THE
POISONOUS EFFECTS OF COAL-GAS
UPON THE
ANIMAL SYSTEM.

BY
C. J. B. ALDIS, M.D. CANTAB., F.R.C.P.,
MEDICAL OFFICER OF HEALTH TO ST. GEORGE'S, HANOVER SQUARE.

Received Dec. 17th, 1861.—Read Jan. 14th, 1862.

I WAS induced to make the present inquiry in consequence of the examination of gas (as to its purity) now forming an important branch of my duties in the care of the public health. I also wished to ascertain whether cannel gas destroyed life sooner than common gas, since this question had arisen at a recent coroner's inquest. The third and fourth objects were to counteract, if possible, by publicity, the want of precaution often displayed by gas-fitters in the discharge of their duties, and to try means for their recovery when rendered insensible.

Mr. S. D. Broughton has published a very interesting inquiry on a similar subject in Brande's 'Journal of Science,' vol. xxix, but the gases which he employed were in a pure state.

The following are the results of some experiments made by myself, Mr. F. G. Evans, engineer of the Chartered Gas Company, and Mr. Henry Banister, assistant engineer, at the works in Horseferry Road, Westminster, November 8th, 1861.

A rat was first killed by means of a sharpened file thrust

into the brain, for the purpose of comparing the appearance of some of the internal organs with those of others destroyed by the gases. The eyelids were closed ; the lungs collapsed, and of a whitish colour ; both ventricles of the heart contained black coagulated blood.

I. *Experiment with cannel gas.*

A rat was placed under a bell-glass, six inches in diameter and ten high, into which cannel gas was passed through a three-eighths of an inch cock and tubing with half an inch bore. The animal soon began to gasp, and became insensible in twenty seconds after a slight struggle. It lay motionless for a few more seconds when convulsive movements were perceptible ; death occurring in sixty-five seconds. The eyes were open and projected greatly. The outer surface of the skull was exceedingly red, not only in this but in the other animals which were examined, and dark fluid blood escaped from the heads when opened. The superficial vessels on the surface of the brain pinkish, and some empty ; the substance of the brain pale. The lungs collapsed and of a pink colour ; the heart distended with darkish fluid blood ; congestion of the abdominal veins.

II. *Experiment with common gas.*

A rat was killed in the same way with common gas. It fell comatose in half a minute, without convulsion, and died in one minute and a half, after spasmodic action of the diaphragm. It lived longer than any other out of a total of twelve exposed to the action of the gases. The eyes open and projecting ; the vessels of the brain and its substance as in the previous experiment ; lungs collapsed and pinkish ; heart and abdominal veins distended with dark fluid blood.

III. *Experiment with cannel gas.*

A rat having been exposed in the same way to the action of cannel gas became insensible in twenty-five seconds, and

died in one minute. A post-mortem examination revealed the same appearances as those previously described, excepting slight coagulation of the blood in the left ventricle of the heart.

IV. *Experiment with foul gas.*

A rat exposed to foul gas under the glass vessel became insensible in eleven seconds, without convulsion, and died in three quarters of a minute. The eyes closed at first and subsequently opened, but did not project so much as in the other examples. On opening the body a strong smell of sulphuretted hydrogen gas escaped. The brain and lungs were much congested, and of a brownish colour; the heart greatly distended with dark fluid blood, the auricles being nearly black; abdominal veins distended with dark blood.

V. and VI. *Experiments with common gas.*

Two more rats were compelled to breathe common gas, one of which became insensible in thirty-three seconds, and died in one minute and twenty-three seconds; the other became comatose in twenty-one seconds, and died in one minute and ten seconds. The post-mortem appearances were identical with those detected in the second experiment.

On November 6th, the author examined six rats killed at the works in the same manner as the last six just mentioned, all of which had died with their eyes open. The post-mortem appearances were similar, but no record had been taken of the experiments during the administration of the gases.

In remarking upon the physiological results of the experiments it may be observed that death ensued from the combined effect of different coal gases, the chief constituents of which are, after purification, light carburetted hydrogen, hydrogen, carbonic oxide, carbonic acid, oxygen, nitrogen, and the condensable hydro-carbons; whereas the foul gas contains, in addition, ammonia and sulphuretted hydrogen.

Again, cannel coal-gas contains more hydro-carbon vapours than common gas, for which reason it probably destroyed life more quickly than the common gas.

The cannel gas supplied by the Chartered Company is made with a mixture of Bog-head and Newcastle coal, while the common gas is made from Newcastle coal enriched with a small per-centage of Wigan cannel coal.

The impurities of common Newcastle coal-gas, according to Lewis Thompson,¹ may be taken at $\frac{1}{2}$ part of ammonia, 8 parts of sulphuretted hydrogen, and 25 parts of carbonic acid in every 1000 measures of the gas. Dr. R. D. Thomson² gives the following analysis of London gas; olefiant 3·86 per cent, carburetted hydrogen 38·93, hydrogen 46·43, vapour of water 2·48, carbonic acid ·46, carbonic oxide 5·62, nitrogen 2·22.

While testing the gases from the Chartered Company with Cooper's tube, which may be considered merely as an approximation to the truth, I have found that the common gas contained about 1 to 2 per cent. of carbonic acid, 4 to 5 per cent. of hydro-carbon vapours, $\frac{1}{2}$ to 2 per cent. of carbonic oxide, but the cannel gas contained of carbonic acid from 1 to $1\frac{1}{2}$ per cent., carbonic oxide ditto, hydro-carbon vapour 12 per cent.

