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other mines amounts to about 20,000,000 of myriagrammes per annum. The mean price of these coals at the mine is 11 cents per myriagramme.

[To be continued.]

III. *Observations and Experiments on the Light emitted by rotten Wood in the different Kinds of Gas, and in Fluids.*
By C. W. BÖCKMAN, of Carlsruhe*.

NOTWITHSTANDING the great number of accurate experiments and of ingenious observations which have been already made known by several eminent philosophers in regard to the light emitted by rotten wood in the different kinds of gas and other mediums, it is still difficult to explain this phænomenon in a satisfactory manner; and this difficulty is increased, because great variations occur both in the observations, and in the consequences deduced from them.

Thus Spallanzani found a perfect analogy between the luminous appearance of rotten wood and that of phosphorus †; and conjectures, that by the putrid fermentation of the wood its hydrogen and carbon come more readily into contact with the oxygen of the atmosphere; and that this combination is a slow combustion, which occasions the luminous appearance of the wood. In the non-respirable gases this, according to Spallanzani's opinion, cannot take place for want of oxygen; and he infers that every kind of rotten wood is not luminous, because the necessary quantity of hydrogen and carbon does not always happen to be extricated at the same time.

On the other hand, Mr. Carradori ‡ is of opinion, from other experiments, that rotten wood emits light without this slow combustion taking place, and that the non-respirable gases make on the wood only a transient impression capable of preventing the efflux of light, which, on the contrary, is promoted and increased by the peculiar action of oxygen gas. The observed decrease in the volume of the oxygen gas he considers as not decisive, because this de-

* Scherer's *Allgemeines Journal der Chemie*, vol. v. no. 1.

† See an Essay on the Phænomena of natural Phosphorus in Atmospheric Air, Oxygen Gas, and other Kinds of Gas, by L. Spallanzani. *Gren's Annalen der Physik*, vol. i. p. 1.

‡ See *Annalen der Physik*, vol. i. p. 2.

crease is produced by many substances without combustion, or without being exactly phosphorus. The above theory respecting this luminous appearance he thinks not altogether improbable, because the wood at the period when it begins to be luminous has, for the most part, lost its resinous particles, and therefore contains little hydrogen or carbon. He is of opinion also that rotten wood approaches nearer to phosphorescence the more it loses its inflammable matter, and that on this depends its susceptibility of absorbing and retaining light. According to Carradori's meaning, however, there is a greater difference between this natural phosphorus and that of Kunckel.

Humboldt*, that assiduous and philosophic observer, deduces from his well known experiments that the luminous appearance of rotten wood in general is possible only during its contact with oxygen gas; and that the wood, which loses its phosphorescence in the non-respirable gases, acquires it again immediately by the access of new oxygen gas.

In the last place, M. Gärtner†, in consequence of his interesting experiments on the luminous appearance of rotten wood, considers a certain degree of moisture as a necessary condition, and is of opinion that oxygen gas is less essential, even though the phosphorescence is promoted by it. But as this phenomenon differs so much from all the hitherto known processes of combustion accompanied with an extrication of light, he proposes this question: May not this phenomenon have more relation to the process of animal respiration than to real combustion? Or whether the luminous appearance of wood be not produced by the union of phosphorus and carbon in a certain proportion still unknown to us? But even if it should be admitted that during the process of emitting light water is decomposed, it is difficult, according to his opinion, to determine what becomes of the liberated hydrogen. M. Gärtner therefore considers it as still impossible to give a satisfactory explanation of the phenomena which occur during this process.

In consequence of the numerous experiments which I have made for several years past on Kunckel's phosphorus in the different kinds of gas, the most remarkable of which I have already communicated to the public in a particular treatise, I was desirous to see what phenomena would be exhibited in them by phosphorescent wood, and also in

* See *Versuche über die Chemische zerlegung des Luftkreises*; ix über die entbindung des Lichtes, p. 209.

† See his Essay in Scherer's *Journal der Chemie*, vol. iii. part 1.

other mediums : I hoped also that during these researches I might fall upon some new fact or idea, as is often the case, which might serve to confirm or to throw some new light on either the one or the other of these opinions. As soon therefore as I had procured some phosphorescent wood I began with it a series of experiments, a part of which, with the consequences deduced from them, I shall here lay before the public, after I have made a few previous remarks.

