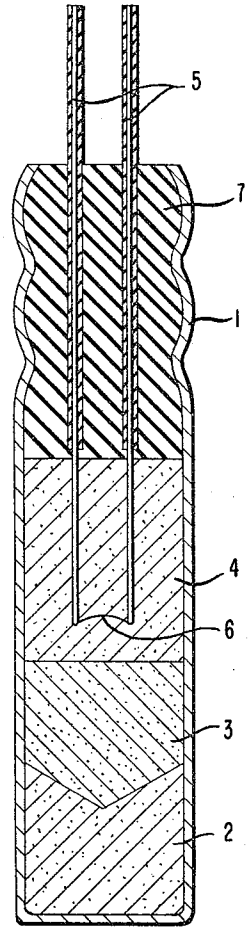
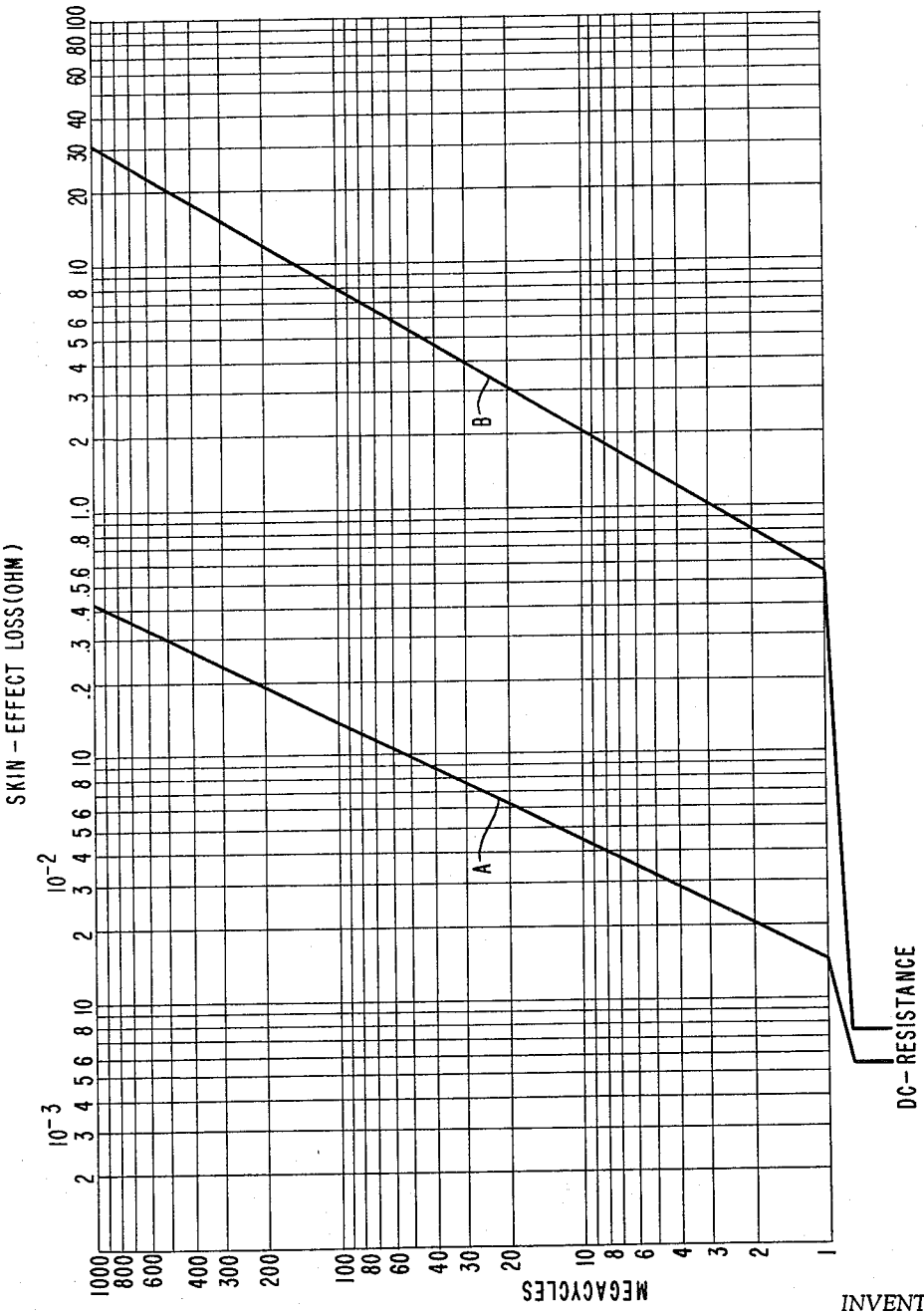
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IGNITION ASSEMBLY RESISTANT TO ACTUATION BY RADIO FREQUENCY AND ELECTROSTATIC ENERGIES
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FIG. 1



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FIG. 2



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IGNITION ASSEMBLY RESISTANT TO ACTUATION BY RADIO FREQUENCY AND ELECTROSTATIC ENERGIES

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The present invention relates to an electric ignition assembly 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 without substantially increasing the base cost of the device.

