MIL-STD-285
25 June 1956

SUPERSEDING
MIL-A-18123(SHIPS)
1 August 1954

MILITARY STANDARD
ATTENUATION MEASUREMENTS FOR ENCLOSURES, ELECTROMAGNETIC SHIELDING, FOR ELECTRONIC TEST PURPOSES, METHOD OF

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1956

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WASHINGTON 25, D. C.

25 June 1956

Supply and Logistics

ATTENUATION MEASUREMENTS FOR ENCLOSURES, ELECTROMAGNETIC SHIELDING, FOR ELECTRONIC TEST PURPOSES, METHOD OF

MIL–STD–285

1. This standard has been approved by the Department of Defense and is mandatory for use of the Departments of the Army, the Navy, and the Air Force.

2 In accordance with established procedure, the Standardization Division has designated the Signal Corps, the Bureau of Ships, and the Air Force, respectively, as Army-Navy-Air Force custodians of this standard.

3. This standard is mandatory for use effective 25 June 1956 by the Departments of the Army, the Navy, and the Air Force

4 Recommended corrections, additions, or deletions should be addressed to the Standardization Division, Office of the Assistant Secretary of Defense (Supply and Logistics), Washington 25, D C

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ATTENUATION MEASUREMENTS FOR ENCLOSURES, ELECTROMAGNETIC SHIELDING, FOR ELECTRONIC TEST PURPOSES, METHOD OF

1. SCOPE

1.1 This standard covers a method of measuring the attenuation characteristics of electromagnetic shielding enclosures used for electronic test purposes over the frequency range 100 kilocycles to 10,000 megacycles.

2. APPLICABLE DOCUMENTS

3. DEFINITIONS

3.1 Attenuation.—Attenuation is the ratio, expressed in decibels (db), of the received powers on opposite sides of a shield when the shield is illuminated by electromagnetic radiation; and as used in this standard, is the figure of merit to designate the shielding effectiveness of electromagnetic enclosures.

3.2 Voltage versus power ratio.—In accordance with 3.1, measurement should be made of powers associated with the incident wave, and the ratio of these measurements should be expressed in decibels. It is acceptable instead, when the wave impedance is identical for E_1 and E_2 to measure only the electric field intensities, E_1 and E_2 and to use the expression:

$$\text{Attenuation (db)} = 20 \log \frac{E_1}{E_2}$$

It is assumed that the wave impedance will be identical and that this method is used for the sake of convenience.

4. REQUIREMENTS

4.1 Test set-up.—The arrangement of signal sources, measuring equipments, pick-up devices, and shielded enclosures shall be in accordance with the following paragraphs and figures 1 through 6. All power lines, RF cables, and other utilities entering the shielded enclosure shall be in place when tests are conducted. Special care shall be taken to make measurements in the vicinity of utility entrances, doors, and access panels.

4.1.1 *Measurement of attenuation low impedance (magnetic) fields.*

4.1.1.1 *Attenuator.*—When an attenuator, the calibration of which is used as a basis for the desired measurements, is employed between either the receiver or the transmitter and its antenna, the antenna shall "look back" into an impedance which is independent of the setting of the attenuator. The attenuator A may be a 50 or 72 ohm transmission line, low input impedance, step attenuator A signal generator shall be used to calibrate the attenuator. The attenuator shall be capable of measuring an insertion loss of over 70 db.

4.1.1.2 *Detector.*—The detector may be any receiver such as the DZ-2 or the BC-348-Q or a field strength meter provided with a low impedance input such as the Radio Test Set AN/PRM-1, AN/PRM-14, and Empire Devices, Incorporated, NF-114. A matching device may be used with high input impedance receivers or field strength meters.

4.1.1.3 *Signal source.*

4.1.1.3.1 Signal source S may be a signal generator or power oscillator of sufficient CW, MCW or Pulsed CW output. In case loop L_1 is connected to the output of a signal generator or power oscillator, a tuning capacitor may be connected in series with L_1 to obtain resonance at the test frequency used.

