



XXXVI. Observations on the different theories of philosophers to explain the phænomena of combustion

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The following fact is fimilar to one which I have related in my memoir*:—"In the year 1762, at Tuscarawas, on Muskingum, while going to fetch water out of the river, I observed," says Mr. Heckewelder, "a large black snake running out on a long limb of a large tree which stood on the water's edge. This limb was nearly horizontal over, and about twelve feet above the level of, the water. I could not, at first, conceive what the snake aimed at, until near the end of this limb I saw the animal stretch downwards, where I observed a hanging† bird's nest, pretty well concealed between some small boughs or leaves, into which the snake put its head, having strung its tail, with part of its body, round the limb above. Determined on killing the snake, if possible, I ran to the house for my gun, and shot the reptile, which fell into the river, with a young bird in its jaws."

"I and another person once observed a snake of this kind run up a tree pretty high, and put its head into a woodpecker's nest, where, as we supposed, it sucked the bird's eggs, it being too early for the young birds to be hatched‡."

On these facts I shall not trouble you with any comments, but shall proceed with my examination of Mr. Blumenbach's Remarks.

[To be continued.]

XXXVI. *Observations on the different Theories of Philosophers to explain the Phænomena of Combustion.* By CHARLES PORTAL, Esq. §

THERE is no phænomenon in nature that has hitherto engaged the attention of philosophers with less success in the elucidation of its principles than that of combustion, and it at present affords one of the chief obstacles to the forming of a clear and satisfactory theory of chemistry. It is not singular, that a subject of so striking a nature, and abounding with a variety of such important phænomena, should have early attracted the attention of philosophers, and we accordingly find that it was made the subject of investigation by lord Bacon and Mr. Boyle.

These two philosophers were, however, more particularly confined in their inquiries to the nature of the unknown element called *fire*, nor did they reach sufficiently far in such

* See pages 67 and 68.

† Oriolus Baltimore of Linnæus.

‡ Letter already referred to.

§ Communicated by the Author.

inquiries as to frame any particular theory on the subject of combustion.

In referring back to the earlier periods of the history of chemistry, we shall find that Becher was the first philosopher who withdrew that science from the contracted limits of pharmacy and alchemy, and laid the foundation of the doctrine of phlogiston.

G. Ernest Stahl, whose genius was formed for the highest improvement of science, succeeded him; and it is to this philosopher that we are indebted for the first positive attempt to explain the phænomena, and to exhibit a regular theory of combustion.

The doctrine of phlogiston, as expounded by this celebrated chemist, is too well known to require being described at any considerable length.

It proceeded on the assumption, that there was only one substance in nature capable of combustion, which he therefore called phlogiston; and he held, that all bodies that were inflammable owed their combustibility only to the presence of this principle. Combustion, therefore, he considered merely as its separation in the form of light and heat; and such bodies as were not inflammable were thought to be devoid of it: for during the combustion of substances he taught that their phlogiston flies off, and the incombustible parts of them alone remain behind. Thus, if iron be exposed to a sufficiently strong heat it will undergo combustion, a complete alteration will take place in its constituent parts, and a residuum will be found left of an incombustible nature.

Stahl explained these phænomena in the following way: Iron he considered as a peculiar earth united to a certain proportion of phlogiston; when it was made to undergo combustion, the phlogiston which formed a part of it, and to which it alone owed its combustibility, made its escape, and there was left behind only the base, which was found to be no longer inflammable. Now, as this separation was always attended with the emission of light and heat, phlogiston was considered only as heat and light combined with some other species of matter in a peculiar and unknown way.

This doctrine was considered as deriving much support from the fact, that a body, after having undergone combustion, (*i. e.* by the dissipation of its phlogiston in the form of light and heat,) was converted into a body that was no longer combustible, but which might again have its combustibility restored by the addition of any inflammable matter. Thus, in the example before adduced, if, after the iron has undergone the process

process of combustion, and formed a residuum that is incombustible, we heat this latter substance with charcoal (an inflammable body), the metal will be again revived—phlogiston is imparted to it from the charcoal, and we again procure a combustible substance. Thus, the light and heat which are evolved during combustion are supposed to proceed from the burning body, and to be occasioned by the separation of phlogiston from the base to which it is united.

