IX. *On the employment of Chromic Acid as an Agent in Voltaic Arrangements.* *By* R. Warington, *Esq.*

Read December 7, 1841.

In a paper "On the Action of Chromic Acid upon Silver," published in the Philosophical Magazine for December 1837, which action was effected by means of a mixture of bichromate of potash in solution and sulphuric acid, I concluded by stating, that in a future communication I hoped to consider the action of the same agents on other metallic bodies. The investigation has been resumed when my engagements permitted, and a great variety of interesting facts on this subject collected; but many analyses will still be necessary to render the subject complete, before the whole results can be submitted to the scientific world.

On making some new experiments, some time since, with the mixture of bichromate of potash and sulphuric acid referred to, I was led to believe that it would form a valuable and powerful agent in voltaic arrangements from possessing the following advantages over every other liquid hitherto employed for the same purpose, namely, the high degree of energy with which it acts upon certain metals, the facility with which it is decomposed by deoxidizing agents, as hydrogen gas and numerous others, with the circumstance that in all these actions of oxidation no gaseous matter is evolved.

My first endeavour was to substitute this mixed fluid for the nitric acid in the powerful arrangement of Professor Grove, so as, if possible, to obviate the inconveniences arising during the action of that battery, without diminishing the splendid effects produced by it. In doing this it was absolutely necessary, from the nature of the materials to be employed, to modify to a certain extent the details of the construction of the battery, retaining the metallic elements unaltered, but enlarging considerably the cell appropriated for the nitric acid. Now as the dilute sulphuric acid in the zinc cell of the battery remains the same in both cases, it will be only necessary to show, by the constitution of the nitric acid and the bichromate of potash, the relative value of these two oxidizing agents in terms of the quantities of the available oxygen they contain, such oxygen combining with the hydrogen eli-

cited by the action of the dilute sulphuric acid on the zinc element.

Liquid nitric acid, of 1·48 sp. gr., is composed of 74 parts by weight of real acid and 26 of water, and these 74 parts contain 32·9 of oxygen and 41·1 of binoxide of nitrogen, which latter body is given off in a gaseous state, as soon as the undecomposed nitric acid has become saturated with it, and assumed a deep green tint. When liberated from the solution the gas combines with the oxygen of the air, generating the nitrous and hyponitric acids, the red noxious vapours which render the use of this form of battery so inconvenient. There must, I imagine, be also a considerable loss of power from this evolution of gaseous matter. I am not aware to what extent the decomposition of the nitric acid can be carried in Grove's battery, for after the action has been going on about five hours, an effect of endosmosis commences between the cells through the pores of the biscuit earthenware, and the amalgamated zinc plates are attacked with rapidity and quickly destroyed. Not expecting such an occurrence, I had left a small battery in action, on one occasion, through the night, and found in the morning, to my great annoyance, that the whole of the zincs were destroyed, and the arrangement all fixed together.

Bichromate of potash is composed of 2 equivalents of chromic acid, or 104 parts by weight, and 47·5 of potash, and these 104 parts contain 80 of the green oxide of chromium and 24 of oxygen. Consequently, to obtain the same quantity of available oxygen as we have in the 100 parts of nitric acid, supposing the decomposition of these to be complete, we shall require 206·9 of bichromate; and to convert this into the double sulphate of chromium and potash, or chrome alum, 275·8 of concentrated sulphuric acid will be necessary. These proportions of materials are requisite, as it is the strong affinities leading to the formation of chrome alum which give rise to the energetic oxidizing action of this mixture.

A number of experiments were tried, to ascertain whether the action of a battery excited by the acid element described would be sustained and continuous, and the results have fully established that it is so. In the action of such a battery no gaseous matter is given off, the oxygen of the chromic acid combining with the hydrogen from the zinc cell to form water, as is the case where nitric acid is employed. And as the deoxidized chromic acid, or the oxide of chromium formed, combines with the sulphuric acid and potash immediately as it is produced, no injurious effect can arise from diffusion between the cells; the whole process goes on steadily and without in-

termission, until either the sulphuric acid in the zinc cell is saturated with the oxide of zinc, or the whole of the chromic acid of the bichromate is deoxidized.

Various other arrangements, in which bichromate of potash is used mixed with sulphuric, muriatic, nitric, and acetic acids, with the usual, and also with different, metallic elements, are under investigation; and the results obtained, with their comparison with other batteries, will be laid before the Society at an early period.