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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

ELECTROLYTIC TANK MEASUREMENTS IN THREE DIMENSIONS

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September 13, 1951

Berkeley, California

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We have become interested in extending the electrolytic tank method to electric fields that are three dimensional. In order to establish the accuracy of the results we used a field that is calculable and which is confined in the sense that no field lines are present at the boundaries of the solution. This situation is satisfied by the field which exists within a cylindrical cavity one half of which $(z > 0)$ is at ground potential and the other half $(z < 0)$ is at potential V_o. The cavity is terminated by conducting planes at $z = \pm c$ and has a radius a.

Measurements of the potential were made for a dozen z values at a radius of .4360a. The z values were known to $\pm$ .001" by the use of a micrometer and gauge blocks. The geometry is shown in Fig. 1. "a" had the value 4.025 inches and c was 4.028_5 inches.

We found that proper probe construction is essential for reliable results. In this regard we were guided by the experience of Makar, et al. with a two dimensional geometry[1]. Current is allowed to enter the probe only on its tip. We used several layers of formvar insulation (total thickness $\sim$1 mil) to accomplish this. The disturbance that the probe sets up in the solution is mainly in the region of the tip. The current flow is disturbed on the shank of

the probe only by the geometrical obstruction it presents since the shank conductivity is effectively zero.

In order to reduce the effect of the probe tip on the measured potential it would seem that one should make it as small as possible. This however led us to erroneous results which we found by using the clipped end of the 30 mil diameter probe. This result is in agreement with the reference quoted since the current density vastly exceeded their tolerances. We obtained more reliable data by using a spherical tip of about twice the probe diameter which increases the conduction area by a factor of sixteen. The probes were made of 30 mil tungsten rod insulated except for the spherical tip, which was silver plated.

For long periods of measurement we found copper electrodes to be unsatisfactory since a non-conductive layer is formed on the electrodes. We found that silver plating the electrodes and the use of an electrolyte containing one gram of silver nitrate per liter gave satisfactory operation over a period of several weeks.

The potential of the probe was determined by a null reading on an oscilloscope. The circuit is shown in Fig. 2. A true null was obtained only when capacity was added in parallel with the resistances in the two known arms of the bridge. In order to obtain proper bridge balance at the frequency used (1000 cycles) it was necessary to use a shielded audio-transformer between the audio-oscillator and bridge. Another shielded transformer was employed to isolate the oscilloscope from the bridge circuit. Unreliable results

are also obtained in agreement with reference 1 if the current thru the electrolyte is too low. We found it necessary to use a single stage 6 L 6 amplifier to boost the audio-oscillator power to a level sufficient to give enough current. The input voltage was fed to the x-axis of the oscilloscope and the difference between the probe voltage and the potentiometer voltage was applied to the y-axis. A null thus consisted of a straight line on the scope with zero slope. The sensitivity was such that one could detect voltages of the order of 10^{-3} of the applied voltage, V_o.

Smythe[2] gives the solution for the potential if the upper half of the cylinder is at potential V_o and lower half at potential $-V_o$. A simple superposition of potentials then gives the potential in our system. The calculation was carried to an accuracy of one part in 10^4 for the 12 points investigated, which were in the region from $z = +4$ inches to $+1$ inch. If one uses $\frac{V_{meas.} - V_{calc.}}{V_o}$ as a criterion for the accuracy of the potential measurement, then this quantity was always less than 0.2%. The z component of the electric field was calculated by using linear and cubic interpolation of the measured and calculated points. Both interpolation methods give the same fields within the accuracy of the measurements. The error made in the fields, $\frac{E_{meas.} - E_{calc.}}{E_{calc.}}$, is of the order of 2% for all points and is largest for the longer probe lengths.

This work was performed under the auspices of the Atomic Energy Commission.

