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IGNITION ASSEMBLY RESISTANT TO ACTUATION BY RADIO FREQUENCY AND ELECTROSTATIC ENERGIES
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FIG. 1

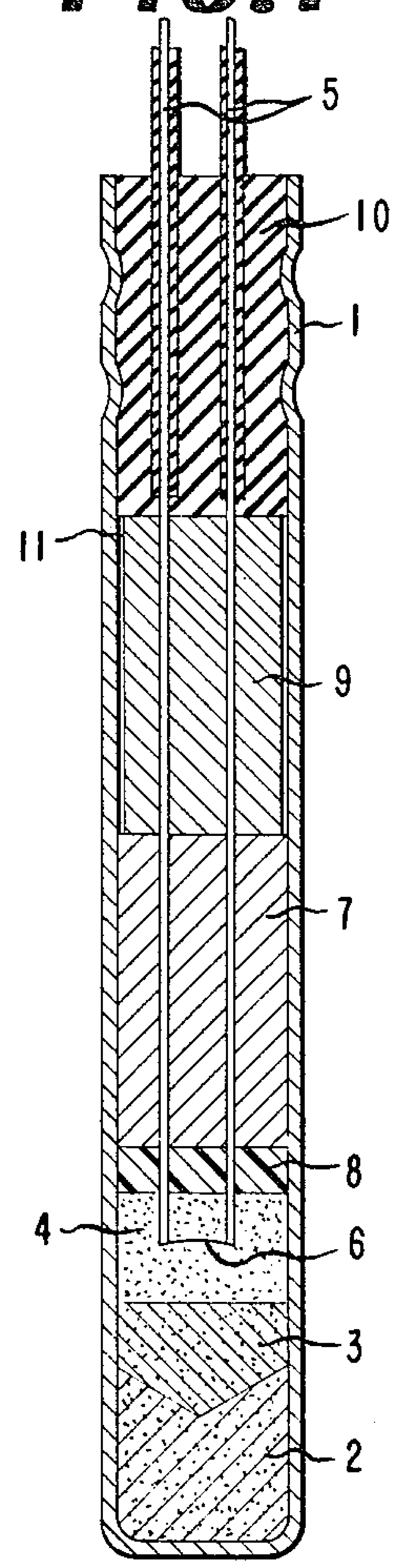

