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U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

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DEVELOPMENT OF RF-PROTECTED ELECTRO-EXPLOSIVE DEVICES

Picatinny Arsenal
Dover, New Jersey

May 64

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TECHNICAL MEMORANDUM 1258

DEVELOPMENT
OF
RF-PROTECTED ELECTRO-EXPLOSIVE DEVICES

BY

FREDERICK M. CORRELL

MAY 1964

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PICATINNY ARSENAL
DOVER, NEW JERSEY

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ACKNOWLEDGMENT

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NOTE

This Technical Memorandum was presented as a paper at the Second HERO Congress on Hazards of Electromagnetic Radiation to Ordnance sponsored by U.S. Naval Weapons Laboratory, Dahlgren, Virginia, and held at The Franklin Institute, Philadelphia, Pennsylvania, 30 April to 2 May 1963.

ABSTRACT

To alleviate the possibility of premature initiation or change in reliability of an electro-explosive device (EED) due to radio frequency (RF) energy, Picatinny Arsenal endeavored to make all EEDs RF-protected. This is being accomplished by substituting a plug composed of RF absorbing material in place of the usual plastic sealing plug through which the lead wires enter the EED. To date, the T24E1, M36A1, XM66E2, T77, T77 conductive mix, M51 Detonators, the M2 Squib, the M6 Blasting Cap and the MK2 MOD 0, MK7 MOD 0 Ignition Elements have been provided with the phosphatized powdered iron attenuating plugs.

DEVELOPMENT OF RF-PROTECTED ELECTRO-EXPLOSIVE DEVICES

Many EEDs utilized in weapon systems have shown vulnerability to electromagnetic radiation emanating from radio and radar transmitters. The results of a premature initiation of an EED can be the unprogrammed launching of a missile, detonation of a warhead, premature stage separation, or any one of a series of events commenced by an EED. Also, an EED can be rendered unreliable after being subjected to current below the firing level for an extended period of time. This is no less serious than premature initiations in some systems.

To alleviate the possibility of premature initiation or change in sensitivity of an EED due to electromagnetic energy, Picatinny Arsenal has endeavored to make all EEDs "RF-protected". The most obvious solution is to discard all EEDs and utilize non-electric initiators only. However, the many advantages inherent to EEDs such as small size, light weight, low cost, reliability and relative simplicity made them highly desirable when compared with non-electric initiators.

In a study of solid-state materials, it was observed that some of these materials act as broadband RF absorbers or attenuators. The advantages of utilizing attenuator materials for RF protection are many. First, these materials can be incorporated within the existing exterior configurations of initiators with no great difficulty and at reasonable cost. This is accomplished by substituting a plug composed of the attenuating material in place of the plastic sealing plug through which the lead wires pass. No external device or fitting is necessary thus eliminating the possibility of a faulty assembly which would provide no RF attenuation, or possibly even attenuate or short out a normal firing pulse. Since the material compressed into the attenuating plug is a single component device, it is far more reliable than multi-component filtering devices. Another advantage is there are no resonant points. Other important advantages in the utilization of RF attenuators are that this approach can be universally applied to all initiators; no additional space or weight requirement is necessary; and this is a low cost solution.

Requirements for the RF attenuating material to be utilized in EEDs were set up as follows:

1. It must provide adequate attenuation of RF energy.

2. It must not significantly alter the normal firing response of the EED.

3. It must be easily molded or formed into configurations and sizes similar to those of the plug it replaces.

4. When assembled into an EED, the EED must still be capable of passing all functioning, reliability, environmental stability, rough handling and other required MIL Standard Tests.

5. In all, the attenuator plug must meet all of the requirements met by the original plastic plug and, in addition, must provide significant RF absorption.

The material selected was phosphated powdered iron which originally was mixed with epoxy resin binder and molded at high pressures. However, product refinement by The Franklin Institute has led us to a standardized product prepared as follows: The iron powder utilized is pure 10-micron iron powder made by the carbonyl process. Then the iron powder is insulated by wetting with acetone, adding a stock solution of dilute phosphoric acid to the wetted powder and stirring until dry under a heat lamp. The molding powder is pressed into plugs at pressures well over 50,000 psi. These high pressures are necessary so the concentration of iron powder in the plug will be high and high attenuation values are obtained. This is exemplified in Figure 1 which shows the dependency of attenuation upon density by the very steep slope of the curve.

The first item to be provided with RF protection was the T24E1 Detonator (Figure 2). This detonator was the first to be provided with protection because it was the most sensitive (an all-fire energy of 500 ergs) Army wirebridge EED. The lead wires which pass through the phenolic plug are kinked. Figure 3 shows the attenuated T24E1 Detonator. The phenolic plug was eliminated and an attenuator plug substituted. There is absolutely no difference in the shape or dimensions of the plug or of the initiator. The only difference is that the lead wires are now tapered instead of being kinked. This change was necessary because the high pressure necessary for molding the attenuator plug caused breaks in the kinked wires. Insofar as pull-out strength is concerned there was no loss. Results of extensive engineering tests on the RF-protected T24E1 Detonator showed that there is absolutely no difference between these two detonators except that the attenuated detonator provides about 20 db of attenuation at 500 mc whereas the original detonator provided none. Figure 4 shows attenuation vs. frequency for the 0.13-inch RF attenuator plugs for the T24E1. Note how the steep slope of the curve gives us very high attenuation values at high frequencies but very low attenuation at low frequencies. We are attempting to correct this low frequency deficiency. The RF-protected T24E1 Detonator has entered the production engineering phase of its development. The T20E1 Detonator in Figure 5 has been provided with RF protection in the same manner (Figure 6).

This detonator is very similar to the T24E1 Detonator except that the spot charge is colloidal lead azide instead of milled lead styphnate, which makes the normal functioning energy 5,000 ergs rather than 500 ergs as required for the T24E1 Detonator.

The T77 Wirebridge, Button-Type Electric Detonator is in Figure 7. This detonator was the first of its kind to be provided with RF protection. The changes in design for the RF-protected T77 Detonator included deletion of the formvar coating and araldite bonding between the pin and plug; and the addition of a steel cup for holding the attenuator which was required for assembling the bridgewire (Figure 8). Figure 9 demonstrates the attenuation vs. frequency for the 0.125 inch-long plugs. A pilot lot testing program, carried out with the RF-protected T77 Detonator, proved it to be practically identical with the unattenuated version in functioning, sensitivity, environmental stability and ability to withstand rough handling. RF attenuators have been provided for the MK2 MOD 0 and MK7 MOD 0 Ignition Elements under Navy sponsorship (Figure 10). Figure 11 shows the RF-protected version of the MK7 MOD 0. Modification of the MK7 MOD 0 electrode to a tapered shape was to permit molding the attenuator plug and also to permit the element to withstand the 50,000 psi blowback test. The groove added below the tapered portion holds the attenuating material in place during assembly. Complete functioning, sensitivity, reliability and rough handling tests have established that there is no difference in performance with this RF-protected ignition element in comparison with the unprotected version except that it provides the attenuation shown in Figure 12.

RF attenuators have been provided for the M6 Blasting Cap, M2 Squib, M36A1 Detonator, XM66E2 Detonator, M51 Detonator, and T77 Conductive Mix Detonator. However, extensive pilot lot studies have not been conducted on these items.

The new Army M6 Electric Blasting Cap is in Figure 13. Figure 14 shows the RF-protected M6 Blasting Cap. The attenuation provided by the attenuator plug is necessarily much greater than any of those before mentioned because of its almost three-fold length increase over the longest attenuator plug incorporated into the EEDs to this time. Figure 15 demonstrates the attenuation vs. frequency for the 0.8 inch-long RF-attenuated M6 Blasting Cap plug.

Production Engineering studies are being planned for the RF-protected version of the M2 Squib utilized in many rocket igniters and the M36A1 Detonator utilized in VT Fuzes. The RF-protected versions of the M2 Squib and M36A1 are in Figure 16 and 17, respectively. Also the XM66E2 Detonator, utilized in the Type 19 Spotting Device, has recently been provided with RF protection.

All of the previously described EEDs which have been provided with RF protection were wirebridge, wirelead items except for the T77 Detonator and the MK 2 Mod 0 and MK 7 Mod 0 ignition elements. Studies have been conducted on a piggy-back design of the phosphatized iron on top of Bakelite for the RF-protected M51 Carbon Bridge, Wire Lead Detonator (Figure 17). Also an attenuated face gap plug design with a spot charge of gold and colloidal lead azide to make up an RF-protected T77 Conductive Mix Detonator has been studied (Figure 18).

Studies are being made to incorporate ferrites such as Cerramag 27 and T1 into the T24E1 Detonator, M2 Squib and M6 Blasting Cap. These materials exhibit superior low frequency attentuation to that provided by the present phosphated iron. It has been shown that these materials provide, at frequencies below 100 mcs, at least a five-fold increase in attenuation over that provided by the phosphated powdered iron. We are also studying organic polymeric semi-conductors which show promise of good broadband attenuation under contract with Midwest Research Institute. Thus Picatinny Arsenal is continually advancing towards the goal of providing EEDs with RF-absorbing plugs having attenuation values of at least 20 db, from 10 kilocycles to 10 kilomegacycles.

The work previously described was carried out with support from The Franklin Institute, Atlas Chemical Industries and Atlantic Research Corporation.

Our goal is to provide the munitions designer with safe, reliable EEDs which are safe from electromagnetic radiation. At the present time we can come close to realizing this goal with the promise of coming even closer in the near future. In the meantime, we are doing our utmost to make available the products of the present state-of-the-art.