REFERENCES

1. R. Makar, A. R. Boothroyd, and E. C. Cherry, Nature, 161 845, 1948.

2. Static and Dynamic Electricity, W. R. Smythe, 1st edition, p. 207, problem 92.

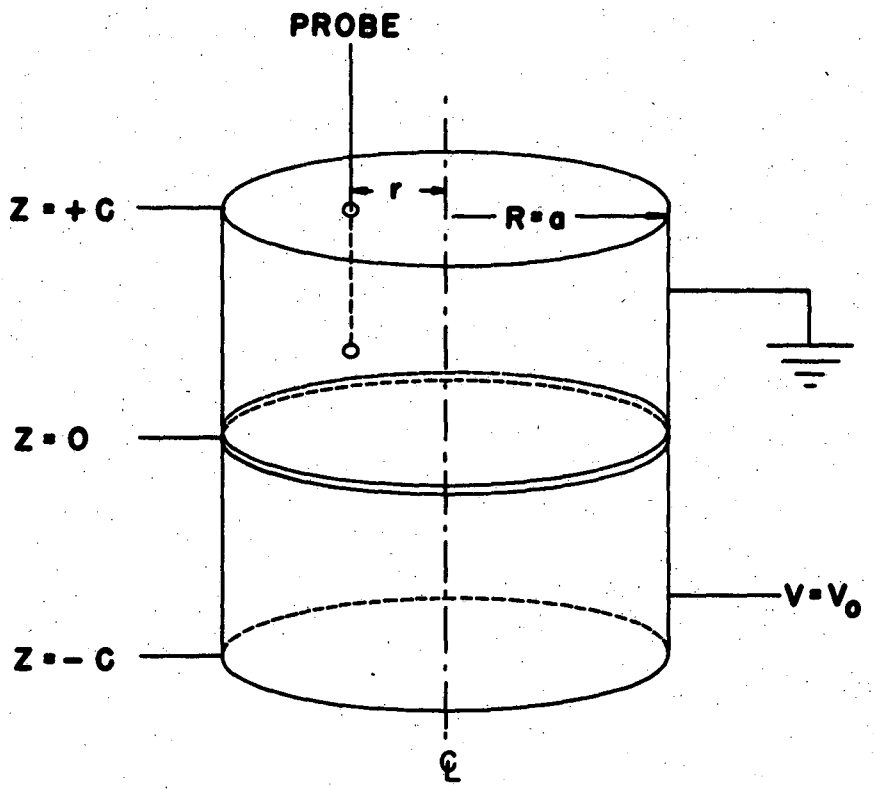

FIG. 1
ELECTROLYTIC TANK

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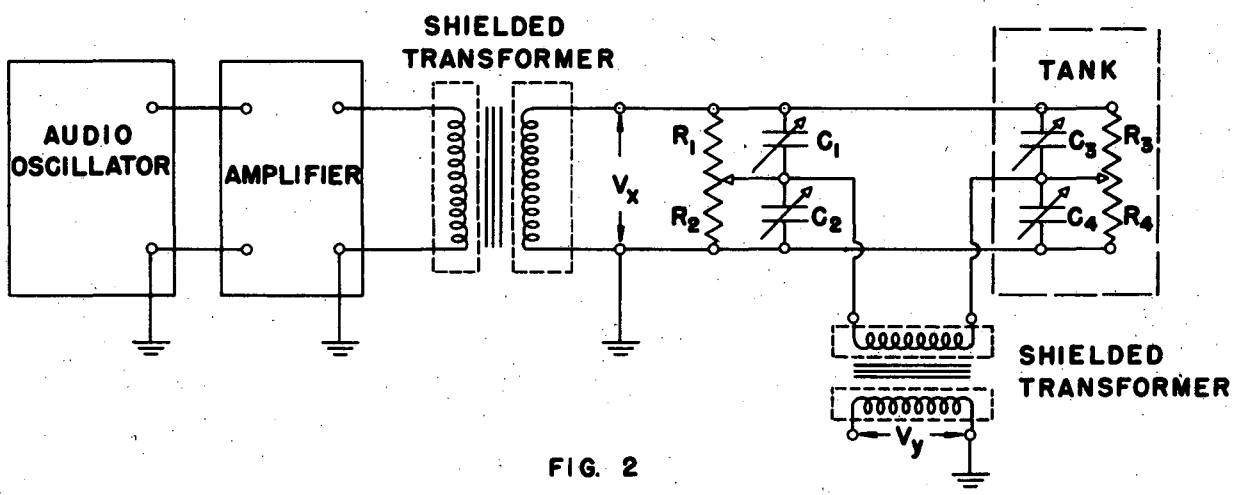

FIG. 2
SCHEMATIC OF BRIDGE
FOR ELECTROLYTIC TANK

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