FIG. 2

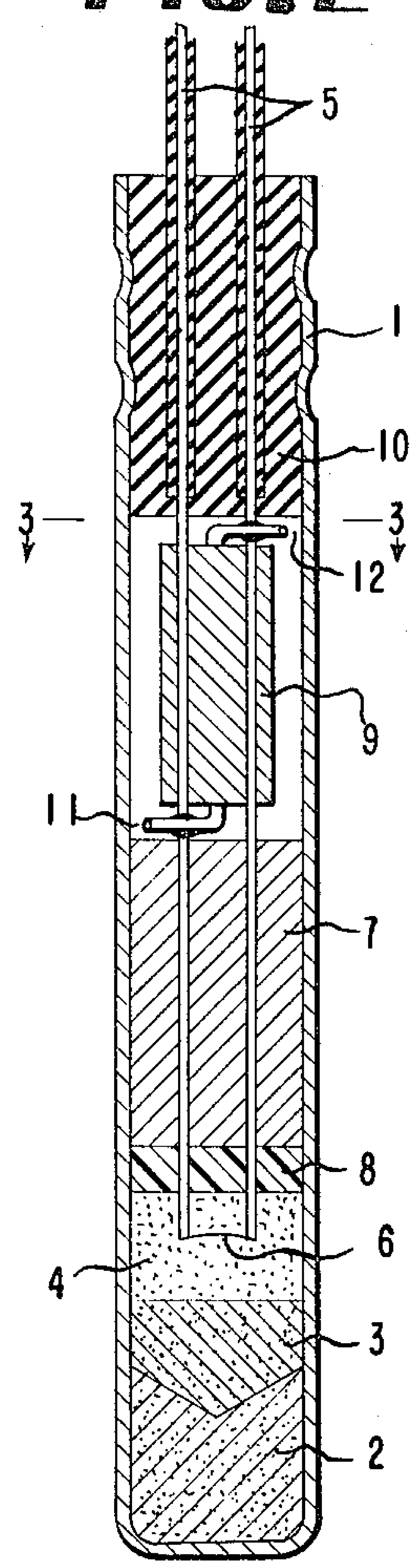

FIG. 3

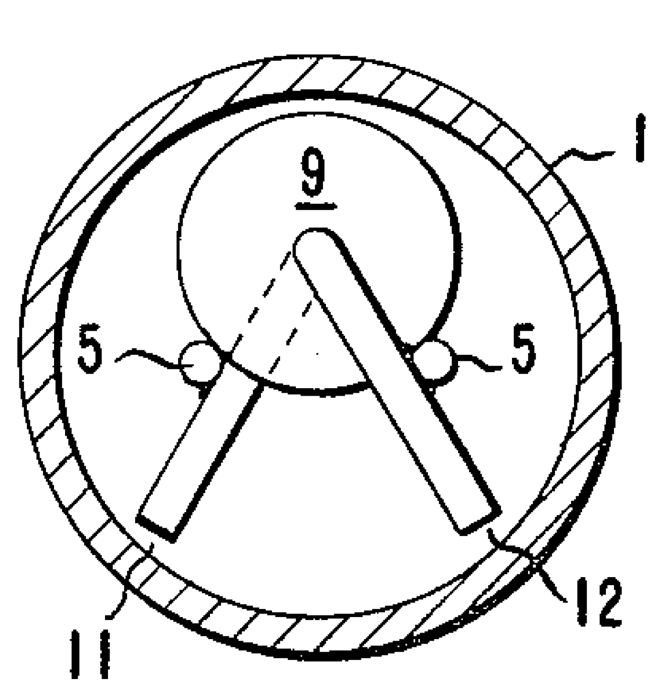

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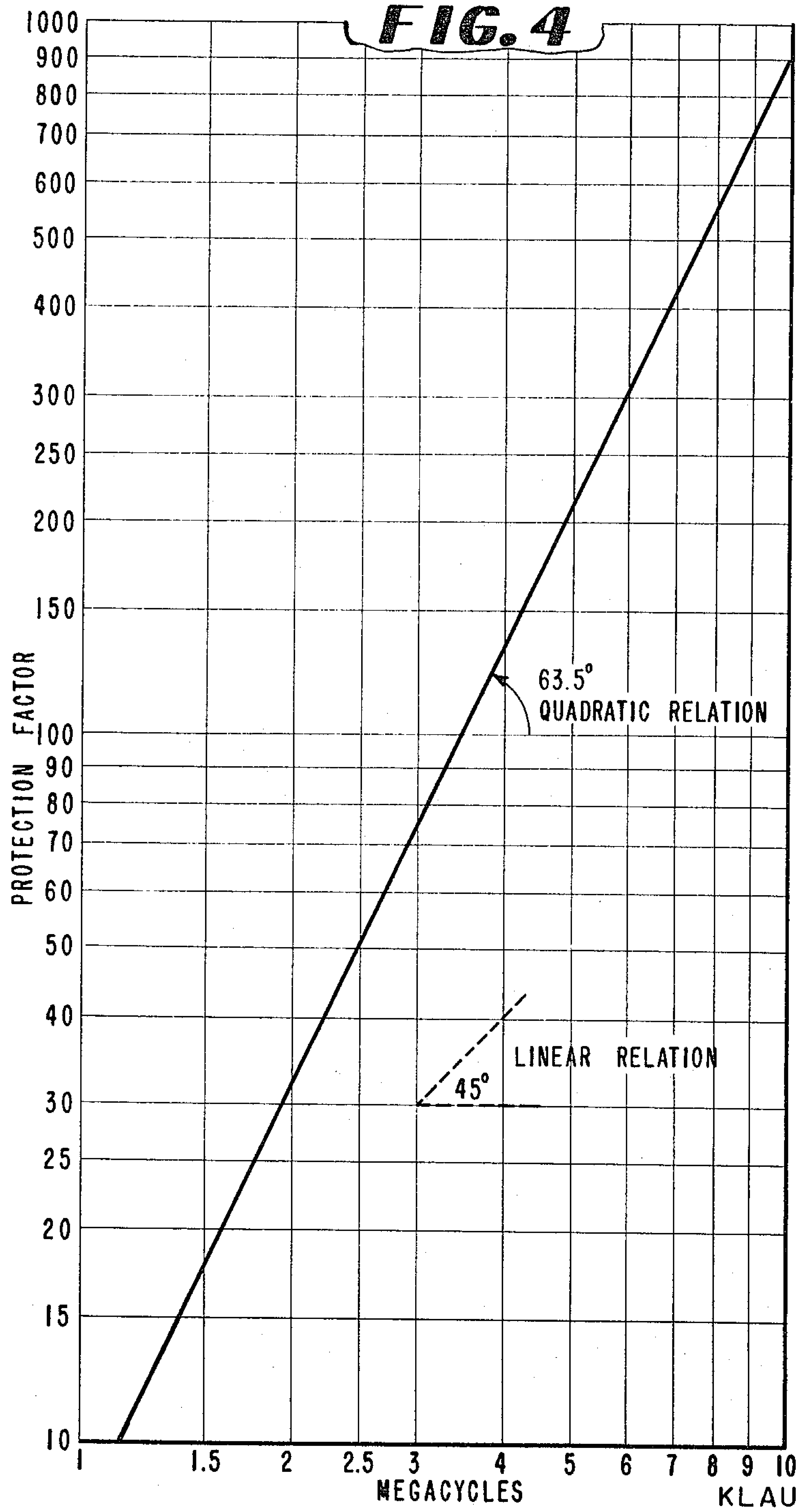
FIG. 4