4.1.1.3.2 If the signal generator has a reliable output attenuator, it may be used, instead of the attenuator A, to obtain an equivalent ratio of E_1/E_2 for the calculation of the attenuation of the shielding enclosure by using the detector D at the same reference level when the shielding enclosure wall is removed. In this case, no precaution has to be taken to guard against case leakage at the detector.

4.1.1.3.3 A signal source shall be constructed as shown on figure 2.

4.1.1.4 *Measurement of db attenuation.*—Measurement of db attenuation to low impedance magnetic fields shall be performed in accordance with figure 1.

4.1.1.4.1 The attenuation of the enclosure is the increase in the db setting of the attenuator A necessary to obtain the same reference reading level in detector D, when the shielding enclosure wall, S_1 S_2 is removed, without changing the relative positions of L_1 and L_2. (The attenuation in db is also essentially equal to 20 log E_1/E_2, where E_2 and E_1 are the voltages induced in the receiving loop, with the enclosure wall in and with the enclosure wall removed respectively, without changing the relative positions of L_1 and L_2.) The equipment as a whole shall be capable of measuring a shielded enclosure attenuation of at least 100 db.

4.1.1.4.2 The position of L_1 with respect to the enclosure shall be anywhere around the enclosure and in any orientation to the section seams and access panel seams. A reading shall be taken on all four sides of the enclosure, and the minimum attenuation recorded. This shall be a minimum of 70 db.

4.1.1.4.3 When it becomes impractical to remove the shielding enclosure wall S_1, S_2, the loops L_1 and L_2 shall be set outside the enclosure in an exactly similar position with no obstruction. Because the strong magnetic field generated by L_1 can penetrate the metal case of detector D and attenuator A, these two equipments shall be left inside the enclosure and the loop L_2 brought out of the enclosure through a transmission line connector. The connector shall be grounded circumferentially where it passes through each wall of the shielded enclosure. Shielded enclosure doors shall be closed during tests.

4.1.1.4.4 A test shall be made to insure that no case leakage exists at D and A. The detector should show no indication whatever above the inherent background when cable C_2 or C_3 is disconnected.

4.1.2 *Measurement of attenuation to high impedance (electric) fields (see figure 3).*

4.1.2.1 *Attenuator.*—The attenuator used may be a high impedance capacity type attenuator, similar to the external attenuator used with the Ferris Model 32A(TS–432/U) or constructed similarly to the one used internally on the AN/PRM–1. A signal generator shall be used to calibrate this attenuator. The attenuator shall be able to measure an insertion loss of over 100 db.

4.1.2.2 *Detector.*—The detector may be a field strength meter such as the Ferris 32A(TS–432/U), the AN/PRM–1, the AN/PRM–14, and Empire Devices, Incorporated, NF–114 In this case, attenuator A may be deleted as these instruments can measure induced voltages in the receiving antenna R_2, and are able to record levels 100 db apart The readings obtained on these instruments shall be checked against a signal generator

4.1.2.2.1 When the receiver is used as other than a fixed reference level indicator, and the signal source is a broadband device such as described on figures 2 and 4, the output indication of the receiver shall drop at least 30 db: (a) when the local oscillator is disabled, (b) while in the strongest field, and (c) at the highest input level to the first tube to be used during the test of the shielded enclosure. Also, the image rejection shall be at least 30 db, and the IF rejection shall be at least 40 db, when broadband signals are used. The case leakage and power-line filtering of the receiver-attenuator combination shall be such that when operating in the strongest field required to be measured, removing the antenna and substituting a shielded dummy antenna simulating the actual antenna impedance will result in at least a 30 db reduction of output indication.

4.1.2.3 A receiver such as the BC–348–Q may be used. In this case, they are used only as reference level indicators. The attenuation may be read on attenuator A. The equal reference level chosen shall be low enough as not to represent any overloading or saturation of the receiver. If necessary, a matching device may be used with low input impedance receivers.

4.1.2.4 *Signal source.*

4.1.2.4.1 Signal source S may be a signal generator or power oscillator of sufficient CW, MCW or pulsed CW output. The termination of cable C_1 may be matched to the signal source S if desired.

