XVI. *On the Gas Voltaic Battery.—Voltaic Action of Phosphorus, Sulphur and Hydrocarbons.*

By W. R. Grove, *Esq., M.A., F.R.S., V.P.R.I., Prof. Exp. Phil., London Institution.*

In a paper which was honoured by publication in the Philosophical Transactions for 1843, I described certain forms of the gas voltaic battery, together with a series of experiments in which different gases were employed as voltaic combinations, and the consequent application of voltaism to eudiometry.

To ensure confidence in the accuracy of the eudiometric experiments, it was essential that the position which I laid down as to the absence of all voltaic action in a combination of oxygen and nitrogen should be rigidly true. I may state with certainty that it is so, but an apparent exception noticed (Exp. 21.) in my last paper obtains during the first few minutes after the circuit is closed, and sometimes for a much longer time. The examination of this temporary action in the first instance, with the view of ascertaining whether it was a specific action of the nitrogen or attributable to adventitious circumstances, led me to the results which I have the honour of laying before the Royal Society in this paper.

Before detailing these results, I will for convenience sake premise that they were all obtained by the form of battery represented in fig. 8 of my last paper (which, with a slight addition to be referred to presently, is again represented at fig. 2, Plate VI.), charged with distilled water slightly acidulated with pure sulphuric acid.

I will also, when alluding to my last paper, to avoid the needless repetition of the word *experiment*, refer to the number of the experiments as though they were paragraphs, and continue those numbers in the paragraphs of this paper.

As the form of battery (fig. 2) by which the interfering action of the atmosphere is entirely prevented was not devised until the greater part of the experiments in my last paper had been completed, I repeated some of them which seemed to require such verification with this battery; to one of these only is it essential that I should now refer. I should likewise mention, that in the experiments to be described the proper reductions for temperature and pressure have been made when necessary; where it was practicable the experiments were examined on days when the temperature and pressure were, as nearly as may be, the same as when they were set by.

(31.) Oxygen and deutoxide of nitrogen, which in the open form of battery gave only a temporary action (9.), when employed in the closed form (fig. 2) gave a continuous current. The following three sets of experiments were continued each for a

month in closed circuit, during which time they were constantly tested by the galva-
nometer and evidenced a continuous voltaic action; at the expiration of the month
the results were as follows:—

Experiment 1.—Rise of liquid in tubes of

Oxygen	=0·32	cubic inch.
Deutoxide of nitrogen. . .	=1·26	cubic inch.

Experiment 2.—In oxygen tubes. . . . .   =0·5   cubic inch.

            Deutoxide of nitrogen. . .   =2·5   cubic inches.

Experiment 3.—In oxygen tubes. . . . .   =0·2   cubic inch.

            Deutoxide of nitrogen   . .   =0·75 cubic inch.

Mean result.   { In oxygen tubes, rise . . .   =0·34 cubic inch.

             { In deutoxide tubes, rise . .   =1·5   cubic inch.

The slight excess being undoubtedly due to the greater solubility of the deutoxide,
it appears that four volumes of deutoxide of nitrogen are absorbed in the gas battery
for one of the associated oxygen, and the result would be a compound of 1 equiv.
nitrogen + 3 oxygen, or hyponitrous acid, which is exactly that formed by the slow
combination of these two gases in the ordinary chemical way. The difference of
amount of action in the three experiments depended on the temperature, the second
experiment being made towards the close of last summer, the last experiment during
the continuous cold weather of the present spring.

These experiments, coupled with the converse ones with hydrogen and deutoxide
of nitrogen (30.), afford very satisfactory instances of the illustration of the law of
definite combining volumes by the gas battery, exhibiting in one result, and itself
registering that result, the action of equivalent chemical combination, catalysis and
voltaism.

