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W.R. Grove Esq. M.A. M.R.S.

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LXXII. *On some Phænomena of the Voltaic disruptive Discharge.* By W. R. GROVE, Esq., M.A., M.R.S.

MY DEAR SIR,

I SHALL be much obliged by your insertion of the enclosed in the Philosophical Magazine at your earliest convenience.

Yours very sincerely,

To Richard Phillips, Esq., F.R.S.

W. R. GROVE.

In the number of the *Bibliothèque Universelle de Genève* for March, is published an extract from a letter of mine to Professor Schœnbein, giving an account of some experiments on the voltaic disruptive discharge*. In the kind and flattering remarks which follow, my friend Dr. Schœnbein deduces a conclusion from those experiments which I had not ventured to make, but as many of the readers of the Philosophical Magazine may not have seen the article in question, I must beg leave to give a summary of its contents.

In considering the experiment communicated to the Philosophical Magazine for 1839, by Mr. Gassiot, in which he points out the remarkable difference between the heating effects at the anode and cathode during the disruptive discharge, it occurred to me that it might be due to the interposed medium, and that were there any analogy between the state assumed by voltaic electrodes in elastic media, and that which they assume in electrolytes, it would follow that the chemical action at the positive electrode in atmospheric air would be more violent than that at the negative, and that if the chemical action were more violent, the heat would necessarily be more intense. Several experiments confirmed this view: the battery with which they were made consisted of 36 elements, each consisting of a square inch of platina foil and of zinc; it was charged with concentrated nitric and dilute sulphuric acid as in my first experiments (Phil. Mag., May 1839) and arranged in single series.

I cannot avoid here a short digression as to the œconomy of this combination: this little battery required a pound of nitric and an equal weight of sulphuric acid† to charge it; and thus for the expense of about a shilling I could experiment for 8 or 9 hours without fresh charge; the arc of light

* After writing that letter I had determined to delay the publication of the experiments, in order to add to them some others, but these have been unavoidably postponed.

† The dilute sulphuric acid should be of sp. gr. 1.2 and four or five times the volume of the nitric; where there is not this disproportion between the cells it will be well previously to mix the nitric with one or two measures of dilute sulphuric acid. By proper attention to these proportions I obtain by electrolysis oxyhydrogen gas at 6*d.* per cubic foot including zinc consumed, &c.

obtained was 0.4 of an inch long. I am anxious to avoid the bad taste of eulogizing my own productions, but I think it ought to be generally known that space is not the only thing economized in this combination. Professor Jacobi, who has recently written a paper on my battery, and who has wrought on a large scale, states that he has readily fused iridium, &c. &c. after it has been at work for a whole day. An obvious point in the practical economy of the voltaic battery is, that the more intense the power of a combination the greater the economy, e. g. if one combination can effect with a series of two pair, what another can only effect by a series of 20, the equivalents consumed are as 1 to 10 in favour of the former.

But to return : experiments made with this battery established the following points :

1st. If zinc, mercury, or any oxidable metal constitute the positive electrode, and platina the negative one, in atmospheric air, while the disruptive discharge is taken between them, a voltameter inclosed in the circuit yields considerably more gas than with the reverse arrangement.

2nd. In an oxidating medium the brilliancy and length of the arc are (with some conditions to be presently noticed) directly as the oxidability of the metals between which the discharge is taken. N.B. Platina is to be regarded as slightly oxidable when influenced by the voltaic discharge ; if this be taken for some time between platina points in oxygen, the volume of the gas is diminished.

3rd. In an oxidating medium the heat and consumption of metal is, as observed by Mr. Gassiot, incomparably greater at the anode than at the cathode.

4th. If the disruptive discharge be taken in dry hydrogen, in azote, or in a vacuum*, no difference is observable between the light and heat, whether the metals be oxidable or inoxidable, or whether the oxidable metal constitute the positive or negative electrode.

5th. The volume of oxygen absorbed by the disruptive discharge taken between a positive electrode of zinc and a negative one of platina in a vessel of atmospheric air, is equal to that evolved by a voltameter included in the same circuit.

These experiments present a remarkable analogy between the electrolytic and disruptive discharges. There are, however, two important elements, alluded to in art. 2. which obtain in the latter, and which have little or no influence on the former ; these are the volatility and the state of aggregation or tenacity of the metal or conducting body. This is remarkably shown in the case of iron. Iron in air or oxygen gives a most

* I have not been able to experiment in a Torricellian vacuum ; in a well-exhausted receiver, the difference, if any, was very slight.

brilliant voltaic arc, while in hydrogen or a vacuum with the same power a feeble spark only is perceptible at the moment of disruption. Mercury on the other hand gives a tolerably brilliant spark in hydrogen, azote, or a vacuum, and one more nearly approaching to that which it gives in air. Thus in an oxidating medium there are three requisites for a brilliant discharge, viz. oxidability, volatility, and looseness of aggregation : in other media the two latter alone obtain ; and the brilliant arc given by charcoal appears to depend principally upon the last ; thus wood charcoal gives a larger and more diffuse flame than the carbon from gas retorts.