4.1.2.4.2 If the signal generator has a reliable output attenuator, it may be used instead of the attenuator A, to obtain an equivalent ratio of E_1/E_2 for the calculation of the db attenuation of the enclosure by operating the detector D at the same reference level when the shielding enclosure wall is removed. In this case, no precaution has to be taken to guard against case leakage at the detector.

4.1.2.4.3 If a large output signal generator or power oscillator is not available, a pulse signal source may be easily constructed as shown on the three set-ups on figure 4.

4.1.2.5 *Measurement of db attenuation, (see figure 3).*

4.1.2.5.1 The attenuation of the enclosure is the increase in the db setting of the attenuator A necessary to obtain the same reference reading level in detector D when the shielding enclosure wall S_1 and S_2 is removed, without changing the relative position of R_1 and R_2 The attenuation in db is also essentially equal to 20 log 10 E_1/E_2, where E_2 and E_1 are the voltages induced in receiving rod with the enclosure wall in and with the enclosure wall removed, respectively.

4.1.2.5.2 The positioning of R_1 with respect to the shielding enclosure walls shall be anywhere around the enclosure, in any orientation to the section seams and access-panel seams. A reading shall be taken at each side of the shielding enclosure and the minimum attenuation recorded. This minimum shall be over 100 db.

4.1.2.5.3 When it becomes impractical to remove the shielding enclosure walls, S_1 and S_2, both rods R_1 and R_2 shall be set outside the enclosure in the exact similar position, with no obstruction. Because the strong electric fields generated by R_1 can penetrate the metal case of detector D and attenuator A, these two equipments shall be left inside the enclosure and the rod R_2 brought out of the enclosure through a transmission line connector. The cable used shall be as short as possible. The connector shall be grounded circumferentially where it passes through each wall of the shielded enclosure. Shielded enclosure doors shall be closed during the test.

4.1.2.5.4 A test shall be made to insure that no case leakage exists at D or A. The detector should show no indication whatsoever above inherent background when cable C_2 or C_3 is disconnected.

4.1.3 *Measurement of attenuation to plane waves (see figure 5).*

4.1.3.1 *Attenuator.*—The attenuator shall be as specified in 4.1.1 1.

4.1.3.2 *Detector.*—The detector may be a receiver such as Receiving Equipment AN/APR–4, RF Interference Test Set AN/URM–28, RF Interference Test Set AN/URM–29, Radio Set AN/ARC–27, or a field strength meter such as the Noise Field Intensity Meter TS–587/U, Radio Test Set AN/URM–17, AN/URM–7 or Empire Devices, Incorporated, NF–105. Detectors which cannot readily give peak indications may be used with an oscilloscope connected to their output.

4.1.3.3 *Signal source.*

4.1.3.3.1 Signal source S may be a signal generator or power oscillator of sufficient CW, MCW, or pulsed CW output. The terminal of cable C_1 may be matched to the signal source when necessary.

4.1.3.3.2 If the signal generator has a reliable output attenuator, it may be used instead of attenuator A, to obtain an equivalent ratio of E_1/E_2 for the calculation of the attenuation of the enclosure by using the detector D at the same reference level. In this case, no precaution may have to be taken to guard against leakage at the detector.

4.1.3.3.3 The signal source may be an AN/ARC–27 transmitter, a high frequency Rollin Signal generator Model 30(TS608/U), or equal, or Radar Set AN/APT–5 radar transmitter. An oscillator, tuned to the frequency of test may be constructed, using a high voltage plate supply and then pulsed, to obtain high peak power. A signal source may be constructed as shown on figure 6.

4.1.3.4 *Measurement of db attenuation (see figure 5).*

4.1.3.4.1 The attenuation of the enclosure in db is equal to the increase in the db setting of attenuator A necessary to obtain the same reference reading level in detector D when the receiving antenna is switched from position R_2 to R_3, without changing the position of R_1 (The attenuation in db is also essentially equal to 20 log 10 E_1/E_2, where E_1/E_2 are the voltages induced in R_3 and R_2, respectively)

4.1.3.4.2 The position of R_1 with respect to the shielding enclosure walls shall be anywhere around the enclosure in any orientation with respect to the section seams and access-panel seams. Several readings shall be taken, and the minimum attenuation recorded. This minimum shall be over 100 db.