(32.) I now pass to the experiments which will form the more immediate subject
of this paper. The temporary action to which I have alluded (21.) being greater
when nitrogen and oxygen were the gases used, if the nitrogen were obtained by
burning phosphorus in atmospheric air, than if procured from other sources, it natu-
rally occurred to me that this action was due either to some phosphorous acid re-
maining in a state of vapour in the nitrogen, or to a slight portion of the phosphorus
itself being held in solution in the nitrogen, as believed by VAUQUELIN and the older
experimentalists. If this last supposition were the correct one, it seemed to offer a
means of rendering phosphorus, though a non-conductor and insoluble in aqueous
liquids, yet a permanent voltaic excitant analogous to the oxidable metals.

(33.) A small piece of phosphorus having been carefully dried, and weighing when
dry 9·6 grains, was passed up through the liquid into the large tube of a gas battery
by means of a small loop of mica, which kept it separated both from the glass and
the platinum; the tube was now charged with pure nitrogen, and the associated tube
with pure oxygen, the level of the gases or water-mark being noted by a little slip of
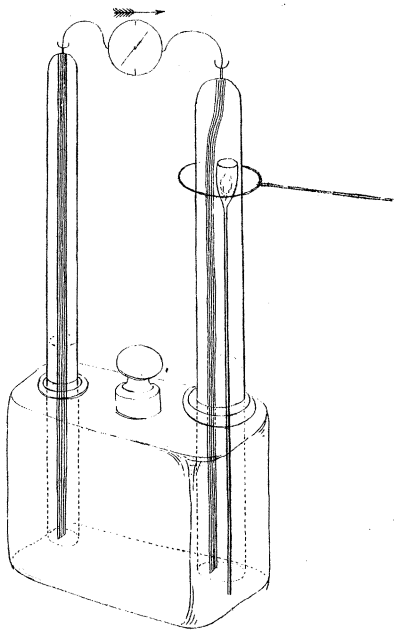paper pasted on the tube; a check experiment of oxygen and nitrogen without phos-
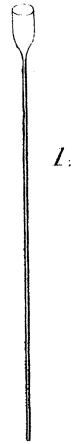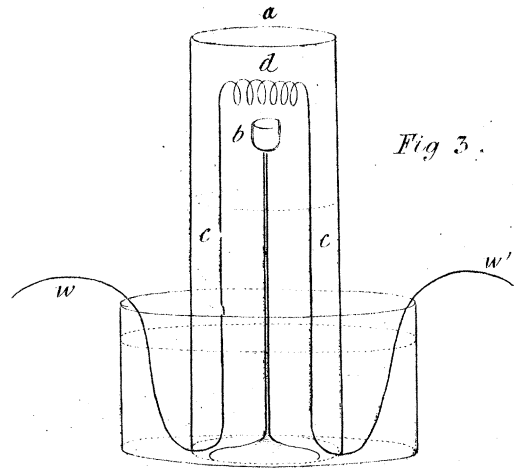
Fig. 2.

Fig. L.

Fig. 3.

