Designation: G 57 – 95a

Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method[1]

This standard is issued under the fixed designation G 57; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers the equipment and procedures for the field measurement of soil resistivity, both *in situ* and for samples removed from the ground, for use in the control of corrosion of buried structures.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 To convert cm (metric unit) to metre (SI unit), divide by 100.

2. Terminology

2.1 *Definition:*

2.1.1 *resistivity*—the electrical resistance between opposite faces of a unit cube of material; the reciprocal of conductivity. Resistivity is used in preference to conductivity as an expression of the electrical character of soils (and waters) since it is expressed in whole numbers.

2.1.2 Resistivity measurements indicate the relative ability of a medium to carry electrical currents. When a metallic structure is immersed in a conductive medium, the ability of the medium to carry current will influence the magnitude of galvanic currents and cathodic protection currents. The degree of electrode polarization will also affect the size of such currents.

3. Summary of Test Method

3.1 The Wenner four-electrode method requires that four metal electrodes be placed with equal separation in a straight line in the surface of the soil to a depth not exceeding 5 % of the minimum separation of the electrodes. The electrode separation should be selected with consideration of the soil strata of interest. The resulting resistivity measurement represents the average resistivity of a hemisphere of soil of a radius equal to the electrode separation.

3.2 A voltage is impressed between the outer electrodes, causing current to flow, and the voltage drop between the inner electrodes is measured using a sensitive voltmeter. Alternatively, the resistance can be measured directly. The resistivity, ρ, is then:

$$\rho, \Omega \cdot \text{cm} = 2\pi\, aR \;(a \text{ in cm})$$

$$= 191.5\, aR (a \text{ in ft})$$

where:
a = electrode separation, and
R = resistance, Ω.

Using dimensional analysis, the correct unit for resistivity is ohm-centimetre.

3.3 If the current-carrying (outside) electrodes are not spaced at the same interval as the potential-measuring (inside) electrodes, the resistivity, ρ is:

$$\rho, \Omega \cdot \text{cm} = 95.76\, b\, R / \left(1 - \frac{b}{b+a}\right)$$

where:
b = outer electrode spacing, ft,
a = inner electrode spacing, ft, and
R = resistance, Ω.

or:

$$\rho, \Omega \cdot \text{cm} = \pi\, b\, R / \left(1 - \frac{b}{b+a}\right)$$

where:
b = outer electrode spacing, cm,
a = inner electrode spacing, cm, and
R = resistance, Ω.

3.4 For soil contained in a soil box similar to the one shown in Fig. 1, the resistivity, ρ, is:

$$\rho, \Omega \cdot \text{cm} = R\, A / a$$

where:
R = resistance, Ω,
A = cross sectional area of the container perpendicular to the current flow, cm^2, and
a = inner electrode spacing, cm.

NOTE 1—The spacing between the inner electrodes should be measured from the inner edges of the electrode pins, and not from the center of the electrodes.

4. Apparatus

4.1 *At-Grade Measurements in situ*:

[1] This method is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals, and is the direct responsibility of Subcommittee G01.10 on Corrosion in Soils.

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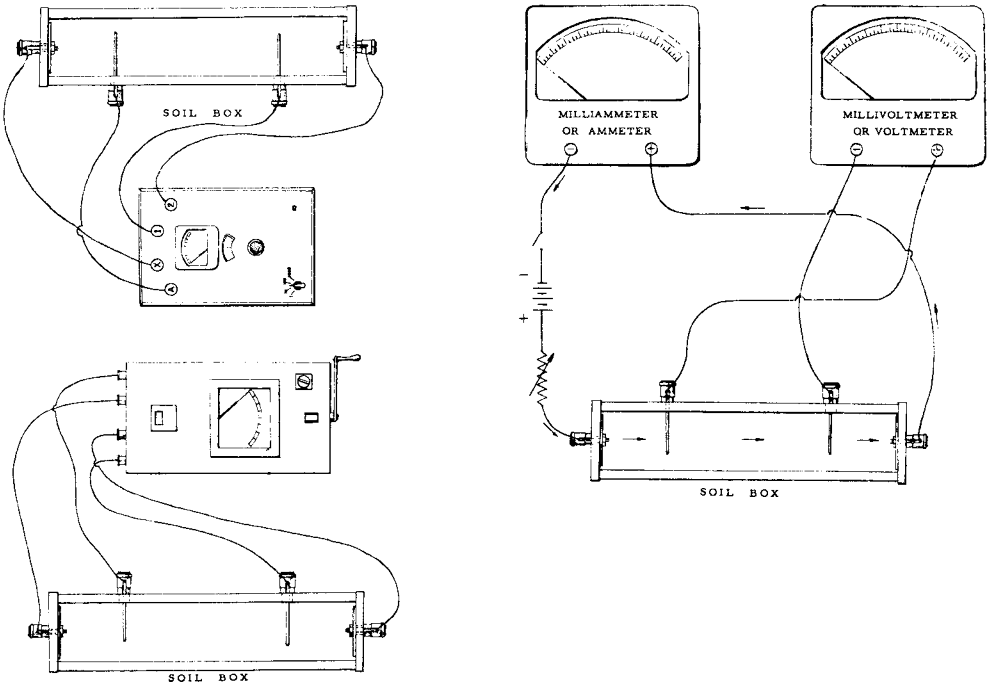

