ART. IV.—*Cause of Irregularities in the Action of Galvanic Batteries;* by HAMMOND VINTON HAYES and JOHN TROWBRIDGE.

IN the May No. of this Journal, 1885, is described an apparatus devised by Prof. John Trowbridge, for photographing the deflections of a galvanometer needle. A spot of light is reflected from the mirror of a galvanometer, and from a fixed mirror, on to a sheet of sensitive paper. When no current passes, the two spots of light coincide; when the mirror is deflected, one spot marks the zero of the scale; the distance between the two spots shows the amount the mirror has been deflected. In this way all variations of current are accurately registered. We have tested a number of batteries in this way, and have found that in some cases the current was comparatively constant, or if any variation occurred, it was of the nature of a gradual and regular fall. Examples of this action are to be seen in figures 1, 2 and 3. In other cases the action was exceedingly irregular; not only were there many marked variations in the strength of the current, but these variations were made up of a multitude of minor fluctuations. Both of these actions can be observed in figures 4 and 5. The variations in some cases are as great as twenty or thirty per cent of the total strength of the current. It seems, therefore, of interest to find to what causes these changes may be assigned, especially as such variations would seriously affect delicate experiments. Moreover, in batteries used for incandescent lighting it is absolutely necessary to obviate this difficulty.

It was observed that batteries without a porous partition were not subject to these fluctuations. Such batteries as the Leclanché exhibit smooth unserrated curves, whereas all batteries employing porous cups show irregularities more or less marked. It will be noticed that the variations may be divided into two classes, one a general undulation, the other a series of rapid fluctuations which make up the undulations. There are, likewise, two separate actions which cause these irregularities: first a diminution in the current strength, caused by the pores of the partition becoming filled with the base, and thus preventing action until it has been dissolved and fresh acid can attack the zinc; second, a diminution of the acid at the positive pole, and a consequent decrease in current. This action is due to electrical endosmose. The undulations are due to the first of these causes; the fluctuations to endosmose. It will be observed that the fluctuations in all cases begin as soon as the current is made, and before it is possible that the partition can have become so impregnated as to cause an interruption to the current. This can be well seen in figures 4 and 5. This shows that the fluctuations and undulations must be due to different causes. In figure 4 the undulation is very marked. This figure is the photograph of the action of a battery using a very dense porous cup. Figure 3 shows the action with a cup, the same size as that used in figure 4, made of ordinary unglazed paper. We find here no action whatever. We should suppose from the above experiments that the more dense the partition the more liable would it be to become clogged, whereas with a very porous cell there should be very little resistance offered. To prove this, a cup of very porous earthenware was compared with one much denser; figures 7 and 8 show the results. In the case of the porous cup the action is without undulations, while with the other the undulations are quite marked.

To investigate the action of endosmose, a very irregular open circuit battery was employed, consisting of a solution of bichromate of potassium and sulphuric acid, into which were plunged a piece of carbon and a porous cup containing zinc surrounded by mercury. In the action of a galvanic battery there are three separate actions which take place:

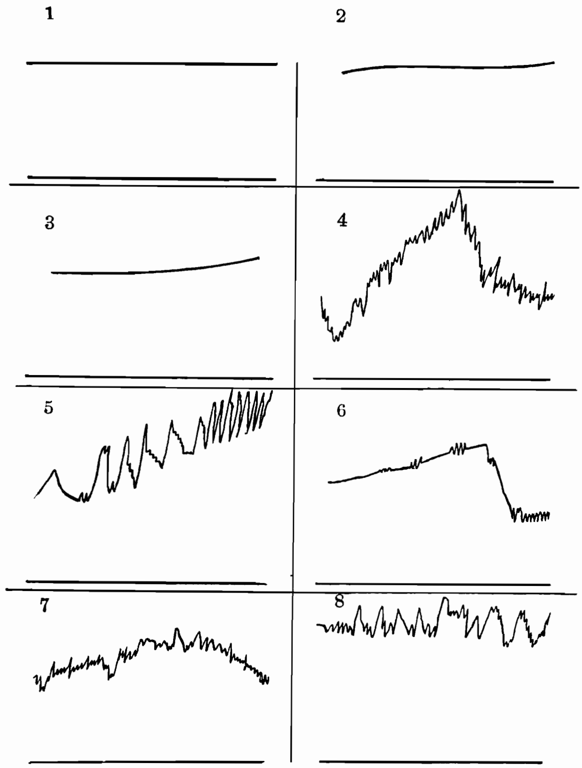
1st. A decomposition of the electro-positive ion at the positive electrode.

2d. A decomposition of the electro-negative ion at the negative electrode.

3d. The electric current carries whatever comes in its way from the positive to the negative electrode.

It is this last which is called endosmose, and which we wish to investigate.

It was discovered by Breda and Logeman that in a continuous liquid this third action disappeared, and only when a porous partition was introduced was this phenomenon observed. This agrees with the above stated theory; for no such fluctuations are observed in single fluid batteries. The laws which govern this action were very carefully studied by Wiedemann. Owing to this transporting force the heights of the liquid on the two sides of the porous jar are different, being higher on the side which is nearest the positive electrode. When a strong current acts, more liquid is driven through the partition than with a weak current; moreover, the greater the resistance of the liquid, the more is driven through. From this we find that the



porous jar increases the base or metal transported to the negative pole, and diminishes the quantity of acid at the positive pole in the case of sulphuric or nitric acids. Again, if we increase the surface of the jar, the force tending to transport the liquid is diminished, but it is increased if we increase the thickness or density of the partition.

If now we have a strong current, and a small, thick cup, there will be a maximum force tending to drive the liquid and base from the positive pole, and a consequent decrease in the strength of the current. The first case is well exemplified in figure 4, in which the fluctuations are very marked. The cup used was very small and dense. Figure 3 shows the action of a cell of ordinary unglazed paper of large dimensions. The current, which was as nearly as possible of the same strength as in figure 4, is perfectly uniform. Figure 1 is a photograph of the action of a cell made of a paper known as parchment paper. We again find a regular action. Wishing to make a slightly more dense cell, one was constructed of parchment of the same size as those employed above. The action of the battery with this cell is shown in fig. 6. It will be noticed that very slight fluctuations occur at the beginning, and in parts of the line.

Figure 7 shows the action of a cell presenting a large surface, but made of very dense earthenware. In this way great advantage is gained, for if the cell had been of the ordinary size, its fluctuations would have resembled those in figure 4.

We can, therefore, say that there are two causes of irregularity in the action of galvanic batteries, and that both difficulties are overcome by making a partition of as large surface dimensions as possible, and by using very porous material.

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