APPENDIX

APPENDIX A

FIGURES

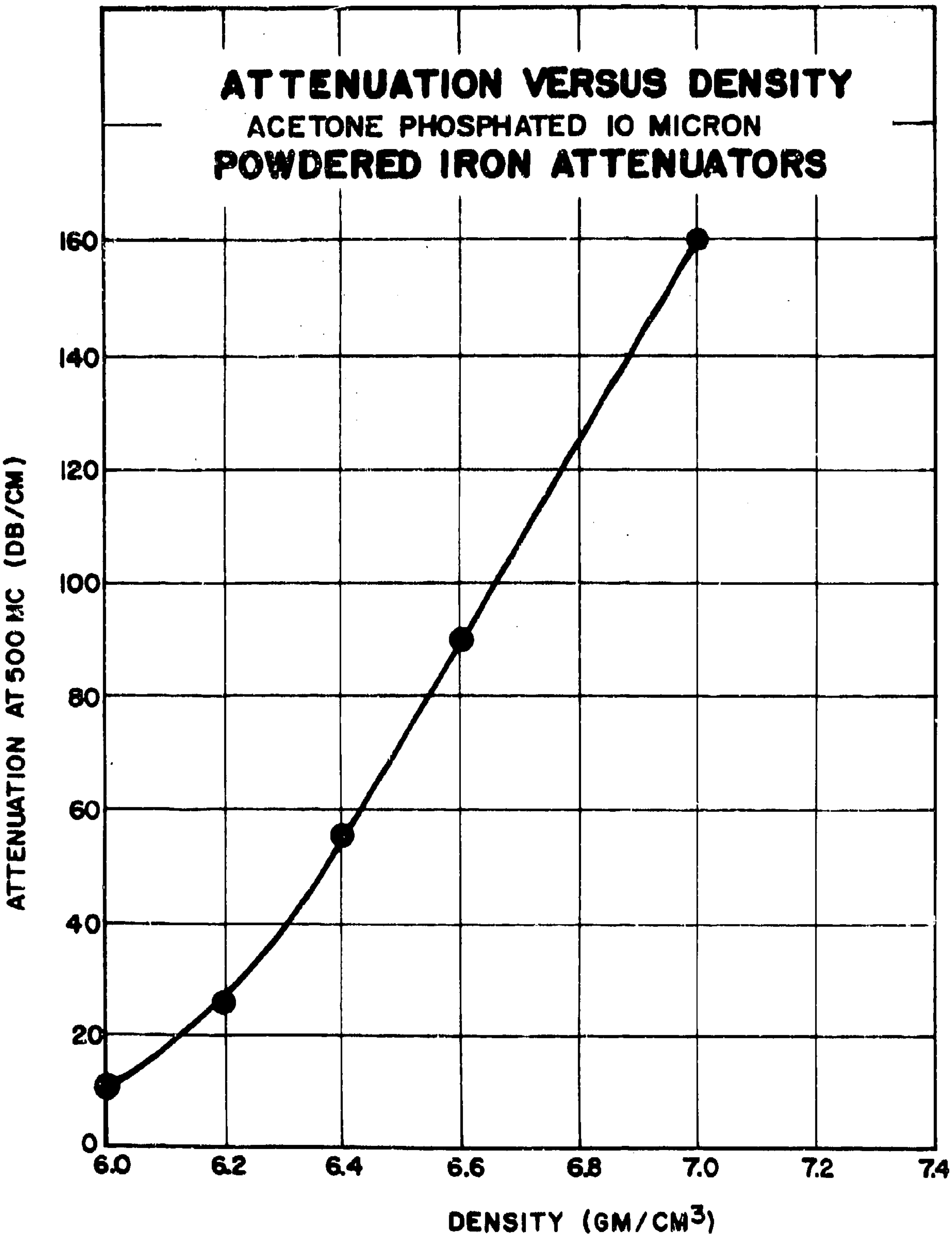
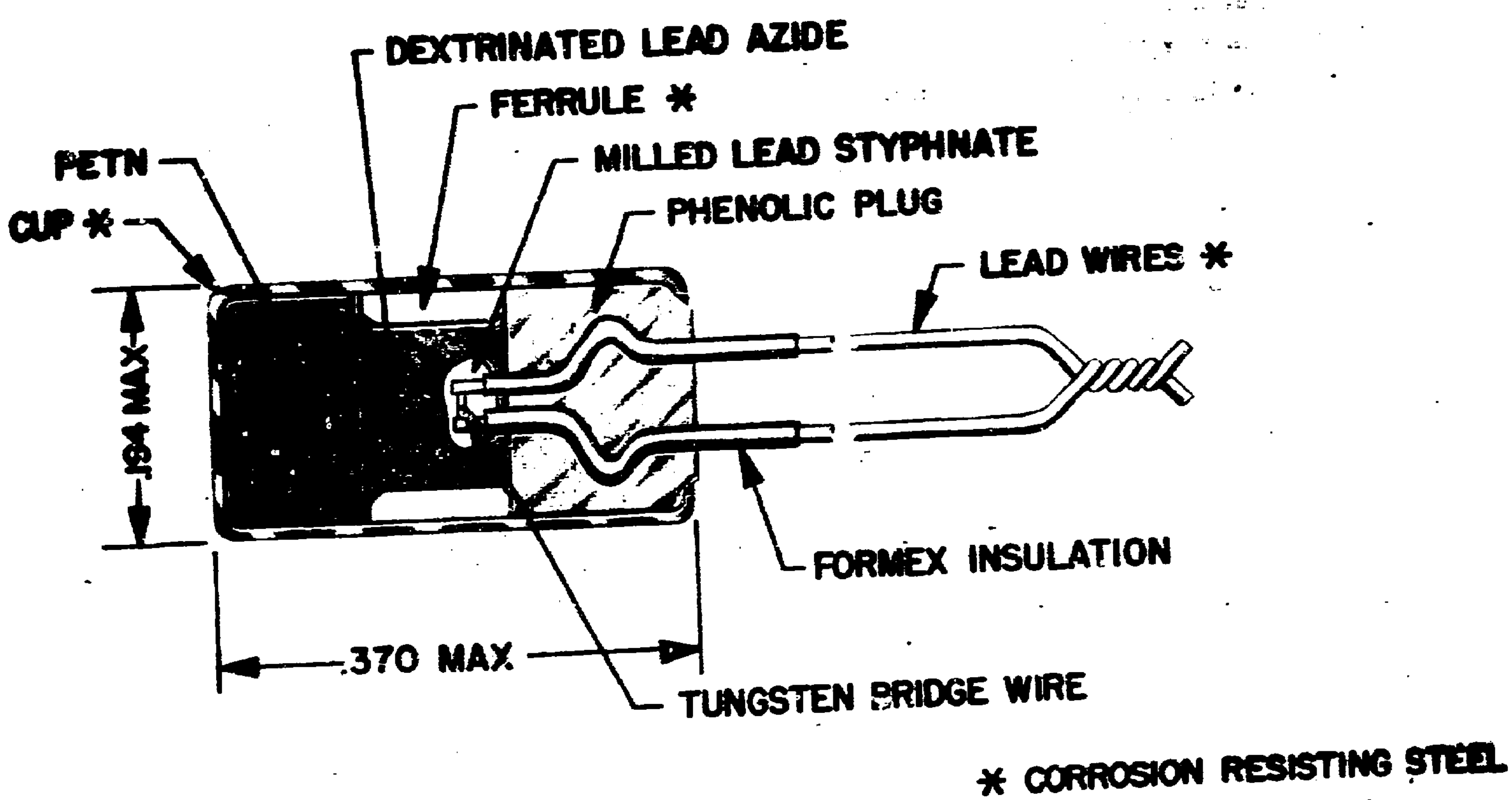
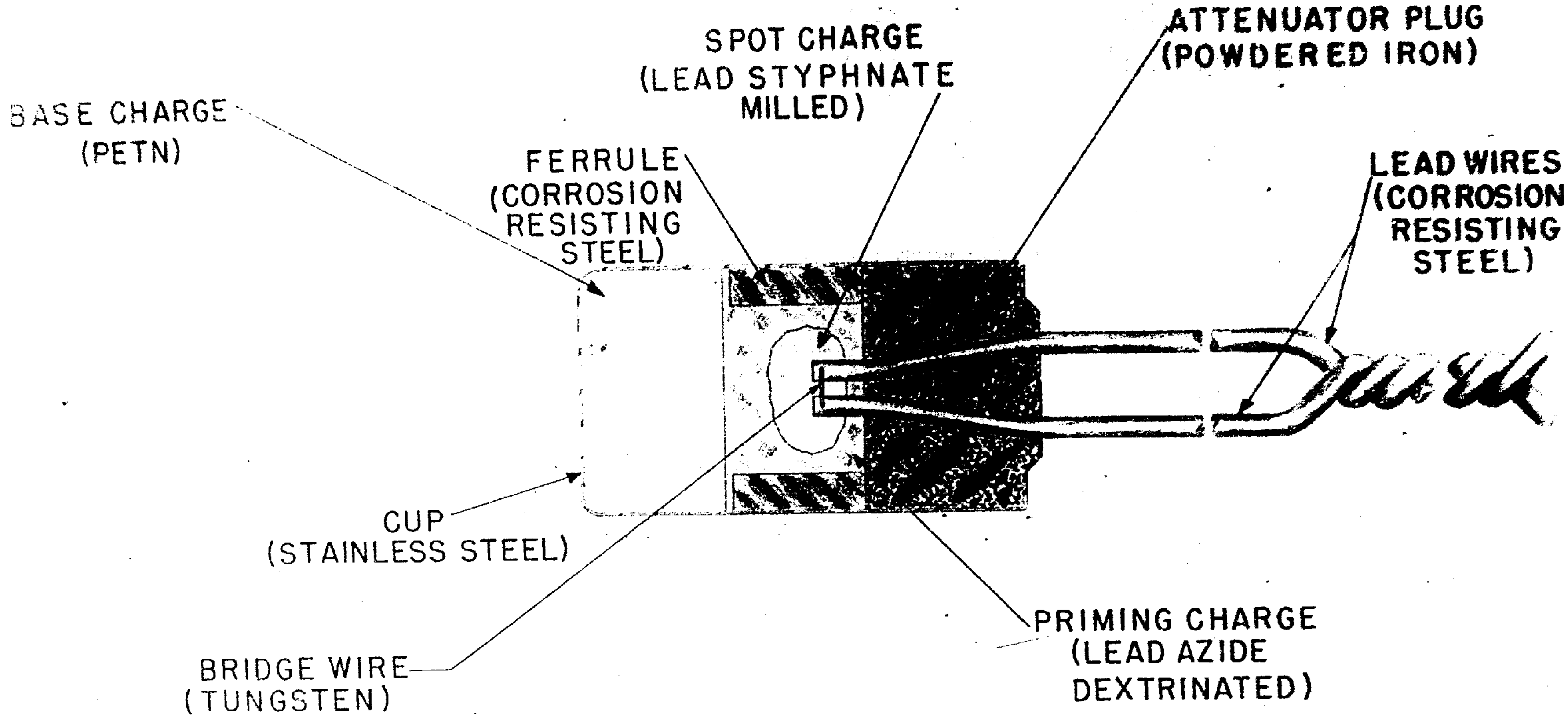