In regard to the wood itself, it was part of the old rotten trunk of a beech-tree, moderately moist, and without any particular mouldy smell. It was not luminous throughout, but emitted light only from its surface to the depth of a few lines. The luminous parts appeared to have lost in a considerable degree their resinous particles. They were friable, full of fibres, and whiter than those parts of the wood which emitted a weaker light, or had no light at all. I preserved the rotten wood in moist filtering paper in a cellar the temperature of which was from 10 to 12 of Reaumur; and in this place I made my observations during the night. The colour of the light was exactly the same as that exhibited by the light of artificial phosphorus in atmospheric air.

I used for my experiments, in general, small bell glasses capable of containing from 8 to 14 cubic inches each, having a neck at the top exactly shut by corks boiled in wax, through which passed a varnished wire. I stuck a piece of phosphorus on the wire in the inside of the bell; filled the vessel, according to the nature of the gas to be employed, either with water or quicksilver; and then placed it on the pneumatic tub. By the pressure which these fluids exercised on the wood, small air bubbles, which must have been contained in the substance of the wood, from time to time, escaped; and therefore before each experiment I took care to immerse the wood in water till no more air ascended, and by these means prevented the gases from being rendered impure.

Experiment I.

I filled a bell with atmospheric air, and preserved it closed by means of water. During the first two days the rotten wood remained luminous; on the third the light was somewhat fainter; on the fourth it had considerably decreased; and on the seventh the light had entirely disappeared. The wood, when taken out and exposed to the atmospheric air, emitted no light either when dry or when moistened with water. I then introduced into the remaining gas a piece of wood which was strongly phosphorescent: it emitted a
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bright light, and even at the end of twenty-four hours I could observe no decrease of any consequence.

The remaining gas, when subjected to examination by means of Fontana's eudiometer, in which I mixed it with the same quantity of nitrous gas, showed a decrease of 30 degrees. A taper immersed in this gas was immediately extinguished. Phosphorus evaporated strongly in it, and it rendered lime water pretty turbid, without a considerable quantity of the gas being absorbed.

Experiment II.

I filled a bell glass with oxygen gas prepared from oxide of manganese well washed with milk of lime. The wood immersed in it did not emit a stronger light than in atmospheric air or water. At the end of forty-eight hours the light seemed to decrease a little, and on the sixth day it was about a third weaker. The phosphorescence afterwards slowly decreased; on the 14th day it ceased entirely, and was not afterwards revived in the open air. The volume of the gas decreased very little, scarcely 0.2. Having put another piece of wood into the remaining gas, it continued to emit light without being weakened.

On trying the gas which remained in an eudiometer, it showed only a decrease of 21 degrees; and in about 15 seconds, when the red vapour of the nitrous acid had disappeared, I observed a faint whitish vapour from the gas floating over the water. For the sake of comparison I tried a portion of the same oxygen gas in a similar bell closed in the same manner with water, but in which no wood had been immersed, and found that in the same eudiometer it showed a diminution of 266 degrees. Artificial phosphorus, when placed in the remaining gas, became luminous and evaporated. A taper immersed in it was immediately extinguished: it was not inflammable, had no considerable smell of mouldiness, and rendered lime water turbid; but it was not absorbed by it in any considerable degree.

Having repeated this experiment several times, I obtained similar results, or results very little different. The phosphorescence of the wood, however, decreased once on the fourth day, and ceased totally on the seventh; though the gas, when subjected to proof, showed a diminution of from 80 to 120 degrees. This difference may have arisen chiefly from a difference in the nature of the wood; for it is not possible to obtain two pieces exactly the same in every respect. On the wood which had emitted light in oxygen gas I observed no mouldiness, nor any perceptible alteration.

It did not appear that the want of moisture was a principal cause of the cessation of the phosphorescence; for I found the wood often moist in a greater or less degree, and especially when it came in contact with the water by which the mouth of the bell was closed.

Experiment III.

