the terminal portion **22** or **28**.

The pellet **18** of FIG. 3 has a bridge wire **26** like that shown in FIG. 2 except that its terminal portions **28, 28** have a circular configuration to provide more exposed surface for contact with an electrode. The portions **28** need not be partly embedded but preferably should not extend appreciably from the exterior of the charge since this might result in its damage or a premature firing due to an earlier than intended electrical contact with a firing circuit.

It will be apparent from FIG. 4, wherein the heating element may be of any of the types above mentioned or

of other conductive, consumable material, that the lengthy, ribbon-like fibers of nitrocellulose (shown much enlarged) have numerous engagements or near-engagements with the heating element. Accordingly, experience indicates a very reliable and prompt ignition is assured once a firing circuit has been energized.

The following table shows, for three different sources of electric energy, the amount of energy required to effect explosion, and the delay in firing following closure of the firing circuit, for different combinations of nitrocellulose pellets and their particular heating elements. Energy requirements for effecting explosion of compacted nitrocellulose by electrical heating, in certain of the sample pellets indicated, are advantageously lower than what is required by the percussion ignition approach referred to above. It may be mentioned that when it is desired to preclude accidental firing by spurious electric currents, for instance to meet the so-called "one watt of power and one ampere of current, 5 minute exposure but no fire" test, the thickness or diameter of the heating element may be enlarged and/or the density of the nitrocellulose surrounding the element increased to the 1.3–1.6 gms./cc. range. For reduced delay, as is desirable in the usual firearm or construction tool, it is found especially desirable that there be, between the heating element and the main pellet body (having a density less than 1.66 gms./cc.), a relatively "fluffy" portion of nitrocellulose fibres having a reduced density, perhaps on the order of about half that of the main body. In the table, the portion of lower density nitrocellulose is referred to as "fluffy," its actual density not being easily ascertainable. This portion presumably facilitates ignition by reason of its having more or larger open air spaces contiguous with the heating element and between the ribbon-like fibres, a condition not illustrated in FIG. 4.

6 v. DC STORAGE BATTERY

Nitrocellulose pellet (fibre density, gms./millilitre)	Heating element	Delay, milli-seconds	Energy, joules
1.54 body; fluffy around wire	3 mils diam. copper wire	2.6	0.263
Do	6 mils diam. copper wire	8	0.270
1.55	47 mils diam. pencil lead	180	6.16
1.55	do	140	8.50
1.60	do	92	8.15
1.5 or more	Tungsten wore from fluorescent lamp	4	.097
1.5	1 mil Ni-Cr. wire	17	.025
0.97	36 mils diam. pencil lead	50	5.4
0.97	47 mils diam. pencil lead	95	6.18
.95	.020" pencil lead	45	1.25
.95	3 mil ni-chrome wire	12.1	0.104
1.2	do	13	.986
1.49	do	5	.092
Cadmium Cell 1.35 v.			
1.54 body; fluffy around wire	6 mils diam. copper wire	22	0.915
Do	3 mils diam. copper wire	12	0.177
1.2 body	Two 3 mils Ni-Cr wires twisted together	190	1.82
Capacitor Discharge (500 microfarads 60 v.)			
1.54 body	3 mils diam. copper wire	3	0.294
0.95 body	3 mils Ni-Cr wire	5	0.025

It will be understood that the representative pellets selected for the table shown were disc-shaped, had substantially constant thickness of about 0.1" and an outside diameter of about .336". They were usually "custom made" in the sense that they initially were provided with a $\frac{3}{32}$" bore for receiving the heating element and the main body of the pellet was thereafter compressed by a hollow die gradually to compact the fibres to cause them to close on the element; where the element-contacting fibres were to remain "fluffy" only a light tamping was given.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. An electrically ignitable solid low explosive charge comprising, in combination, fibrous nitrocellulose compacted to a density of less than 1.6 gms. per cc. to pro-

vide a pellet having substantially interconnected interstitial air spaces between its fibres to form continuous burning surfaces, and an electric conductor extending through the pellet between surfaces thereof for effecting its ignition by resistance heating, said conductor being of a material and dimensions selected to remain substantially intact during ignition of the fibres and produce substantially no residue due to combustion resultant from their explosion.

2. A charge as set forth in claim 1 and further characterized in that said pellet is in the form of a disc having its opposite surfaces substantially planar.

3. A charge as set forth in claim 1 wherein said conductor is a metal wire the terminal portions of which are exposed to provide contact ignition terminals on the opposite surfaces of the pellet, the melting point of the wire being higher than 1082° C.

4. An explosive charge as set forth in claim 3, wherein said terminal portions extend radially and are partly embedded in opposite surfaces of the pellet.

5. An explosive charge as set forth in claim 1 wherein said conductor has an intermediate portion extending axially of the pellet and parallel terminal portions partly embedded in opposite external surfaces of the charge.

6. An explosive charge as set forth in claim 5 wherein at least one of said terminal portions is circular.

7. An explosive charge as set forth in claim 1 wherein the density of the pellet in a portion contiguous with the conductor is less than the density in other portions remote therefrom.

8. An electrically ignitable caseless low explosive charge comprising, in combination, fibrous nitrocellulose compacted to a density of less than 1.6 gms. per cc. to provide

a pellet having substantially interconnected interstitial spaces between its fibres to form continuous burning surfaces, and an electrical conductor in integral linear contact therewith at least along a suitably extension portion of the external surface of said pellet, said corresponding linearly contacting portion of the conductor having adequate resistance between two spaced points thereof such that when said two spaced points of the conductor are connected to a source of current and by reason of the nature of its material and its dimensions, to develop sufficient heat while intact to ignite and explode the remainder of the pellet thereby causing substantially all of the conductor to be consumed.

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U.S. Cl. X.R.

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