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ANALOG FOR THE ELECTRIC FIELD OF A LINEARLY POLARIZABLE ELECTRODE

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The method consists in the use of an insulating coating uniformly perforated; there is an exact analogy between the boundary conditions at a linearly polarizable electrode and those at a coated metal.

Practical problems in electrolysis and electrochemical corrosion demand a knowledge of the electric fields around metals as influenced by polarization. In general, polarization gives rise to a nonlinear relation between surface potential and current density, but in many cases the working part of the curve may be taken as linear, so it is easy to make an analog to the electric field. The assumption then amounts to representing the potential for boundary conditions of the 3rd kind:

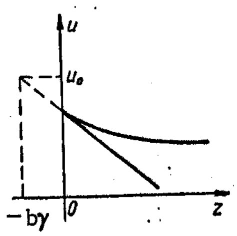

Fig. 1. Variation of potential along the normal to the surface of the metal.

$$U - k\frac{\partial U}{\partial n} = U_0, \tag{1}$$

in which U is the potential, U_0 is the electrode potential of the metal, n is the exterior normal to the surface of the electrode, $k = b\gamma$, b is the specific polarizability of the metal, and γ is the specific conductivity of the electrolyte.

Conditions (1) can be satisfied approximately by dividing the surface into sufficiently small isolated parts, each being connected to a voltage source via a resistance equal to the ratio of the specific polarizability to the area of the part. This method has not found much use, for it leads to complicated models and difficulty with phase differences in the parallel circuits.

Other methods follow from the specific features of the conditions of (1).

One of these features is illustrated by the potential along the normal (Fig. 1). From (1) it is readily seen that the potential of the characteristic surface [1] (locus of the points distant $b\gamma$ from the surface) is equal to the electrode potential of the metal, so (1) may be reproduced approximately by locating equipotential electrodes at the characteristic surfaces. Further, there is no need to choose the sites empirically as in oscillographic analogs [2]. The method is restricted to the cases in which the largest dimension of the electrode does not exceed $b\gamma$.

The simplest and most effective method is to use conducting and perforated coatings.

The use of conducting coatings is based on the exact analogy between the boundary conditions at a coated metal and those at the electrode; the analog can be produced by the application of coatings of specified conductivity.

In principle, the method is extremely simple, though there is some difficulty in making coatings of a specified conductivity. This can be overcome by the use of nonconducting coatings uniformly perforated; at distances exceeding the distance between holes, the coating may be considered as continuous and as having a specific resistance ρ given by

$$\rho = \frac{1}{\gamma} \cdot \frac{S}{S_0} \cdot h, \tag{2}$$

S being the surface area of the metal, S_0 the total area of the holes, and h the thickness of the coating. The latter two may be adjusted to give the required specific conductivity of the coating.

Measurements were made with a tank 4.5 × 3.5 × 2 m by means of the apparatus shown in Fig. 2. Fig. 3 (curve 1) shows the potential along the axis of a disc. The error of the system was deduced by measuring the field for equal polarizabilities (curve 2).

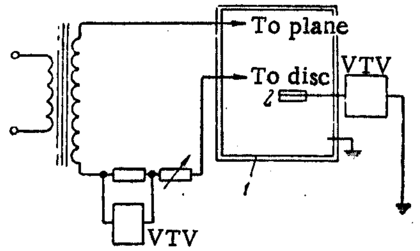

Fig. 2. Apparatus for measuring the electric field of a linearly polarizable electrode: 1) tank; 2) probe electrode

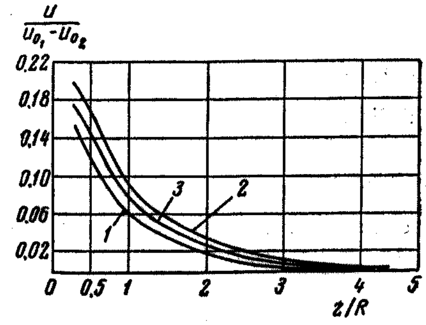

Fig. 3. Results for potential along the axis of a disc.

The potential on the axis of this system in this case is

$$U_{r=0} = \frac{U_{0_1} - U_{0_2}}{b\gamma}\left(z + R - \sqrt{z^2 + R^2}\right), \tag{3}$$

in which U_{0_1} and U_{0_2} are the electrode potentials of the metals and R is the radius of the disc.

Curve 3 shows values given by this formula; they agree well with experiment. The results show that the perforated coating behaves as continuous even at distances 3-5 times the distance between adjacent holes.

LITERATURE CITED

1. A. V. Lykov, Theory of Thermal Conductivity [in Russian], Gostekhteoretizdat (1952).
2. N. P. Gnusin, Zhurnal prikladnoi khimii, 33, No. 3 (1960).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**
