

injures its use for general purposes; it can, however, be utilized for colliery work, to the economy of the better coal. The coal from the lower portion is equal to the average of that mined in Pictou County. The theoretical evaporative power compares favorably with that of the coals from the various counties of the Province, as will appear from the following table:

Pictou Co'y, average of 5 coals.							Theoretical evaporative power	8·66
Cumberland Co.,	3	"	"	"	"	"	"	8·32
Cape Breton	12	"	"	"	"	"	"	8·56
Inverness	2	"	"	"	"	"	"	7·60

The average evaporative power of the lower part of the seam under consideration is 8·47. All the evaporative powers are calculated by REGNAULT'S formula, for comparison with the admiralty coal trials, although later researches have somewhat altered the values determined by him. The table is taken from the analysis given in my paper on "Canadian Coals," published in the transactions of the North of England Institute of Mining Engineers, for the year 1878.

ART. VI.—ON THE RESISTANCE TO THE PASSAGE OF THE ELECTRIC CURRENT BETWEEN AMALGAMATED ZINC ELECTRODES AND SOLUTIONS OF ZINC SULPHATE. BY PROF. J. G. MACGREGOR, M.A., D.Sc., F.R.S.E.

(Read April 9th, 1883.)

AFTER attention had been directed to the measurement of resistance by the establishment of OHM'S Law, the question was raised whether or not there was at the surface of separation of conductors of different substances a special resistance to the passage of the current, such that the current was weakened by the mere transition from the one conductor to the other. POGGENDORFF* settled this question for metals by so arranging two circuits

* Pogg. Ann. LII (1841).

whose parts had the same aggregate resistance that in the one there was a single passage from one metal to another, in the other several such passages, and finding that the resistances of the two circuits were the same.

In the case of electrolytes there may be not only the form of transition resistance mentioned above, but also another arising from the chemical decomposition which the current effects. Even when no solid or liquid substances are deposited on the electrodes and no gas is given off from them, there is usually some change produced by the current in the surfaces of the electrodes, for they are usually polarised. It is possible therefore that the very process of electrolysis may give rise to such a state of the surfaces of the electrodes that the current is weakened in passing across them.

These two possible forms of transition resistance are usually spoken of together under the one name, there being no experimental means of separating them. The determination of their existence or non-existence is rendered difficult by the fact, that the passage of the current through an electrolyte modifies the resistance of the electrolyte by changing its constitution, and changes the electromotive force of the circuit by producing polarisation.

LENZ† and POGGENDORFF* thought to eliminate polarisation by the use of rapidly alternating magneto-electric currents; and the latter, basing on this assumption, not only regarded the existence of a transition resistance proven, but made an investigation of its laws. VORSSELMAN DE HEER,‡ however, has pointed out that this assumption is not only unwarranted but shown by experiment to be inaccurate. I have arrived at the same result in some experiments made to test the method which KOHLRAUSCH and NIPPOLDT used to measure the resistance of electrolytes. Although I made 250 currents per second pass through various saline solutions from a magneto-electric machine which was made to work with great regularity, yet a sensitive galvan-

† Pogg. Ann. XLVII (1839).

* Pogg. Ann. LII (1841).

‡ Pogg. Ann. LIII (1841).

ometer gave quite large deflections due only to polarisation of the electrodes, and that, however long or however short the time during which the alternating currents were allowed to pass through the electrolytic cell.

LENZ,* admitting the error of his assumption, investigated the subject again in a different way. Assuming the existence of both polarisation and transition resistance in various electrolytic combinations, he showed by experiment that the latter, if it existed at all, must be opposite in its properties to all other kinds of resistance. He therefore regarded its existence as unlikely and joined with OHM† and VORSSELMAN DE HEER‡ in holding that since a transition resistance need not be assumed to account for any known phenomena, (all phenomena which may have such a resistance as their cause being capable of being regarded as consequences of polarisation), it may be ignored.

There is one case, however, in which this transition resistance is dissociated from polarisation, so that its effects cannot be confounded with the effects of polarisation. That is the case in which a current is sent through weak neutral solutions of zinc sulphate between electrodes of amalgamated zinc.§ The electrodes of such an electrolytic cell are not appreciably polarisable. If, then, there is any reduction of the intensity of the current produced by the surfaces of the electrodes, it must be due to transition resistance, not to polarisation. For the change in the resistance of the cell produced by change of its constitution, due to electrolysis, can be made so small by using currents of sufficiently short duration as not to affect the result. BEETZ|| has already made use of this combination for the detection of transition resistance. His method was that which POGGENDORF used for metals. In two circuits of the same aggregate resistance he passed the current across two and across several surfaces of contact respectively, and found the measured resistance to be the same.

*Pogg. Ann. LIX (1843).

†Schweig. Journ. LXIII, LXIV. See also Fechner's reply Ibid. LXVII.

‡Bull. Sc. phys. nat. Neerland, 1839 (Liv. V), 1840 (Liv. II).

§Du Bois Reymond, Monatsber. Berl. Akad., 1859; Patry, Pogg. Ann. CXXXVI (1869).

|| Pogg. Ann. CXVII (1862).