4.1.3.4.3 A test shall be made to insure that no case leakage exists at D or A. The detector D should show no indication whatsoever above inherent background when cable C_2 or C_3 is disconnected.

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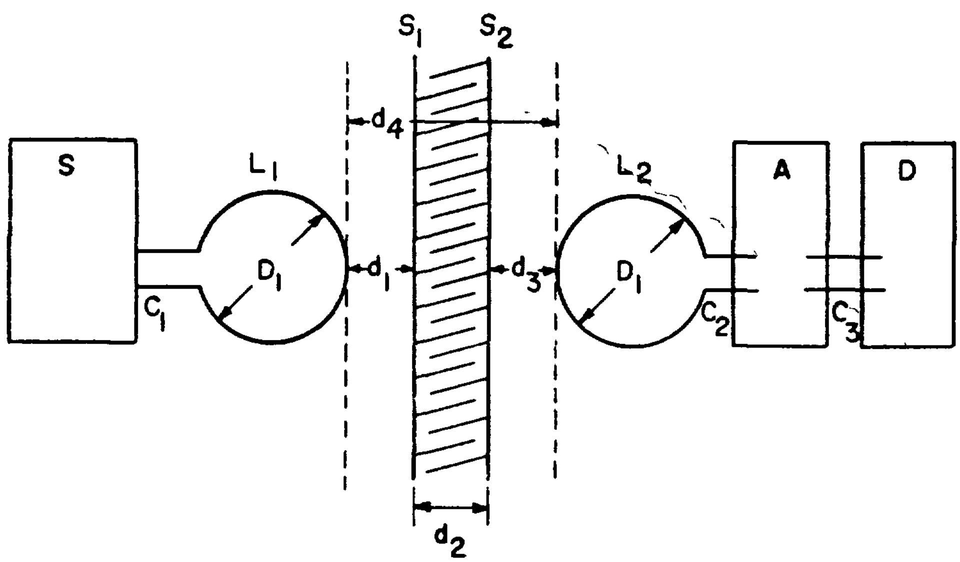

FIGURE 1 —*Attenuation measurement low impedance magnetic field*

d_1 = 12 inches.
d_2 = separation between inner and outer shields.
d_3 = 12 inches
d_4 = 25 inches—($d_1 + d_2 + d_3 = d_4$)
S_1 = Outer screen
S_2 = Inner screen
S = Low impedance signal source to obtain adequate output at the frequency of test.
D_1 = 12 inches
Frequency of test = One frequency in the 150 to 200 kc range
L_1 = Transmitting loop radiator, low impedance One turn of No 6 AWG copper wire Oriented at any angle in a plane perpendicular to the shielding enclosure wall
D = Detector of adequate sensitivity tuned to frequency of test Used only as a reference level indicator
L_2 = Receiving loop antenna, positioned in the same plane as L_1
A = DB attenuator of low impedance input, calibrated at the frequency of test.
C_1, C_2, C_3 = Shielded transmission line cables As short as possible and used only if necessary

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL-STD-16)