a

d

b

c *c*

w *w'*
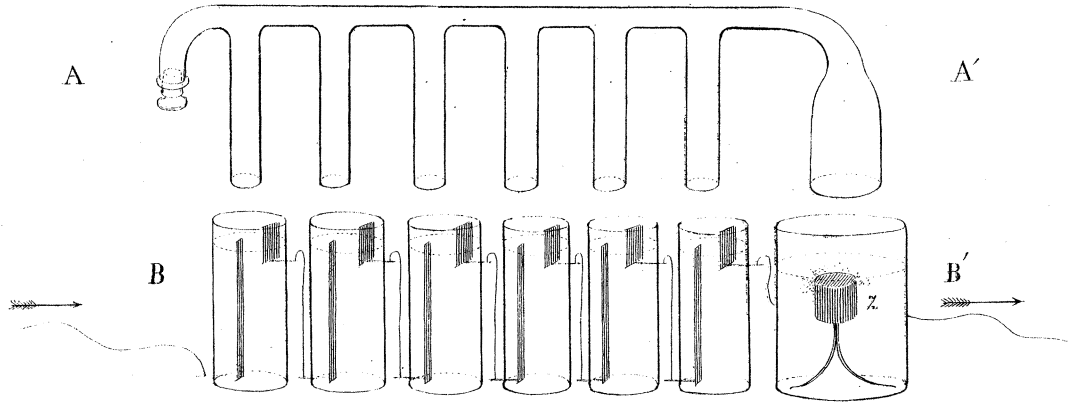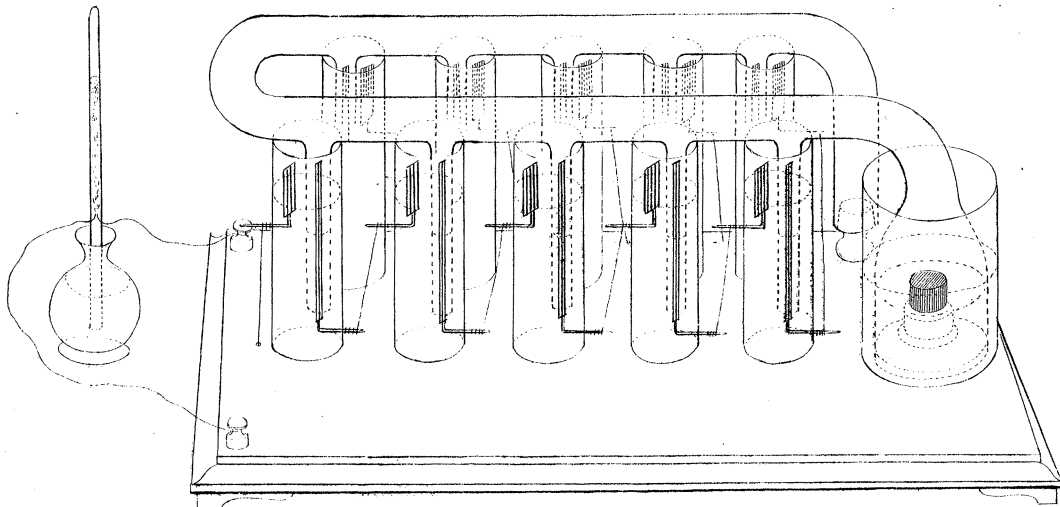
Fig. 4.

A A'

B B'

z

Fig. 5.

phorus was charged at the same time; the whole was carefully closed from the atmosphere and set by for twenty-four hours in closed circuit, to get rid of any current from adventitious circumstances; the next day, when tested by the galvanometer and iodide of potassium, a very decided action was apparent in the phosphorus battery, the iodide being decomposed and the galvanometer needle swinging round to 30°, the nitrogen with the phosphorus representing the zinc of an ordinary voltaic combination; the check experiment gave not the least deflection or decomposition. The experiments were suffered to remain in closed circuit for four months, from August 10th to December 14th, 1844, having been frequently tested in the interim, and the galvanometer always evidencing a continuous voltaic action in the phosphorus battery. On the 14th of December, the water in the oxygen tube having by its rise denoted the absorption of a cubic inch of oxygen plus the slight quantity 0·05 cubic inch of oxygen due to solution, as proved by comparison with the second battery, the experiment was examined; the result was as follows:—

> Rise of liquid in oxygen tube 1 cubic inch.   In nitrogen tube 0.
> Original weight of phosphorus 9·6 grains.
> Present weight of phosphorus 9·2 grains.

The battery was again charged in a similar manner, and put by on the 19th December 1844; the phosphorus weighed 2·8 grains. This, in consequence of the extremely cold weather which has prevailed almost without intermission from that time to the present period, proceeded much more slowly, and was not examined until May 17th, 1845, when the results were as follows:—

> Permanent deflection of galvanometer 8°.
> Rise of liquid in oxygen tube 0·35 cubic inch.   In nitrogen tube 0.
> Weight of phosphorus = 2·65.

Taking a mean of these two experiments, which in their relative results approximate more closely than I could have anticipated under the circumstances, we get 0·415 as the proportional weight of phosphorus lost for a cubic inch of oxygen. Now as 24 : 31·4 :: 0·34 : 0·444. The result of these experiments therefore leaves no doubt that phosphorous acid is the product of the voltaic action, as it is of the slow combustion of phosphorus in air. The experiment was repeated with distilled water; the action was at first very trifling, but increased every day, and the water gradually acquired an acid reaction.