Such is the outline of that theory of combustion the foundation of which was first laid by Becher, and afterwards reduced into a regular system by the immortal Stahl. The phlogistic doctrine of this chemist was universally adopted until the middle of the present century, when the discoveries of Mayow and Hooke, of Priestley and Lavoisier, led the way to a new theory of combustion, which soon displaced the former, and established itself on its ruins. Stahl, from being wholly occupied in demonstrating the existence of phlogiston, seems to have paid no attention to the influence of air on combustion. The experiments of Boyle and of Hales had already pointed out the influence of this element on many of the phenomena of combustion, and the increase of weight that bodies acquire during such a process, is a fact totally irreconcilable with the theory of phlogiston.

Many attempts, however, were made to overcome the weight of this objection by the disciples of Stahl; and they even had recourse to the supposition that phlogiston was the principle of levity, and that, when abstracted from any body, that body, by losing so much absolute levity, became heavier. So strongly were they fettered by the tenets of their master, that, without submitting to the labour of investigation, they implicitly adopted any illustration that was conformable to his ideas; affording a strong proof of the desire that pervades the human mind to reduce every thing to first principles, and to adopt hasty generalizations, without having recourse either to an extensive collection of facts or the more certain evidence of accurate experiment.

Whilst other chemists were intent on reconciling the various discoveries that had been recently made with the hypothesis of Stahl, Lavoisier (of a bold and creative genius) was led to call into question the very existence of phlogiston itself. This arose from his having discovered that during the process of combustion a portion of air constantly enters into union with the body which is made to undergo this operation, and that the weight of the air which disappears in the process is exactly equal to the increase of weight gained by the

the body that has undergone combustion. These important facts led to the adoption of a new theory of combustion well known at present by the name of its illustrious author.

The theory of Lavoisier is founded on the absorption of oxygen by a combustible body, and proceeds upon the following principles :

1st, That combustion never takes place without the presence of oxygen gas.

2dly, That in every combustion there is an absorption of oxygen gas.

3dly, That there is an augmentation of weight in the products of combustion equal to the gas absorbed ; that the oxygen likewise imbibed by the combustible body may be again recovered from the compound formed, and the weight regained will be equal to the weight which disappeared during combustion.

And, lastly, That in all cases of combustion there is a disengagement of light and heat.

These facts have been established by the most accurate experiments, and are too well known to require any further illustration ; they incontrovertibly prove the general principle, "that combustion is only a play of affinities between oxygen gas, caloric, and the base of the combustible body. It is a further part of this theory, that the light and caloric which are evolved during combustion proceed from the oxygen gas, and that they are not emitted, as should follow from the phlogistic doctrine, from the combustible body.

As this theory, however beautiful, is not capable of explaining with clearness and accuracy many of the phænomena of combustion, Dr. Thomson, of Edinburgh, has lately (see Nicholson's Journal, New Series, for May and June 1802,) offered another which places this subject in a point of view somewhat different, and which certainly bids fair to enable us to estimate the phænomena of combustion with more success than has hitherto been done. Chemists have been lately accustomed to give to the term combustion, according to the foregoing theory, a new meaning, and to make it stand for the general combination of a body with oxygen. Nothing, however, can be more evident than the difference that in numberless instances prevails between the act of oxygenation of bodies and that of combustion, inasmuch as neither the phænomena attending them, nor the results arising therefrom, are the same.

It is probable that this error has arisen from the consideration that all bodies during their combustion combine with oxygen, without at the same time recollecting that this latter effect

effect may be produced without any of the phænomena usually attendant on combustion; and that, though certainly all combustion presupposes the combination of oxygen with a base, yet this combination may be, and repeatedly is, effected where no combustion can possibly take place.