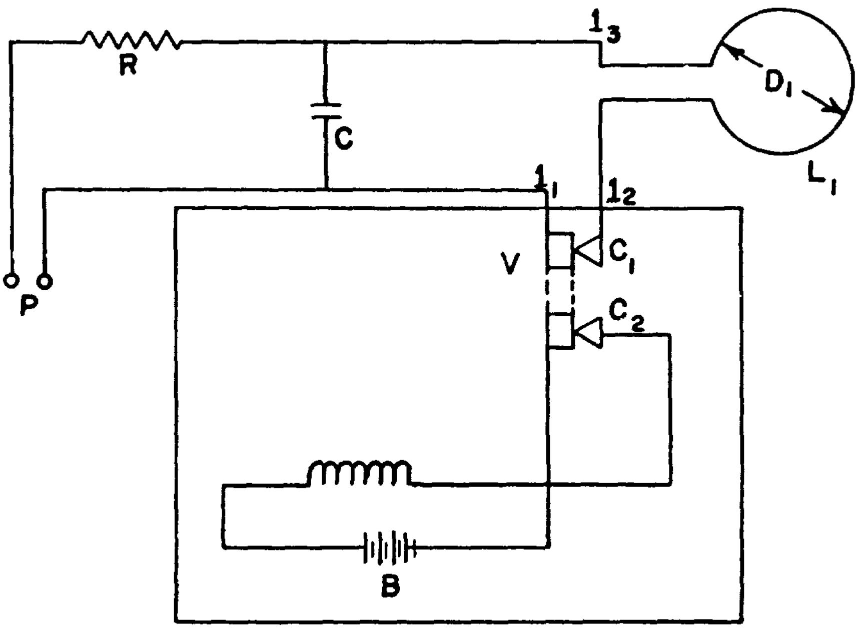

FIGURE 2. —*Source of intense peak power magnetic field.*

L_1, D_1 = See figure 1.
C = 1.0 mfd. paper, 600 volts.
10,000 ohms, 5 watts.
B = Dry cell, 3 to 45 volts
P = 300 volts d c. Battery or rectifier power supply.
C_1 = Contact interruptor shorting out capacitor C at a rate of 20 to 100 pulses per second. Operated by C_2 but not electrically connected to it.
V = Vibrator
1_1, 1_2, 1_3 = Leads; shall be as short as possible.

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL–STD–16)

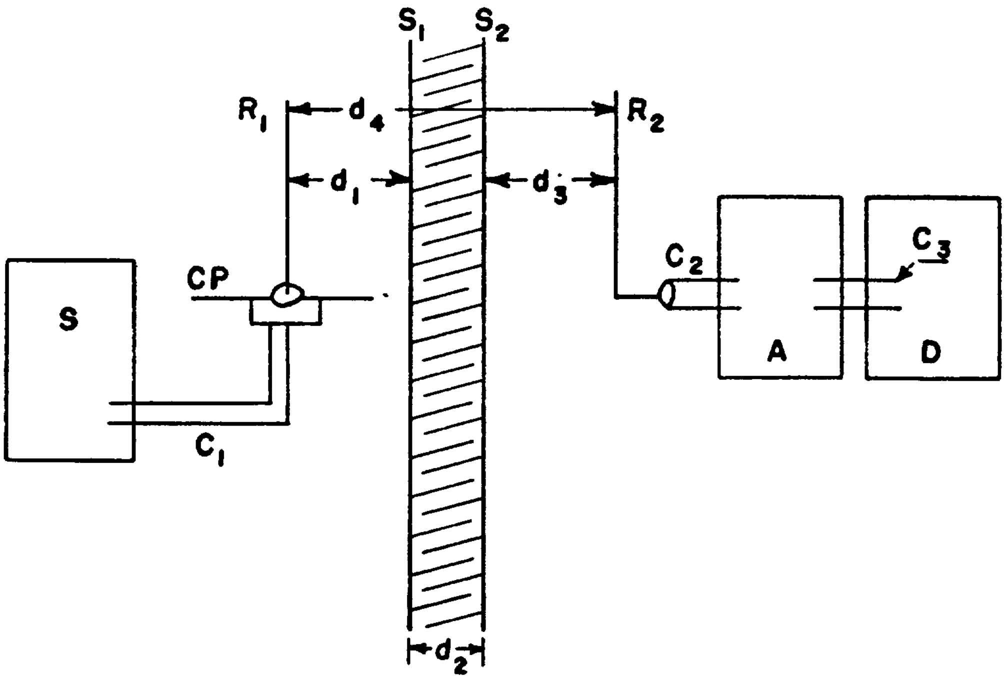

FIGURE 3 —*Attenuation measurement high impedance electric field*

d_1 = 12 inches.
d_2 = Separation between inner and outer shields
d_3 = 12 inches
d_4 = 25 inches = ($d_1 + d_2 + d_3 = d_4$)
S_1 = Outer screen.
S_2 = Inner screen
S = High impedance signal source to obtain adequate output at the frequency of test.
Frequencies of test = 200 kc, 1 0 mc and 18 0 mc
R_1 = Transmitting rod radiator, 41 inches long High impedance oriented in any position parallel to the shielding enclosure wall.
C_1, C_2 and C_3 = Shielded transmission line cables As short as possible and used only if necessary
A = Capacity type db attenuator High input impedance.
CP = Counterpoise.
R_2 = Receiving rod antenna, 41 inches long. High impedance, positioned parallel to R_1 and in the same plane
D = Detector of adequate sensitivity Tuned to frequency of test Used only as an equal reference level indicator.

