these gentlemen. The value and significance of being in touch with minds striving toward the upbuilding of dental science, and the intrinsic worth of their assistance in setting up definite standards and regulations will be an enduring influence, we hope, in making the administration of our research funds an increasingly effective stimulus to professional and scientific growth.

In accordance with the policy of the college to give public recognition to one who in any field of science has made an outstanding contribution to the progress of dentistry, the Centennial Celebration in Baltimore was selected as a most fitting occasion for the initial William John Gies Award of the college. It was therefore bestowed, on March 17, 1940, upon Peter John Brekhus, of Minneapolis, for distinguished services in the cause of dental education and research in this country. The award, in the form of a suitably engrossed citation, was presented not only to glorify the recipient in the eyes of his fellow-workers, thus adding to the prestige of the quietly effective labors to which our research workers are faithfully devoting themselves, but also to acknowledge, as openly and strikingly as possible, the debt of all members of our profession to those who fulfil in highest measure the avowed function of us all—to enlarge the scope of dental science so far as experience, ability and opportunity will permit. It is the earnest hope of our committee that the simple ceremony at Baltimore may have impressed upon the public at large the fact that we—the whole body of our profession—are engaged upon an endless quest, to seek out the ultimate laws of health and discover more and more surely the principles which govern their application to human welfare.

Our research fellowships and grants-in-aid are intended as a practical expression of this same fundamental need in our professional life—a need not only of the results which research may produce, but also of the pervading influence of the spirit of research. We must live not only in the present, with its task and its reward; but with the zest of fresh discoveries and new insights which may lie just ahead—with the constant expectation that old difficulties will vanish as the forces of nature are better understood. Little by little we can gain upon the vast areas of the unknown; and to promote this conquest the research funds have been awarded, with our best wisdom and discrimination, after due study of the credentials and projects of the applicants by a subcommittee which had previously set up the necessary mechanism of appropriation, application, supervision and publication of results. The names of the successful applicants, with the sums awarded, the inquiries and where they are to be pursued are as follows:

Dr. Harrison R. Hunt and Dr. Carl A. Hoppert, $100.00, "Inheritance factor in resistance and susceptibility to dental caries in rats," Michigan State College.

Dr. Albert H. Kniesner, $500.00, "The factors in saliva which influence the growth of *L. acidophilus* and are indicative of the presence or absence of dental caries," School of Dentistry, Western Reserve University.

Dr. Sidney B. Finn, $1,200.00, "The effect of applications of sodium fluoride in preventing and controlling dental caries in children," School of Dentistry, University of Rochester.

Dr. Samuel Seltzer, $500.00, "The anti-bacterial action of drugs which have been recommended for cavity sterilization," Dental School, University of Pennsylvania.

Dr. M. L. Tainter, $400.00, "The general problems involved in the evaluation of the abrasiveness of dentifrices and their individual constituents," College of Physicians and Surgeons, San Francisco, Calif.

Dr. James Nuckolls, $500.00, "The primary centers of lobular development, growth and calcification in the tooth," Dental College, University of California.

Dr. B. Orban, $500.00, "Wound healing after different methods of gingivectomy and post-operative treatment," Dental School, Northwestern University.

William J. Furuta, $1,000.00, "Histologic study of the effect of various mineral deficiencies in dental and oral structures in animals," College of Dentistry, University of California.

A. L. MIDGLEY,
Chairman

COMMITTEE ON DENTAL RESEARCH OF
THE AMERICAN COLLEGE OF DENTISTS

SPECIAL ARTICLES

THE VOLTAMMETRIC DETERMINATION OF OXYGEN

BY the term "voltammetry" we mean the determination and interpretation of current-voltage curves obtained in electrolysis experiments using a suitable microelectrode as an indicator electrode. By indicator electrode we mean that the current is determined entirely by the phenomena occurring at that particular electrode, the potential of which may be varied by varying the e.m.f. applied across the electrolysis cell consisting of the indicator electrode and a depolarized reference electrode of practically constant potential. When using the dropping mercury electrode the terms "polarography" (self-registering apparatus) and "polarometry" (manual apparatus), introduced by Professor J. Heyrovsky in Prague, are synonymous with voltammetry.

Oxygen can be determined in a simple way with the dropping mercury electrode.[1,2,3] Our studies have

[1] V. Vitek, *Coll. Czech. Chem. Comm.*, 7: 537, 1935.

