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THE INFLUENCE OF THE COMBUSTION OF COAL UPON OUR ATMOSPHERE.

A PAPER READ BEFORE THE SECOND GERMAN MINING ENGINEERS' CONVENTION AT DRESDEN, SEPTEMBER 5, 1885.

BY DR. CLEMENS WINKLER,
PROFESSOR OF CHEMISTRY AT THE MINING ACADEMY AT FREIBERG,
SAXONY.

Translated from the German by Dr. Paul Carus.

A hundred years ago people were still in doubt whether atmospheric air is a mechanical mixture or a chemical combination of its chief elements, oxygen and nitrogen. The fact that the two gases could be so easily separated, was in favor of its being a compound, while the extraordinary constancy of its proportional composition seemed to indicate a chemical combination. The interest taken in this problem ceased rapidly as soon as it was proven with certainty that the oxygen and nitrogen of the atmosphere exist beside each other in a free state, and that the extraordinary and never subsiding motion of the aeric ocean which is produced by the influence of the sunbeams, causes a constant and intimate mixture of its elements.

Later investigations proved that solar radiance, beside this merely mechanical influence, exercises also a chemical, or rather a chemico-physiological influence to preserve the constancy of its mixture. It was further recognized at an early date that atmospheric air always and everywhere contains some carbonic acid. But its amount seemed to be too insignificant a share to be worth any attention, yet how enormous is the absolute magnitude which this small proportion of carbonic acid in the air constitutes, considering the great expanse of the atmosphere. This was not fully understood until man's horizon extended, until his perceptive faculty grew and his intellectual eye learned to comprise worlds, until he had succeeded in determining the weight of this our earth and its atmosphere. Then the imposing transmigration of

carbon taking place in the atmosphere was recognized. It was stated that all carbonic acid which enters into the air by combustion, respiration, decay and otherwise, is converted under the influence of sunlight through the vegetable kingdom into organized carbon-combinations, viz. into plants, and the liberated oxygen returns into the atmosphere. As this change takes place on a large scale, it is the chief condition of a constant composition of the atmospheric air. Thus the carbonic acid is prepared as food for the vegetable kingdom, and the aeric ocean serves as a store-house, the stock of which by this unceasing exchange is kept at constant level. Since our observations were recorded which certainly is no longer than a few hundred years the amount of carbonic acid in atmospheric air remained almost unchanged at an average proportion of 0.04 vol perc. = 4: 10000 vols. It appears to be little, but in reality it is enormous. The weight of the whole terrestrial atmosphere being 5,000 billion tons, this minute proportion represents a quantum of 3 billion tons of carbonic acid, or 800,000 million tons of carbon. This enormous quantity of carbon is suspended invisible, and scarcely perceptible in our atmospheric air, it is constantly consumed and constantly reintegrated. In consequence of this change of matter there is a state of perpetual migration.

Such is the state of things to-day. But geology tells us that there has been a period in which the atmosphere which is our store-house of carbonic acid was more saturated. In their early era the temperature of our planet, being like that of a hothouse, produced gigantic flora which later on in its decline formed the large coal deposits on earth. The same carbonic acid which in immemorial times roared and stormed through the high calamities of the paleozoic era, sunk as petrified vegetable organism into a long and deathlike sleep awaiting a new resurrection in our days. It is the miner who awakens it to a new life which means a new chemical activity, and civilized mankind are busily engaged to restore it to the great circulation of nature. Thus the man of our century heats with the glow which was blazing down upon earth long before men were living on its surface, and it is this heat to which the present time owes the gigantic development by which it is characterized.

Compare conditions of to-day with those fifty years ago in countries where large industries exist, and you will be astonished at the change in such a short space of time. It is almost a superabundance of force in which humankind indulges, since we have succeeded to unlock the coal treasures underground, and make them subservient to our wants. Man indeed fully understood how to put the talent in his trust on usury. On the one hand he is not free from the reproach of profusion, yet on the other he must be credited for having lifted

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himself with the help of the black bounty, to an intellectual height which never before was attained, not even in classical antiquity.

Our era is in the full sense of the word an era of combustion. Everywhere in places of industrial activity we see glowing hearths fed with fossil carbon; we meet with stationary, with movable, and with swimming chimneys which unceasingly send forth into the aeric ocean, the gaseous products of combustion, viz., carbonic acid.