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IGNITION ASSEMBLY RESISTANT TO ACTUATION BY RADIO FREQUENCY AND ELECTROSTATIC ENERGIES

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6 Claims. (Cl. 102—28)

The present invention relates to electric initiators protected against accidental firing by radio frequency and static electrical energies.

Protection against accidental exposure to radio frequency is desirable for most military electroexplosive devices and is sometimes needed for commercial caps. Electrostatic and lightning discharges are as much a hazard to electroexplosive devices as electromagnetic radiation, and all should be obviated. The problem is to render this protection at a cost which will not substantially increase the base cost of a conventional electric blasting cap. This limitation excludes extraneous filters, which afford good protection, but are expensive. For example, the classical low-pass filters protect effectively against radio frequencies if built heavily enough to absorb inevitable losses in coils and capacitors, however they are expensive and are of negligible value against leg-to-leg electrostatic discharges because the basic D.C. component passes through with little loss. Other protection devices known in the art are expensive, some of these do not provide protection against all extraneous electricity and are therefore impractical.

In accordance with this invention an electric initiator having a metal shell integrally closed at one end and open at the other end and containing an ignition composition is protected against accidental firing by radio frequency and static electrical energies with an electrical ignition assembly comprising, in sequence from the ignition composition:

(A) A pair of electrical conductors extending into said metal shell and joined at their terminals by a bridgewire contacting the ignition composition,

(B) A plug of a magnetic inductance composition surrounding and contiguous to said electrical conductors adjacent said ignition composition,

(C) A resistance slug having an electrical resistance two to six times that of said bridgewire adjacent said inductance plug, said slug being in contact with said electrical conductors and spaced from said metal shell to provide a spark gap of a width less than the distance between the bridgewire and shell, and

(D) A sealing plug surrounding said conductors and closing said open end of said metal shell.

In a preferred embodiment of the invention the electrical conductors are of aluminum-cored stainless steel and copper-cored stainless steel wires.

In order to describe the invention more clearly, reference is made to the accompanying drawings, in which:

FIGURE 1 is a cross-sectional elevation view of an electric initiator of this invention;

FIGURE 2 is a cross-sectional elevation view of a different embodiment of initiator of this invention;

FIGURE 3 shows a cross-section of FIGURE 2 taken along line 3, 3; and

FIGURE 4 illustrates the protection factor afforded by a preferred embodiment of the invention.

The drawings are for illustrative purposes only and are not to be regarded as limiting in any manner.

Referring now to FIGURE 1, the radio frequency and static protected electric initiator has a shell **1** which has one closed and one open end. In sequence from the closed end, there is placed within the shell **1** a base charge **2**, a

priming charge **3** and a heat-sensitive ignition composition **4**. Extending into the shell **1** is a pair of electrical conductors **5** which can be of copper, iron, or aluminum and preferably are wires having high skin-effect loss, e.g., wires whose cross-sectional area is 28% stainless steel clad on 72% copper, joined at their terminals by an electrically resistant bridgewire **6** in contact with the ignition composition **4**. An inductance plug **7** of a magnetic inductance composition surrounds and is contiguous to the conductors **5** and is separated from the ignition composition **4** by optional heat insulation element **8**. A resistance slug **9** having an electrical resistance two to six times that of the bridgewire **6** is spaced from the shell **1**, contiguous to the inductance plug **7** and surrounds the conductors **5**. Above the resistance slug **9** and surrounding the conductors **5** is a sealing plug **10**, the composition of which can be any suitable solid material, e.g., rubber, which closes the open end of the shell **1**. The electrostatic spark location provided by the gap between shell **1** and slug **9** is indicated at **11**.

