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Irish, Jr. et al.

[11] **3,799,055**
[45] **Mar. 26, 1974**

[54] **ELECTRICAL INITIATOR**

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[22] Filed: **Sept. 5, 1972**

[21] Appl. No.: **286,388**

Related U.S. Application Data

[62] Division of Ser. No. 4,480, Jan. 21, 1970, abandoned.

[52] **U.S. Cl.** **102/100,** 102/103
[51] **Int. Cl.** **F42b 9/08**
[58] **Field of Search** .... 102/99–104, 102/38, DIG. 1, 46

[56] **References Cited**

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3,336,871	8/1967	Quinlan	102/38
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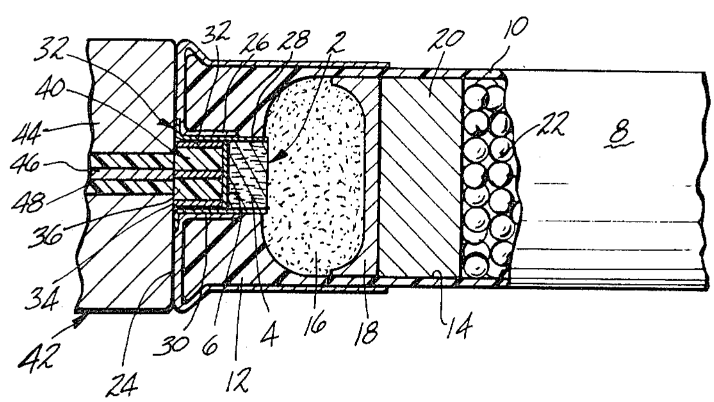
Primary Examiner—Robert F. Stahl
Attorney, Agent, or Firm—Donald R. Motsko; H. Samuel Kieser; William W. Jones

[57] **ABSTRACT**

An initiator having a body of nitrocellulose material having a surface characterized by thin fibres or thin webs with a film of a conductive material adhered to said surface.

