Aug. 13, 1957 C. F. HORNE ET AL 2,802,421

STATIC RESISTANT ELECTRIC INITIATOR

Filed Nov. 9, 1953

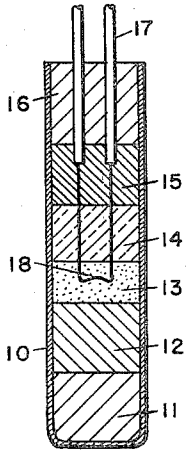


FIG. 1

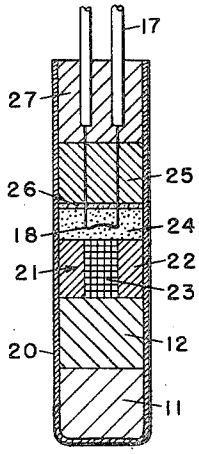


FIG. 2

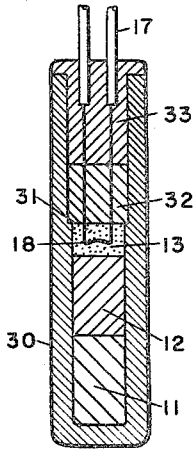


FIG. 3

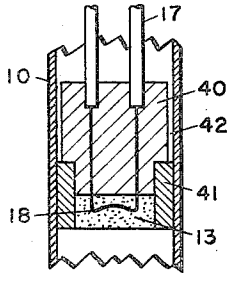


FIG. 4

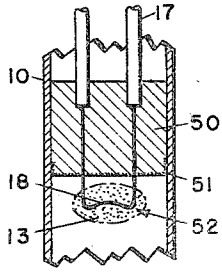


FIG. 5

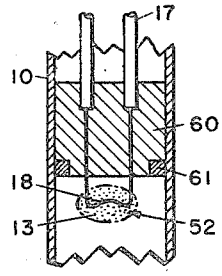


FIG. 6

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STATIC RESISTANT ELECTRIC INITIATOR

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Application November 9, 1953, Serial No. 391,096

24 Claims. (Cl. 102—28)

This invention relates to electric initiators and more particularly to electric initiators which are highly resistant to premature firing by static electricity.

The art has long recognized the dangers inherent in accidental discharge of electric initiators by means of static electricity. Accidents, which at the time of their occurrence have seemed without explanation, have been subsequently traced to the firing of an initiator by a static discharge. Since normally used ignition compositions necessarily are highly heat sensitive, a discharge of relatively high voltage is quite capable of igniting the composition and firing the initiator. The art has generally considered that such accidental firings result from a direct discharge from a lead wire to a metallic initiator shell in the locus of the ignition composition. Obviously, caps can also be fired by direct discharge through the bridge wire via the two lead wires. What is not so well understood, however, is the fact that an initiator can also be fired by the passage of a static voltage through the bridge wire when the discharge is from shunted lead wires to shell at a point other than through the explosives charge.

While the danger of premature firing due to static discharge is present in all types of electric initiators, the procedures employed in seismographic prospecting and the sensitive ignition compositions employed in seismic-type blasting caps have tended to make this type of initiator more susceptible to static than regular electric blasting caps and delay electric blasting caps. Until very recent years, commercial seismograph caps generally required a discharge in the order of 5000 volts to fire the cap by direct discharge through the ignition composition and a discharge in the order of 12,000 volts to fire the caps by heating of the bridge wire when the charge was supplied by a 750 micromicrofarad capacitor and the discharge was from shunted lead wires to shell. It has been established that voltages of this magnitude may be developed by a man under proper conditions and that much higher voltages may be generated in equipment employed by seismic prospectors such as drill rigs and trucks. Actually, conditions favoring high voltage static generation, such as low humidity, high winds, sandstorms, and the like, are common in the localities where most seismic prospecting is done. Consequently, it will be seen that a definite danger of accidental firing of seismic caps is present under such adverse conditions. As a result of this danger, seismographic prospecting organizations and blasting cap manufacturers have been constantly attempting to raise the static resistance of all electric initiators and especially that of the seismic-type blasting cap.

