SCIENTIFIC APPARATUS AND LABORATORY METHODS

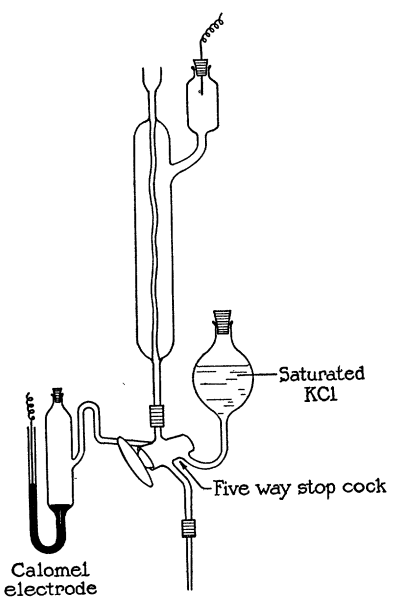
GLASS ELECTRODE WITH GALVANOMETER READING[1]

THE successful development of the use of the glass electrode for pH measurement has depended on the use of electrostatic instruments, either electrometers of the quadrant type or related instruments or electronic valve devices. The high resistance of the glass membrane has discouraged the use of the potentiometer with a galvanometer as zero instrument in spite of the otherwise considerable advantages of such an outfit as to simplicity in equipment and handling. In this laboratory we succeeded in building a relatively simple glass electrode device with galvanometer reading which has proven most satisfactory for more than two years. The problem was solved simply by lowering the resistance of the glass membrane as much as possible and using a sufficiently sensitive galvanometer.

The glass electrode used is essentially the sealed-in type described by MacInnes and Belcher.[2] It is made of the same type of glass and differs from the original model only by the shape and thickness of the glass membrane. The wall of the glass membrane is as thin as the glassblower could manage to make it, and the shape of the inner tubing is not a spiral but almost straight, just a little curved to obviate strains in the glass. The length of this inner tube varied, in different samples of the electrode, from 25 to 40 cm and its volume from 3 to 5 cc. The thinness of the wall has not only the advantage of lowering the resistance but also of abolishing the asymmetry potential. Such an electrode, after two or three days' contact with aqueous solutions, has as a rule practically no asymmetry potential. The resistance amounted in various samples to from 4 to 10 megohms. Samples of somewhat higher resistance can be used, but the sensitivity may not be sufficient for all purposes.

This electrode was used in combination with an ordinary potentiometer and a galvanometer. The type of galvanometer usually used with the Leeds and Northrup potentiometer, Type K, is not sensitive enough. We used a galvanometer of the Cambridge Instrument Company which is critically damped by an external shunt of 20,000 ohms (the permanent shunt built into the Type K potentiometer must be removed, and a shunt of 20,000 ohms across the galvanometer used instead), and has a period (when undamped) of 10 seconds. The sensitivity is such that 1 mm deflection in 1 meter's distance corresponds to 2.5×10^{-10} amperes. Under these conditions 1 millimeter deflection corresponds, for electrodes of the above mentioned low range of resistance, to from 1 to 2 millivolts. So it is easy to read the millivolts and to estimate the tenths of a millivolt. Several such electrodes are in permanent use in this laboratory. They are mechanically astonishingly resistant and practically unbreakable, as the delicate parts are entirely sealed in.

Two types of set-up are in use in this laboratory. Type I is used to measure pH in a sample of a liquid. It is quite convenient to equip it with MacInnes' and Belcher's five-way stop-cock for the establishment of fresh liquid junctions. The solution is poured in from above. Three to six cc are necessary, according to the volume capacity of the glass tube. If only less liquid is available, it is sufficient to fill the tube only to a half or less, provided the whole tube has been well rinsed by the liquid when pouring it in. The result is not altered whether the tube is entirely full or not. Type II is used for acidimetric titrations. The samples of the liquid are sucked into the glass tube from the beaker.