ATTENUATION VERSUS DENSITY
ACETONE PHOSPHATED 10 MICRON
POWDERED IRON ATTENUATORS
ATTENUATION AT 500 MC (DB/CM)
0
20
40
60
80
100
120
140
160
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
DENSITY (GM/CM3)

Figure 1



T24 EI ELECTRIC DETONATOR

Figure 2



T24E1 DETONATOR
ATTENUATED

Figure 3

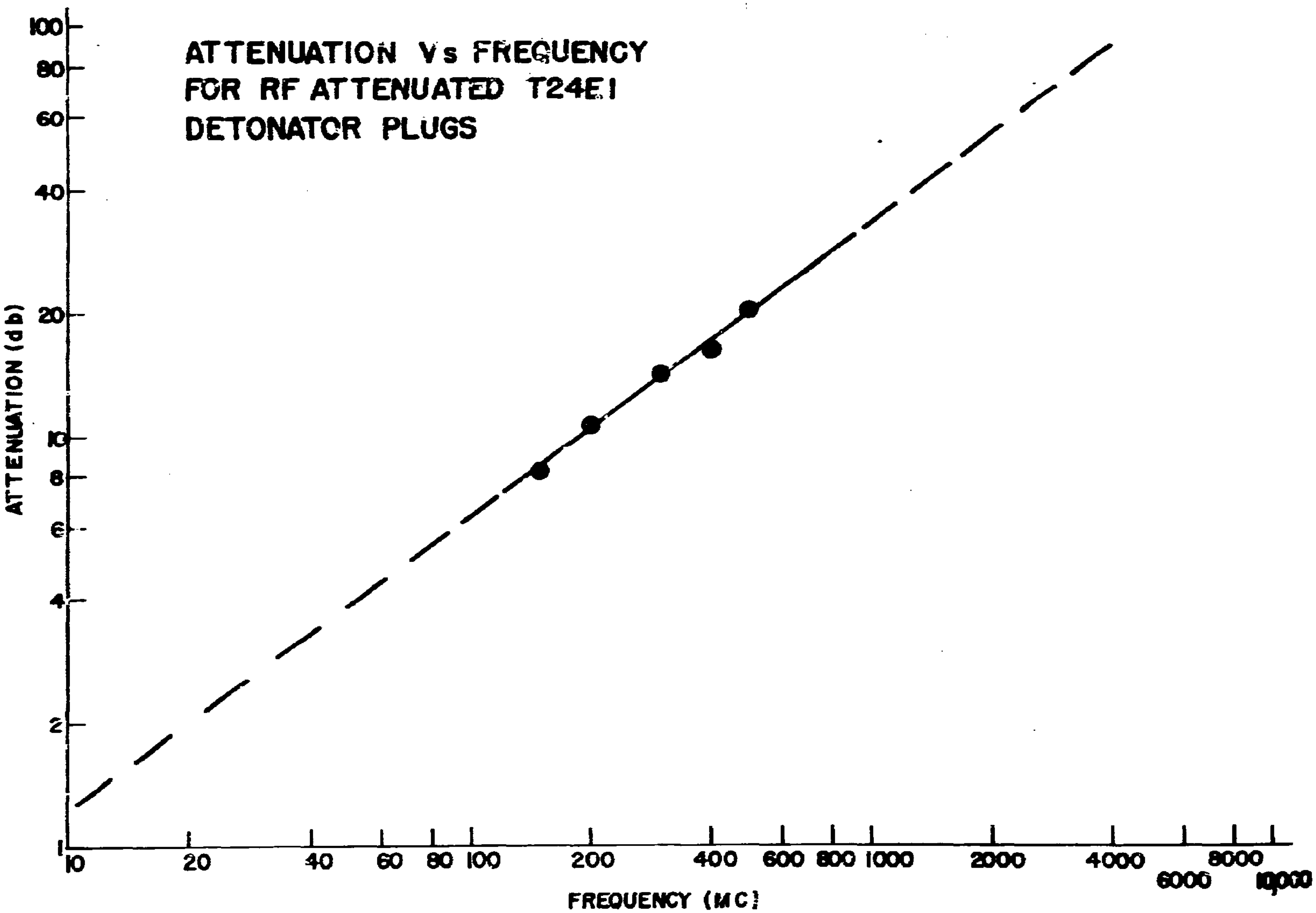
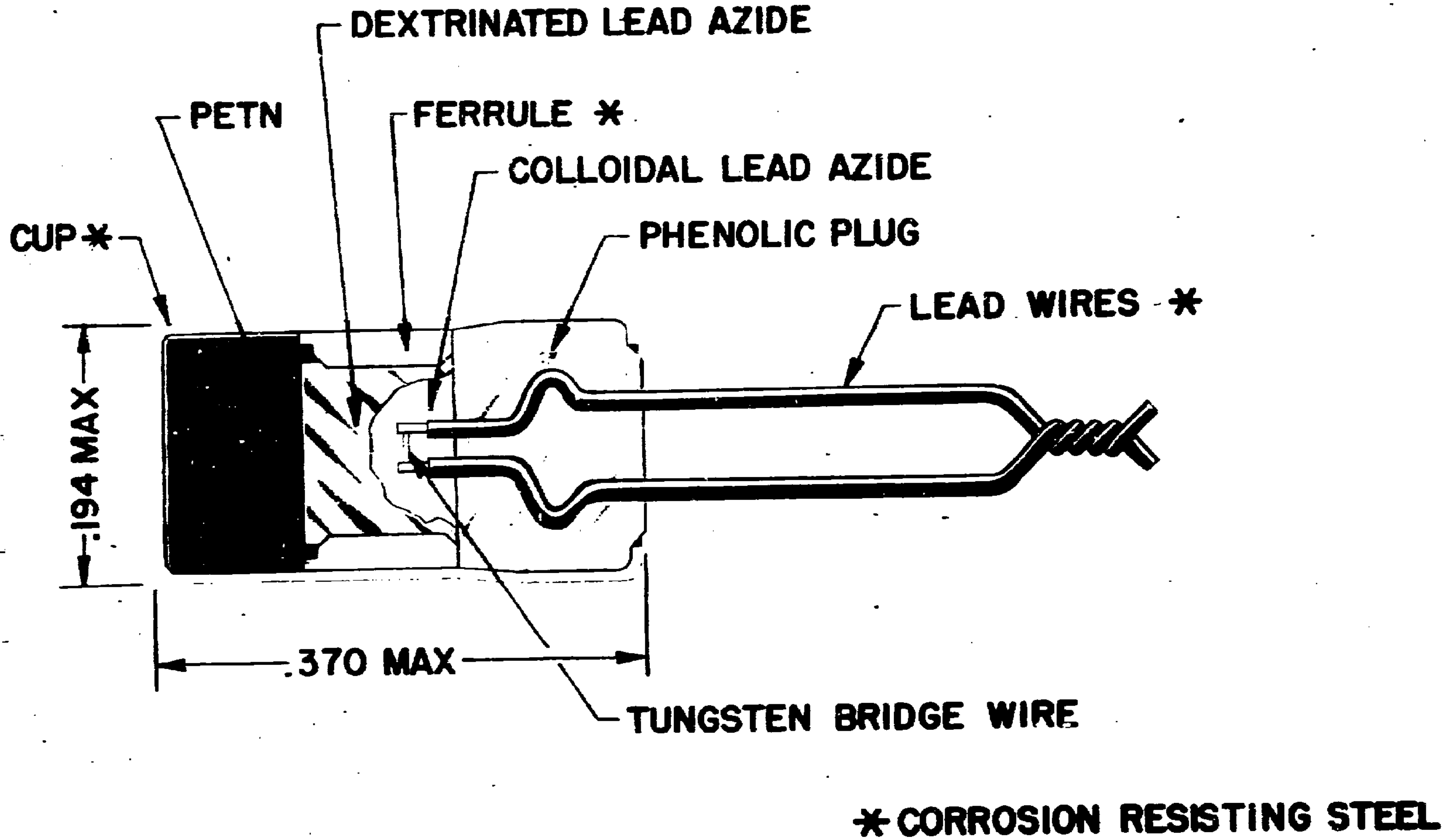
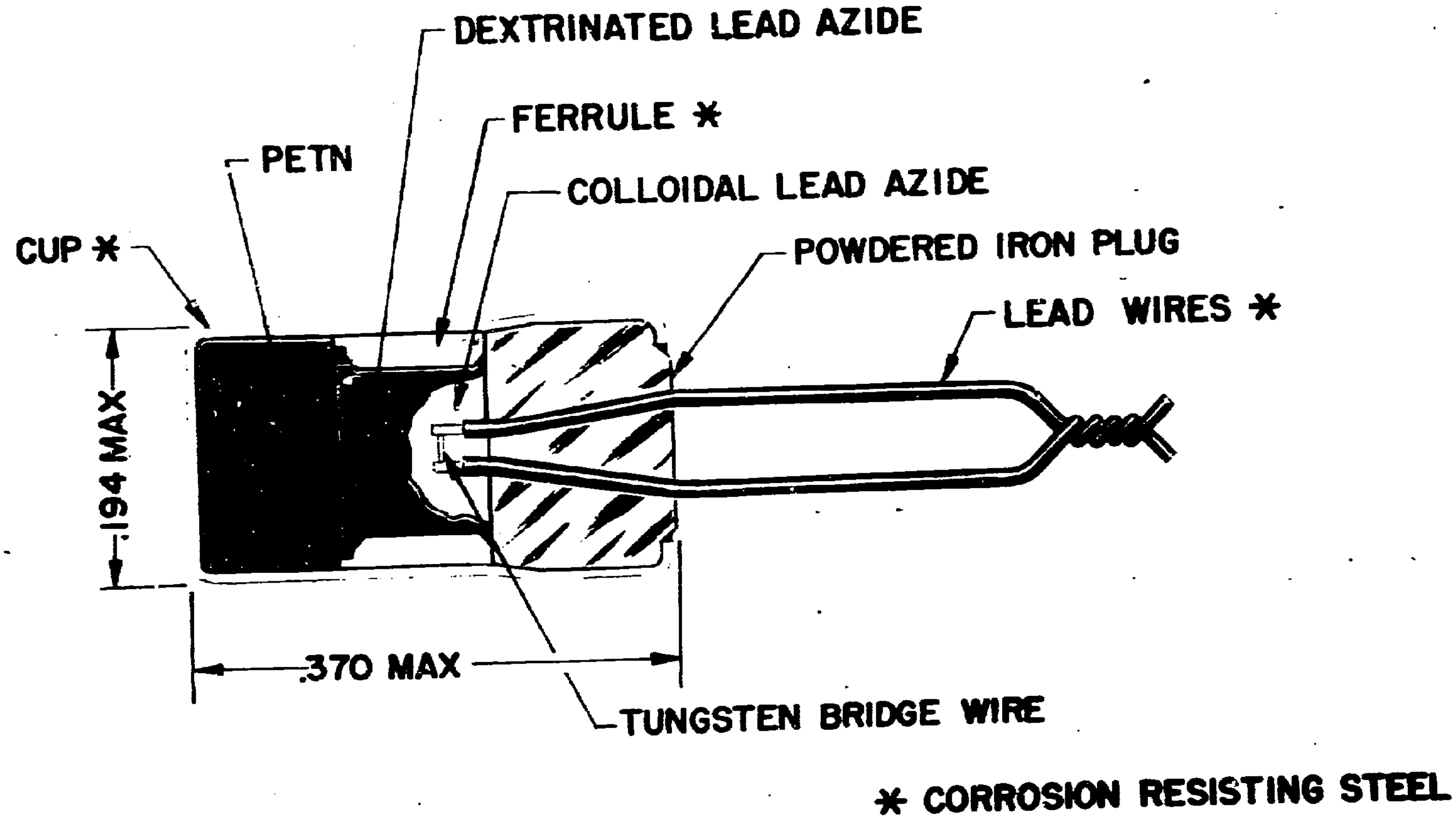