A blasting cap structure has previously been proposed in which a lead wire is disposed in contact or almost in contact with the metallic shell, at a point removed from the ignition composition, in order to provide for a discharge of the static electricity from the lead wire to the shell. However, this type of structure offers good protection from static or firing of the cap only when the charge passes down the one lead wire to the shell. Little or no benefit is obtained when the current passes through both

lead wires. Even when both lead wires are so disposed, discharge will occur from only one wire in many instances and protection will be limited as far as heating of bridge is concerned.

A structure has also been proposed wherein one or both of the bared lead wires are connected to the metallic shell by means of semiconductive material outside the locus of the ignition composition. This construction affords a considerable improvement in static resistance. However, it is very difficult with such a structure to maintain a proper balance of conductivity that will allow a discharge from both wires to the shell and still have sufficient resistance for protection against the low voltage currents which attend many commercial blasting operations. Additionally, it has been found that in some instances, the static resistance of this type of structure diminishes with storage. Furthermore, such caps have been known to fire when 10–40 volts from a battery are applied between lead wires and shell.

In another proposed structure, conductive material is disposed about the bared lead wires and extends to the metallic shell. This conductive material acts as a true resistor in that the resistance is low, normally from 10–100 ohms. The resistance of such a body of material is similar to that of a regular carbon resistor, being fairly constant, but subject to variation due to temperature. The resistance does not change greatly due to passage of current until the current is sufficient to cause heating. This type of cap gives good static protection in most instances. However, it has been found that in some instances discharges occur from only one wire which allow a firing of the cap by the heating of the bridge wire. Even more than in the case of the semiconductive material, this structure has a serious deficiency of insulation from shell to lead wires and can be fired in this manner with a very low voltage. In other words, this structure, while removing a considerable part of the hazard of static electricity, has introduced an equally undesirable hazard in the form of undesirably low resistance between lead wires and shell.

In still another structure, it has been proposed to equip the bared lead wires with protrusions which extend toward the metallic shell. This structure is usually employed with a matchhead ignition element which is insulated. However, a discharge usually takes place from only one wire and a firing of the cap by the heating of the bridge wire is thus permitted. In addition, a hotter spark is obtained when the discharge is directed from localized points. Even though the protrusions are outside the locus of the ignition composition, such violent discharges are to be avoided when the same results can be obtained in a less violent manner.

While all of these preceding structures give an initiator a measure of static resistance, it will be seen that in each case, the protection from static is not complete and, in most instances, what protection is obtained is brought about by a structure which is characterized by low voltage breakdown. Furthermore, these structures are not characterized by a sufficient resistance to heating of the bridge wire by a static discharge through the bridge wire itself. It will be further noted that the structures above described have all employed a conductive metal shell with the emphasis being placed on promoting a discharge of static from the leg wire to the shell through a conductor for such a charge or by means of arcing outside the locus of the ignition composition.

In recent years initiators employing a plastic shell have appeared on the market. It is at once apparent that a dielectric shell of plastic or equivalent material will afford protection against stray currents and at initial consideration it might also be surmised that the plastic shell would also furnish a satisfactorily complete answer to the problem of accidental firings by means of static discharge,

In fact, such claims have been made for commercially available initiators employing plastic, nonconductive shells. It is true that when a low voltage potential is built up on a high capacity condenser and such a potential is applied between shunted lead wires and shell, the initiator with the plastic shell does exhibit satisfactory resistance to firing due to the insulatory characteristics of the plastic. The fallacy in such a demonstration, however, lies in the fact that such charges are not the type static charges which are encountered in actual blasting operations and more particularly in seismic prospecting. The static charges which have caused the accidents which the art now seeks to avoid have resulted from a high voltage buildup at low capacitance. It is for this reason that when determining the static resistance of an initiator it is customary to employ a 750 mmf. condenser and voltage ranging between 10,000 and 50,000 volts. When exposed to such a realistic test it has been found that the initiators with plastic shells which are now available to the art are demonstrably more susceptible to accidental discharge than the static resistant structures hereinabove described.

In view of obvious advantages of a plastic shell, one of which is the resistance to firing by stray currents, it is most desirable to have an initiator employing a dielectric shell which has low susceptibility to accidental firing by the high voltage static charges encountered in the field. In accordance with the present invention, initiators with dielectric shells may be readily and economically manufactured which have the necessary resistance to accidental firing either by stray currents or static electricity.