2 Claims, 7 Drawing Figures



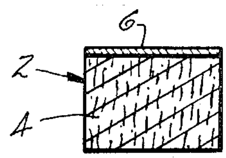


FIG-1

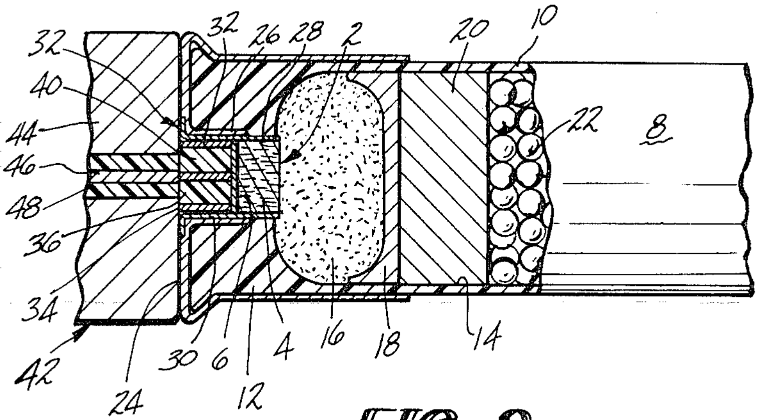


FIG-2

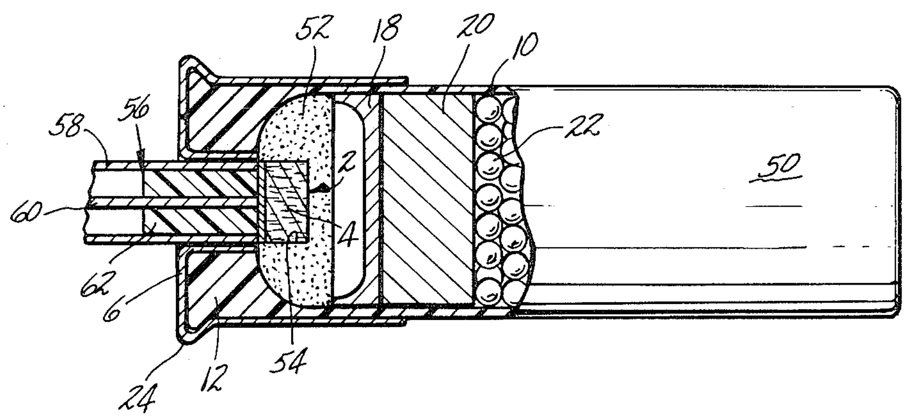


FIG-3

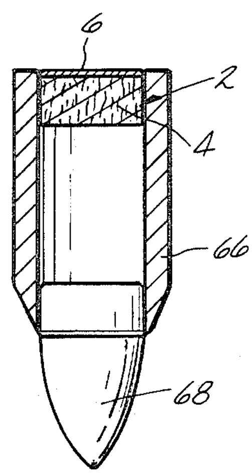


FIG-5

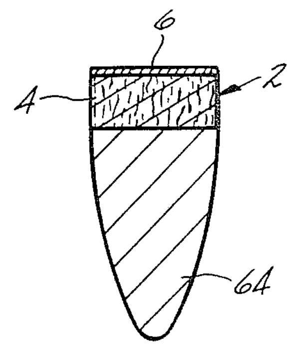


FIG-4

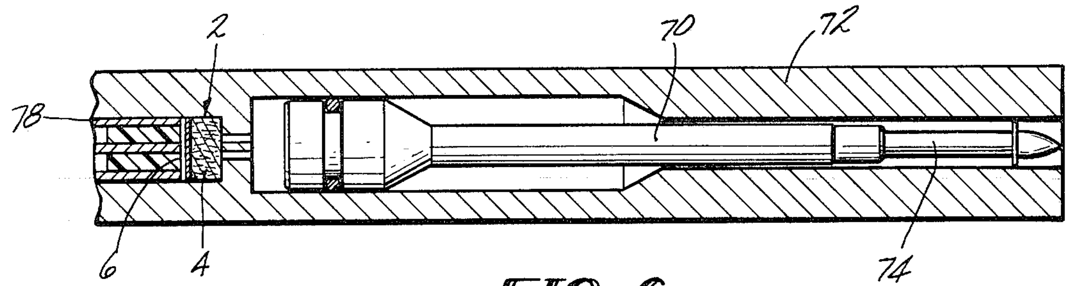


FIG-6

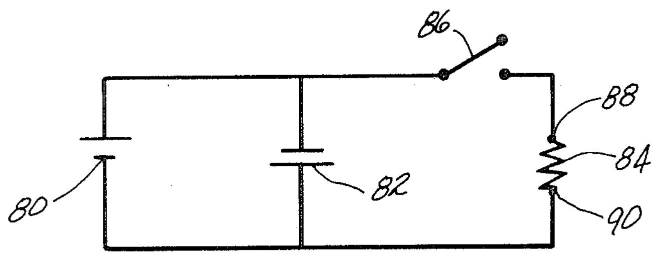


FIG-7

ELECTRICAL INITIATOR

This is a division of application Ser. No. 04,480, filed Jan. 21, 1970 now abandoned.

This invention relates generally to the field of initiators. More particularly, this invention relates to an initiator of a smokeless propellant which is capable of being electrically ignited.

An initiator is the first element in a device using explosive, propellant, or pyrotechnic materials, The initiator responds to an input stimulus and starts the burning or explosive reaction. Initiators are classified according to the nature of the input stimulus which can be either mechanical or electrical. Initiators may be further classified according to their intended output function as primers, squibs, or detonators. As will be disclosed, this invention concerns an initiator which responds to an electrical input impetus and whose output characteristics are such as to enable it to act as a primer, a squib, or the first element of a detonator.

Electric initiators may be further categorized by the type of transducer used to convert the electrical input energy into heat energy. Transducers that may be used with electrical initiators include a hot bridgewire or an exploding bridgewire, a conductive mix, a conductive film bridge, and a spark gap. The input sensitivity varies sharply with the type of transducer; each type having a characteristic threshold firing energy and current requirements. This invention concerns that type of electric initiator wherein the transducer is a conductive film bridge.