It is the object, therefore, of Dr. Thomson's theory to point out the difference which in numberless instances prevails between the act of oxygenation of bodies and that of combustion, and particularly to account, in a more satisfactory manner than has hitherto been done, for the emission that takes place during combustion of light and caloric. The two following are the leading positions of the doctor's theory:

1st, That during combustion all combustibles emit light, which previously formed a necessary ingredient to their own composition: and,

2dly, That the heat which is evolved during the process of combustion proceeds from the decomposition of oxygen gas.

It has been before observed, that by the phlogistic theory the light and heat are supposed to proceed from the combustible body; but that by the theory of Lavoisier they are held to proceed from the decomposition of oxygen gas, of which body they are considered as forming constituent parts.

In the infancy of chemical knowledge, and before the discovery of vital air, that the extrication of heat proceeded from the combustible body, was the only natural conclusion that could present itself to the mind; and as light and heat were considered as only modifications of the same substance, the supposition of course prevailed that both were evolved from the inflammable body.

Since, however, the later experiments of philosophers, and particularly those of Drs. Herschel and Woolaston, have disproved this supposed identity, it evidently becomes no longer necessary to trace these two substances to the same source; and this, as is before stated, is the case with the theory we are now reviewing.

That the caloric which is evolved during combustion should proceed from the decomposition of the oxygen gas, is, amongst a variety of other reasons, rendered the more probable from the consideration that bodies possess a greater share of caloric in the gaseous state than in any other; and consequently the probability is greatly strengthened, that the heat which is evolved during the process of combustion proceeds rather from the oxygen gas than from the inflammable matter, and that it is from the condensation of oxygen gas that caloric is chiefly evolved; or, according to the explanation of Lavoisier, that the oxygen of the gas, possessing a stronger affinity for

for the base of the combustible body than for caloric, is thereby attracted, and that the heat combined with it is consequently set at liberty, and diffuses itself among the adjacent bodies.

To the second position of Dr. Thomson, that the light invariably proceeds from the combustible body, and not from the oxygen gas, there are much stronger objections, and such as, with our present collection of chemical facts, are, I apprehend, not readily to be explained.

It is a part of the theory of the doctor, that oxygen gas possesses no light: indeed this is so material a part, that, unless it can be substantiated, the theory is inadequate to elucidate the phænomena intended by it.

How shall we, however, reconcile the following facts on the above supposition? If nitric acid be exposed to the light, it changes colour; it first grows yellow, afterwards green, and lastly red, and oxygen gas is disengaged; and on examining the acid we find that it is converted from nitric into nitrous acid.

It is evident that, as this decomposition is of a chemical nature, the light that occasions it either combines with the oxygen to form oxygen gas, or with the acid to form nitrous acid: that the latter is not the case we are justified in supposing, because we find no difference between acid so procured and that gained by any other means, and we are necessitated to conclude that the light has combined with the oxygen, and that the latter is by this mean converted into oxygen gas. The same reasoning may be applied to the conversion of oxygenated muriatic acid by light into simple muriatic acid. Unless these facts can be otherwise satisfactorily accounted for, the position of Lavoisier still remains with all its force, that light is a constituent part of oxygen gas. That light forms a necessary part in the constitution of many bodies, is a fact too well authenticated to be refuted. The experiments of the Dutch chemists, who heated together the filings of different metals with sulphur under mercury; the phænomena of the pyrophori; the inflammation that takes place from the action of many of the acids on the oils; and the recent experiments of Dr. Hulme, illustrate this fact beyond the possibility of contradiction.