Generally described the present invention is a static resistant electric initiator having in combination a dielectric shell; an ignition assembly disposed within the shell comprising a pair of lead wires connected at their terminals by a bridge wire and an ignition composition disposed about the bridge wire; and a body of semiconductive material disposed about and in conductive relationship with bared portions of both lead wires; said shell forming a nonconductive layer between the semiconductive body and ground of substantially less thickness than the distance between either lead wire and ground in the locus of the ignition composition, the path from either lead wire to grounded shell having substantially less total resistance through the semiconductive body outside the locus of the ignition composition than the path from either lead wire to grounded shell in the locus of the ignition composition. Therefore, in the initiators of the invention, static charges which can be expected to be encountered in the field are safely discharged from the semiconductive body through the shell to ground or else are discharged simultaneously from both lead wires through the semiconductive body instead of through the bridge. Thus, the accidental firing of caps having dielectric shells may be substantially completely eliminated.

The body of dielectric material may be a separate plug disposed above the ignition plug and thus completely outside the locus of the ignition composition. To enhance manufacturing ease and to prevent undesirable elongation of the device, however, it is preferred that the semiconductive body actually make up the ignition plug itself. In this modification the semiconductive plug will be the element in the initiator structure which is immediately adjacent the sensitive ignition composition. Therefore, in order to assure complete protection against accidental ignition by a static discharge to ground at the interface of plug and ignition composition, structural provision must be made to insure discharge outside the locus of the ignition composition. This may be accomplished by employing a dielectric coating or thin layer of dielectric material on the base of the semiconductive plug. Alternatively and preferably the semiconductive ignition plug will be stepped to provide a lower portion of reduced diameter. A dielectric ring, ferrule, sleeve, or shell liner is then disposed about the portion of reduced diameter and thus the portion of the plug immediately adjacent the ignition composition is spaced farther from ground than the portion above such element. Alternatively, the plastic shell may be formed or molded in such manner that a shoulder extends into the interior of the shell to produce a region of diminished inside diameter. Thus, a stepped or cylindrical ignition plug may engage this shoulder and confine the ignition composition in a portion of the shell where the resistance of the path to ground is greater than the path to ground above such a shoulder. If desired, for ease of manufacture or any other reason, the semiconductive bodies, whether separate plugs or ignition plugs, may be made somewhat smaller than the inner diameter of the plastic sleeve and concentrically situated in the shell as long as the distance at the point of desired discharge outside the locus of the ignition composition between the semiconductive body and ground is less than the distance between either lead wire and ground in the locus of the ignition composition. As will be more fully described, the semiconductive bodies or plugs are bodies which afford high resistance to passage of currents employed to intentionally fire electric initiators but offer low resistance to high voltage static charges against which protection is desired.

As has been initially indicated, the initiator art in its consideration of the static susceptibility of electric blasting caps has apparently overlooked the fact that accidental firing by static may also take place by heating of the bridge wire as well as by arcing through the ignition composition to the grounded shell. In the case of the initiator which has a plastic or dielectric shell, the resistance to arcing to ground by employing the dielectric layer in place of the metallic casing is obviously raised somewhat. Thus, in the plastic shell cap there is an even greater tendency for accidental shots by heating of the bridge wire, since lower but still dangerous static potential which might ordinarily arc to a grounded metallic shell, will generously discharge by breakdown from one of the lead wires to ground above the plastic shell. If the breakdown is from only one lead wire through the bridge, an accidental shot will be encountered depending on the potential involved and the heat sensitivity of the particular ignition mixture. If the bridge wire has been broken or detached from a lead wire terminal, an ignition arc may be obtained at potentials too low to arc to ground or to heat the bridge to a dangerous level. Thus, the disposition of the semiconductive body around the bared lead wires takes on even added importance as a high voltage shunt which tends in a great majority of cases to cause breakdown from both lead wires simultaneously rather than by a unidirectional surge of current through the bridge wire from one lead wire alone.

In copending application of Charles F. Horne, Serial No. 340,821, filed March 6, 1953, now U. S. 2,658,451, issued November 10, 1953, and assigned to Hercules Powder Company, it is disclosed that the resistance to accidental firing of initiators through the heating of the bridge wire by static discharge through the bridge may also be increased greatly by employing a bridge wire of higher heat capacity. The use of a bridge wire of increased heat capacity is also included in the present invention and will be subsequently discussed.