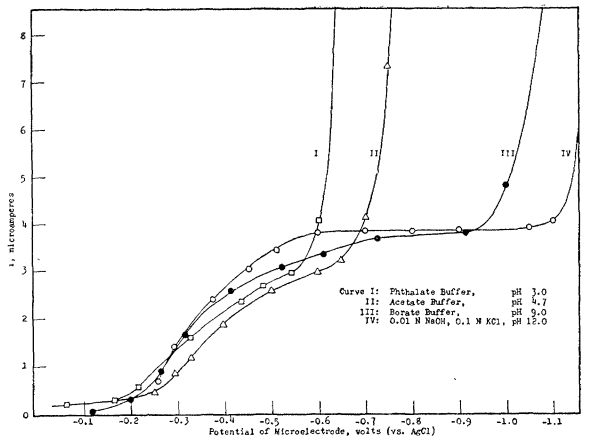

FIG. 1. Reduction of oxygen in various air-saturated solutions.

shown that oxygen can also be determined voltammetrically by using a platinum wire microelectrode. The electrode consisted of a platinum wire 4 mm long and 0.5 mm in diameter sealed on the end of a glass tube and suspended in the solution. A 0.1 N silver-silver chloride electrode was used as a reference electrode. Fig. 1 shows some current-voltage curves obtained at 25.00° C. in various air-saturated buffer solutions with pH values between 3 and 12. The diffusion current was found to be proportional to the oxygen concentration, but it changed markedly (about 4 per cent. per degree) with the temperature. From our results we calculated that the diffusion coefficient of oxygen is 2.38×10^{-5} cm^2 sec^{-1} at 25° C.

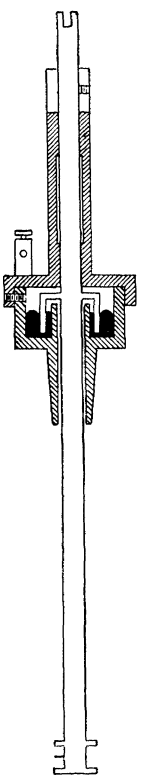

FIG. 2.

A disadvantage of the wire electrode is that at each value of the applied e.m.f. it is necessary to wait about two minutes until a steady state has been reached. From then on the current remains constant for relatively long periods of time. This constancy of the current is an advantage over the dropping mercury electrode, with which a fluctuating current is obtained. A disadvantage is that the hydrogen overvoltage on platinum is very small, so that in relatively weakly acid medium (pH less than 6) the discharge of hydrogen interferes with the determination of the diffusion current of oxygen.

The disadvantage of waiting for a steady current state can be eliminated by working with a rotating electrode. The speed of rotation must be kept constant in order to get reproducible results. Fig. 2 shows a mercury-sealed electrode which was rotated at 600 R.P.M. by means of a synchronous motor. From a practical viewpoint the rotating electrode has the following advantages: (1) the current is immediately constant and (2) the measured currents are much larger than with the stationary electrode. For example, the diffusion current of oxygen in an air-saturated solution was 3.5 microamperes with the stationary electrode and about 60 microamperes with an electrode of the same size rotating at 600 R.P.M. Thus, the rotating electrode can be used for the determination of traces of oxygen.

Fig. 3 shows some current-voltage curves obtained with an air-saturated solution of 0.1 N potassium chloride, and the same solution after bubbling tank nitrogen through the solution for 10 minutes.

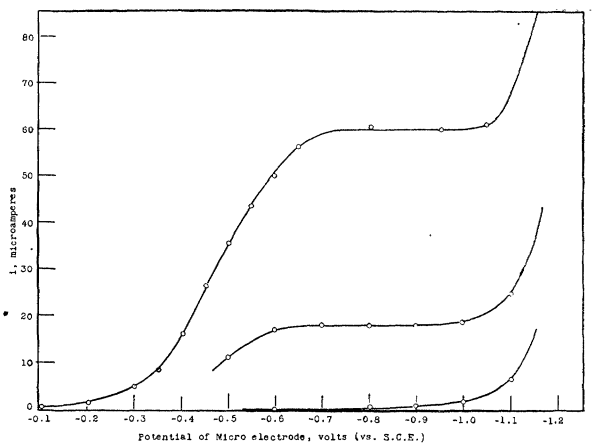

FIG. 3.

The rate of removal of dissolved oxygen by bubbling unpurified tank nitrogen through the solution at a rate of about 4 bubbles per second is shown by the data given in Table 1, which shows the diffusion current as a function of the time of bubbling nitrogen through the solution.

TABLE 1

Time of bubbling N_2, min.	0	5	10	15	20	30	40	60
i_d, microamperes ...	61.0	31.7	18.0	8.87	3.55	1.40	0.94	0.79

A longer time of bubbling did not appreciably lower the diffusion current. Tank nitrogen from which oxygen was removed by passage through an electric heating tube containing copper turnings at a temperature of about 500° did not give an appreciably lower diffusion current, even after prolonged bubbling. It was shown that the trace of oxygen remaining in the solution diffused through the agar plug and sintered glass plate

[2] H. G. Petering and F. Daniels, *Jour. Am. Chem. Soc.*, 60: 2796, 1938.