FIGURES 2 and 3 show a radio frequency and static protected electric initiator similar to that of FIGURE 1 having a shell **1** which has one closed and one open end. In sequence from the closed end, there is placed within the shell **1**, a base charge **2**, a priming charge **3** and a heat-sensitive ignition composition **4**. Extending into the shell **1**, is a pair of electrical conductors **5** which can be of copper, iron, or aluminum and preferably wires having high skin-effect loss joined at their terminals by an electrical resistant bridgewire **6**, which is in contact with the ignition composition **4**. An inductance plug **7** of a magnetic inductance composition surrounds and is contiguous to the conductors **5** and is separated from the ignition composition **4** by optional heat insulation element **8**. Adjacent to the inductance plug **7** is a cylindrical resistor **9**, of an electrical resistance of two to six times that of the bridgewire **6**, with two copper wires at each end which are in electrical contact with conductors **5** and extend to a point within a narrow margin of the shell **1** to provide spark gaps **11** and **12**. Above the resistor **9** and surrounding the conductors **5** is a sealing plug **10** of any suitable composition, e.g., rubber, which closes the open end of the shell **1**.

The electrical conductors may be of copper, iron, or aluminum, or preferably for added protection they are of aluminum- or copper-cored stainless steel, e.g., having a cross-sectional area of 28% stainless steel clad on 72% copper.

The inductance plug may be any magnetic material exhibiting high permeability and may be in the form of a solid plug or a multiturn coil. Preferably it will have an inductance of at least one microhenry. Good examples of such a material are the ferrites which are usually spinels containing an oxide of iron in combination with some other metal oxide or combination of oxides, for example $M(Fe_2)O_4$ wherein M is divalent Mn, Fe, Co, Ni, Cu, Mg, or Zn. A preferred ferrite is composed of 24.9 weight percent of nickel oxide, 24.9 weight percent of zinc oxide and 50.2 weight percent of ferric oxide. The inductance plug need not contact the shell as shown in the drawings but may contact the shell as well as the ignition composition and/or resistance slug. The plug must surround and either contact or be closely adjacent to the conductors. The inductance plug may be designed so that the conductors can be passed therethrough one or several times, the latter being preferred because the protection factor is increased by using several loops of the wire.

The resistance slug or resistor may be any material having a resistance 2–6 times that of the bridgewire, e.g., a radio carbon-resistance material in an organic binder or a ceramic-resistance material. It is necessary that uniform electrical contact be made between the resistance slug and the electrical conductors. This can be accomplished by (1) molding metallic tubes in the resistance slug to tightly engage the wires, (2) cementing the conductors in the resistance slug with a conductive cement, (3) molding the resistance slug directly onto the electrical conductor wires, or (4) by welding or soldering the resistance slug containing molded-in wire, to the electrical conductors by means of the molded-in wires. In order to divert extraneous electricity away from the bridgewire, the resistance slug is spaced a small distance from the metal shell thereby forming an arc gap, for electrostatic discharge at a safe location. This distance must be less than that between the bridgewire and the shell. The resistor preferably is cylindrical in shape with copper wires attached to both ends which are hard soldered or spot welded to the electrical conductors and extend to a point within a narrow margin of the shell to create an arc for an electrostatic spark discharge. Preferably the gap is sufficiently narrow that it will discharge when the potential between the shell and resistor is 1000 volts or more. The heat insulation element **8**, e.g., nylon or Teflon, insures against degradation of the ignition composition.

The protected initiators of this invention operate as follows:

(1) Radio frequency current on both leg wires enters the cap and is split inversely proportional to the ratio of the 2–6 ohm resistance to the impedance of the bridge-inductance loop.

(2) Radio frequency potentials between the leg wires and the shell cause flash over at the resistance slug if their amplitude exceeds several hundred volts.

(3) Electrostatic leg-to-leg discharge splits as in the radio frequency case inversely proportional to the ratio of the 2–6 ohm resistance to the bridge loop impedance. Only a small fraction of the electrostatic energy goes through the bridgewire in this case.

(4) Electrostatic leg-to-shell discharge causes part of the current to discharge from one leg wire to the shell through the resistor and the remaining current to discharge from the other leg wire through the bridgewire to the shell. This bridge current passes through the inductance plug twice or several times in the case of loops and hence the major part of the total current goes through the resistor to the shell.

(5) Direct current firing requires only 25% more energy due to the leakage through the resistance shunt. This higher firing current is acceptable, or where not desired, can be compensated for by a smaller diameter bridgewire or a more sensitive ignition compound.

(6) Series firing should be more reliable because breaking of the bridgewires still leaves the resistance shunt intact to carry current for the slower firing caps.

(7) Parallel firing from high voltage power lines is improved, because the shunts in all caps will maintain enough current flow to keep the potential below the striking point of a destructive arc, and yet they will not cause enough drain to drive current requirements up.