Having generally described the invention, more specific illustration of specific embodiments will be given with reference to the accompanying drawing in which Figs. 1, 2, and 3 are sectional views of completed electric initiators in accordance with the invention and in which Figs. 4, 5, and 6 are sectional views of additional embodiments of ignition assemblies of initiators in accordance with the invention.

In Fig. 1 is shown a seismic type instantaneous initiator having a dielectric shell **10** formed from ethyl cellulose. A base charge **11** of pentaerythritoltetranitrate is disposed in the base of the shell **10**. Above the base charge **11** is a priming charge **12** of diazodinitrophenol. An ignition composition **13** of diazodinitrophenol-potassium

chlorate is loaded upon the priming charge **12**. A plastic ignition plug **14** of ethyl cellulose is pressed upon the ignition charge. A semiconductive plug **15** is disposed above the ignition plug and contacts the shell **10**. A plastic sealing plug **16** of ethyl cellulose is disposed in the mouth of the shell **10** to provide a waterproof seal by moistening plug and shell with a mutual solvent prior to insertion of the plug. Lead wires **17** extend into the initiator through the sealing plug **16**, the semiconductive plug **15**, and the ignition plug **14**. The lower portions of the lead wires **17** are bared for most of their passage through the semiconductive plug **15** and all of their passage through the ignition plug **14**. A bridge wire **18** joins the terminal ends of the lead wires **17** and is surrounded by the ignition composition **13**. If a static charge having a voltage sufficient to fire the ignition composition **13** by arcing from the leg wire **17** through the shell **10** to ground is applied between the shunted leg wires and the grounded shell **10**, discharge will take place from the bared lead wires **17** through the semiconductive plug **15** and through the shell wall **10** to ground and thus prevent arcing in the locus of the ignition composition. The semiconductive plug **15** further acts as a high voltage shunt between the bared lead wires **17** and greatly raises the static voltage necessary to cause firing by heating of the bridge wire **18**.

In Fig. 2, a delay electric initiator is shown which has a plastic shell **20** formed from cellulose acetate. Conventional base charge **11** and priming charge **12** are employed. A conventional delay fuse element **21** is disposed above the priming charge **12** and consists of a dielectric tube **22** containing a delay fuse train **23** of barium peroxide—selenium composition. Disposed above the delay fuse element **21** is a lead styphnate ignition composition **24**. A semiconductive ignition plug **25**, the base of which is coated with a dielectric film **26** of nitrocellulose lacquer, is pressed upon the ignition composition. A cellulose acetate sealing plug **27** is cemented into the mouth of the shell **20** to form a waterproof seal. Lead wires **17** extend through the sealing plug **27** and the semiconductive ignition plug **25**. The terminals of the wires **17** extend into the ignition composition and are joined by a bridge wire **18**. As in the device of Fig. 1, when a dangerous static potential is applied between the shunted lead wires **17** and the grounded shell **20**, discharge will occur between a lead wire **17** and ground through the semiconductive plug **25** and shell wall **20**. Again the ignition plug **25** also acts as a high voltage shunt to greatly increase the resistance of cap to accidental firing through heating of the bridge by passage of the static charge.

In Fig. 3, an instantaneous blasting cap is shown which employs a cellulose acetate shell **30**. The shell **30** has a region of reduced inside diameter below the shoulder **31**. Disposed in the region of reduced diameter is a conventional base charge **11**, priming charge **12** and ignition composition **13**. A cylindrical semiconductive ignition plug **32** formed from graphite and rubber rests upon the shoulder **31** of the shell **30** and contacts the shell wall. A cellulose acetate sealing plug **33** is cemented in the mouth of the shell to produce a waterproof seal. Lead wires **17** pass through the sealing plug **33**, the semiconductive plug **32**, and extend into the ignition composition where their terminal ends are joined by bridge wire **18**. The lead wires are bare throughout their passage through the semiconductive ignition plug **32**. In the structure shown a static discharge to ground will occur through the semiconductive plug and the thinner portion of the wall of the shell **30** above the shoulder **31** rather than in the locus of the ignition composition **13**. The semiconductive plug **32** again acts as a high voltage shunt and greatly raises the static potential necessary to cause breakdown from one leg wire through the bridge.