I filled several bell glasses with azotic gas as pure as possible, which I had separated from atmospheric air by long continued agitation of an amalgam of lead, or by six months action of a solution of alkaline sulphuret, or by moist garden earth, and which tried in an eudiometer mixed with nitrous gas exhibited no diminution. The phosphorescence of the wood in this gas continued at first without any decrease, and as strong as in oxygen gas; but after from one to four hours it became weaker in the different bells: in some it ceased entirely at the end of an hour and a half, in others not till the end of from five to fourteen hours; the cause of which, in all probability, was the unavoidable diversity in the nature of the pieces of wood. After 24 hours I introduced into several of these bells from half a cubic inch to an inch of fresh azotic gas; but in neither of these cases was there the least appearance of light. But having introduced, with proper care, a new piece of wood, it emitted, in these as well as in the other vessels which had received no mixture of new azotic gas, as strong a light as in atmospheric air, and continued undiminished for some time. In some of the bells it was not extinguished till the end of 2, 4, or 5 hours, though no oxygen gas had been introduced.

Experiment IV.

I put into some of the bells along with the rotten wood small bits of phosphorus; and having introduced some of the above azotic gas, the wood and the phosphorus both began to be luminous. At the end of an hour the luminous appearance of the wood was considerably weakened, and it at length decreased so much that its light could no longer be distinguished any more than that of the phosphorus. At the end of 24 hours, when the light of both substances had already ceased for a considerable time, I introduced, with proper caution, a new piece of wood into the gas in which the former still continued luminous. A proof that by this operation no atmospheric air had been introduced was, that the phosphorus remained dark, and I could observe no luminous vapour in the glass. In about
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an hour and a half the phosphorescence of the wood had for the most part ceased. At the end of 24 hours I therefore introduced another piece of wood, which exhibited the same phænomena as the preceding. This operation was often repeated in the same gas. When the luminous appearance of the wood became weak, it recovered nearly its original splendour, in the course of a few minutes, on placing it in atmospheric air. I tried the remaining gas in the eudiometer, but could observe no decrease; which proves that the gas had remained free from any mixture of oxygen gas.

When a piece of luminous phosphorus is placed near the wood, it is difficult to determine the moment when the light of the latter becomes entirely extinct: for I found that the phosphorus generally remains luminous a considerable time longer than the wood, and even after its light is extinguished a somewhat luminous vapour arises; so that on account of this vapour it is not easy to ascertain when the phosphorescence of the wood ceases. It is equally difficult to observe, whether, on the admission of oxygen gas to azotic gas containing wood and phosphorus, the light of which is extinct, both these substances begin to be luminous at the same time, or not; for at first the gas is entirely illuminated by the luminous vapour; and besides this, the surface of the rotten wood becomes entirely luminous, in consequence of the phosphoric particles deposited on it; and hence it is difficult to determine whether the light proceeds from itself or from these particles. I often found such pieces of wood when taken out entirely penetrated with particles of phosphorus. This observation may be of utility to the future observer.

Experiment V.

I filled a common bell glass with phosphorated azotic gas, in which a considerable quantity of phosphorus had remained several weeks, at the temperature of from 14 to 24° of Reaumur, and in which fresh phosphorus neither evaporated nor became luminous. A piece of wood placed in this gas continued at first luminous, without any decrease of intensity. In about half an hour however its light became weaker, and in an hour entirely disappeared. Next evening I introduced into the same gas a fresh piece of wood, and observed the same phænomena. On introducing more phosphorus it emitted as little light as before.

Experiment VI.

I prepared impure phosphoric azotic gas by combustion and long exposure to heat, with a sufficient quantity of phosphorus shut up in a close vessel with atmospheric air. In this gas a piece of rotten wood continued luminous for an hour. Having introduced another piece of wood, the phosphorescence was the same as before; and at the same time artificial phosphorus emitted no light.

Experiment VII.

Rotten wood appeared phosphorescent in hydrogen gas, prepared from iron and sulphuric acid, in which phosphorus emitted no light; but in the course of 30 or 40 minutes it considerably decreased, and at length became entirely extinct. By the contact of atmospheric air the light was in some measure revived. As often as a fresh piece of rotten wood was introduced into the remaining gas, it became luminous. This experiment I several times repeated with the same result.

Experiment VIII.

Having placed rotten wood in carbonic hydrogen gas, prepared from the saw-dust of the beech tree, it became luminous at first, as in atmospheric air; but after 45 minutes the phosphorescence gradually decreased, and in about an hour entirely ceased. Every time I introduced a fresh piece of wood into the remaining gas I observed the same result. Artificial phosphorus in this gas gave no signs of light whatever.

