Electrical Earth Resistivity Surveys

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One of the natural and quite variable properties of earth material is to offer resistance to the passage of an electric current conducted into it. It is advantageous to be able to measure the resistance of predetermined volumes of earth material to given depths, and such measurements are possible by the use of certain methods and electrical apparatus. An electrical earth resistivity survey consists of a survey of an area to determine the average apparent resistivities to various depths at different stations. The interpretation of the data obtained in such a survey may be used in a practical manner to determine:

1. The depth to bedrock for highway and dam construction.
2. The depth of a body of water and nature of the underlying material.
3. The locations of ore bodies and placer deposits.
4. To aid in the location of possible water-bearing sand and gravel deposits.

In 1916, Frank Wenner[2] introduced a method of measuring effective resistivity of a given volume of earth material to a given depth. Later, in 1925 and 1927, Gish and Rooney, of the Department of Terrestrial Magnetism, Carnegie Institute of Washington, designed and developed an instrument for electrical earth resistivity surveys. With this apparatus and the Wenner method they collected much vital resistivity data. Other researchers have carried on much theoretical work.

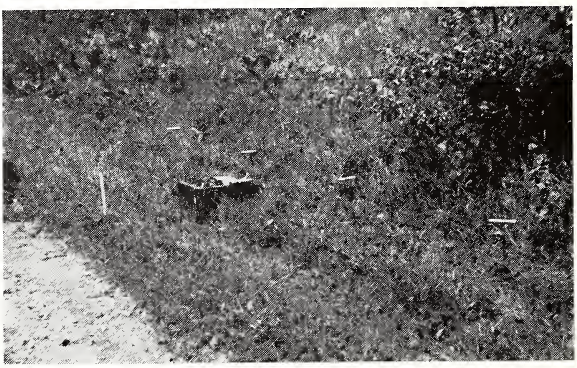

Fig. 1. Instrument set up in field.

The method (Fig. 1) consists of placing four electrodes in a straight line in the ground at equal distances apart on a relatively plane surface.

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[2] Bulletin of the Bureau of Standards **12**:469-478.

Then a commutated current is conducted into and through the ground between the two outer electrodes, and the voltage drop is measured between the two inner electrodes. The depth to which each reading is taken is determined empirically by the separation of any two electrodes. The formula applied for the determination of the average apparent resistivity of the entire thickness of material being measured between the inner electrodes is:

$$\rho = 2 \pi a V/I$$

where ρ equals the average apparent resistivity, a the distance between adjacent electrodes, V the voltage drop or potential between the inner two electrodes, and I the true current through the ground.

The voltage drop is measured between the inner electrodes because the paths of the current through this section are more evenly distributed and more nearly parallel than at the electrodes where the current is introduced into the ground. There it is radiating from the electrodes, the paths are closer together, and interference is greater due to high contact potentials.

The readings taken on the instrument are in direct current. The current conducted into the ground is alternated in order to reduce interference from polarization at the electrodes and stray earth currents. And the potential difference between the inner electrodes is rectified so that readings can be taken with the direct current potentiometer, and any outside potentials in the earth are reversed so rapidly they do not register.

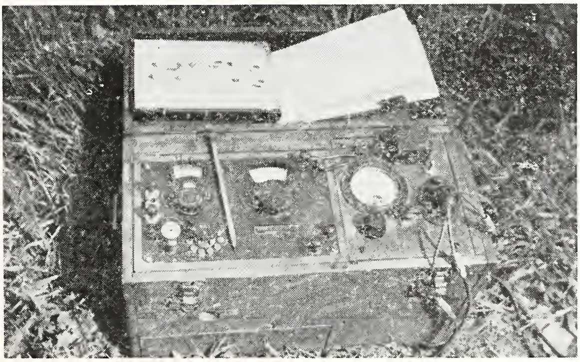

Fig. 2. Close-up view of instrument panel.

The instrument (Fig. 2) possesses a Leeds and Northrup potentiometer, on the left side of the control panel, the purpose of which is to measure the voltage drop. Two forty-five volt B batteries connected in series furnish the direct current the output of which is controlled by a rheostat and registered on an ammeter on the right side of the control panel. A double commutator is inserted into the circuit between the meters and the leads to the electrodes, and it is turned by a hand crank.

The Illinois State Geological Survey in recent years has used this method successfully in the location of ground water supplies in sand and gravel deposits in over 90 per cent of the surveys made for that purpose.

The Indiana Division of Geology, of the Department of Conservation, has inaugurated a program of using electrical earth resistivity surveys to assist in the location of ground water supplies in Indiana in sand or gravel deposits in glacial drift or alluvium above the bedrock. Such surveys are based on the principle that sand, gravel, limestone and sandstone have higher resistivities than clay, silt, till or shale, in or upon which, the sand and gravel might lay. All the data are plotted on graphs, and maps are prepared. Knowing the general range of resistivities for each type of material and taking into consideration the interpretation of the resistivity data in the light of all known geological information for the area under consideration, the favorable water-bearing deposits in the area are outlined and the locations for test drilling are recommended.

The Indiana Geological Survey is making this service available to the public, especially to municipalities, industries engaged in the War Effort and to various schools in the War Department. The survey furnishes the instrument, equipment, technician and report free of charge. The ones for whom the survey is to be made furnish the labor to run the electrodes and purchase the stakes for station locations.