In Fig. 4 is shown a further embodiment of a static resistant ignition assembly in accordance with the invention in which a stepped semiconductive ignition plug **40** is employed. A plastic sleeve **41** is disposed about the lower portion of the stepped plug **40** having the smaller diameter and spaces the upper portion of the plug **40** slighlty from the wall of the shell **10**. Ignition composition **13** is disposed in the cavity formed by the sleeve **41** and the lower surface of the plug **40**. Bared portions of lead wire **17** extend through the semiconductive plug **40** into the ignition composition **13** and are joined at their terminal ends by a bridge wire **18**. In this structure discharge from leg wire to ground will take place above the sleeve **41** outside the locus of the ignition composition, while the plug **40** acts as a high voltage shunt between the bared leg wires.

In Fig. 5, a cylindrical semiconductive ignition plug **50** is employed, the lower portion of which has been dipped in a dielectric lacquer solution to produce a dielectric film **51**. The plug **50** is in contact with the wall of the shell **10**. Bared portions of lead wires **17** are in conductive relationship with the plug **50** and are joined at their terminals by a bridge wire **18** below the lower surface of the plug **50**. A matchhead ignition element **52** is employed which consists of a bead of ignition composition **13** disposed about the bridge wire **18**. Discharge from leg wire to ground will take place from leg wire **17** through the plug **50** to ground above the film **51**, while the plug **50** acts as a high voltage shunt between the bared leg wires.

In Fig. 6, a stepped semiconductive ignition plug **60** is employed and a plastic ring **61** is fitted about the portion of reduced diameter of the plug **60**. The plug **60** contacts the wall of shell **10**. Bared portions of lead wires **17** are in conductive relationship with the plug **60** and are joined at their terminals by bridge wire **18** below the surface of the plug **60**. A matchhead ignition element **52** is again employed consisting of a bead of ignition composition **13** disposed about the bridge wire **18**. Static discharge to ground in this structure will occur from lead wire **17** through the plug **60** to ground above the ring **61** rather than in the locus of the matchhead **52**. The plug **60** again acts as high voltage shunt between the bared lead wires **17**.

In the structures described in the drawing it will be noted that the semiconductive body or plug is usually in contact with the shell wall but may be spaced therefrom as in Fig. 4, if desired. However, the plastic shell itself affords adequate protection against accidental discharge by stray currents and it is therefore preferred that the semiconductive body or plug contact the dielectric shell wall, since such a structure is easier to manufacture and affords a static discharge path to ground of less total resistance. Since the total resistance of path to ground is less through that portion of the semiconductive plug which is not adjacent the ignition composition, static discharge will in all cases take place at a point safely spaced from the sensitive composition.

The semiconductive body in accordance with the invention acts as a nonconductor for the voltage employed to fire the electric initiator but is a good conductor for a high voltage static discharge. Therefore, while the semiconductive body or plug has no effect on the normal operation of the cap, it does, as indicated, constitute a shunt for high voltage discharge between the lead wires within the shell when the static voltage is applied to both lead wires. This effect is not only beneficial in a properly constructed cap but, as already indicated, adds an additional factor of safety where a bridge wire is inadvertently broken or loosened from one of the terminals during or subsequent to manufacture.

Although the semiconductive plug does greatly increase the strength of static charge necessary to fire the cap through heating of the bridge wire, the overall susceptibility to accidental ignition in this manner may be still further decreased by using a bridge wire of high heat capacity which impedes the generation of sufficient heat

in the bridge to bring about ignition of the ignition composition. The combination of the high voltage shunt and the high heat capacity bridge wire will prevent firing through heating of the bridge wire by any static charge which can reasonably be expected to be encountered even in geophysical prospecting. The heat capacity of a bridge wire can be increased by increasing the length or the diameter of the bridge. The dimension of an electric initiator and manufacturing considerations place a limitation on the permissible length of a bridge wire, and it is consequently preferred to increase heat capacity by increasing the diameter. An increase in diameter will give the desired increase in protection against static electricity but for a given material the increase in diameter will also result in a corresponding increase of the minimum firing current of the cap. While this fact has no bearing upon the reduction of static susceptibility of the initiator, it is desired to maintain the minimum firing current of an electric initiator at a low level in the neighborhood of 0.5 to 1 amp. Therefore, if, in accordance with a further embodiment of the invention, the diameter of the wire is to be increased, it is desirable to employ a metal or alloy in the bridge wire which is characterized by a high specific resistance and a high specific heat. It has been found that with most of the ordinary materials used by the art, the minimum firing current of the initiator is undesirably raised if the diameter of the bridge wire exceeds about 0.0015 inch, which is the usual diameter employed by the art. It has been found that greatly increased static resistance is obtained if a diameter of 0.0020 inch is employed. It is preferred to employ a bridge wire diameter of about 0.0025 inch and in order to avoid any substantial increase in minimum firing current, it is preferred to employ a bridge wire made from a nickel-chromium alloy.