No light was apparent in any part of the apparatus when examined in the dark, indeed the action was much too slow to render such an effect probable; though if subsequently by heat or other means I should succeed, as I hope, in producing light, it will be curious to observe in what part of the circuit the luminous effect in the voltaic combustion is perceptible.

A series of ten cells of phosphorus and nitrogen associated with oxygen were charged, and perceptibly decomposed water with platinum electrodes.

The result of the above experiments gives, I believe, the first instance of the employment of a solid, insoluble non-conductor as the excitant of a continuous voltaic current; it proves that the existence of diffused phosphorus in nitrogen, as noticed by the old experimentalists, is not a consequence, as was once believed, of a partial combustion, but of an effusion continuing as long as the previously diffused phosphorus is abstracted, and it gives the very curious result of a true combustion, the combustible and the ' *comburant* ' being at a distance; phosphorus burned by oxygen which is separated from it by strata both of water and gas, of an indefinite length. This result, arrived at by a progressive series of inductions, scarcely now appears extraordinary, but would have been in all probability listened to with incredulity if simply stated as a fact a few years ago.   By the galvanometer we may also ascertain the rate of this very slow and minute chemical action; thus if by an apparatus, as above described, my galvanometer gives a deflection of 8 degrees, I know that the phosphorus is being consumed at the rate of the seven millionth part of a grain per minute.

(34.) The next step was to ascertain whether this action was peculiar to nitrogen or common to other gases; for this purpose, a day or two after the first experiment was set aside, the following were also made, and the dates and results were as follows :—

No. 1. Phosphorus suspended in protoxide of nitrogen associated with oxygen: weight of phosphorus 5·3 grains.   Charged August 11th, 1844.

No. 2. Similar experiment, but without phosphorus.

Tested occasionally by galvanometer, the first battery gave invariably a small deflection, but less than in experiment (33.); the second gave no deflection.

Examined the 22nd April, 1845.

No. 1. Water risen in tube of oxygen 0·75 cubic inch.

In protoxide tube 1·7 cubic inch.

No. 2. Water risen in oxygen tube 0·1 cubic inch.

In protoxide tube 1·6 cubic inch.

Phosphorus weighed 5 grains, therefore loss =0·3 grain.

In this experiment the rise of liquid in the tubes containing protoxide was evidently due to the solubility of that gas, as it was very nearly equal in both the batteries, and the second gave not the slightest galvanometric deflection; the result gives 0·65 cubic inch of oxygen consumed by 0·3 grain of phosphorus, bearing nearly the same relative proportions as experiment (33.); the only difference between the action of phosphorus in nitrogen and in protoxide of nitrogen is, that in the former it is more rapid, as proved both by the galvanometric deflection and by the quantity of oxygen absorbed in a given time.

(35.) Charged August 11th, 1844.

No. 1. Phosphorus in carbonic acid gas associated with oxygen; weight of phosphorus 5·9 grains.

No. 2. Same without phosphorus.

Tested by galvanometer, No. 1. always gave a deflection, No. 2. none.

On the 3rd of December the carbonic acid gas in both batteries had been absorbed, and the liquid had reached the extremities of both tubes.

In the oxygen tube of

No. 1, rise of liquid $=0\cdot75$ cubic inch.   In No. 2, $0\cdot05$ cubic inch.

Phosphorus weighed $5\cdot6$ grains, the proportional weight was therefore $0\cdot3$ grain phosphorus to $0\cdot7$ cubic inch oxygen.

Here again the proportions came out just as in (33.) and (34.), the intensity of action being intermediate, less than the former and greater than the latter.

(36.) Charged 18th December, 1844.

No. 1. Phosphorus in pure oxygen associated with oxygen, great care being taken to exclude atmospheric air: this arrangement having been kept in closed circuit for twenty-four hours, gave a very feeble deflection of the galvanometer.

Examined 15th February, 1845. The rise of liquid in the tube containing phosphorus was equal to $0\cdot3$ cubic inch, in that containing the associated oxygen $= 0\cdot05$. I find no note of the phosphorus being re-weighed; probably I considered it useless, as the consumption of oxygen in the associated tube was so very trifling, scarcely sufficient to be distinguished from the effect of its solubility.