It is thought that an understanding of the nature, construction, and electrical input characteristics of a conductive film bridge initiator which existed prior to this invention would be helpful in understanding the present invention. Conductive films may be applied to the surface of insulators by a variety of techniques to produce bridges which can be heated or exploded to initiate explosive reactions. The only type of film bridge applied in standard fuzes has been the low-energy graphite or carbon bridge. These bridges are all made by essentially the same process. A droplet of a colloidal suspension of graphite in water is deposited on a surface which consists of two or more metal electrodes separated by, and usually imbedded in, an insulator. Because graphite has a negative resistance temperature coefficient and because of the inherent variable film thickness and path length, the electric current is channeled into a path which is only a small part of the total volume of the film. Only this small portion of the film is heated. Characteristically, the resistance spread is very wide ranging from 700 to 14,000 ohms. Because of thechanneled path, the energy required for ignition is low, in the order of only a few hundred ergs. As a further consequence of the channeled path, the mass of graphite heated is small. To be effective as an ignitor, this small mass of graphite must be in intimate contact with a primary explosive which is thermally sensitive and has good propagation characteristics. The primary explosives, lead azide and lead styphnate, are universally used as spotting charges not only for graphite or carbon bridge devices but also for every type of present initiator except the exploding bridgewire whose greater energy release permits the use of secondary explosives under special conditions of particle size and confinement.

We may summarize the salient characteristics of currently employed conductive film initiators as follows:

1. The conductive film may be metallic or non-metallic but non-metallic carbonaceous materials are most usual.
2. The carbonaceous film bridge is electrically characterized by a high resistance of 700 to 14,000 ohms and is very sensitive to electric energy input requiring, at the most, a few hundred ergs for initiation.
3. All present conductive film bridge initiators require the presence of a primary explosive, commonly lead styphnate or lead azide, in direct and intimate contact with the bridge.
4. Generally, the conductive film bridge is applied to the surface of an insulating material into which are imbedded two or more electrodes.

The critical dimensions, the non-uniformity, and, above all, the susceptibility of the low-energy carbon bridge to accidental discharge, as, for example, by the static electricity accumulated on a person, or that induced by radio frequency or radar energy sharply limit the uses of the carbon bridge conductive film device and it is found that bridgewire devices are almost universally used to fulfill the present day needs for electric initiators.

The bridgewire initiator requires an assembly which is relatively complex and costly. Further (except in the special case of the exploding bridgewire) it universally requires the presence of a primary explosive to be in intimate contact with the wire to act as the initiator for what is usual train of several explosive materials.

In view of the above, it is an object of the present invention to provide an electric initiator that does not require the presence of a primary explosive material.

A further object of the present invention is to provide an electric initiator of the conductive film type which possesses the electrical and safety characteristics of the bridgewire type without the attendant complexity and high cost.

Yet another object of the present invention is the provision of an electric initiator which does not require a primary explosive and which may be used by itself as a source of power to drive projectiles, bolts, studs or the like, or which can be used as a means for igniting additional powder, pyrotechnic material or as the first element in a train of explosives.

Generally, the initiator of the present invention comprises a body of nitrocellulose material having a surface characterized by thin fibres or, alternately, thin webs with a thin film of a semi-conductive material adhered to said surface.

The objects and advantages of the present invention will become more apparent by reference to the following description of several preferred embodiments and to the accompanying drawing in which:

FIG. 1 is a cross-sectional view of an initiator constructed in accordance with the present invention;

FIG. 2 is a cross-sectional view of one embodiment of a shotshell incorporating the initiator of the present invention;

FIG. 3 is a cross-sectional view of a second embodiment of a shotshell incorporating the initiator of the present invention;

FIG. 4 is a corss-sectional view showing a projectile attached to the initiator of the present invention;

FIG. 5 is a sectional view showing the initiator used in conjunction with caseless ammunition;

FIG. 6 is a cross-sectional view showing the initiator used in an industrial type fastening tool; and

FIG. 7 is a schematic diagram of an electrical circuit which may be used to supply the power for the initiator.

Referring to the drawings, and in particular FIG. 1, the initiator 2 of the present invention includes a body 4 of either fibrous or porous nitrocellulose having a surface characterized by either thin fibres or thin webs of nitrocellulose. A thin film 6 of a semi-conductive, non-metallic material is adhered to the surface with the thin fibres or thin webs being intimately coated with the conductive material.