FIG. 1 Typical Connections for Use of Soil Box with Various Types of Instruments

4.1.1 The equipment required for field resistivity measurements to be taken at grade consists of a current source, a suitable voltmeter, ammeter, or galvanometer, four metal electrodes, and the necessary wiring to make the connections shown in Fig. 2.

4.1.2 *Current Source*—An ac source, usually 97 Hz, is preferred since the use of dc will cause polarization of most metal electrodes, resulting in error. The current can be provided by either a cranked ac generator or a vibrator-equipped dc source. An unaltered dc source can be used if the electrodes are abraded to bright metal before immersion, polarity is regularly reversed during measurement, and measurements are averaged for each polarity.

4.1.3 *Voltmeter*—The voltmeter shall not draw appreciable current from the circuit to avoid polarization effects. A galvanometer type of movement is preferred but an electronic type instrument will yield satisfactory results if the meter input impedance is at least 10 megaohm.

4.1.4 *Electrodes* fabricated from mild steel or martensitic stainless steel 0.475 to 0.635 cm (3⁄16 to 1⁄4 in.) in diameter and 30 to 60 cm (1 to 2 ft) in length are satisfactory for most field measurements. Both materials may require heat treatment so that they are sufficiently rigid to be inserted in dry or gravel soils. The electrodes should be formed with a handle and a terminal for wire attachment.

4.1.5 *Wiring*, 18 to 22-gage insulated stranded copper wire.

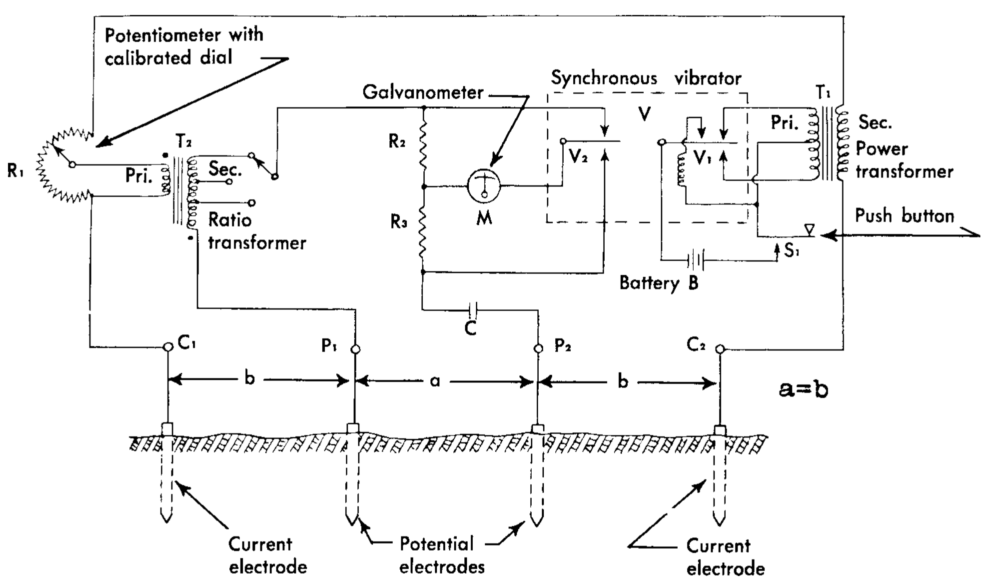

FIG. 2 Wiring Diagram for Typical dc Vibrator-Current Source