As I have already pointed out,* however, it is not clear that in the two circuits he used, the number of the times of the current's passing across surfaces of contact was different; and, therefore, the equality of their resistance cannot be held to be decisive of the absence of transition resistance.

I had occasion some time ago, in connection with some experiments on the resistance of solutions of zinc sulphate, to determine whether there was sufficient transition resistance to interfere with the accuracy of my results. Although the measurements, which I made for my own satisfaction, apply only to one special case, it may be worth while to put them on record.

The method which I used was essentially the same as that of BEETZ, but I took precautions which excluded doubt as to the number of times the current had to pass from electrode to electrolyte, and from electrolyte to electrode. I chose as electrolytic cell one devised by Prof. TAIT, for the absolute measurement of the conductivity of saline solutions. It consisted of a box about 20 cm. long, 10 cm. wide and 10 cm. deep, made of pieces of plate glass cemented together with marine glue. It was divided into two nearly equal compartments by a plate of glass cemented to its bottom and sides. The two compartments were joined by a tube which passed through this plate. On both sides of the box, near both ends, narrow strips of glass were cemented to form grooves for holding the electrodes; and the latter were so accurately fitted that their position in the box could not vary. Thus the column of liquid between the electrodes had a perfectly constant length. Two similar sets of strips of glass were cemented on each side of each compartment near those intended for the electrodes. These were intended to hold thin plates of zinc. Thus four such plates could be inserted parallel to the electrodes. The current through the cell passed both across these plates and around them; but the plates were fitted so accurately that the fraction of the current which passed around them must have been indefinitely small. The section of the compartments was so large relatively to that of the connecting tube, and the plates which I used were so thin (about 0.8 mm.) that, though their

*Proc. R. S. Edin., 1874-5. p. 555.

insertion across the cell increased slightly the depth of the liquid and displaced a certain quantity of liquid by a better conductor, the change produced in the resistance of the cell must have been very small. The specific resistance of the solutions I used was about 28 ohms, and the ends of the tube connecting the compartments were about 6 cm. from the electrodes. The total resistance of the cell was about 3000 ohms. With these data it may be easily shown that the change in the resistance of the cell produced by the insertion of the plates could not be more than between $\frac{1}{15000}$ and $\frac{1}{20000}$ of the resistance of the cell itself. The fact that the connecting tube was completely surrounded by the electrolyte and the large volume of the box rendered it easy to prevent any variation of the resistance of the cell due to change of temperature during the short time necessary to make a measurement. The electrodes and the four plates described above, were of zinc, carefully amalgamated. The resistance of the cell was determined by using WHEATSTONE'S bridge, in the same way as when the resistance of a metallic conductor is measured. In the galvanometer branch of the bridge, I used one of Sir WM. THOMSON'S very sensitive galvanometers, whose resistance was so proportioned to the resistances in circuit as to give it the greatest possible sensitiveness. The solutions which I used were of zinc sulphate, bought as pure and refined by crystallization. Their density was about that of minimum specific resistance. In order to prevent the condensation of dissolved gases on the surface of the electrodes and plates, the solutions were boiled before each set of experiments, and the electrodes and plates were kept for some time in a boiling solution of approximately the same density as that in the cell, before being used. I found great difficulty in getting the electrodes and plates into such a state that they would neither originate a current themselves when dipped in the solution, nor become polarized when a current was sent through the circuit. In some cases, however, I succeeded, and was therefore able to make the necessary measurements. In these cases the observations were, of course, very simple. They consisted in the measurement of the resistance of the electrolytic cell, first without the plates, then with the plates,

and again without the plates, each measurement being preceded and succeeded by tests of the electrical similarity of electrodes and plates. Without the plates the current had to pass across two surfaces of contact between amalgamated zinc and electrolyte. With the plates it had to cross ten such surfaces. If there had been any transition resistance, therefore, the measured resistances in these two cases should have been different. In no case, however, was I able to detect any difference greater than could be accounted for by the mere insertion of the plates. In some experiments in which I used a connecting tube so small that the resistance of the cell was about 4,000 ohms, I could detect no difference at all. In others in which I used a tube of larger bore, so that the resistance was about 1700 ohms, differences were noticeable, but they were not such as to necessitate the assumption of a transition resistance to account for them.

The apparatus which I used enabled me to measure resistances accurately to .1 ohm. It is therefore clear that the transition resistance which the current meets in passing eight times across the bounding surface between amalgamated zinc electrodes, of the area mentioned above, and solution of zinc sulphate, does not amount to one-tenth of an ohm, and that therefore the transition resistance at one such surface is not so much as .0125 ohm.

This result was sufficient for the purpose for which I made the experiments.

The above experiments were made in the Physical Laboratory of the University of Edinburgh. I am indebted to Prof. TAIT for his kindness in furnishing me with the necessary apparatus.

ART. VII. NOVA SCOTIAN GEOLOGY—HALIFAX AND COLCHESTER COUNTIES. BY Prof. D. HONEYMAN, D.C.L., &c.

(Read 14th May, 1883.)

By looking at the Map of Nova Scotia it will be observed that the Counties of Halifax and Colchester are large. Halifax County extends from Lat. 62 deg. 13 min. to 64 deg. 5 min. The