In practicing the present invention, any nitrocellulose may be used which when formed into its desired shape will have a fibrous, stringy, or porous structure, such that the overall density of the nitrocellulose body will be between about 0.85 and 1.40 grams per cubic centimeter. The receptive surface of such a body to which the conductive film is applied is characterized by having either exposed thin fibres or exposed thin webs of nitrocellulose which are intimately coated with the conductive material. It is these thin fibres and thin webs of nitrocellulose which are readily heated to their ignition point by the transfer of heat from the conductive film as the film is heated by the applied electrical energy.

One type of material ideally suited for the purposes of this invention is bulk powder as is fully described in U.S. Pat. No. 3,463,086. This powder is characterized as being fibrous, stringy, or fuzzy and may be compacted in the dry state to form pellets, grains, charges or shapes which faithfully retain the form into which they are compacted and whose ignition and combustion characteristics may be varied. This type of powder, when compacted, will have a surface which includes exposed thin fibres which can be intimately coated with the conductive material.

However, other means are available of attaining the proper receptive surface. Fibrous, non-gelatinized, virgin nitrocellulose may be used. The sponge-like irregular particles of precipitated nitrocellulose provide exposed thin fibres on the surface which is receptive to the conductive coating. Preferably, precipitated nitrocellulose may be made by first dissolving nitrocellulose in a solvent such as acetone to form a lacquer and then pouring the lacquer into an excess of water under vigorous agitation. Under this treatment the nitrocellulose precipitates out as solid particles which, under microscopic examination, are of irregular shape and of sponge-like character.

In addition, nitrocellulose prepared by the "wash out" process may be utilized in the forming of the body 4 of the initiator 2. In this process, nitrocellulose together with a stabilizer and a suitable water-soluble salt is gelatinized with a solvent, extruded or molded into a pellet shape, extracted with hot water to remove the water-soluble salt and dried. A homogeneous structure results which, under microscopic examination, resembles a slice of bread, i.e. irregular pores formed by relatively thin webs. An additional method of providing a receptive surface on a nitrocellulose body which is otherwise fully gelatinized, is by mechanically abrading or scoring the surface or by treating the surface with a solvent.

The conductive film 6 which is applied to the nitrocellulose 4 is formed from a material of moderate electrical resistivity which also has a negative temperature coefficient of electrical resistivity. Of particular value because of their ready availability and low cost are graphite, partially graphitized carbon black, and finely divided lead peroxide. Other materials which might be employed would include the more exotic semiconductors such as germanium and silicon which also have a negative temperature coefficient of electrical resistivity.

The preferred materials for the present invention are graphite, graphitized carbon black and lead peroxide. These are preferably applied as colloidal or semi-colloidal suspensions in an aqueous or non-aqueous media together with suitable organic or non-organic binders. These are applied in a manner such that the dried, adherent film has a thickness which may be varied from 0.5 mil to 2.0 mils and may, with the electrode employed, show resistance from about 2 ohms to about 100 ohms with the range of 5 ohms to 20 ohms being preferred.

If desired, an oxidizing material may be incorporated into the conductive film 6 or into the receptive surface of the nitrocellulose body to enhance the ignition. Suitable oxidizers include the nitrates, chromates and dichromates of barium, potassium and sodium, the peroxides of barium and strontium, the chlorates, perchlorates and sulfates of potassium, and the oxides and peroxides of lead.

The initiator 2, either alone or supplemented by additional propellant, may be used as a source of power to drive projectiles, bolts, studs, nails, etc. It may also be used as a power capsule to start a small gasoline engine or the like or it may be used as a means of igniting a larger propellant mass, a mass of pyrotechnic composition or as the first element in a tain of explosives. FIGS. 2–6 depict various ways of utilizing the initiator of the present invention.