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL–STD–16)

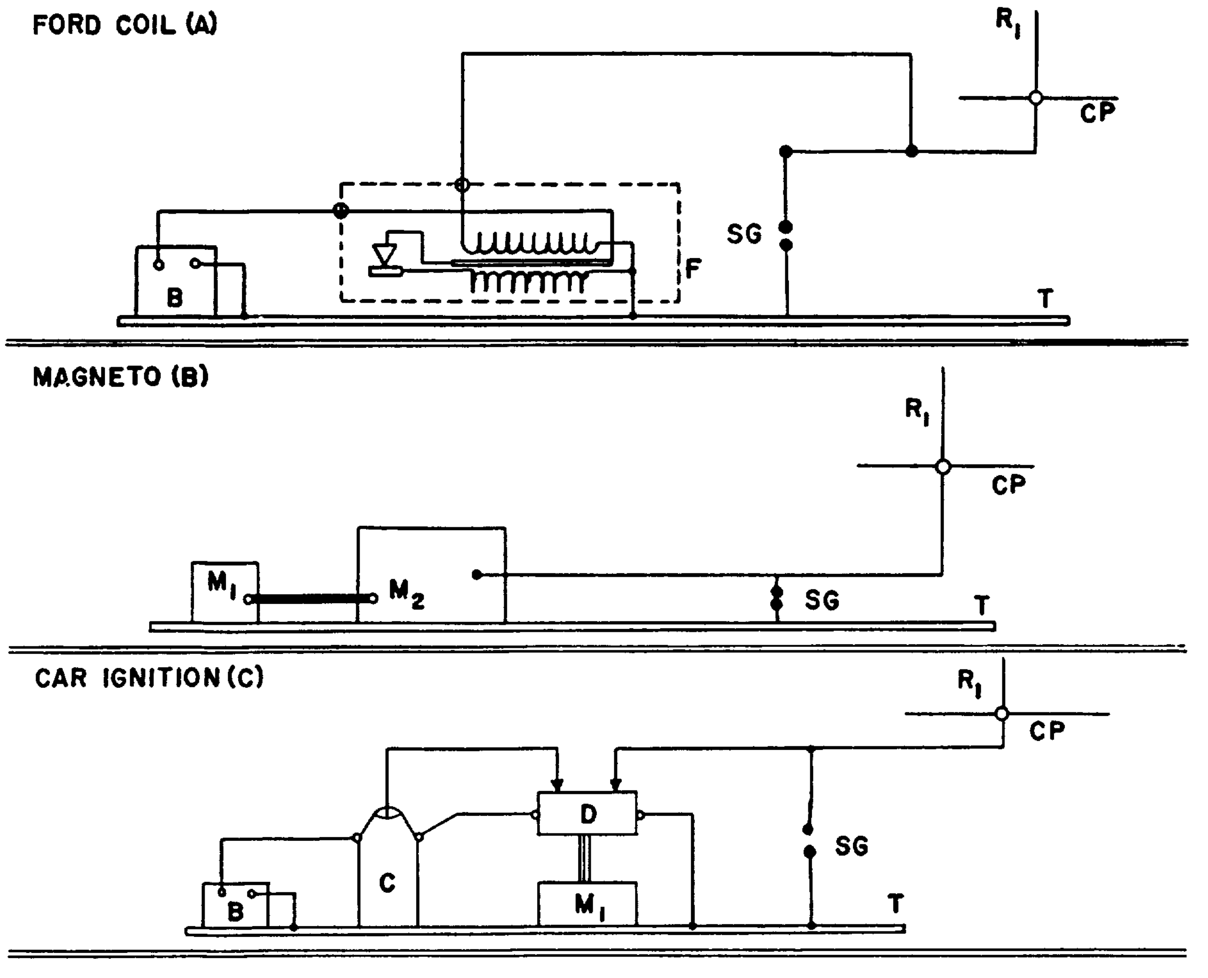

FIGURE 4 —*Source for intense peak power electric field.*

R_1 = Radiator (fig 3)
M_1 = Motor drive.
C = Ignition coil.
CP = Counterpoise
T = Ground metal table
F = Ford coil (ignition)
M_2 = Magneto.
B = Battery.
D = Ignition distributor.
SG = Spark gap