(37.) Charged 23rd April, 1845.

No. 1. Phosphorus suspended in deutoxide of nitrogen associated with oxygen; weight of phosphorus $= 4\cdot3$ grains.

No. 2. Same without phosphorus.

Examined May 27th, 1845.   Galvanometer gave 25° permanent deflection in No. 1, and 10° in No. 2.

No. 1. Rise of liquid in deutoxide tube $=0\cdot7$ cubic inch.
       Rise of liquid in oxygen tube $=0\cdot6$ cubic inch.

No. 2. Rise of liquid in deutoxide tube $=0\cdot7$ cubic inch.
       In oxygen tube $= 0\cdot2$ cubic inch.

Weight of phosphorus $4\cdot17$ grains.

Consequently had lost $0\cdot13$ grain for $0\cdot4$ cubic inch of oxygen.

In this and all the preceding experiments the residual gases were unchanged in quality, and in this experiment it appears that the action of the deutoxide of nitrogen and the oxygen was perfectly unaffected by the phosphorus, the consumption of deutoxide of nitrogen being exactly the same in both batteries. In another experiment, which I did not record on account of a minute bubble of air having entered the tubes containing the deutoxide, the phosphorus appeared to have exercised a retarding influence on the voltaic combination of deutoxide of nitrogen and oxygen; this I attributed to a slight deposit of phosphorous acid upon the platinum, by which its catalytic power was deteriorated.

(38.) It thus appears that the effect we have been examining, of the diffusion of

phosphorus in gas, is not due to any peculiarity of nitrogen, and is not peculiar to any particular gas, as once believed; but being in all probability common to all gases which do not exercise a specific action on the phosphorus, it may be more properly called a volatilization of phosphorus at ordinary temperatures than a solubility in gas; the ordinary slow combustion of phosphorus in air is, in fact, a combustion of its vapour. I incline to think that the inferiority of its vaporization in pure oxygen is due to a protecting film being formed, and that the phenomenon is in some respects analogous to the inactivity of iron in nitric acid.

(39.) Phosphorus in nitrogen was associated with hydrogen in the gas battery to ascertain their voltaic relation; the hydrogen was positive to the phosphorus, i. e. represented the zinc of an ordinary voltaic combination.

(40.) To realize the curious novelty of two non-conducting solids forming the elements of a voltaic battery, and producing a continuous current, phosphorus suspended in nitrogen in one tube of a gas battery was associated with iodine in nitrogen in the other; a very decided current was the result, which continued for months, the nitrogen remaining unaltered in volume, but the liquid becoming gradually tinged by the excess of iodine vapour. The following is the result of the experiment:—

Charged January 1, 1845.	Examined May 17, 1845.
Weight of iodine . . =5·9 grains.	Weight of iodine . . =4·6 grains.
Weight of phosphorus . =6·4 grains.	Weight of phosphorus . =6·28 grains.

The phosphorus has consequently lost 0·12 grain, the iodine 1·3. Assuming that the phosphorus consumed 3 equivalents of oxygen, as in experiments (33.), (34.), (35.), (37.), we should have 3 equivalents of hydrogen eliminated, and consequently 3 of iodine consumed, or

$$31\cdot4 \; : \; 126\cdot6 \; :: \; 0\cdot12 \; : \; 0\cdot48$$
$$0\cdot48 \times 3 = 1\cdot44.$$

The result is tolerably near, but from the iodine vapour in solution an excess and not a deficit in the consumption of this was to have been expected.

(41.) It was necessary for my own satisfaction to make a great number of other experiments for the purpose of checking and eliminating any adventitious results which might possibly interfere with the actual voltaic action of the gas battery, such as placing phosphorus in single tubes containing the different gases, but with platinum foil and without associated tubes, others without the platinum foil or associated tubes; but as these had no influence on the results, and were merely used as tests for my own satisfaction, it would be useless and tedious to detail them.