ATTENUATION Vs FREQUENCY
FOR RF ATTENUATED T24E1
DETONATOR PLUGS
ATTENUATION (db)
100
80
60
40
20
10
8
6
4
2
1
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
6000
8000
10000
FREQUENCY (MC)

Figure 4



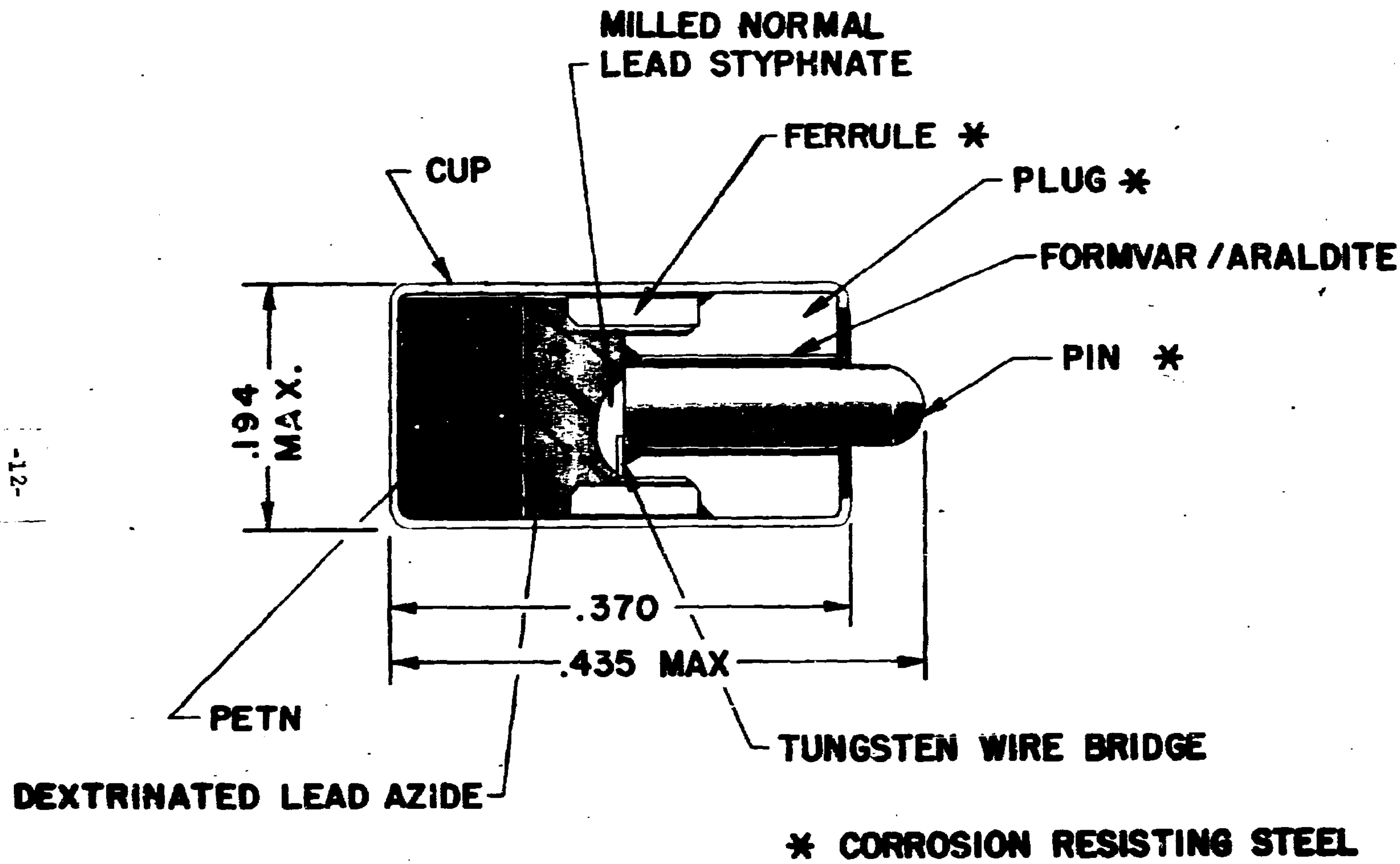
T20E1 ELECTRIC DETONATOR

Figure 5