Although it is usually preferred to employ a conductive metal powder as the conductive component of the semiconductive ignition plug, especially aluminum powder, other particulate conductive materials, such as conductive carbon may be employed. The nonconductive component which acts as a binder and carrier for the conductive particles is preferably wax. The wax employed will desirably have a melting point of 120° F. or above in order to prevent substantial cold flow of the wax subsequent to manufacture. The melting point of the wax, or any other operable carrier, will, of course, depend largely upon practical considerations. If a rubber or resin sealing plug is employed and is placed in position in cold form, the only consideration then is to use a wax which will not cold flow. If a molten resin is employed, a wax should be chosen which, in its admixture with the conductive filler, will not become undesirably soft. Preferred waxes include such natural waxes as candelilla, montan, and carnauba, synthetic waxes and mixtures thereof. Various mixtures of these waxes may also be employed.

Instead of wax, however, rubber or rubber-like materials, resinous materials, sulfur and equivalent materials may be employed. Since it is desirable that the body of semiconductive material be molded about the lead wires, readily moldable nonconductive materials are preferred.

The amount of a particular conductive filler employed in the semiconductive body will depend on the conductivity of the particular material and on the degree of static protection desired. The method of forming the semiconductive body about the lead wires will also dictate the optimum quantity of particulate conductive filler employed. In the preferred composition of wax and aluminum, it has been found that best results are obtainable when between 60 and 70% of particulate aluminum is employed. The upper limit of 70% is primarily dictated by the fact that it is desired to employ a pourable mixture for molding. The use of more than 70% of aluminum powder usually results in a mixture which is undesirably viscous for pouring operations. It has been found that adequate protection against static discharge from the lead wire to the shell through the ignition composition can be obtained with about 60% of particulate aluminum. Lesser amounts of aluminum can be employed with very beneficial results. From all considerations a 35/65 mixture of wax/aluminum has been found to give excellent results and is preferred.

In order to demonstrate the improvement of the initiators in accordance with the invention in terms of static susceptibility, commercially available plastic shell caps were purchased. A static charge was built upon a 750 mmf. condenser to simulate the actual static conditions encountered in the field. The caps had vinyl plastic shells .038 inch in thickness, and employed cyclonite base charges, lead azide priming charges, and a lead styphnate ignition composition. The ignition plugs were also of vinyl plastic. Each cap tested was tightly wrapped in aluminum foil and the indicated potential was applied between shunted lead wires and the foil. The following results were obtained:

Example 1

Voltage Applied*	Cap Number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10,000	F	F	F	F	F	F														
13,000										BD	BD	BD	BD	BD	BD	F	F	F	F	
15,000	BD								S	S	BD	BD	S	S	BD					
16,000	BD				BD		S	BD			S	BD			S					
18,000	S	BD			BD	BD		BD				BD				S	S	F		F
20,000		BD		S	BD	S		BD				S							BD	F
21,000																				
25,000		BD			S			BD										BD	S	
26,000																				
30,000		BD	BD					BD										S		BD
31,000																				
40,000		S	S					S												S

F—Cap failed.
BD—Cap broke down, i. e., a circuit was established, but cap did not detonate.
S—Cap shot.
*Voltage applied by discharging of a 750 mmf. condenser.

In the foregoing tests, a dangerous situation existed at the voltages where breakdown occurred even though the cap did not shoot. If the breakdown was from both lead wires simultaneously, the danger of a shot was not great. However, if the breakdown was from one lead wire through the bridge and the cap did not shoot, the element of luck played a major part, since caps **9, 10, 13** and **14** establish that the particular ignition composition can be shot by static discharge at voltages at least as low as 15,000 volts. It will be noted that only three of the caps tested withstood a discharge of 40,000 volts and that thirteen of the remaining seventeen fired at 20,000 volts or below.