(42.) Having examined the action of phosphorus in the gas battery under these various circumstances, my next step was to ascertain if any other substance produced a similar effect. Sulphur, the nearest analogue of phosphorus, was the body which naturally presented itself, but from its different characteristics required a different mode of manipulation. The following was adopted. Into a little capsule of glass,

having a long solid leg (see fig. 1), was placed a small piece of solid sulphur; this was held in the large aperture of a gas battery cell, while the tube was passed carefully over it; the platinum in this tube was connected with the zinc of a single cell of the nitric acid battery, while an anode of platinum was placed in the liquid through the central aperture; by this means all the oxygen of the atmospheric air was exhausted, and the surplus hydrogen was in turn taken away by connection with the associated tube charged with oxygen; the same effect might have been more slowly produced by the process described (29.). The sulphur was now in an atmosphere of pure nitrogen, and this could have been effected in no other way that I am aware of without wetting or forming some deposit on the sulphur. Having connected it in closed circuit with the oxygen tube for twenty-four hours, the galvanometer gave no deflection. A small hoop of iron with a handle was now heated and passed over the tube containing sulphur and nitrogen, the wires being connected with the galvanometer (see fig. 2). The result was very striking : I had directed my assistant to watch the galvanometer while I attended to the manipulation. At the same instant he exclaimed that the galvanometer was deflected, and I that the sulphur was melting; the galvanometer continued deflected during the whole time that the sulphur remained fused, and indeed some time afterwards, until all the sulphur vapour diffused in the nitrogen had become exhausted. The sulphur represented the zinc of an ordinary voltaic combination. It was of course impracticable in this case to ascertain the equivalent consumption. This experiment very strikingly exhibits the analogy of sulphur with phosphorus, and proves that the instant sulphur is fused it becomes a volatile body, as phosphorus is when solid; the suddenness of its action, coupled with the insoluble character of sulphur, leads to the conclusion that solution in the electrolyte is not a necessary antecedent to voltaic action in the gas battery. Indeed this might have been deduced from the experiments with phosphorus, as its vapour must have been nearly, if not absolutely insoluble in the electrolyte, or the equivalent results would not have come out so accurately; possibly solution and electrolysis are in these cases synchronous.

(43.) I was now led to try in the gas battery other substances differing from phosphorus and sulphur, but possessing characters which had hitherto prevented their being used as voltaic excitants; as, if my view of the volatility of phosphorus and sulphur were correct, other volatile bodies ought to act similarly. Camphor was the first substance I experimented on. A piece of camphor weighing 12·9 grains, was placed in a similar manner to the phosphorus (33.) in nitrogen, and associated with oxygen; tested by the galvanometer it gave a feeble deflection, which, however, was continuous; it was allowed to remain four months in closed circuit; at the expiration of that time the liquid had risen in the oxygen tube 0·3 cubic inch; the nitrogen in which the camphor was suspended had increased in volume 0·15 of a cubic inch. The camphor weighed 11·4 grains, but some minute crystals of it were observed at the top of the tube, so that the loss of weight was greater than that due to voltaic action.

(44.) The smallness of the quantity of the gas which had been added to the nitrogen, precluded an accurate analysis of it; enough was ascertained, however, to lead me to believe that it was hydrocarbonous, and it then became my aim to produce it in greater quantities. I attached a piece of camphor to a platinum wire, and to the same wire I also attached a piece of sponge platinum; I passed these up into a tube of nitrogen over distilled water, and at the expiration of three months the gas had increased 0·1 cubic inch; this proved that the camphor vapour was decomposable by the catalytic action of platinum at ordinary temperatures, and that the effect in the nitrogen cell of the battery was not due to its voltaic association; but the experiment did not give me a sufficient quantity of the gas for analysis.

(45.) I therefore had recourse to the apparatus, fig. 3. *a* is an inverted cylindrical test-glass; *b* a platinum capsule with a pin-hole in the bottom for drainage, standing on an ivory pedestal; *c*, *c* two very stout platinum wires; *d* a coil of fine platinum wire. Into the capsule *b* was placed the camphor, the glass *a* filled with distilled water was inverted over it and charged with pure nitrogen, to a level marked somewhere below the capsule; the wires *w w'* are now connected with a voltaic battery of sufficient power fully to ignite the wire *d*.