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL-STD-16)

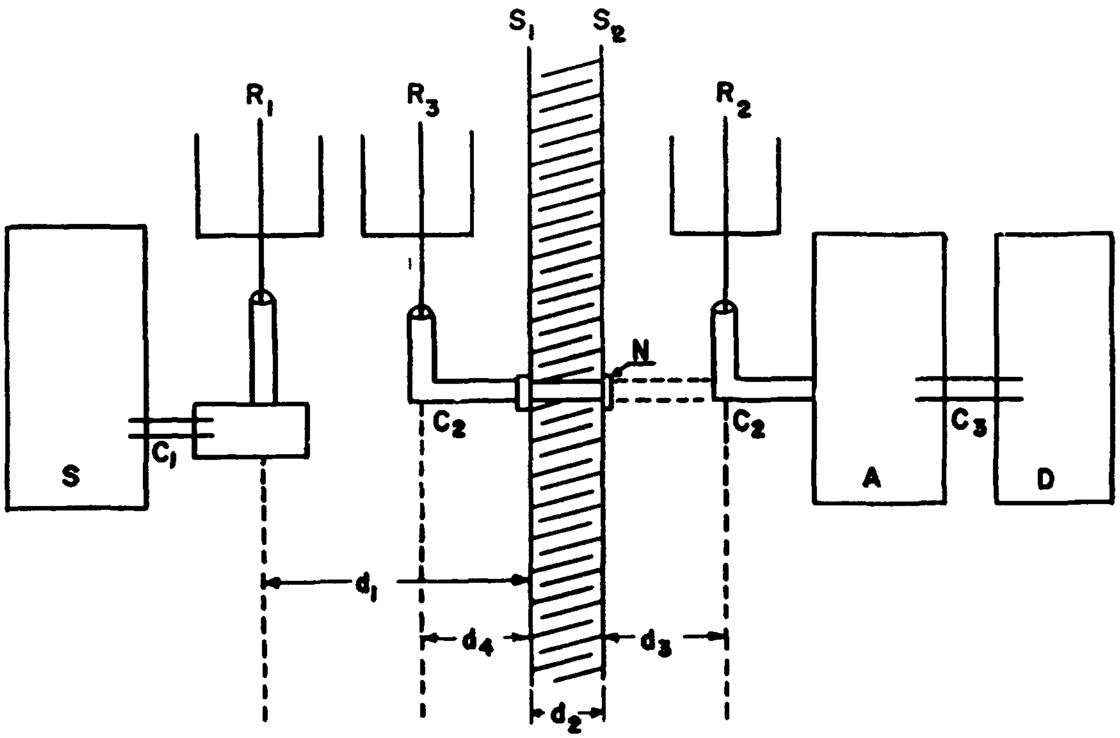

FIGURE 5 —*Attenuation test for plane waves (wave impedance = 377 ohms).*

d_1 = 72 inches minimum Distance shall be as great as possible and limited only by the output of S. However, always hold more than two times the wave length from S_1, S_2.

d_2 = Distance between shields

d_3 = 2 inches. Two inches is the minimum value R_2 is positioned anywhere inside the enclosure and oriented for maximum indication on detector D, in order to minimize the effect of reflections.

d_4 = Not less than 2 inches, and not more than 24 inches—R_3 is positioned anywhere outside the enclosure and oriented for maximum indication on detector D, in order to minimize the effect of reflections The entire region, from 2 to 8 inches shall be explored for maximum indication R_3 shall never be closer than 2 inches to S_1 or S_2, in order to prevent capacity coupling

S_1, S_2 = Outer and inner shields, respectively.