After a body has undergone combustion, we learn from this theory that it is deprived of light, and that it is only by means of a combustible body that light can be again transferred to the product of combustion. Thus water is considered by Dr. Thomson as a product of combustion, and consequently deprived of light. If, says he, we decompose
this

this water by means of iron or zinc, we restore it to its former combustibility by occasioning it to imbibe light, which is afforded it by the metal. If such decomposition is effected by means of iron, 73 parts of this latter unite with 27 of oxygen. Now, as every 27 parts of oxygen require about four of hydrogen to form water, of course these four parts of hydrogen are liberated during such decomposition: but, as it is not probable that combustibles are capable of combining with light in all proportions, it may be asked, Whether the 73 parts of iron which are oxidated contain just light enough, and no more, to restore the combustibility of the four parts of hydrogen? for, if there be too much for that purpose, the superabundant quantity ought to become visible; and if too little, a part only of the hydrogen should recover its combustibility, and be converted into gas. The same reasoning may of course be urged with regard to the decomposition of water by any other metal; for it is somewhat singular, that the combustible should always contain and give out the precise quantity of light that is sufficient to restore combustibility to the base of the product of combustion, and in no case either more or less. These, as well as some other objections to the above theory, were pointed out by me in a paper entitled *Remarks on Dr. Thomson's Theory of Combustion*, and inserted in *Nicholson's Journal* for the month of July 1802.

It should appear, then, that we are not in possession of a sufficient collection of facts to enable us to form any theory of combustion that is perfectly free from objection, and calculated to explain all the phænomena attendant on it. Whether the light evolved during combustion is emitted from the combustible body or from the oxygen gas, must still be considered as a matter of doubt; for the supposition seems perhaps the more probable, that it is partly derived from both. The subtle nature of light itself is highly adverse to any inquiry into its real essence. The same observation will likewise apply to caloric. The theory last noticed is, however, possessed of a high degree of merit; it satisfactorily explains many phænomena that were before but little understood; it points out, with sufficient perspicuity, the difference that prevails between the act of oxygenation in bodies and that of combustion; and though certainly liable to some objections, it approximates the nearest to a satisfactory explanation of the phænomena of combustion of any that have hitherto been offered.

CHARLES PORTAL.

* * * Mr.

* * Mr. Portal is probably not aware that the theory which he attributes to Dr. Thomson as its author was first proposed by Dr. Gren, whose doctrine is briefly as follows:

Oxygen gas is composed of *oxygen and caloric*—*Combustible bodies* consist of *their respective bases* in chemical combination with the *matter of light*—*Free light* consists of the *matter of light* united to *caloric*.

Combustion, then, is a mere play of chemical affinities; the oxygen of the oxygen gas uniting with the base of the inflammable body to form an oxide or an acid, while the caloric of the gas unites with the matter of light of the combustible body, and forms free or visible light. By this theory, no combustible substance can be a simple body—by Lavoisier's, they may.—See Gren's *Principles of Modern Chemistry*, English edition, chap. ii. articles *Caloric, Light, Phlogiston, Combustion*.—A. T.

XXXVII. *History of Astronomy for the Year 1802. Read in the Athenæum of Paris December 30, by* JEROME LANDE.

[Concluded from p. 179.]

ON the 7th of June I published the two last volumes of the large History of the Mathematics by Montucla. The fourth is almost entirely devoted to the history of astronomy and navigation, which I communicated to the present period.

There has appeared also, in two volumes quarto, with 23 plates, *Histoire de la Mesure du Temps par les Horloges*, by Ferdinand Berthoud, mechanist of the marine, member of the National Institute, and of the Royal Society of London. It contains a description of escapements, compensation balances, moving spheres, and of the principal inventions of clock-work. The author speaks of all the celebrated clock-makers, except Louis Berthoud, his nephew, to whom we are indebted for all the time-keepers made since 1784. I shall here take occasion to observe, that Mr. Emery died at London, and that his widow has four time-keepers which she wishes to dispose of: they would be a valuable acquisition.

We have received the 7th volume of the Transactions of the Royal Irish Academy, published in 1800, and in which Mr. Young examines the solution given by Newton of the problem respecting precession of the equinoxes; also the 8th volume of the Irish Transactions, Dublin 1802.

On the 18th of July my small tables of logarithms appeared: they are the most convenient and the most correct yet given.