It has been found that electric initiators can be protected against accidental firing as a result of extraneous electricity without modifying normal manufacturing methods, by using electrical conductors having high skin-effect loss as the lead or leg wires. In conventional electric initiators, insulated copper wires generally are used as the electrical conductors. However, copper wire has comparatively low skin-effect loss and therefore offers very little protection against extraneous electricity.

The present invention provides an electric ignition assembly employing as its lead wires electrical conductors having high skin-effect loss. It further provides an electric initiator which is protected against accidental firing by radio frequency and static electrical energies by such an ignition assembly. The initiator comprises a shell integrally closed at one end and open at the opposite end, and containing in sequence from said closed end—

(A) A base charge,

(B) A priming charge contiguous to said base charge,

(C) An ignition composition contiguous to said priming charge, and

(D) An electrical ignition assembly comprising a sealing plug closing the open end of the shell, a pair of spaced electrical conductors having high skin-effect loss extending through said plug and into said shell, and a bridgewire joining the terminals of said conductors and contacting said ignition composition.

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

FIGURE 1 is a cross-sectional elevation view of a radio frequency and static protected electric initiator of this invention; and

FIGURE 2 is a graph comparing the skin effect losses of copper wire with those of a leg wire contemplated by this invention.

Referring now to FIGURE 1, **1** designates a shell of metal or plastic which has one closed and one open end. In sequence from said closed end, there is placed within 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 insulated electrical conductors **5** possessing high skin-effect loss, e.g., wire composed (exclusive of insulation) of a cross-sectional area of 28% stainless steel clad on 72% copper or a solid magnetic wire, joined at their terminals by an electrical conductor of high resistance, i.e., bridgewire **6**, which contacts ignition composition **4**. The open end of the shell **1** is closed by a sealing plug **7** composed of any suitable solid material, e.g., rubber.

All parts of the ignition assembly and initiator of this

invention, with the exception of the electrical conductors, are conventional.

The skin-effect loss of a wire is the increase in its resistance at high frequencies. The protection against accidental firing is quite adequate for most purposes if the quotient of the wire's radio frequency resistance divided by its direct current resistance is at least about 25 at one megacycle. At one megacycle, a 0.0254 inch diameter copper wire has a radio frequency resistance 2.7 times greater than its direct current resistance. By comparison, the resistance of the above lossy stainless steel-copper conductors increases 72 times when the frequency increases from zero to 1 megacycle. Such electrical conductors are therefore $72/2.7 \approx 27$ times better than pure copper wire at 1 megacycle.

The conductors can be wires composed of any conductive metal core, preferably copper or aluminum, coated with an alloy exhibiting high permeability and resistivity. The higher the product of the alloy's permeability and resistivity the greater the skin-effect loss and the protection against firing by radio frequency and static electrical energies. For example, when the alloy is coated on a highly conductive metal core such as copper or aluminum, this product should be about 10^{-10} ohm henry to provide an increase in resistance of about 25. The preferred coating consists of, by weight, a chrome (14–18%)-iron (85–81%) alloy, comprising 28% of the wire's cross section. Also, the electrical conductors can be any solid magnetic wire with a high quotient, preferably about 10^4 (henry ohm^{-1} meter^{-2}), when its permeability is divided by its resistivity, e.g., a wire composed of 78.5% Ni-21.5% Fe or 79% Ni-5% Mo-16% Fe. Such conductors give an increase in resistance of at least about 25.

FIGURE 2 is a graphical illustration which compares the skin-effect loss of a 4-in.-length of 0.025 in.-diameter copper wire (A) and a wire of the same diameter and length composed of a cross-sectional area of 28% stainless steel (14–18% Cr, 85–81% Fe, no more than 1% impurities) clad on 72% copper (B). From the graph it can be observed that the R.F. losses of (B) increase greatly from D.C. to one mc. (megacycle), therefore protection is assured in the broadcast band and improves even more at higher frequencies.

The following examples illustrate the invention:

EXAMPLE 1

Table I shows the radio frequency loss resistances of different lengths of leg wires having the cross-sectional composition described above in connection with FIGURE 2 and represented in the table by B. The indicated R.F. resistances are based on Q-meter measurements.