Experiment IX.

I introduced rotten wood into phosphorated hydrogen gas above a year old, during all which time a considerable piece of phosphorus had remained in it, and which had been continually exposed to the solar heat. In this gas the wood continued luminous without any decrease of its intensity. At the end of an hour the light began to decrease, and in an hour and a half it had almost entirely ceased. Fresh wood introduced into the remaining gas exhibited the same phenomena: artificial phosphorus however gave no signs of light.

Experiment X.

I prepared fresh phosphorated hydrogen gas, which, as is well known, is so unfavourable to the luminous property of phosphorus, even in small quantity, in azotic gas or atmospheric

spheric air: in this gas the rotten wood was exceedingly luminous. Even at the end of an hour and a half I observed no decrease of the light; and it did not cease entirely till the end of several hours. Having introduced a piece of fresh wood, at the end of 24 hours it was as luminous as in atmospheric air, and the case was the same with the 4th and 5th piece which I afterwards brought into contact with it. At the conclusion of this experiment I could easily inflame the single bubbles of gas by means of a burning coal.

Experiment XI.

I introduced into a common bell glass over mercury strong fuming sulphurized hydrogen gas, disengaged from a solution of alkaline sulphuret and tartaric acid. A piece of rotten wood placed in this gas immediately ceased to be phosphorescent. If taken out when the light began to be extinguished, the light could in some measure be revived by washing it with water in atmospheric air. A fresh piece of wood introduced exhibited the same phænomenon. Want of oxygen gas was not, in some cases where this experiment was repeated, the cause of the light being suddenly extinguished; for the gas was not always perfectly pure. Artificial phosphorus would even at times emit in it a faint vapour.

Experiment XII.

In carbonic acid gas prepared with proper care from chalk and sulphuric acid diluted with water, and in which phosphorus, partly by a natural heat and partly by gentle heating in a vessel with hot water, had entirely ceased to be luminous, a piece of rotten wood retained at first its full phosphorescence: the phosphorescence however in the course of four or five minutes considerably decreased, and in 15 or 20 minutes no light was to be seen. Wood which had thus lost all its luminous appearance, when washed with water, seldom recovered its phosphorescence: if however it retained any light when taken out, it was somewhat strengthened in atmospheric air, but after some time greatly decreased, and at length entirely disappeared.

Rotten wood exhibited almost the same phænomena in carbonic acid gas, prepared with great care, but in which no phosphorus had previously been exposed.

Experiment XIII.

Having brought nitrous gas, mixed with about 0.11 parts of azotic gas, into contact with a piece of rotten wood,

wood, it at first appeared perfectly luminous: the light however speedily decreased, and in general ceased entirely at the end of from a minute and a half to three minutes: it was seldom renewed by washing the wood with water in atmospheric air. When a fresh piece of wood was introduced into this gas, its phosphorescence and the duration of the light were the same as before.

Experiment XIV.

I brought muriatic acid gas into contact with phosphorescent wood, and observed that in the course of from one minute to a minute and a half its light ceased entirely. This phenomenon took place several times, as often as a new piece of wood was brought into contact with the gas. It appeared to me, in this experiment, that moist wood sooner became dark than dry wood. The phosphorescence could not be revived by the usual means.

Experiment XV.

Rotten wood, placed in ammoniacal gas newly prepared, shone from one and a half to six minutes; and the decrease of the light was pretty speedy. When I took the wood from the gas, I observed that it had a strong smell of ammonia; and after being washed with water it assumed, in a considerable degree, its luminous property. The moister the wood, the more the phosphorescence decreased; and the gas was absorbed by it in the same proportion.

Experiment XVI.

Rotten wood appeared phosphorescent in newly prepared muriatic gas a shorter time than in ammoniacal gas; and when the light became extinguished, I was not able to revive it. A part of the gas was absorbed by the somewhat moist wood.

[To be continued.]

IV. Of the general Relation between the Specific Gravities and the Strengths and Values of Spirituous Liquors, and the Circumstances by which the former are influenced.*

§ 1. ALL spirituous liquors may, with respect to their strengths, be regarded as compounds of two ingredients, alcohol, or pure spirit of wine, and water; and as differing

* From Atkins and Coy's Essay on this subject, of which we gave some account in our last volume.

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