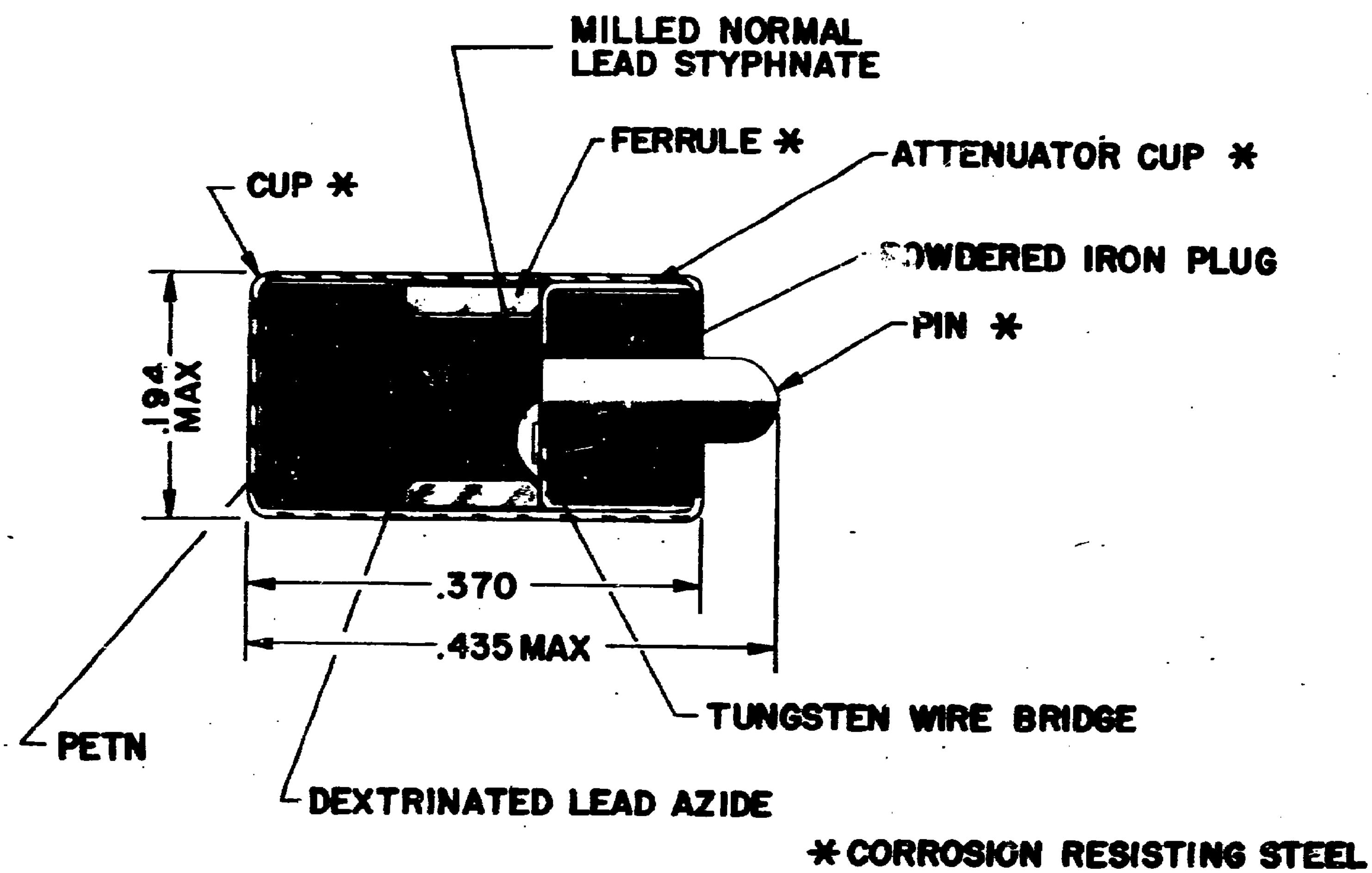
RF PROTECTED T20E1 ELECTRIC DETONATOR

Figure 6



T77 ELECTRIC DETONATOR

Figure 7



RF PROTECTED T 77 ELECTRIC DETONATOR

Figure 8

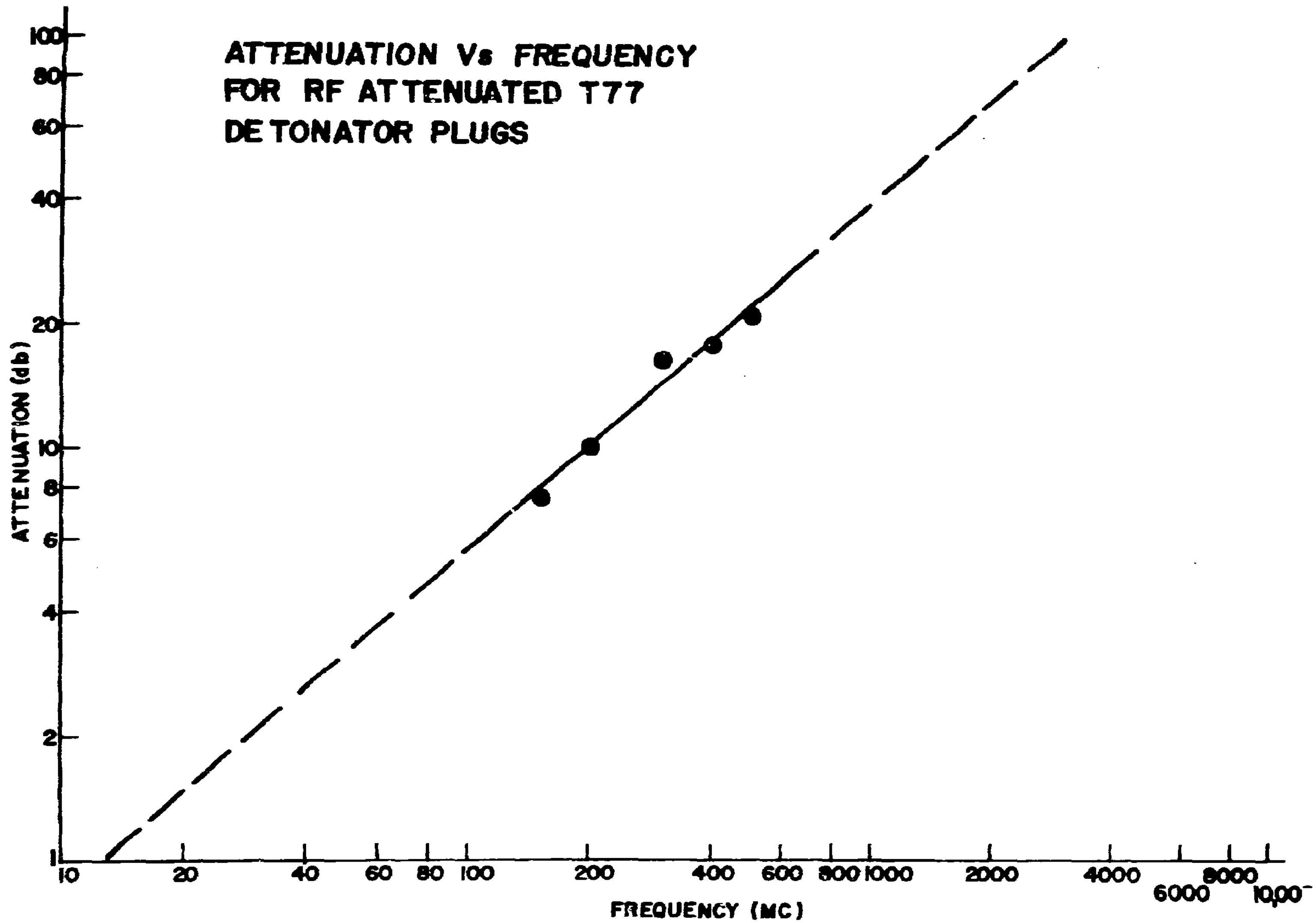
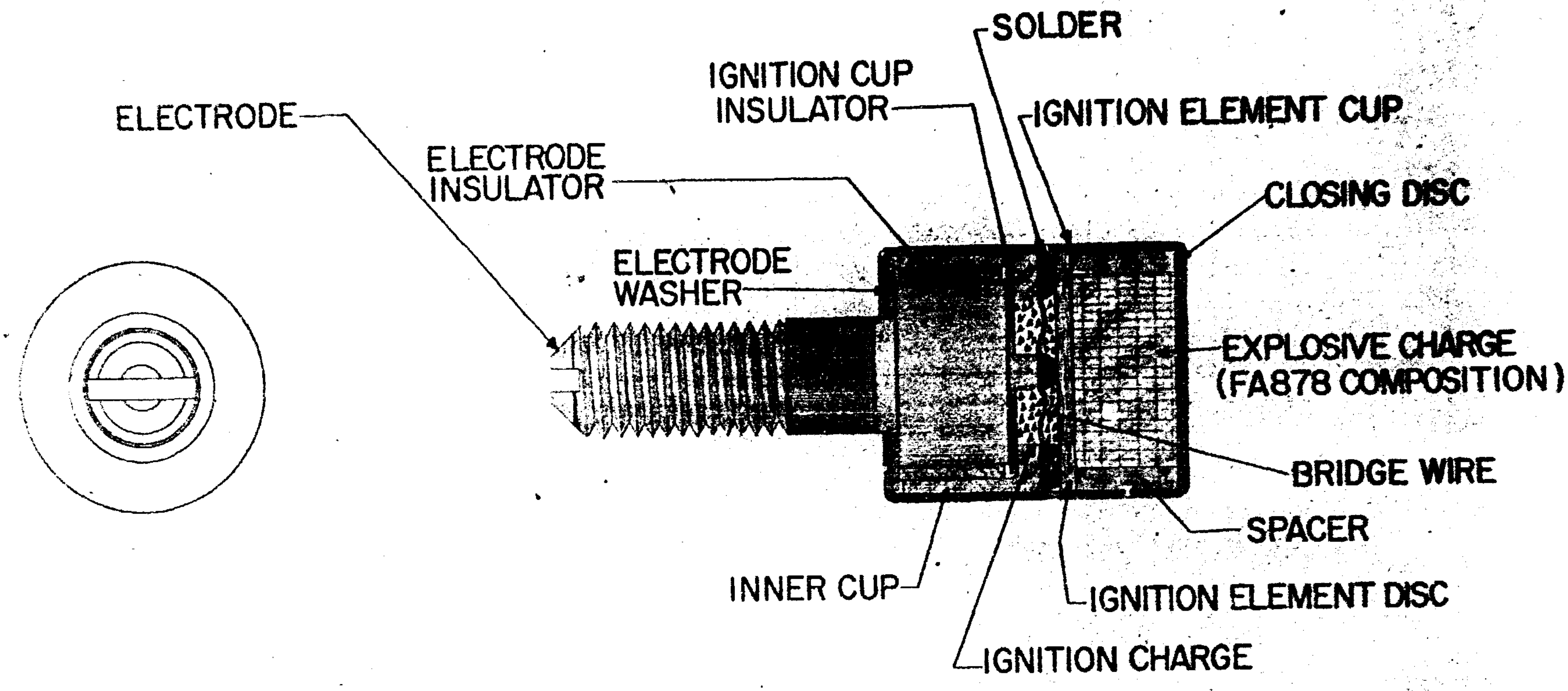
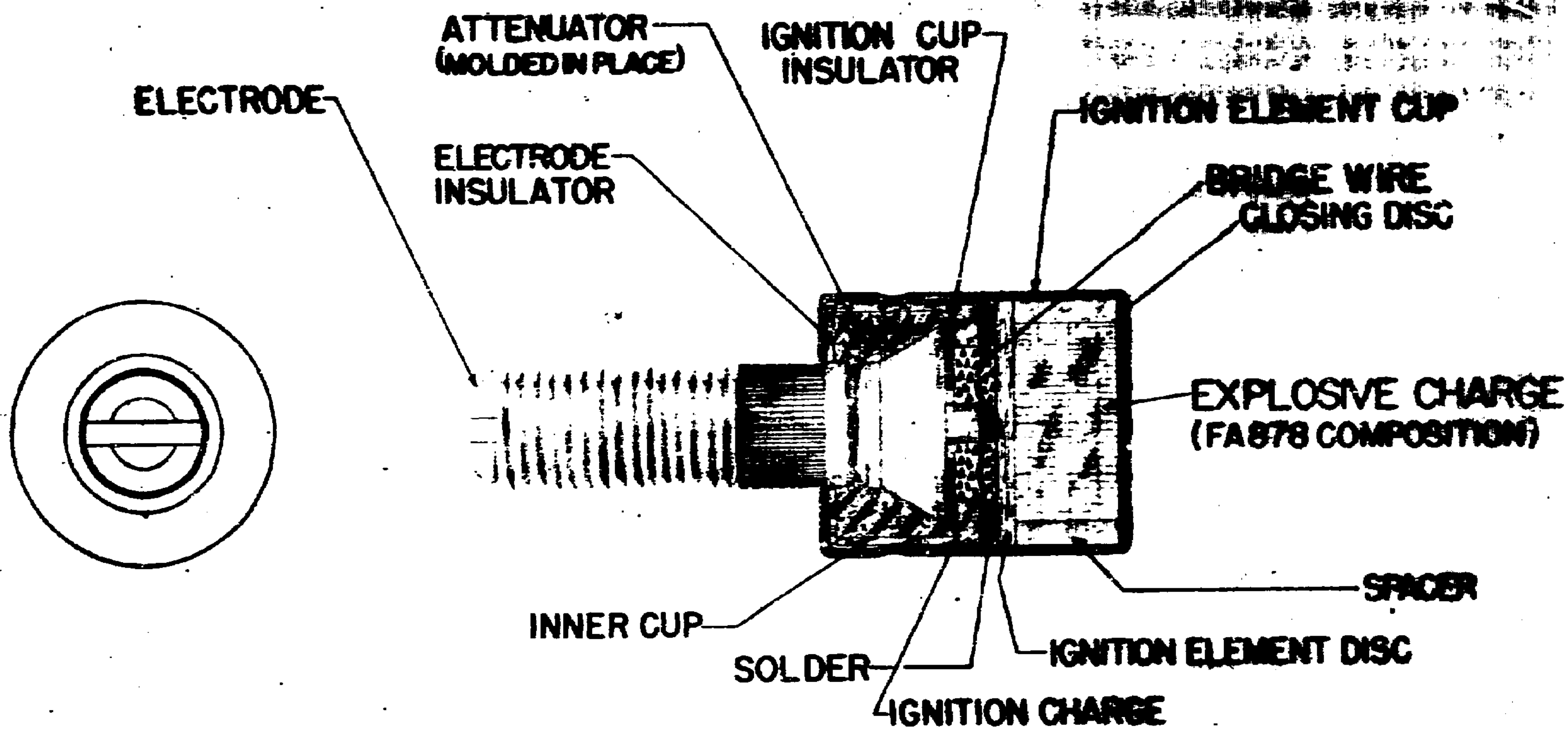