Example 2

Other plastic shell caps of the same manufacture were then modified in accordance with the invention. The plastic sealing plugs were removed and were replaced by a semiconductive plug composed of 64% particulate aluminum and 36% candelilla wax disposed about bared portions of the lead wires. Five such caps were then tested as in Example 1 at voltages of 17,000, 21,000, 26,000 and 31,000. All caps failed. These same caps were then retested at voltages of 21,000, 26,000, 31,000, and 40,000. One cap shot at 40,000 volts.

Example 3

The semiconductive plugs were then removed from four caps which failed in the test of Example 2. When the test of Example 1 was again applied, one cap shot at 21,000 volts and three caps shot at 26,000 volts.

The initiator shells may be made from any desired dielectric material such as plastic, rubber, fiber, and the like. The tough cellulosic esters and ethers are preferred such as cellulose acetate, cellulose acetate-butyrate, and ethyl cellulose. However, vinyls, such as vinyl chloride, vinyl chloride-acetate, polystyrene, acrylic polymers, etc., also are operable as are condensation resins such as the phenol aldehydes and melamine type resins. Conceivably, conventional metal shells could be coated with a suitable dielectric coating, layer, or casing. However, such a composite shell would be undesirably expensive unless used in an application where great physical strength is an essential and justifies the additional expense.

As indicated in the drawing, the dielectric spacing body employed may have various configurations and may be made of many different solid dielectric materials. Such materials include cardboard, paper, fiberboard, rubber, plastic, and the like. For most purposes, cardboard is preferred due to its ease of fabrication, economy, and excellent dielectric qualities.

If it is desired to employ the structure of Fig. 5, any suitable material may be employed as the dielectric film 51. Lacquer is preferred due to ease of application. Generally, however, it is preferred to employ structure in which the spacing sleeve extends below the base of the semiconductive plug unless the plug is stepped as in Figs. 4 and 6.

As will be apparent to those in the initiator art, the conventional components of the initiators may be replaced by equivalents. The lead wires may be made of any of the conventional materials such as copper and iron, and may be tinned if desired. The lead wires may be insulated with any desired material such as cotton servings, rubber or various plastics. The base charges may be formed from any secondary detonative explosive such as pentaerythritol tetranitrate, cyclonite, tetryl, trinitrotoluene, and the like, and may be cast or pelleted as well as pressed when the nature of the explosive permits. The priming charge may be omitted if the base charge is capable of initiation by the action of the ignition composition. When a priming charge is employed as is preferred, any primary explosive or mixture may be used such as diazodinitrophenol, diazodinitrophenol-potassium chlorate, lead azide, lead styphnate, and mercury fulminate. Any of the known ignition compositions may also be employed such as finely divided diazodinitrophenol-chlorate mixture, fulminates, lead- or tin-selenium mixtures, etc.

As indicated in the drawing, the ignition assemblies may employ cavity ignition plugs, matchheads, or loose ignition charges in acordance with conventional structures employed in the blasting initiator art. The shell may be sealed by more than one sealing layer, or, as indicated, a single seal may be employed such as a cast or molded resin plug.

Since, as indicated, the initiators within the scope of the invention can be altered in many respects without changing their mode of operation, it is intended that the invention be limited only by the scope of the appended claims.

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

1. A static-resistant electric initiator having in combination a dielectric shell, an ignition assembly disposed within the shell comprising a pair of lead wires connected at their terminals by a bridge wire and an ignition composition disposed about the bridge wire, and a body of semiconductive material disposed about and in conductive relationship with bared portions of both lead wires, said shell forming a nonconductive layer between the semiconductive body and ground of substantially less thickness than the distance between either lead wire and ground in the locus of the ignition composition, the path from either lead wire to grounded shell having substantially less total resistance through the semiconductive body outside the locus of the ignition composition than the path from either lead wire to grounded shell in the locus of the ignition composition.

2. An electric initiator in accordance with claim 1 in which the semiconductive material comprises particulate conductive material in admixture with a nonconductive binder.

3. An electric initiator in accordance with claim 1 in which the semiconductive material comprises particulate conductive metal in admixture with a nonconductive binder.

4. An electric initiator in accordance with claim 1 in which the bridge wire has a diameter of at least 0.0020 of an inch.