In FIG. 2, a standard shotshell 8 comprises a plastic body 10 having a head portion 12 and open cavity 14. Within the cavity 14 is placed a propellant charge 16 of suitable composition. A cup wad 18 and fibrous wad 20 overlie the power charge 16 in a manner well known in the art. The remainder of the cavity 14 is filled with shot 22 and the end of the tube (not shown) closed in any conventional manner. A metallic head 24 overlies the plastic head 12 of the shotshell and has a portion 26 inturned into the primer orifice 28. A battery cup 30 extends through the primer orifice 29 and communicates with the powder charge 16. The initiator 2 is mounted in the battery cup 30 in a position adjacent to propellant charge 16. The conductive film 6 of the initiator 2 is in contact with an electrode structure 32 mounted in the rearward end of the battery cup 30. The electrode structure 32 includes a hollow, cylindrical band 34 of conductive material which is in electrical contact with the battery cup 30 and a central electrode 36 of suitable conductive material separated from the outer electrode 34 by suitable insulating material 40. This type of shotshell may be mounted in a cartrige chamber of a firearm having a breech 42 provided with a suitable electrode which comprises an outer electrode 44 generally circulr in transverse crosssection which is adapted to be placed in electrical contact with the metallic head 26 and a central electrode 46 which is adapted to engage the central electrode 46 of the electrode structure **32**. The electrodes **44** and **46** are separated from each other by means of suitable insulation **48**. It is to be understood that the battery cup **30** with the initiatoe **2** and electrode structure **32** could also be used in place of the percussion primer normally used in conventional rifle and pistol ammunition to fire a single projectile.

In FIG. **3**, a second embodiment of a shotshell **50** is shown which includes as in FIG. **2**, a plastic case **10** having a head portion **12** and suitable wadding **18** and **20**. A suitable amount of shot **22** is provided in the forward end of the shell. Immediately below the wadding **18** is placed a compacted or bonded pellet **52** formed of an appropriate smokeless powder. A hollow **54** is formed in the rearward end of the pellet **52** and an initiator **2** inserted into the pellet with the conductive film **6** facing the opening in which the primer would normally be inserted. With this particular shotshell, the use of a metallic head **24** is optional. The shotshell **50** is adapted to be placed in the cartridge of a firearm which is equipped with an electrode probe **56** adapted to extend through the primer opening into intimate contact with the conductive film **6** of the initiator **2**. The electrode **56** may take the form of a hollow, cylindrical, outer electrode member **58** and a central rod-like electrode **60** spaced from the outer electrode **58** by suitable insulation **62**. It is to be noted that as in the modification shown in FIG. **2**, the modification of FIG. **3** could be used in connection with centerfire rifle ammunition to propel a bullet. As another alternative, instead of the additional powder being in the form of a pellet **52**, it is possible to form such powder as part of the initiator body **2** whereupon the conductive film **6** would simply be of such a size as to insure that it would come into intimate contact with the electrode.

FIG. **4** shows the use of the initiator **2** as a propellant for ammunition. In this particular case, the initiator body **4** is in the form of a pellet. One surface of the pellet is attached to a bullet **64** by mechanical means, by adhesives or in a number of other ways well known to those skilled in the art. The opposite surface of the initiator body **4** contains the conductive film **6** as heretofore described.

FIG. **5** shows yet another form of caseless ammunition in which the initiator **2** of the present invention may be utilized. A generally cylindrical, hollow, molded propellant body **66** may be provided as mentioned in U.S. Pat. No. 3,311,057. The usual projectile **68** may be adhesively or otherwise secured in the forward end of the propellant body **66** and an initiator **2** of the present invention secured within the rearward end of the body **66** with the conductive film **6** being exposed for contact with the electrode structure of an appropriate firearm.

TABLE I

Capacitance	Voltage for 99.95 Probability to Fire	Energy for 99.95 Probability to Fire
30 microfarads	251 volts	0.94 joules
120 "	110 volts	0.73 joules
480 "	57 volts	0.77 joules

The following examples are intended to illustrate some of the many uses to which the initiator **2** of the present invention may be put as well as illustrate the various parameters used for its successful functioning.