The quantum of carbonic acid which human kind at present produces by combustion, for either the procreation of heat or energy, or light or electricity, is extraordinary and greatly enhanced in comparison to former times. This is done to such an extent that we may ask whether a re-introduction of carbon which has been latent for many geological periods into the circulation of the terrestrial interchange of matter, by the combustion of coal on so large a scale, may not possibly cause a change of our atmosphere so as to disturb its chemical equilibrium.

We may decidedly answer this question in the negative, but it will afford sufficient interest to look at the problem somewhat closer.

The entire production of pit coal on earth has been calculated to be per annum 360 million tons, or, on an average, one million tons per day. If we reconvert this quantum of fossil carbon into the living vegetable individuals in the shape of, for instance, our native pines, we will have a more vivid idea of its amount. 360 million tons of coal would be 942 million tons or 3588.5 million cubic feet logs. Now imagine all these pine at the fittest age for being cut, say of 80 years, their number would be, according to a calculation kindly made for this purpose by my learned friend Mr. Judeich professor of forestry in Tharandt, 2,625 million trees and would cover almost double the area of the kingdom of Saxony. Pine forests grown by a rational cultivation should cover the area of about four times the German empire in order to produce regularly this quantum of octogenary wood.

For a further comparison, and with regard to the mere carbon of coal, we may calculate how much human force is represented by the quantum of heat annually produced by combustion. Of course our calculation is only approximative and in some respects may not be indisputable.

One man gives off by respiration 22 liters* of carbonic acid per hour; accordingly his lungs oxidize 12 grams carbon. Now if it were possible to use carbon directly as food, viz., exclusively to feed the respiratory organs for the required production of animal heat, one man power would consume 150 kilo. carbon per year. If it were possible thus to consume coal by respiration of human organisms, that is to say, by feeding the engine man, the annual production of coal would suffice for 2,400 million man power.

The entire population of the earth is fully one-half of this number. So we produce by machines annually, twice the amount of force which is represented by the muscle power of all humankind. In other words, the labor of man has been tripled by the use

of coal. The generation of to-day works three times as much as generations of former ages, which is done by a three times greater consumption of carbon. One-third is used as food for respiration and is produced by the sun's labor of to-day; two-thirds are taken from the prehistoric store-room of the coal formation. One-third of the carbonic acid produced by combustion is exhaled through the lungs, two-thirds are emitted through chimneys of all sorts into the aerie ocean, and this same carbonic acid is used upon earth, according to the circulation of matter, for the growth of new vegetable organisms. Thus we experience another resurrection of the very same black bounty which the miner brought up to daylight, after it has afforded us heat and energy. Or should it be otherwise? Is it possible that the carbonic acid which is produced in so great quantities by modern industry, may not be consumed by plants, but amassed gradually in our terrestrial atmosphere? There is no reason to fear such outcome, but we must confess that we do not know. However, in pondering upon such problems, we are impressed with the truth, that nature cannot be measured by human work. Even on our little planet, which is diminutively small in comparison to the universe, proportions are too gigantic to show any traceable human influence.

The amount of carbon which is wrested from the interior of the earth by thousands of diligent hands and by other thousands is used for combustion, this whole amount of carbon is so exceedingly small as to dwindle away if compared to the gigantic stock contained in our terrestrial atmosphere. In spite of the small proportion of 0.04 vol. perc., it amounts to 800,000 million tons of carbon, and we add to this by annual combustion only 252 million tons of carbon, which is an increase of 0.0315 per cent. In addition to the 0.04 vol. perc. of the average proportion of carbonic acid in atmospheric air, the whole amount would be raised to 0.0400126 vol. perc.

The difference is so insignificant that it could not be determined by the most minute methods of investigation, especially as the homogeneity of air is great but by no means absolute.

From these and similar considerations we learn modesty when we compare human work to that of nature. Man's hand is too weak to interfere noticeably with the imposing mechanism of the cosmic gear. We work on a small scale, and too slowly to disturb the

*One gallon—three and four-fifths liters.

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equilibrium of the proportions ruling on earth. Ever suppose we used all pyrites which can be produce at all by mining, irrespective of pecuniary gains, and submitted them to the process of roasting and the manufacture of sulphuric acid in order to submerge all dolomites and limestones, the enormous quantity of carbonic acid which would develop, would be swept away by the wind, and soon be lost in the aerie ocean.

This our smallness must not affect or oppress us! In spite of it our time is great, perhaps the greatest which humankind lived. We may indulge in comparisons like those we made, but an estimation of our works must be done according to a human measure, for after all—we are men.