5. An electric initiator in accordance with claim 1 in which the semiconductive body is spaced from the shell wall by a distance substantially less than the distance between either lead wire and the shell wall in the locus of the ignition composition.

6. An electric initiator in accordance with claim 1 in which the dielectric shell is a moldable plastic.

7. A static-resistant electric initiator having in combination a dielectric shell; an ignition assembly disposed within the shell comprising, a dielectric ignition plug, a pair of lead wires passing through the ignition plug, a bridge wire connecting the terminals of the lead wires, and an ignition composition disposed about the bridge wire; and a body of semiconductive material disposed about and in conductive relationship with bared portions of both lead wires at a point within the shell outside the locus of the ignition composition, said shell forming a nonconductive layer between the semiconductive body and ground of substantially less thickness than the distance between either lead wire and ground in the locus of the ignition composition, the path from either lead wire to grounded shell having substantially less total resistance through the semiconductive body outside the locus of the ignition composition than the path from either lead wire to grounded shell in the locus of the ignition composition.

8. An electric initiator in accordance with claim 7 in which the semiconductive material comprises particulate conductive material in admixture with a nonconductive binder.

9. An electric initiator in accordance with claim 7 in which the semiconductive material comprises particulate conductive metal in admixture with a nonconductive binder.

10. An electric initiator in accordance with claim 7 in which the bridge wire has a diameter of at least 0.0020 of an inch.

11. An electric initiator in accordance with claim 7 in which the semiconductive body is spaced from the shell wall by a distance substantially less than the distance between either lead wire and the shell wall in the locus of the ignition composition.

12. An electric initiator in accordance with claim 7 in which the dielectric shell is a moldable plastic.

13. A static-resistant electric initiator having in combination a dielectric shell, a pair of lead wires, a semiconductive ignition plug disposed about bared portions of the lead wires within the shell, a thin layer of dielectric material covering at least the bottom of the semiconductive ignition plug, a bridge wire connecting the terminals of the lead wires below the dielectric layer, and an ignition composition disposed about the bridge wire, said shell forming a nonconductive layer between the semiconductive body and ground of substantially less thickness than the distance between either lead wire and ground in the locus of the ignition composition, the path from either lead wire to grounded shell having substantially less total resistance through the semiconductive body outside the locus of the ignition composition than the path from either lead wire to grounded shell in the locus of the ignition composition.

14. An electric initiator in accordance with claim 13 in which the semiconductive material comprises particulate conductive material in admixture with a nonconductive binder.

15. An electric initiator in accordance with claim 13 in which the semiconductive material comprises particulate conductive metal in admixture with a nonconductive binder.

16. An electric initiator in accordance with claim 13 in which the bridge wire has a diameter of at least 0.0020 of an inch.

17. An electric initiator in accordance with claim 13 in which the semiconductive body is spaced from the shell wall by a distance substantially less than the distance between either lead wire and the shell wall in the locus of the ignition composition.

18. An electric initiator in accordance with claim 13 in which the dielectric shell is a moldable plastic.

19. A static-resistant electric initiator having in combination a dielectric shell having a shoulder extending interiorly thereof to form a region of decreased inside diameter, a semiconductive ignition plug resting on said shoulder, a pair of lead wires passing through the semiconductive ignition plug and having bared portions in conductive relationship with the plug, a bridge wire connecting the terminals of the lead wires below the plug, and an ignition composition disposed about the bridge wire, said shell forming a nonconductive layer between the semiconductive body and ground of substantially less thickness than the distance between either lead wire and ground in the locus of the ignition composition, the path from either lead wire to grounded shell having substantially less total resistance through the semiconductive body outside the locus of the ignition composition than the path from either lead wire to grounded shell in the locus of the ignition composition.

20. An electric initiator in accordance with claim 19 in which the semiconductive material comprises particulate conductive material in admixture with a nonconductive binder.

21. An electric initiator in accordance with claim 19 in which the semiconductive material comprises particulate conductive metal in admixture with a nonconductive binder.

22. An electric initiator in accordance with claim 19 in which the bridge wire has a diameter of at least 0.0020 of an inch.

23. An electric initiator in accordance with claim 19 in which the semiconductive body is spaced from the shell wall by a distance substantially less than the distance between either lead wire and the shell wall in the locus of the ignition composition.

24. An electric initiator in accordance with claim 19 in which the dielectric shell is a moldable plastic.

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