EXAMPLE I

Pellets of propellant were made by compacting dense bulk powder to a diameter of about 0.650 inch and a thickness of about 0.250 inch. The pellets weighed between about 20 to 24 grains and had a density of about 1.3 grams per cubic centimeter. On one of the flat faces of each pellet a drop of a diluted suspension of colloidal graphite in water was placed. The graphite suspension was oven-dried for two hours at 150°F. A portion of the graphite suspension permeated between and adhered to the exposed fibres of the pellets. The remainder of the graphite suspension formed a film on the surface of the pellets. The films had a thickness of between about 0.5 to 1.0 mil. With concentric electrodes having a center conductor of 0.040 inch outer diameter and an insulation thickness between the inner and outer electrodes of about 0.040 inch, the films displayed an individual resistance ranging from about 3 ohms to 100 ohms with a predominating majority being between 5 ohms and 15 ohms. Each pellet was placed in the end of a shotshell in place of the regular powder charge and primer. The shotshells were provided with conventional type wadding and shot pellets. The shotshells were placed into a test vehicle for firing which included a battery-capacitor circuit with suitable switching to permit the charging of the capacitor from the battery and, susequently, the discharge of the capacitor through the electrode which was placed in firm contact with the conductive film on the pellet. The capacitor, having a capacitance of 480 uF, was charged to a voltage of 65 volts. Thus the energy in the power supply was equal to 1 joule. The pellets ignited within a period of 1 to 2 milliseconds after application of the electrical energy and burned as a propellant yielding the pressure and velocity characteristics normally expected in a shotshell. In the case of graphite films having a thickness of 0.5 mil, a burn out of the conductive film occurred before the energy was drained from the capacitor. In these instances, the actual energy consumed for ignition was of the order of 0.2 to 0.5 joule.

EXAMPLE II

In a manner similar to Example I, an ignition pellet was dry compacted from bulk powder to a density of about 1.2 grams per cubic centimeter and a diameter and thickness of about 0.2 inch. One face of the pellet was coated with a graphite film as explained in connection with Example I. The electrode employed had a gap dimension of about 0.020 inch. The pellet was placed in a suitable text fixture for firing a 0.22 caliber rifle bullet. Utilizing the power supply of Example, I, the pellet ignited and burned yielding the pressure and velocity characteristics normally expected from the firing of conventional 0.22 caliber ammunition. The ignition delay after application of the energy was in the order of 1 to 2 milliseconds and the energy consumed less than 1 joule.

EXAMPLE III

In manner similar to Examples I and II, an ignition pellet was dry compacted from bulk powder to a density of about 1.2 grams per cubic centimeter and a diameter of about 0.4 inch and a thickness of about 0.150 inch. One face of the pellet was coated with a graphite film in a manner mentioned in connection with Example I. The pellet was placed in a test fixture resembling an industrial type powder-actuated fastening tool of the piston type similar to that shown in FIG. 6. On application of electrical energy by use of the circuit mentioned in Example I, the pellet ignited and burned and successfully drove the piston which in turn drove the fastener into the work surface.

EXAMPLE IV

An ignition pellet was compacted into the form of a wafer from bulk powder to a density of 1.25 grams per cubic centimeter. One surface of the wafer was coated with an aqueous dispersion of graphite as heretofore mentioned. A conventional shotshell was modified by removing the primer and the ignition pellet was inserted into the opening leaving room for the insertion into the primer opening of an electrode. Over the ignition pellet was placed a propellant charge of conventional granular propellant and the shell charged normally with shot and wads, On application of about 1 joule of electrical energy, the pellet initiated the combustion of the granular propellant yielding pressure and velocity characteristics normally associated with a conventional shotshell.

EXAMPLE V

A conventional shotshell was modified by substituting for the standard percussion primer a battery cup closed at one end with the electrode of Example I into which was pressed a cylindrical ignition pellet of compacted bulk powder having a face coated with graphite film in intimate contact with the electrode. This arrangement is depicted in FIG. 2 of the drawings. Upon the application of about 1 joule of electrical energy, the pellet initiated the combustion of the granular propellant yielding expected pressure and velocity characteristics normal to shotshells.

EXAMPLE VI

A densely colloided smokeless powder was formed into a pellet using the "wet solvent" process taught by U.S. Pat. No. 3,092,525. An initiator pellet of the type described in Example III was placed into a suitable hollow molded into the pellet. In this instance, the weight of the bulk powder initiator pellet was about 3 grains and the weight of the colloided smokeless powder pellet was about 18 grains. The pellet and initiator were loaded into a shotshell in a manner shown in FIG. 3. Upon application of electrical energy from the aforementioned power supply and electrode, the initiator functioned to ignite the main charge of propellant in a manner which yielded the pressure-time relationship and shot velocity expected of a shotshell.

EXAMPLE VII

A shotshell was construced in accordance with Example VI except that lead peroxide was used in place of the graphite film. The lead peroxide film was about 2 mils in thickness and showed, with the electrode employed, had bridge resistance of about 10 to 15 ohms. Upon application of electrical energy as in Example VI, the initiator functioned to satisfactorily ignite the main charge of propellant.