Table I

Length of Cap Leg Wire (ft.)	D.C. Resistance with 22 gage B wire (ohm)	R.F. Resistance of B at 1 mc. (ohm)	R.F. Resistance of B at 5 mc. (ohm)
1	0.044	3.18	8.4
2	0.088	6.36	16.8
4	0.177	12.7	33.6
6	0.265	19.1	50.4
8	0.353	25.4	67.2
10	0.442	31.8	84.0
12	0.531	38.2	101
14	0.619	44.5	118
16	0.707	50.5	134
20	0.884	63.6	168
24	1.061	76.4	202
30	1.326	95.4	252
40	1.768	127.2	336

The resistance of the stainless steel layer is much higher than that of the copper core and can be neglected where direct current flows in the copper. Since 22 gage (0.0254-

inch-diameter) B wire has a copper core of 72% of cross section, its resistance at direct current is therefore $\frac{1}{0.72}$ or 1.39 times higher than that of a pure copper wire (0.0162 ohm/ft.) of the same gage.

The protection factor of an electric initiator is obtained from the following relationship.

$$\text{Protection factor} = \frac{\text{R. F. energy into cap to fire}}{\text{D. C. energy into cap to fire}} = \frac{\text{bridgewire resistance} + \text{R. F. resistance of the leg wires}}{\text{bridgewire resistance} + \text{D. C. resistance of the leg wires}}$$

Since energy in each case equals I^2Rt and the current which must pass through the bridgewire of a given cap to cause initiation is a constant, it is readily seen that the protection factor for an initiator is equal to (the R.F. resistance of the leg wires plus the bridgewire resistance) divided by (the D.C. resistance of the leg wires plus the bridgewire resistance). Consequently, for a conventional cap having a 1 ohm bridgewire and 6 ft. leg wires (B), the protection factor at 1 megacycle is 20.1/1.265 (see Table I), which equals approximately 16. Thus, at 1 mc., 16 times more energy than the actual bridge firing energy must be fed into a 6 ft. leg cap in order to fire it.

EXAMPLE 2

Table II shows leg-to-leg static tests of pure copper wire and of the same wire (B) employed in Example 1. The tests were conducted by applying the indicated potential to a capacitor of 800 picofarads and then discharging it to ignite the bead. The normalized protection factor was based on arbitrarily assigning the value of 1 unit to the 6" copper wire which offered almost no protection against extraneous electricity. Increasing the copper wire from 6" to 8 ft. gave only about 15% more protection, but when the copper wire was replaced by (B) as shown in Table II, the protection tripled.

Table II

Material	Potential, kv.	Energy to Fire, ws.	Normalized Protection Factor
Ignition bead with 6" copper wire	14.4	0.083	1
Ignition bead with 8 ft. copper wire	15.5	0.096	1.16
Ignition bead with 8 ft. (B) wire	26.2	0.254	3.06

This example shows that electrostatic discharges, which are transients of some microseconds duration, are attenuated in the stainless steel layer.

I claim:

1. An electric initiator protected against accidental firing by radio frequency and static electrical energies comprising a shell integrally closed at one end and open at the opposite end, and containing in sequence from said closed end

(A) a base charge,

(B) a priming charge contiguous to said base charge,

(C) a heat-sensitive ignition composition contiguous to said priming charge, and

(D) an electrical ignition assembly comprising a sealing plug closing the open end of the shell, a pair of spaced electrical conductors extending through said plug and into said shell, the radio frequency resistance of said conductors at one megacycle being at least about 25 times their direct current resistance, and a bridgewire joining the terminals of said conductors and contacting said ignition composition.

2. An electric initiator of claim **1** wherein said electrical conductors are solid magnetic wires having a quotient of permeability divided by resistivity of at least 10^4 (henry ohm^{-1} $meter^{-2}$).

3. An electric ignition assembly for explosive initiators, comprising a pair of electrical conductors separated from each other by insulation and connected to each other at one of their ends by a bridgewire, the radio frequency resistance of said conductors at one megacycle being at least about 25 times their direct current resistance.

4. An ignition assembly of claim **3** wherein the conductors are composed of a cross-sectional area of 28% stainless steel clad on 72% copper, said stainless steel consisting essentially of 14–18% chromium and 85–81% iron.

5. An electric initiator protected against accidental firing by radio frequency and static electrical energies, comprising a shell integrally closed at one end and open at the opposite end, and containing in sequence from said closed end

(A) a base charge,

(B) a priming charge contiguous to said base charge,

(C) a heat-sensitive ignition composition contiguous to said priming charge, and

(D) an electric ignition assembly comprising a sealing plug closing the open end of the shell, a pair of spaced electrical conductors extending through the plug and into the shell, and a bridgewire joining the terminals of the electrical conductors and contacting the ignition composition, said conductors being wires composed of a conductive metal core of the group consisting of copper and aluminum coated with an alloy having a product of permeability and resistivity of at least 10^{-10} ohm henry.

6. An electric initiator of claim **5** wherein said electrical conductors are wires composed of a cross-sectional area of 28% stainless steel clad on 72% copper, said stainless steel consisting essentially of 14–18% chromium and 85–81% iron.

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