[3] C. S. Miller, Ph.D. Thesis, University of Minnesota, 1940.

separating the two halves of the electrolysis cell,[4] since the diffusion current of oxygen increased from 0.79 microampere to 1.10 microamperes when the solution was allowed to stand for 10 minutes with no nitrogen bubbling, but the electrode rotating. By using a large silver anode in a simple cylindrical electrolysis cell, it was possible to reduce the diffusion current of oxygen to 0.60 microampere using unpurified tank nitrogen and to 0.20 microampere using the purified nitrogen.

Assuming that the residual current in an entirely air-free solution was given by the current obtained in the sulfite experiment described below (0.15 microampere at 0.8 V vs. S.C.E.), the oxygen content of the unpurified tank nitrogen is calculated to be 0.15 per cent., and that of the purified nitrogen 0.02 per cent.

Heyrovsky[5] and Hohn[6] describe the use of sodium sulfite to remove dissolved oxygen, but give no quantitative data regarding its efficiency, or the rate of the reaction between oxygen and sulfite in neutral or alkaline medium. In the present study, 0.1 gm of sodium sulfite was added to 100 ml of 0.1 N potassium chloride, allowed to stand for 10 minutes, and a current voltage curve was determined with the rotating electrode. No trace of oxygen was detectable in the solution. The current-voltage curve is shown as the lowest curve in Fig. 3.

The stationary and the rotating wire microelectrodes are also useful for the voltammetric determination of other constituents which can be electro-reduced or electroöxidized. These applications and experimental details will be discussed in forthcoming papers.

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A DEFICIENCY DISEASE OF FOXES

A DIETARY disease that occurs in animal populations and is associated with the feeding of fish has been found in our investigations to be a vitamin deficiency and to be the counterpart of the alcoholic polioencephalitis of man described as Wernicke's disease. This condition, which we have for years termed "Chastek paralysis," is of considerable economic importance in the fox-raising industry. Clinically, it presents a well-defined syndrome characterized by a preliminary period of anorexia lasting a week or ten days, followed by a rapid development of weakness, ataxia and spastic paralysis. Death usually occurs within 48 to 72 hours after the onset of neurologic disturbances. Up to the present time we have observed outbreaks of this disease on fox ranches located in five different states. Most of them have occurred during the months from November to May, inclusive, and no large outbreaks have been noted during the summer. The mortality has varied from 1 to 37 per cent. of the total herd, according to the type of treatment instituted. Small ranches with as few as 17 pairs of foxes and large ranches having several thousand foxes have been affected.

The clinical characteristics of the disease have been essentially the same in all outbreaks. They have, without exception, occurred on ranches where fish or fish products were fed as 10 per cent., or more, of the diet. The first evidence of disease among the foxes usually appears from three to six weeks after fish have been added to the diet. The foxes show only anorexia for a week or 10 days and then a few animals at a time begin to exhibit signs of neurologic disturbances. These include weakness and unsteady gait, ataxia, hyperesthesia and spastic quadriplegia. Convulsions may occur shortly before the animal dies. The symptoms are always progressive and lead to death within a few days.

Repeated attempts to demonstrate an infectious agent as the cause of the disease have been consistently negative. A total of about 190 red foxes, 20 dogs, 7 ferrets, 6 mice, 6 squirrels and 12 rabbits and guinea pigs have been inoculated with suspected material by intraperitoneal, subcutaneous, intramuscular or intracranial routes or have been fed the material by stomach tube in attempts to transmit the disease. In no case has the disease been successfully transmitted.

Dietary experiments show that this disease can readily be produced by feeding foxes a ration poor in vitamin B_1 and containing fresh fish.

Carp has been the most common species of fish used on ranches where this disease has appeared. However, quillbacks, mullets and suckers, and Atlantic whiting have also been incriminated. The fish causing this disease have come from a variety of sources, including the Atlantic Ocean, fresh-water lakes in Utah, Minnesota and Canada, and the Cedar River in Iowa.

It is clear that the course of all the outbreaks has been determined by the dietary management on the ranch. In all cases the disease has been progressive, involving an increasing number of foxes as long as fish remained in the diet. In most instances the owner of the fox farm has suspected fish to be a cause of the disease and has eliminated it from the diet within a short time after the first death occurred. On one ranch, however, the feeding of fish was not discontinued until three weeks after the first death, and the result was a mortality of 34 per cent. in a herd of over 200 foxes.

After fish has been eliminated from the fox ration,

[4] J. J. Lingane and H. A. Laitinen, *Ind. Eng. Chem.*, Anal. Ed., 11: 504, 1939.

[5] J. Heyrovsky, "Polarographie," in W. Böttger, "Physikalische Methoden der Analytischen Chemie," Bd. 2, Akad. Verlagsgesellschaft, Leipzig, 1936.

[6] H. Hohn, "Chemische Analysen mit dem Polarographen," Verlag von Julius Springer, Berlin, 1937.