In the following list the metals are arranged, as nearly as may be, in respect to the length and brilliancy of the arc they give in atmospheric air, the discharge being taken between two points of the same metal :

Potassium,	Antimony,
Sodium,	Bismuth,
Zinc,	Copper,
Mercury,	Silver,
Iron,	Gold,
Tin,	Platinum.
Lead,	

It has been noticed by Sir H. Davy, Dr. Hare, and Mr. Daniell, that a certain portion of matter is projected from the positive to the negative electrode : the quantity thus perceptibly projected is indeed very small ; but I observed that when the discharge was taken in a close vessel the whole interior was lined with a pulverulent deposit, which if the vessel contained atmospheric air was an oxide of the metal employed, but if it contained azote or hydrogen was a reguline precipitate of the metal. Faraday's researches have established, that in electrolysis a voltaic current can only pass by a derangement of the molecules of matter ; that the quantity of the current* which passes, is directly proportional to the atomic disturbance it occasions : he deduces from this that the quantity of electricity united with the atoms of bodies is as their equivalent numbers, or in other words, that the equivalent numbers of different bodies serve as the exponents of the comparative quantities of electricity associated with them. Now what takes place in the disruptive discharge ? When we see the dazzling flame between the terminals of a voltaic battery, do we see electricity, or do we not rather see matter, detached, as Davy supposed, by the mysterious agency

* However unpredicable the words quantity, current, &c. may be of an agent imponderable, and having no definite relation to space, these words express understood functions, and it seems impossible to devise others which would not be open to similar objections.

of electricity, and thrown into a state of intense chemical or mechanical action? Matter is undoubtedly detached during the disruptive discharge, and this discharge takes its tone and colour from the matter employed. Now as this separation is effected by electricity, electricity must convey with it either the identical quantity of matter with which it is associated, or more or less; more it can hardly convey, and if less, some portion of electricity must pass in an insulated state, or unassociated with matter, and some with it. This seemed a highly improbable effect, and these considerations, immediately deducible from Faraday's researches, led me to suppose that the third alternative was most probably the true one, and consequently that the quantity of matter detached by the voltaic disruptive discharge was definite for a definite current, or bore a direct equivalent relation to the quantity electrolyzed in the liquid portions of the same circuit. The difficulties of testing this view by the weight lost, being insuperable without incurring an unjustifiable expense, led me to have recourse to Experiment 5. Zinc having only one oxide which sublimes when deflagrated in air by voltaic electricity, it should follow that if the particles of zinc detached were the equivalents of the matter electrolyzed in the same circuit, the quantity of oxygen absorbed by these particles would be exactly equal to that evolved in a voltameter placed in the circuit. The experiment presented more difficulties than I had at first anticipated: if the intensity of the battery was high, I frequently observed the metal, from the heat it had acquired, burn independently of the discharge; while if the intensity were lowered, the discharge could not be kept up without frequent contacts which gave a gush of gas to the voltameter. The following means afforded me the most uniform results. Between a positive electrode of distilled zinc of such size as to prevent by the cooling effect of its mass an independent combustion, and a negative electrode of platina, a moderated discharge was taken in a graduated vessel filled with atmospheric air: an average of 40 experiments gave me 1.17 to 1.00 as the inverse ratio between the volume of oxygen evolved in the voltameter, and that absorbed by the deflagration, and in several of these experiments the volumes were exactly equal. The nature of the experiment defied perfect accuracy, but considering a few unavoidable contacts, it appears to me to afford strong ground for presumption if not for conviction, that the separation of matter in the voltaic arc is definite for a definite quantity of electricity, and that the all-important law of Faraday is capable of much extension. Uniting this view with the experiments of Faraday

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on the identity of electricity from different sources, and with those of Fusinieri on the statical electrical discharge, it would follow as a corollary that every disturbance of electrical equilibrium is inseparably connected with an equivalent disturbance of the molecules of matter. In the remarks of Professor Schœnbein to which I have alluded, he says that my experiments seem to prove the transmission of the current from one electrode to the other to be effected only by chemical action. In Exp. 5, I employed the diminution of oxygen as a measure of the quantity detached, conceiving that at the intense heat which is produced not a particle of zinc would escape oxidation, and without concluding that chemical action was absolutely essential to the existence of the voltaic arc. I must at the same time state that the passage of the current is, as proved in these experiments, materially modified by the nature of the elastic medium through which it passes, and is greatly aided when such medium is capable of uniting chemically with the electrodes. In pure dry hydrogen, I have never yet been able to maintain a continuous arc, except with charcoal, which forms carburetted hydrogen; and Davy in reference to his experiment of burning charcoal *in vacuo* states, that a gas was formed which detonated with oxygen; the probability is that some slight portion of air obtained access, and thus carbonic oxide was formed. On the peculiar relation between the electrodes and the elastic intermedium, I feel at present unable to give a clear opinion; the subject is peculiarly difficult; I will content myself with stating my present notion to be, that the voltaic arc bears a similar relation to common flame, to that which electrolysis bears to ordinary chemical action.

4, Hare Court, Temple, May 7, 1840.

LXXIII. *On two Norwegian Cobalt Ores from the Skutterud Mine. By TH. SCHEERER.**

IN the cobalt mines of Modum in Norway (near Christiania) are found, besides the common cobalt glance, two other distinct cobalt minerals, which differ in their external characters from the usual ore. The following are the descriptions of these minerals:—

First kind. It occurs massive as well as crystallized, has the lustre of arsenical iron, and exactly the same crystalline form, even the characteristic brachydiagonal striæ. In hardness likewise, and also its spec. grav. = 6·23, it does not differ much from that mineral. It is shown by the blowpipe,

* An extract, communicated by the Author, from the original article published in Poggendorff's *Annalen*, vol. xlii. p. 546.