(46.) After the wire was ignited the volume of the gas gradually increased; when the original volume was doubled, the gas was examined. It had a strong disagreeable odour, very similar to that of coal-gas; it burned with a blue flame, slightly tinged with yellow: placed in an eudiometer, such as I formerly described[*], and mixed with hydrogen, it underwent no alteration. Two volumes of it, mixed with one volume of oxygen, contracted one-sixth of the whole volume, and subsequently agitated with lime-water, contracted two-sixths more, lining the tube with a crust of carbonate of lime. The residual gas was nitrogen. It was thus clear that the vapour of camphor was decomposed by the ignited wire into carburetted hydrogen and carbonic oxide, and the analogy is too direct to leave any doubt that these gases were also formed in experiments (43.) and (44.) by the influence of the platinum foil and spongy platinum.

The apparatus (fig. 4) offers a most convenient means of decomposing volatile hydrocarbons, and possibly other substances.

(47.) Portions of oil of Turpentine and of Cassia were now placed in capsules (fig. 1), weighed and exposed each to an atmosphere of nitrogen in the large tube of a gas battery, by the same means as described (42.); they gave a very decided deflection (the nitrogen representing zinc). This deflection continues, and the liquid is slowly rising in the oxygen tubes, but the rise is too slight at the time of my writing this paper to derive any useful result from examining the present weight[†].

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[*] Philosophical Magazine, August 1841, p. 99, and Philosophical Transactions, 1843, p. 105.

[†] Dec. 1845.—The rise of liquid has been slow but continuous, and the galvanometer feebly deflected. In the Turpentine experiment the rise is =0·7 cubic inch, in the Cassia 0·5; the weights, however, from the irregularity of absorption and evaporation, give no data as to the equivalent consumption; thus the Turpentine has lost 0·7 grain, the Cassia gained 0·05 grain.

(48.) Alcohol and ether were tried in a similar manner, and produced notable voltaic effects ; alcohol the most powerful probably, on account of its greater solubility in water.

(49.) The rationale of the action in experiments (43.) and (47.) is curious. It seems that the platinum in the nitrogen tube first decomposes the vapour of the hydrocarbons*, and then the same platinum, with its associated plate, recombines the separated constituents with oxygen. In experiment (43.) the decomposition takes place more quickly than the recomposition, as indeed would be expected from the absence of the resistance of the electrolyte in the former case, and hence the increase of gas in the nitrogen tube.

(50.) The analogy of the action of the above volatile substances strengthens the position advanced (38.), that solid phosphorus should be regarded as volatile at ordinary temperatures, and sulphur when fused ; the whole of these experiments also serve to introduce the galvanometer as a new and delicate test, and in some cases a measurer of volatilization.

(51.) As the gas battery was shown in the former paper, which I had the honour to communicate to the Society, to give us the power of introducing gases which had been previously untried as voltaic excitants, and to ascertain their electro-chemical relations, it has, by the means detailed in this paper, opened a field for ascertaining the voltaic relations and quantitative electro-chemical combinations of solid and liquid substances, which from their physical characteristics had not hitherto been recognised in lists of the voltaic relations of different substances, and consequently formed to a certain extent a blank in the chemical theory (may we not now call it law ?) of the voltaic pile. These results, coupled with the previously-arranged tables of electro-chemical relations, and with the great improvements in apparatus for measuring these relations recently made by Mr. WHEATSTONE and others, offer every promise of the ultimate establishment of accurate measures of affinity. I give the following tables as an approximative list, without attempting to give the degrees of intensity, which can only be filled up by a careful series of researches exclusively devoted to this object.

(52.) Chlorine.

Bromine.

Iodine.

Peroxides.

Oxygen.

Deutoxide of nitrogen.

Carbonic acid.

Nitrogen.

Metals which do not decompose water under ordinary circumstances.

Camphor.

Essential oils.

Olefiant gas.

Ether.