On a post-mortem examination of five bodies of persons quoted by Mr. Taylor in his work on poisons, there was congestion of the brain and its membranes, the pia mater gorged with blood and the whole surface of the brain intensely red and the blood coagulated. In two other cases there was congestion of the brain, but the blood was remarkably liquid. The effects, however, produced by the coal-gas were owing to its long-continued respiration in a diluted state, which may account for their difference when compared with the results of the preceding experiments. In these the blood of only one rat was loosely coagulated in the left ventricle of the heart. The brains also of all, excepting that killed by the foul gas, were free from congestion.

¹ 'Chemistry of Gas-Lighting,' p. 34.

² 'Evidence on Gas (Metropolis) Bill,' 3523, June 29th, 1860.

Mr. William Bloxam, junior, has kindly favoured me with the following notes of a case of poisoning by coal gas :

"On November 21st, 1861, at about three o'clock p.m. I was hastily summoned to No. 20, Mount Street, where I found the deceased, William Dunkley, supported in a sitting posture upon the shop floor; the surface of the body being cool, cornea glazed, face pale and placid, some froth in the mouth, pupil rather dilated, limbs supple.

"The premises smelt strongly of gas; and I suggested the desirability of stopping the further escape of gas and occurrence of accident, by plugging the pipe with clay, and as the sewers of the street were under repair, clay was at once obtained and used.

"I carefully examined the scene of accident, and in order to reach it, had to pass through a large workshop on the basement, which was so full of gas that I had to stoop very low, in order to breathe freely.

"In a narrow area, and at one end of it, was a small closet which appeared to have been formerly a larder. The door was open, but there being a fanlight over the door, an atmosphere of gas yet remained in the upper part of the closet.

"Tools lay on a shelf at the top; and I am told that the deceased was found on the top of a pair of steps in the closet, in a sitting posture, his head on one side, arms hanging down, and back leaning against the wall. He was connecting a meter.

"It is worthy of remark that he did not appear to have even attempted to descend from the steps.

"Autopsy twenty-four hours after finding the body.—External appearance—Face and upper part of body pale, no marks of violence; rigor mortis well marked; sugillation on whole of back of body and limbs. General appearance that of a somewhat feeble man. Blood everywhere fluid. Brain and membranes by no means congested, rather pale than otherwise. Lateral ventricles contained much pale serum. No coagulation in corpus striatum, optic thalamus,

crus cerebri, cerebellum, nor other position; brain and cerebellum apparently healthy. *A powerful odour of gas* on opening cranium and slicing brain down to corpus callosum. Lungs did not collapse on raising sternum and cartilages; were dark-red; darker at back of lobes, from gravitation of blood. Tissue healthy. Trachea and bronchi contained frothy mucus in some quantity. On securing a bronchus, removing lung, and collapsing by pressure, *a very strong odour of gas was perceived*. Right side of heart disturbed, left nearly empty. Blood black everywhere. Heart healthy. No signs of irritation or disease in abdominal viscera; congestion of abdominal system.

"The deceased was last seen alive an hour prior to the detection of the accident, and it seems reasonable to suppose that he died from the narcotic effect of the rapid inhalation of the gas. If asphyxiated, he would probably have made an attempt to get down; but there was, it seems, enough air to sustain life while the narcotic element was gaining upon him."

I cannot help believing that the deceased committed an error of judgment, which is too frequently the case, while adjusting the meter. For it appeared, from an inquiry at the works, that he had connected the pipe with the meter first, instead of with the pipe from the main, which latter he was effecting with a running socket so imperfectly united that sufficient gas escaped to destroy life. When we reflect that he was working with his head at the upper part of the closet, on a level with the fan-light of the door, he should have been doubly cautious; for when the gas escaped this part became a kind of gas-holder, and the deceased, having become insensible, was unable to lower his head beneath the frame of the fan-light; or had he but struggled and fallen, his life might have been spared.

In numerous instances gas appears to act like an anæsthetic agent by rendering the men, while at work, comatose, many of whom, when removed into the fresh air, gradually recover. They complain generally of a pricking sensation,

resembling that from pins and needles ; there is stupor with violent headache, giddiness, nausea, and sometimes vomiting. The countenance is puffy and livid, being of a dark bluish-black colour ; they look tipsy, and are obliged to be led, their legs giving way from under them, and the breath smells strongly of gas.

I made some further experiments, with Mr. Banister, on December 11th, which were conducted in the same manner as the preceding, except that the animals were rendered insensible only, and four were afterwards exposed to fresh air, but the other to the action of ammonia and fresh air.

I. *Experiment with common gas.*

A rat was stupefied in twenty-five seconds, after which it revived in thirty-five seconds on being placed in fresh air, and became quite lively.

II. *Experiment with common gas.*

A rat became insensible in thirty seconds, and afterwards recovered in fifty-five seconds on exposure to fresh air.

III. *Experiment with common gas.*

A rat was made insensible in thirty seconds, and afterwards placed under an inverted glass, having an opening at the top. A capsule containing a small quantity of ammonia was also put under the glass. The rat recovered in 105 seconds.

IV. *Experiment with cannel gas.*

A rat was stupefied in twenty-six seconds, and afterwards recovered in fifty-five seconds on exposure to fresh air.

V. Experiment with cannel gas.

Another rat, similarly treated, became insensible in twenty-nine seconds, and afterwards recovered in fifty-six seconds.

VI. Experiment with common gas.

This experiment was made on December 13th, when a rat was rendered insensible in thirty seconds, and afterwards passed through water into a large glass vessel filled with oxygen, where it recovered in eighty-five seconds.

From these experiments it appears that the animals recovered more quickly when exposed to fresh air than when other means were adopted.