ATTENUATION Vs FREQUENCY
FOR RF ATTENUATED T77
DETONATOR PLUGS
ATTENUATION (db)
100
80
60
40
20
10
8
6
4
2
1
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
6000
8000
10,00
FREQUENCY (MC)

Figure 9



MK-7-MOD 0 ASSEMBLY

Figure 10



ATTENUATED MK-7-MOD-O ASSEMBLY

Figure 11

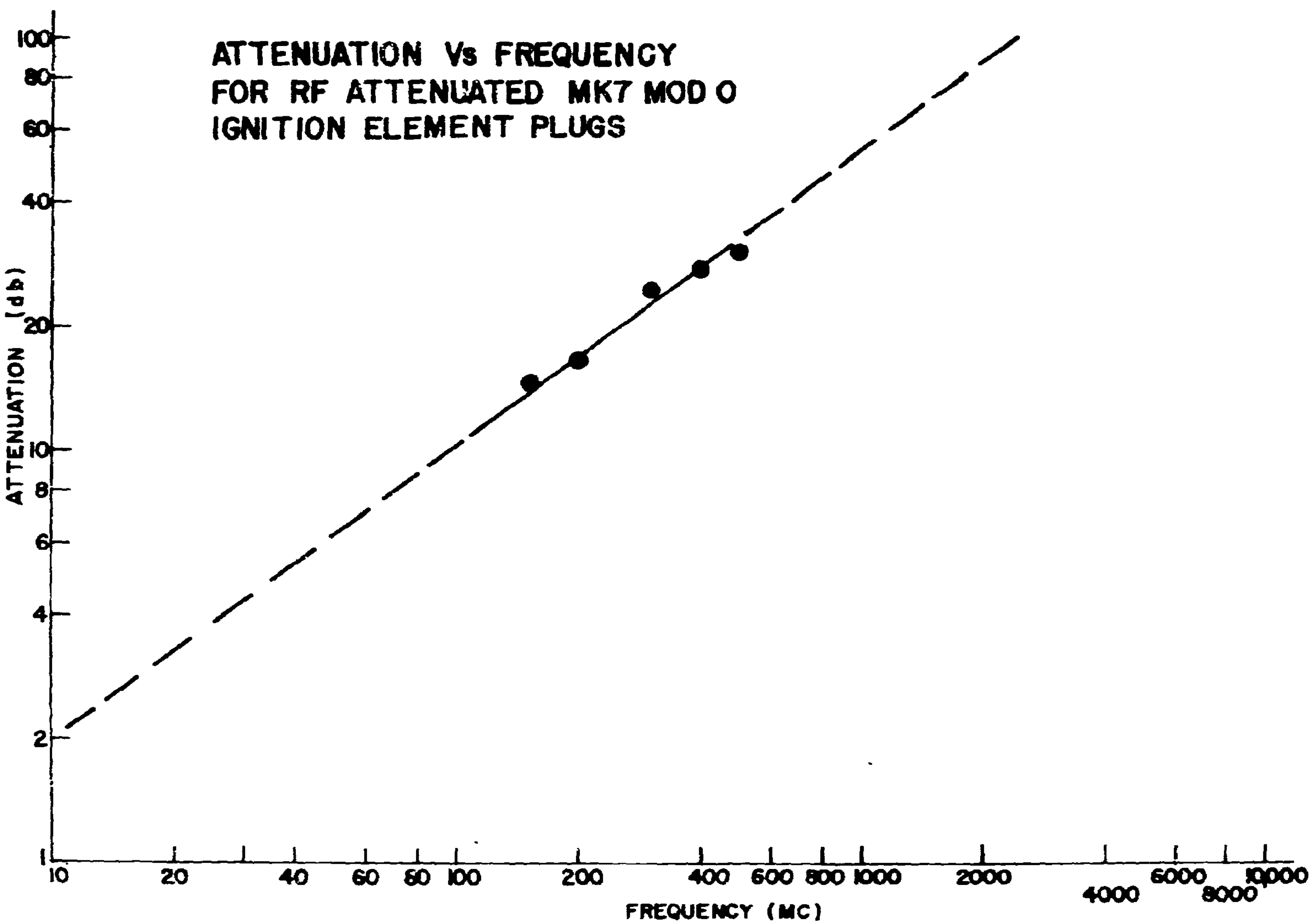
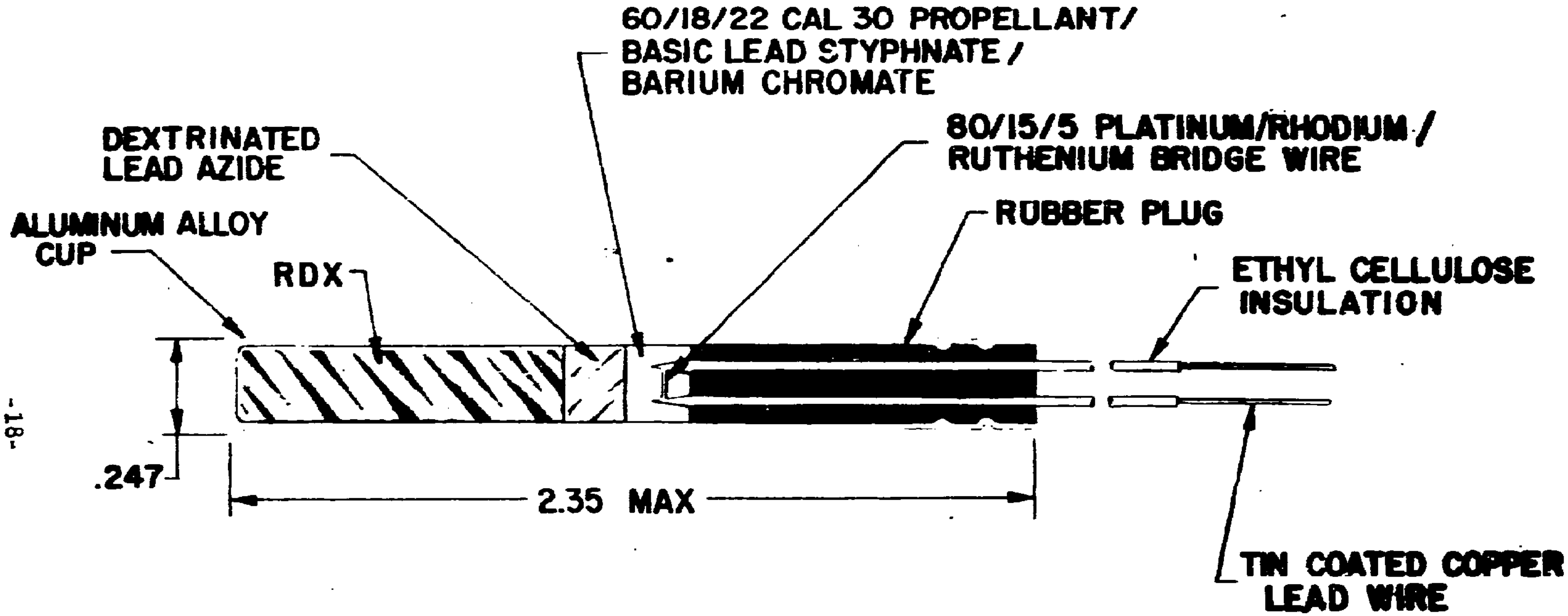
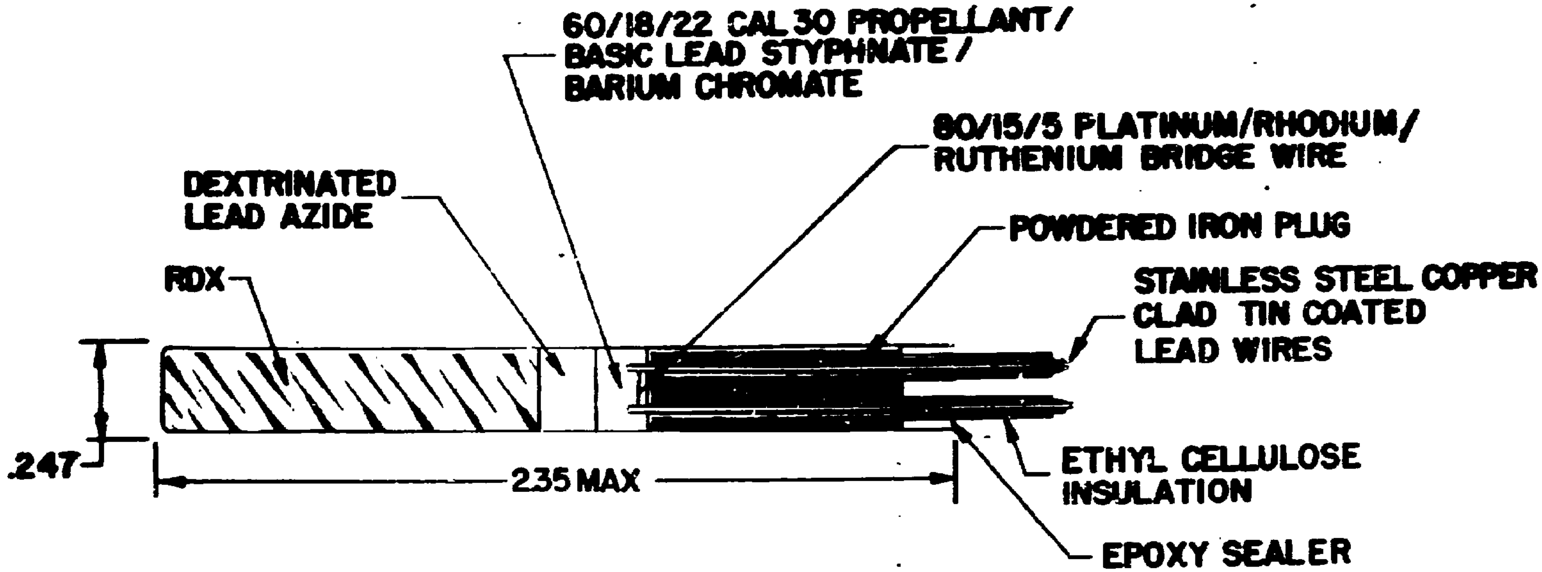

ATTENUATION Vs FREQUENCY
FOR RF ATTENUATED MK7 MOD 0
IGNITION ELEMENT PLUGS
ATTENUATION (db)
100
80
60
40
20
10
8
6
4
2
1
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
6000
8000
10000
FREQUENCY (MC)

Figure 12



M6 ELECTRIC BLASTING CAP

Figure 13



RF PROTECTED M6 ELECTRIC BLASTING CAP

Figure 14

ATTENUATION vs FREQUENCY FOR THE RF PROTECTED M6 BLASTING CAP PLUG (U)