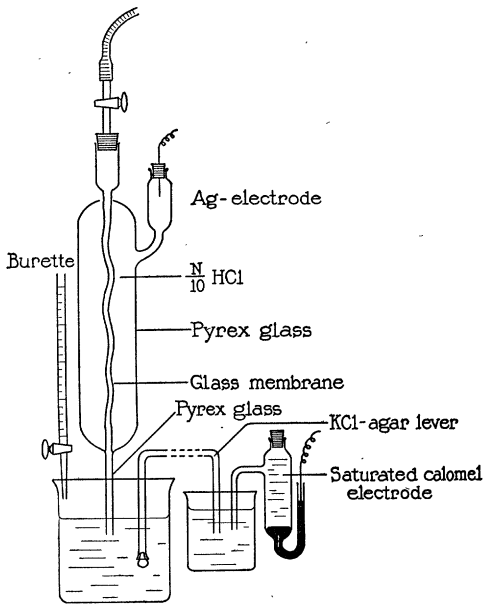
TYPE I

The outer compartment is permanently filled with 1/10 N HCl, containing a chlorinized silver electrode.[3] This solution is never changed. Each set of experiments begins with the measurement of a sample of standard acetate (100 cc *N* NaOH, 200 cc *N* acetic acid, filled up with H_2O to 1 liter). A stock solution of this buffer keeps unchanged over many months. Its pH is taken = 4.62 and used as reference value. The slope of the potential against pH is within the limits of error the one thermodynamically expected for a reversible hydrogen electrode at least within pH 1 and 9, and even to pH 11 the deviations are very small.

[1] From the laboratories of the Rockefeller Institute for Medical Research, New York.

[2] D. A. MacInnes and D. Belcher, *Ind. and Eng. Chem.*, Analytical Edition, 5: 199, 1933.

[3] Alfred S. Brown, *Jour. Amer. Chem. Soc.*, 56: 646, 1934.



TYPE II

The correctness of the slope is shown in the following experiment.

A solution containing 1 mole NH_4Cl per liter, and NH_3 in the concentration indicated in the table showed the following potentials at 30° C. = (in a constant temperature room).

$[NH_3]$	Electrode I, 7 megohms (filled with .1 N HCl)	Difference	Total difference	Electrode II, 4 megohms (filled with .5 N HCl)	Difference	Total difference
.001000	.2566			.3109		
		.0602			.0598	
.01000	.3168			.3707		
		.0600	.1805		.0601	.1802
.1000	.3768			.4308		
		.0603			.0603	
1.000	.4371			.4911		

The difference should be theoretically in each case .0601 volts; and the total difference over three units of pH is theoretically .1803 volts. This table is taken from measurements made by Dr. J. Bjerrum in this laboratory, who has used this glass electrode for various investigations to be published later.

Except on very warm and humid summer days, no trouble of any kind was encountered in the use of this method.

LEONOR MICHAELIS

A SIMPLIFIED PROCEDURE FOR THE VOLUMETRIC MEASUREMENT OF SERIALLY SECTIONED STRUCTURES

BIOLOGISTS have frequently been able to determine the volume of glands, etc., too small or diffuse to be otherwise handled by outlining serial sections and measuring the outlines either by cutting out and weighing or by use of a draftsman's planimeter. The use of this latter instrument is somewhat simpler, though in either case the method is laborious.

In extensive use of this technique the author has found it possible to so simplify the procedure that, aside from the preparation of the slides, very little effort is involved.

The outlines, by projection or camera lucida, are prepared in sequence on a continuous sheet of wrapping paper. The planimeter is set upon a large sheet of heavy clear celluloid (or other thin flat transparent material) which is tacked down at the ends. A pinhole near the center is made and marked as the starting point. The celluloid sheet should be large enough so that in all measurements the planimeter rides entirely upon it.

The sheet with outlines are slipped *under* the celluloid and a point on the first perimeter is brought under the starting point. The pointer is traced around, measuring the first outline. Then without disturbing the planimeter the outline sheet is slipped along until a point on the next outline is under the starting point. When this is measured the planimeter automatically adds its area to that of the preceding. If it is desired to subtract any particular part of the outline the planimeter is run backwards. The final sum of the areas is given by one reading of the planimeter. From this and the thickness of the sections the volume is calculated.

By this method a gland involving over one hundred sections can be carefully outlined, measured and checked in less than two hours. A comparison with the paper weight method showed somewhat less variability and the further advantage of giving actual volumes.

WILLIAM ETKIN
COLLEGE OF THE CITY OF NEW YORK
AND
THE AMERICAN MUSEUM OF NATURAL HISTORY

BOOKS RECEIVED

CRILE, GEORGE. *The Phenomena of Life: A Radio-Electric Interpretation.* Pp. 379. 113 figures. Norton. $3.50.

EDGEWORTH, F. H. *The Cranial Muscles of Vertebrates.* Pp. viii + 493. 841 figures. Cambridge University Press, Macmillan. $30.00.

PETERS, J., A. LODGE, E. J. TERNOUTH and E. GIFFORD. *Mathematical Tables.* Vol. V: *Factor Table: Giving the Complete Decomposition of All Numbers Less than 100,000.* Pp. xv + 292. British Association for the Advancement of Science. Cambridge University Press, London. 20/–.

STOKLEY, JAMES. *Stars and Telescopes.* Pp. xiii + 319. 40 figures. 49 plates. Harper's. $3.00.