Electrical inductance compositions, e.g., ferrite beads, alone do not confer immunity to electrostatic discharges. However, the electric initiator of this invention gives both electrostatic and radio frequency protection, a combination which is rarely found. The protection factor of an electric initiator is obtained from the following relationship.

$$\text{Protection factor} = \frac{\text{R.F. energy into cap to fire}}{\text{D.C. energy into cap to fire}}$$

FIGURE 4 shows the protection factor as a function of frequency, calculated for a 1 ohm bridgewire cap constructed as shown in FIGURE 1, with one foot copper leg wires and containing a 4 ohm radio-carbon resistance slug and a cylindrical ferrite inductance plug (0.22 inch diameter, 0.472 inch in length, and having two holes of 0.035 inch diameter) composed of 24.9% of nickel oxide, 24.9% of zinc oxide and 50.2% of ferric oxide. The inductance and loss of the ferrite were measured with a Q-meter. A ferrite plug alone gives protection linearly proportional to the frequency whereas the initiator of this invention gives a quadratic slope of the protection factor.

The following example illustrates the invention, but it is to be understood that the invention is not limited thereto. Conventional 1 ohm bridgewire caps using 1 foot copper leg wires without radio frequency and static protection were connected to a transmitter with frequencies of 0.6, 35 and 500 megacycles and the minimum firing energy was arbitrarily assigned the value of one unit. Protected caps as described in FIGURE 1 with a 1 ohm bridgewire, a 4 ohm resistance slug spaced 0.02 inch from the shell wall, a ferrite plug as described in the above in conjunction with FIGURE 4, and leg wire lengths of 1 foot, were then tested under the same circuit conditions. It can be seen from the table that considerably more energy was required to fire the protected caps than the unprotected ones.

Table

Frequency, mc.	Calculated protection factor based on Q-meter measurements	Measured by comparison with unprotected caps
0.6	3	4 times more power.
35	11,000	Could not be fired with available transmitter peak power, but fired after heating up for about one minute.
500	100,000	

An electrostatic test was carried out with a conventional blasting cap in a leg-to-leg discharge in which both wires of the cap were connected to a capacitor and the firing power required was observed. A protected cap the same as described for the above radio frequency tests was tested under the same conditions and found to require 5 times more power than the unprotected cap.

It will be seen that in accordance with the foregoing description of this invention, an electric initiator protected against radio frequency and static electrical energies has been provided. It should be understood that the detailed description has been given only for a clear understanding of the invention and therefore no undue limitations are to be construed therefrom.

I claim:

1. In an electric initiator having a metal shell integrally closed at one end and open at the opposite end and containing an ignition composition, an electrical ignition assembly comprising, in sequence from said ignition composition:

(A) a pair of electrical conductors extending into said metal shell and joined at their terminals by a bridgewire contacting said ignition composition,

(B) a plug of a magnetic inductance composition surrounding and contiguous to said electrical conductors adjacent said ignition composition,

(C) a resistance slug having an electrical resistance two to six times that of said bridgewire adjacent said inductance plug, said slug being in contact with said electrical conductors and spaced from said metal shell to provide a spark gap of a width less than the distance between the bridgewire and shell, and

(D) a sealing plug surrounding said conductors and closing said open end of said shell.

2. In an electric initiator having a metal shell integrally closed at one end and open at the opposite end and containing an ignition composition, an electrical ignition assembly comprising, in sequence from said ignition composition:

(A) a pair of electrical conductors extending into the metal shell and joined at their terminals by a bridgewire contacting the ignition composition, said electrical conductors being selected from the group consisting of aluminum-cored stainless steel and copper-cored stainless steel wires,

(B) a plug of a magnetic inductance composition surrounding and contiguous to said electrical conductors adjacent said ignition composition,

(C) a resistance slug having an electrical resistance two to six times that of said bridgewire adjacent said inductance plug, said slug being in contact with said electrical conductors and spaced from said metal shell to provide a spark gap of a width less than the distance between the bridgewire and shell, and

(D) a sealing plug surrounding said conductors and closing said open end of said shell.

3. An electric initiator of claim 2 wherein the electrical conductors are wire having a cross-sectional area of 28% stainless steel clad on 72% copper.

4. An electric initiator of claim 2 wherein the inductance plug is a ferrite bead composed of 24.9 weight percent of nickel oxide, 24.9 weight percent of zinc oxide and 50.2 weight percent of ferric oxide.

5. An electric initiator of claim 1 wherein the resistance slug is a composition selected from the group consisting of a carbon resistance material in an organic binder and a ceramic resistance material.

6. An electric initiator of claim 1 wherein the inductance plug has an inductance of at least one microhenry.

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