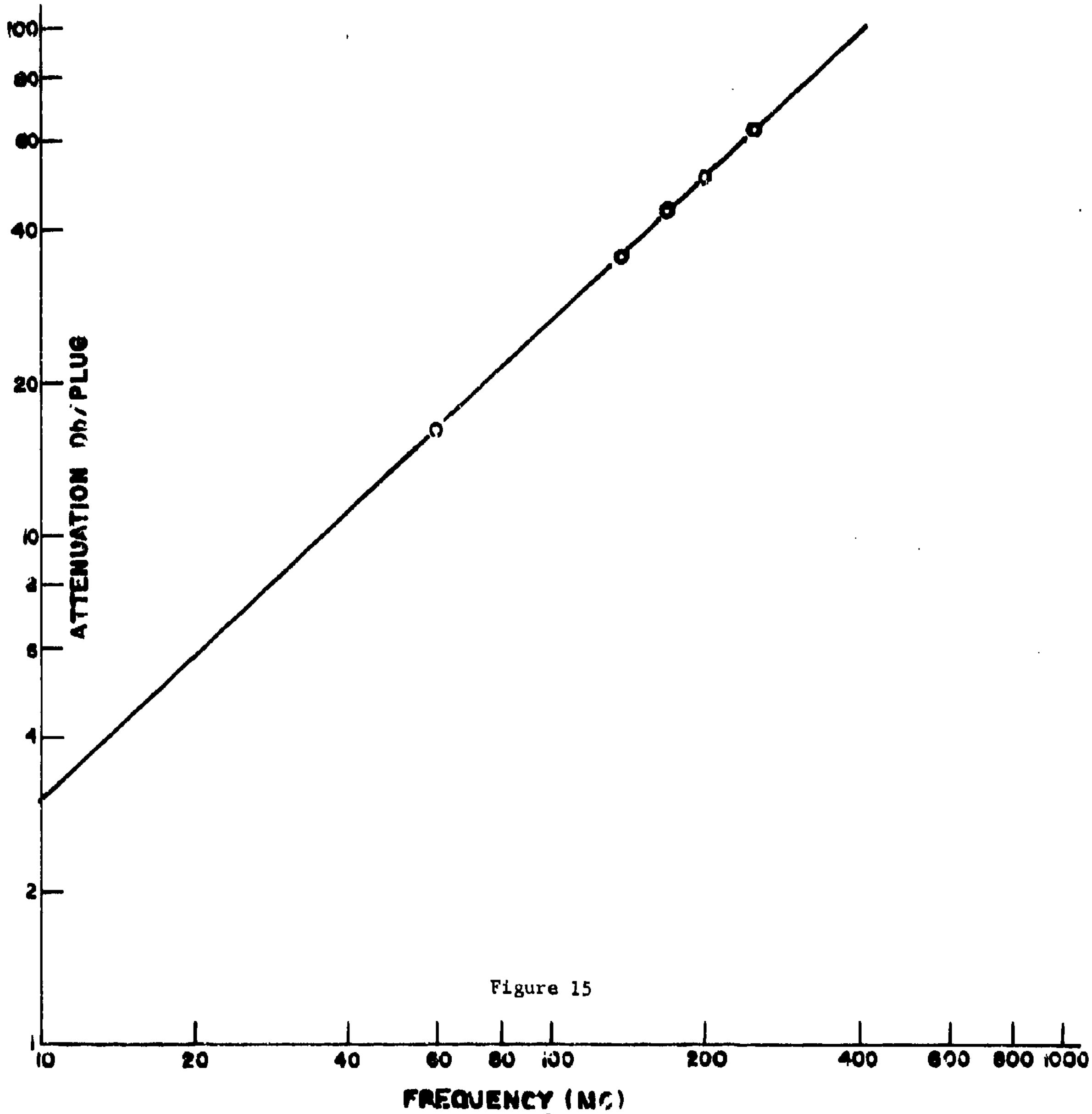
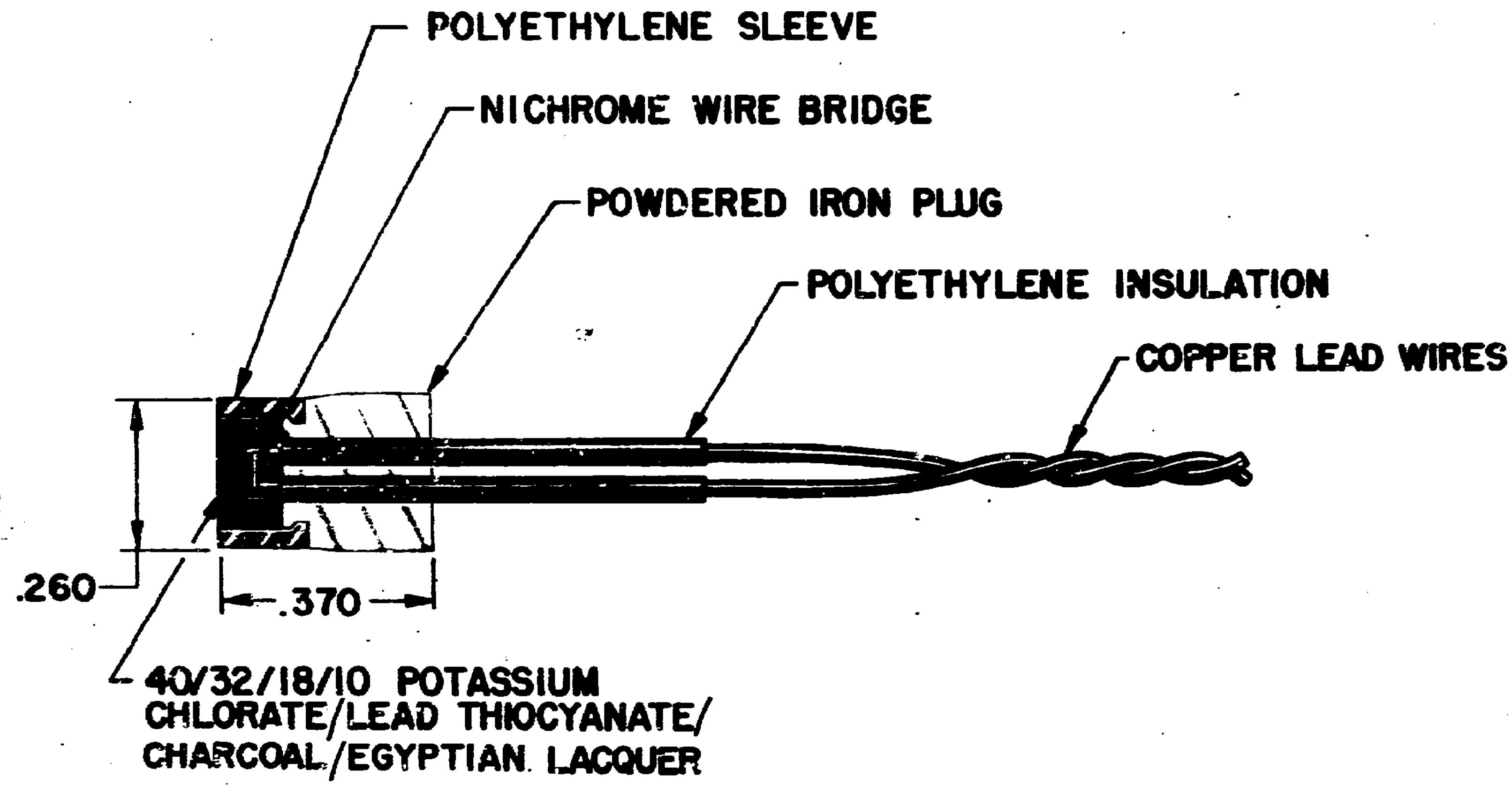
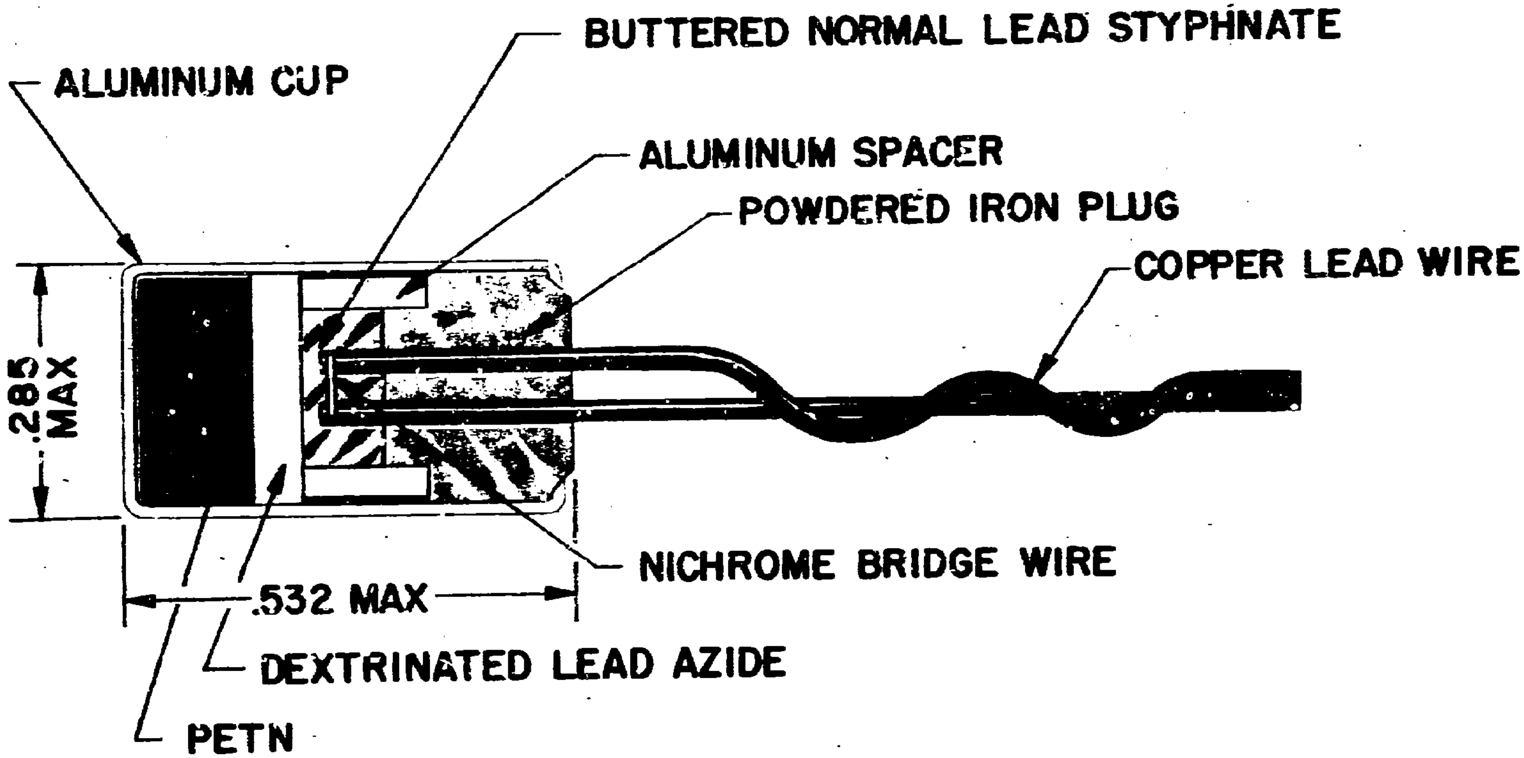


Figure 15



RF PROTECTED M2 ELECTRIC SQUIB

Figure 16



RF PROTECTED M36A1 ELECTRIC DETONATOR

Figure 17

ABSTRACT

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Picatinny Arsenal, Dover, New Jersey

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Frederick M. Correll

Technical Memorandum 1258, May 1964, 26 pp, figures. UNCLASSIFIED report from the Artillery Ammunition Laboratory, Ammunition Engineering Directorate.

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The material selected was phosphated powdered iron. Picatinny Arsenal's goal is to provide the munitions designer with safe, reliable EEDs which are safe from electromagnetic radiation.

UNCLASSIFIED

1. Radio Frequency - Electromagnetic pulses

I. Correll, Frederick M.

UNITERMS

Electroexplosive devices (EED)
Radio frequency (RF)
Hazard
T24E1
M36A1
XM66E2
T77
M51 Detonators
M2 Squib
M6 Blasting Cap
MK 2 Mod 0 Ignition Elements
MK 7 Mod 0 Ignition Elements
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Acetone
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  Elements
MK 7 Mod O Ignition
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Acetone
Type 19 Spotting Device
Correll, F. M.

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