N = Transmission line connector

S = Signal source, to obtain adequate output at the test frequency.

Frequency of test = 400 megacycles.

R_1 = Transmitting radiator. Dipole, tuned to 400 mc. If a tuned dipole is used with a single coaxial line, it shall be a balanced dipole, similar to the Antenna AT-275/URM-28. Other suitable antenna types are· Antenna AT-141A/ARC, used with the Radio Set AN/ARC-27, Antenna AT-292/URM-29 used with Radio Interference Measurement Equipment AN/URM-29, and Antenna AT-90/AP used with Radar Set AN/APT-5 The radiator shall be positioned to obtain maximum field intensity at the shielding enclosure

R_2 = R_3 = Receiving antenna May be similar to R_1

C_1, C_2, C_3 = Shielded transmission line cables As short as possible, and used only if necessary.

A = Attenuator, calibrated at the frequency of test.

D = Detector of adequate sensitivity, tuned to the frequency of test Used only as an equal reference level indicator.

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL-STD-16)

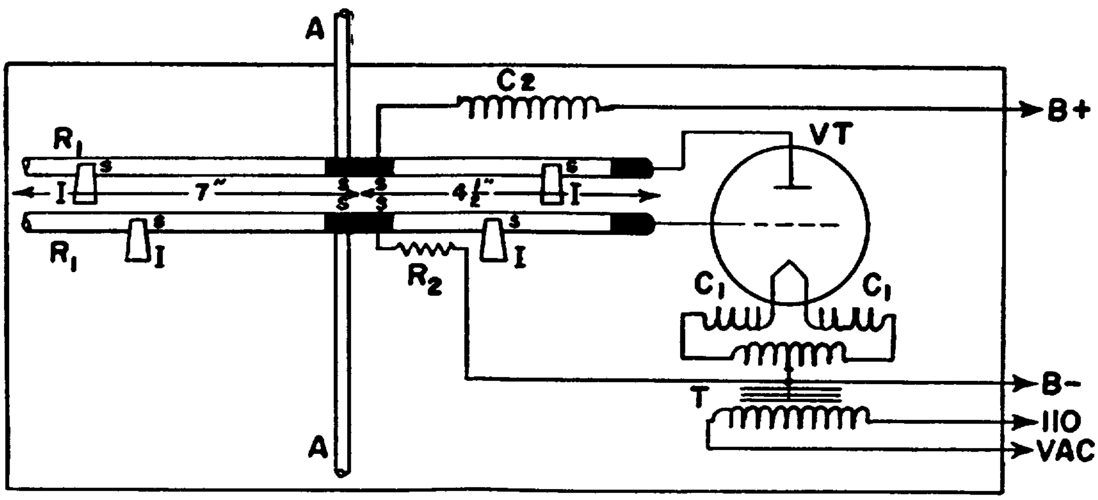

FIGURE 6 —*Signal source for plane waves at 400 mc*

A = Dipole antenna. Each rod 1/16 inch diameter, 7 inches long, horizontal
R_1 = ¼ inch solid copper rods, ¼ inch apart, 2 inches from insulating board
I = Porcelain insulators, 2 inches high
C_1 = Chokes, 30 turns No 18 wire, ¼ inch diameter, suspended in air.
C_2 = Choke, 40 turns No 28 wire, ¼ inch diameter, suspended in air
R_2 = 15,000 ohms, 10 watt S = Fuse clips B = Insulating board
T = Filament transformer, 2½ volt secondary, center tapped, or two 1½ volt dry cells with proper limiting resistor
V T = Vacuum tube W E 316A, Ep = 450 volt, Ip = 80 MA, Ef = 2 0 volt, If = 3 65 amperes, Ig = 12 MA, output = 7 5 watts.
B + = Plate voltage, 450 volts direct current from any dry cells or rectified alternating current power supply, or 1000 volts alternating current r m s , 60-cycle from high voltage transformer

Note.—Similar circuits may be used using an RCA 8012A or 8025A tube or equivalent.

Note —The code letters used on this figure should not be confused with electrical and electronic reference designations (see MIL–STD–16)

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