EXAMPLE VIII

A pellet was fabricated from virgin, fibrous, non-gelatinized nitrocellulose (13.1 percent nitrogen) by forming a relatively loose mat or wad from a slurry of fibres and water on a filter and then compacting the relatively loose wad in a press to a density of about 1.2 to 1.3 grams per cubic centimeter. The resulting pellet was of the same dimensions as the pellet of Example III. A graphite film was applied to one face of the virgin nitrocellulose pellet according to the previously cited Examples. The pellet was placed in the test fixture of Example III and upon the application of electrical energy ignited and burned with the necessary characteristics required for industrial driving tools.

EXAMPLE IX

A pellet was made by dry compacting in a press a material made by first dissolving nitrocellulose in a solvent such as acetone to form a lacquer and then pouring the lacquer into an excess of water under vigorous agitation. Under this treatment, the nitrocellulose precipitates out as solid particles. Pellets compacted from this "precipitated nitrocellulose" were teated exactly the same as the pellets cited in Example III and yielded the same desirable characteristics.

EXAMPLE X

A porous pellet was fabricated by the "wash-out" process as hereinbefore described. Pellets made by this process were treated exactly as the pellets cited in Example III and yielded the same desired performance.

The functioning time of the conductive film initiator described in this disclosure is desirably short. The functioning time may be defined as that time which elapses from the first application of electrical energy to the first evidence of a pressure rise caused by the burning of the propellant body. This functioning time is between 1 and 2 milliseconds. the channeled

It is to be understood that the initiator of the present invention with a suitable amount of nitrocellulose body 4 may be used by itself as a replacement for the powder charge and primer in convenitonal ammunition. It may also be used alone to provide the energy to drive a bullet, to drive the piston of an industrial type fastening tool or to start a small internal combustion engine. It may be used as a replacement for the conventional primer to ignite additional propellant or to serve as a means of igniting a mass of pyrotechnic composition or as the first element in a train of explosives.

What is claimed is:

1. In combination, a propellant charge of smokeless powder having a unitary configuration, said propellant charge having a hollow therein, an initiator mounted in said hollow, said initiator comprising a body of nitrocellulose having a surface characterized by a plurality of exposed fibres, a conductive film adhered to said surface and in intimate contact with the exposed fibres, said film having a negative temperature coefficient of electrical resistivity.

2. The combination of claim 1 wherein said conductive film has a thickness of between about 0.5 mil and 2.0 mils and a resistance of between about 2 ohms and 100 ohms.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,799,055 Dated March 26, 1974

Inventor(s) Charles G. Irish, Jr.; Joseph W. Silva; Raymond I. Cowles.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the list of inventors, the name Raymond I. Cowles has been misspelled as Raymond I. Owles.

The following two paragraphs have been omitted in Column 5, after the paragraph ending line 54.

--Another application of the initiator 2 of the present invention is shown in Figure 6 wherein it is desired to utilize the initiator 2 as a source of power for driving the piston 70 of an industrial type, powder-actuated driving tool. The piston 70 is generally mounted in a suitable barrel 72 and the fastener 74 which is desired to be driven inserted into the muzzle end thereof. The nitrocellulose body 4 of the initiator 2 is generally pellet-shaped with the conductive film 6 applied to the rearward end thereof. The initiator 2 is inserted into a suitable pellet chamber 76 with the conductive film 6 being positioned so that it will be intimately engaged by a suitable electrode 78 of the type shown in Figure 3.

A preferred electrical circuit for providing a source of electrical energy for ignition of the initiator 2 is shown in Figure 7. Such circuit may include a suitable battery 80 having a capacitor 82 in parallel therewith. The conductive film 6 of the initiator 2 is represented by the resistance 84. A suitable on-off switch 86 is provided between the capacitor 82 and the two electrodes 88 and 90 for firing control. It is to be noted, however, that any direct current source of equivalent power and energy may be used. The capacitances and voltages may be varied widely but should be so selected that the total energy available for initiation is about 1 joule. This effect is shown in the following table which represents "Bruceton" type testing, at three values of capacitance, to determine the all-fire voltage required.--

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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