E. M. F. in a given cell, without producing oxygen bubbles at the smaller plates.

In a perfectly "balanced" rectifier, as long as the impressed E. M. F. is not too high, the quantity of current capable of doing unidirectional work is proportional to the impressed E. M. F.

If the active E. M. F. of a rectifier be too high a continuous current will flow, and the amount of rectification be dependent on the impressed E. M. F.; if the latter below, rectification may cease completely.

If the active E. M. F. be too low the amount of rectification is dependent on the impressed E. M. F., and may become zero if the latter be low. This property prevents the use of rectifiers in circuits in which any considerable counter E. M. F. is produced.

Rectifiers for high E. M. F. can be formed by joining a number of cells in series. The passive plates in each can then be correspondingly increased in size, while the whole set gives the same efficiency as one of the cells gave before its electrode was enlarged. The number of rectifiers and the impressed E. M. F. should be proportioned to their circuit exactly as primary cells are proportioned, each primary cell being represented by a rectifier and a certain portion of the impressed E. M. F.

[CONTRIBUTIONS FROM THE HAVEMEYER LABORATORIES OF COLUMBIA UNIVERSITY, NO. 24.]

A METHOD FOR THE DETERMINATION OF ELECTRICAL CONDUCTIVITY WITH DIRECT CURRENT INSTRUMENTS.

BY J. LIVINGSTON R. MORGAN AND W. L. HILDBURGH.

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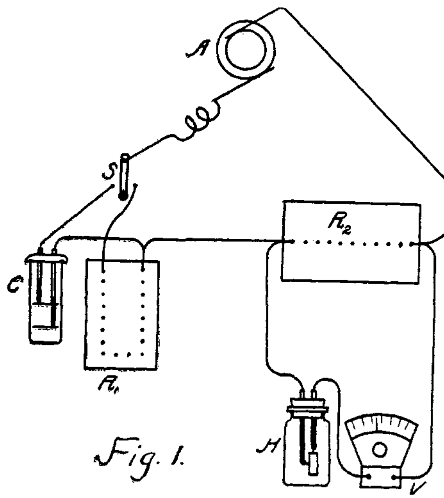
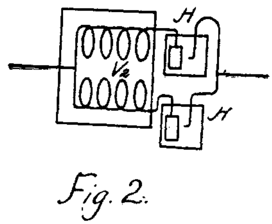
IN the determination of electrical conductivity, in order to prevent errors, it is necessary to use an alternating current whose frequency is of such a value that the electrodes, during a half period of the alternating current, receive a polarization which is negligible compared to the voltage impressed. Up to the present time it has been difficult to detect small quantities of an alternating current, except by aid of the telephone. In the

Kohlrausch-Ostwald method the electrolyte is placed in one arm of a Wheatstone bridge, an alternating current passed through it and the resistance balanced on the bridge wire against a known value by aid of the telephone. McIlhiney[1] passes a direct current through a direct current measuring instrument and then transforms it into an alternating current with a rotating pole changer and carries it through the electrolyte.

One of us[2] has designed a number of rectifying cells for the purpose of permitting the passage of current in one direction only, so that an alternating current in going through them is more or less rectified and has many of the properties of a direct one. Of these cells the most suitable for laboratory use is the continuous acting hydrogen cell, which has been applied to conductivity measurements in the following way: The apparatus for the substitution method is arranged as in Fig. 1. The alter-





A is the source of the alternating current. S a switch allowing either C or R_1 to be in the circuit, C is the unknown resistance, R_1 and R_2 resistance boxes, H the hydrogen cell rectifier, and V the voltmeter or galvanometer.

nating current from A passes through the electrolyte in C and the non-inductive resistance R_2, to the terminals of which is connected a direct current instrument in series with the rectifying

[1] This Journal, 20, 206 (1898).

[2] W. L. Hildburgh: This Journal. Also Ph.D. thesis in press and *School of Mines Quarterly*, July and October, 1900. Also *Elec. World and Eng.*, 1900.

cell. The reading of the instrument is noted when the current passes through the unknown resistance C, then S is moved so as to replace C by R_1, a non-inductive adjustable resistance, and this varied until the same reading is observed as before. If the proper precautions have been observed, the resistance of R_1 is equal to C and the conductivity may be calculated.

For the source of the alternating current we have found a small alternator to be more satisfactory than the small induction coils commonly used; there is, however, apparently no reason why a properly arranged coil should not be available. With the ordinary (Kohlrausch) electrodes and an alternating pressure of 2 volts the results were found to agree very satisfactorily with those obtained by the Kohlrausch-Ostwald method.

For the highest sensitiveness the following conditions should obtain. The resistance of R_2 which must be small compared with C, should be as large as possible.

The instrument V (galvanometer) should give large readings with small currents, and its resistance should be low. The frequency of the alternating current should be as low as allowable, the voltage as high as allowable, and the electrodes in C large. The area of the inert electrode in the rectifier should be small so as to give a high asymmetrical efficiency (percentage of rectification).

A considerably more sensitive arrangement is obtained by replacing R_2, H and V by a differential wound instrument whose two windings are exactly alike and are in series each with a rectifier. If these two coils are properly arranged all waves of one sign will go through one winding, and all of those of the opposite sign through the other (Fig. 2). This utilizes the whole of both half waves of current, instead of only a part of one, so that the deflection of the needle is very much greater.

The hydrogen cell rectifier can be "balanced" by adding a small electromotive force in series, so that up to a certain point a direct current instrument in series with it will give readings almost exactly proportional to the alternating current. Knowing the alternating voltage, the rectification constant of the hydrogen cell and the resistances of C and H, the resistance of C can be calculated directly from the readings of V. This method can be used without "balancing" the cell by calibrating V, using different known resistances in place of C. The resistance of C can then be read directly from the scale of the instrument. In both these modifications the frequency of the alternating current must remain the same, and neither is as accurate as the first one by substitution.

The hydrogen cell rectifier permits the use of an optical detector instead of the telephone in the Kohlrausch-Ostwald method. The telephone is replaced by a resistance and a sensitive galvanometer in series with the "balanced" cell, arranged like R, V and H in Fig. 2. The point on the slide wire which gives no deflection is then the same one as found by the telephone.

To "balance" the cell the circuit of a Leclanché is closed through a high resistance and a slide wire. The alternating current being stopped, an electromotive force is taken from the slide wire and sent through the rectifier, the slide being left just below the point which shows deflection. If "overbalanced" the cell will give a constant deflection, but if "underbalanced" the low voltage current obtained will give no deflection. An arrangement like Fig. 2 will give here greater sensitiveness, but the method of substitution as first described is the simplest and gives the best results.

[CONTRIBUTION FROM THE LABORATORY OF ANALYTICAL CHEMISTRY, UNIVERSITY OF MICHIGAN.]

ON THE PREPARATION OF POTASSIUM XANTHATE FOR NICKEL DETERMINATIONS.

BY E. D. CAMPBELL.

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IN 1895 the author with W. H. Andrews published a method for the determination of nickel in nickel steel.[1] This method has been in use in this laboratory since its publication and has given very satisfactory results, provided the potassium xanthate used had been properly prepared. The potassium xanthate usually found on the market has not been satisfactory owing to the fact that the salt after making has not been carefully washed and dried. The practice in this laboratory has been to have each student prepare the potassium xanthate used in his own work.

[1] This Journal, 17, 125.