Alcohol.

Sulphur.

Phosphorus.

Carbonic oxide.

Hydrogen.

Metals which decompose water.

* I use this word here and in the title to avoid periphrasis ; it is not quite correct as applied to some of these bodies.

Though carbonic acid and nitrogen appear to be neutral, and consequently might be bracketed with the metals which do not decompose water, as forming the nodal point or zero of the table, yet, in consequence of the peculiar action exercised by them, and detailed (29.) and (30.), I have placed them above the metals*.

(53.) The results embodied in my present and my former paper, I think sufficiently indicate the field of research opened by the gas battery, a field which may of course be indefinitely extended. I have never thought of the gas battery as a practical means of generating voltaic power, though in consequence of my earlier researches, which terminated in the nitric acid battery, having had this object in view, I have been deemed by some to have proposed the gas battery for the same purpose; there is, however, a form of gas battery which I may here describe, which, where continuous intensity or electromotive force is required, but the quantity of electricity is altogether unimportant, appears to me to offer some advantages over any form of battery hitherto constructed, and which, independently of any practical result, is, from circumstances peculiar to the gas battery, not without interest. It is shown at figs. 4 and 5. A A' is a long glass tube, with a series of legs or glass tubes attached to and opening into it; the lower extremities of these are open, and the main tube or channel A A' terminates at the extremity A in a glass stopper, and at A' opens out into a funnel, as shown in the figure. Into a series of glasses B B' are cemented platinum wires having attached to them strips of platinized platinum foil, two to each glass, the one being four inches long and half an inch wide, the other $1\frac{1}{2}$ inch long by one inch wide; the former set are placed lower than the latter, so that when the glasses are filled with liquid the former set shall be just covered, and the latter bisected by the water-mark; the last glass B has no platinum. These platinum strips are connected metallically by external wires, the narrow platinum of one cell with the wide one of the next, and so on in series. The glasses having been filled to the top of the narrow platinum with acidulated water, let a piece of zinc be placed on a pedestal in the vessel B, and the stopper being out of the extremity A, the apparatus A A' lowered into the glasses, the tubular legs covering each one of the narrow platinum plates. The tubes will of course be full of water, and the main channel full of atmospheric air; this will gradually be displaced by the hydrogen ascending from the zinc, which hydrogen, in consequence of the curve at A, will retain its position. When it is judged that the greater portion of air has been expelled, the stopper at A, covered with a little grease, is to be inserted; the hydrogen now will rapidly descend in all the tubes until the zinc is laid bare, and then remain stationary.

We have now a gas battery, the terminal wires of which will give the usual voltaic effects, the atmospheric air supplying an inexhaustible source of oxygen, and the hydrogen being renewed as required by the liquid rising to touch the zinc; by supplying a fresh piece of zinc when necessary, it thus becomes a self-charging battery,

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* I have been lately much struck with the difficulty of reconciling the theory of GROTTHUS with many of the combinations in the gas battery, and have stated this difficulty in the Philosophical Magazine for Nov. 1845.

which will give a continuous current ; no new plates are ever needed, the electrolyte is never saturated, and requires no renewal except the trifling loss from evaporation, which indeed is lessened, if the battery be in action, by the newly composed water. There is an aperture in the pedestal with a moveable slide, through which the vessel B' can be removed, when necessary, to replace the zinc, and the remaining part of the apparatus is never disturbed.   This battery would form an elegant substitute for the water battery ; it would much exceed in intensity a similar number of series of that apparatus ; it would be applicable to experiments of slow crystallization and possibly to the telegraph.   Its construction is difficult and makes its prime cost expensive, but after that it is the most durable, the most easily charged, and the most free from local action of any known form.   I have had one of ten cells constructed, shown at fig. 5, which succeeds perfectly, giving sparks, decomposing water, &c., and is ever ready for use.   Any number of such sets might be united by adapter-tubes ; or indeed it would be much more economical, and reduce to a minimum the damage from breakage, to have the main channels A A' made of varnished wood or porcelain, with apertures into which separate glass tubes might be cemented.

London Institution, May 30, 1845.