

That is, any variation caused by the sound on the discharge from the Nernst filament must have been less than  $\frac{2}{3}$  of  $2 \times 10^{-14}$  or  $\frac{4}{3}$  of  $10^{-14}$  amps, since the current was passing through  $\frac{2}{3}$  as much resistance.

The resistance coupled amplifier used in the case of the ionization current from incandescent platinum was considerably more sensitive than the other two cases mentioned. It was so sensitive that unavoidable capacity changes due to the circuit itself caused an audible tone in the telephone receivers.

We conclude that whatever effect there may be in any of the three cases, it is too small to be of any practical importance when used with materials and apparatus now available.

The writer of this paper wishes to thank Dr. Foley, who directed the research, for his interest and helpful suggestions during the progress of this work, and also the other members of the staff, who from time to time have shown interest in the problem and have given many valuable suggestions. I wish also to thank the Messrs. Price, Buell, and Foreman for help in making observations with the telephone.

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## METHODS OF MEASURING SURFACE POTENTIALS

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In the study of frictional electricity we observe the existence of large potential differences only when two surfaces have been separated to a relatively large extent. If we can observe the existence of a small potential difference with the surfaces at a small distance apart, we can understand the large potential due to their separation. Based upon this principle, a method of measuring surface potentials was devised by Volta and later used by Pellat.<sup>1</sup> This method, known as the condenser method, consists of two parallel surfaces, one of which is fixed, and the other is caused to move so as to vary the distance between them. In this way, an existing small potential difference between the surfaces is magnified and the effect can be measured with an electrometer. By inserting a counter source of potential in the circuit, the two surfaces may be adjusted to the same potential whereby no effect is produced by their relative motion. The condenser method, though simple in theory, has proved very delicate in operation. If one of the surfaces is a solution and the other a metal plate, it was found that the adsorption of moisture on the surface of the metal affects its potential to a considerable extent.

A second method has been used where a solution is concerned<sup>2</sup> and consists in measuring the potential difference between two flowing solutions. One of the solutions flows down the inside wall of a glass tube,

<sup>1</sup> H. Pellat: *Ann. de Ch. et Phys.*, 24:5, 1881.

<sup>2</sup> Kenrick: *Z. Physik Chem.*, 19:625, 1896.

the other, in the form of a jet, through the air space in the center of the glass tube. The results obtained by this method have not been consistent, and it is also difficult to separate the so-called ballo-electric effect, due to the breaking up of the jet, and the potential which is to be measured.

A third, and perhaps most convenient to use, is known as the ionization method.<sup>3</sup> It is similar to the condenser method with the exception that the surfaces are fixed and the space between them is made conducting by the use of some source which will ionize the air space. Radioactive materials are well suited for this purpose. However, such radioactive substances which ionize a small space have been found to give more consistent results. Polonium and uranium can be used, since they emit only the alpha particles which are completely absorbed in less than two inches of air.

We have used the ionization method for measuring the surface potentials of solutions. Instead of using an upper plate, our upper electrode was a silver wire with a small silver bead on the end and upon which polonium has been deposited. A sensitive Lindemann electrometer was used and its deflection was brought to zero by means of a potentiometer. In all the measurements the electrode making contact with the solution was either a reversible electrode or a siphon bringing the solution in contact with a normal calomel cell. If the concentration of the experimental solution is varied, any change in the potential at the surface layer of the solution can be calculated, since the behavior of the reversible electrode is accurately known. In this way the change of surface potential can be studied as a function of the concentration of the underlying solution. For these results to be accurate we can easily see that the potential of the radio-active electrode must be constant throughout the measurement.

This arrangement was found to be subject to the same errors which have been mentioned before with regard to the condenser method, namely, that due to the adsorption of moisture on the surface of the upper electrode, its potential changes.<sup>4</sup> Other sources of error have been suggested by Williams and Vigfusson.<sup>5</sup> We observed in the course of our experiments that when the surface of the experimental solution was covered with a single layer of stearic acid molecules the potential difference in the whole circuit was nearly constant over a several hours interval. The effect of adding a larger number of layers did not change the final value. In order to eliminate the moisture effect on the upper electrode, the possibility of making use of the above observation was suggested by Dr. Lark-Horovitz.

In Fig. 1 is given the new arrangement which we finally used. The solution at the tip of the glass siphon was covered with several layers of stearic acid. The polonium covered bead ionized the space between the stearic acid layers and the experimental solution and was not metallically connected with either.

<sup>3</sup> Guyot: *Ann. de Phys.*, 2:506, 1924. Frumkin: *Z. Physik Chem.*, 116:485, 1925.

<sup>4</sup> Guyot: *Loc. cit.*

<sup>5</sup> Williams and Vigfusson: *J. Phys. Chem.*, 35:345, 1931.

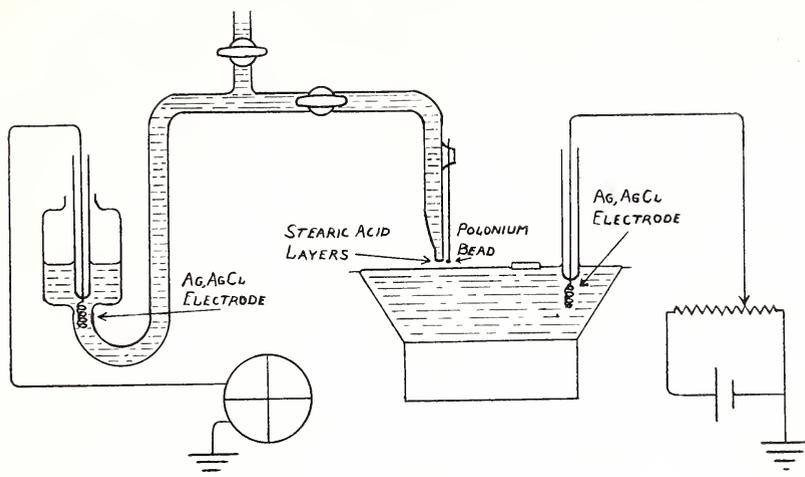


Fig. 1.

So far we have studied the relation between the concentration of the solution and the corresponding change in the potential of the circuit and found our results with the new arrangement much more reproducible, and constant with time, than with a metallic upper surface.

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## RADIO FIELD INTENSITY MEASUREMENTS ABOUT ATHENS, OHIO

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A meter for measuring radio field intensities was constructed along lines similar to the instruments of England<sup>1</sup>, Friis and Bruce<sup>2</sup>, and Byrne<sup>3</sup>.

The meter is essentially a vacuum tube voltmeter, reading the radio frequency voltage produced across the tuning condenser of the loop antenna circuit. It consists of a tuned loop antenna, feeding a superheterodyne receiver with an adjustable, calibrated attenuator in the intermediate frequency amplifier circuit. A calibrating oscillator furnishing a known voltage for comparison is coupled to the loop. Plate meters in the first and second detector circuits are used as volume level indicators.

<sup>1</sup> Proc. I. R. E. V. 5 P. 248, 1917.

<sup>2</sup> Bell Tel. Lab. reprint B-209, Sept., 1926.

<sup>3</sup> Ohio State U. Studies, V. 1, No. 4, Part 2, July, 1932.