XLIX.—On Wilkinson's Process for the Manufacture of Illuminating Gas from Wood.

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Though many substances have, from time to time, been suggested as proper materials from which to procure illuminating gas when subjected to destructive distillation, none seemed to equal coal, either in the quality of gas yielded or in the economy of manufacture. Fats, factory refuse, oil, petroleum have all even now a more or less extended use, and wood is frequently resorted to.

Practical difficulties, however, have always stood in the way of its more general employment. The moisture even in the harder varieties of wood causes a lowering of the temperature of the retorts to such a degree as to largely increase the yield of tar, pyroligneous acid, and gas liquor generally. Besides this, the water, by diminishing the heat, renders the amount of gas produced very small, while the oxygen it contains goes to augment the carbonic acid, the quantity of which may even exceed twenty-five per cent. of the gas. This large amount of carbonic acid necessarily diminishes the illuminating properties of the gas, or as it is commonly expressed, "kills the light." Its removal is therefore requisite, and the cost of purification increased. Except, therefore, in few cases, wood as a source for gas has been practically abandoned.

For several years past it has been customary in some gas works to push the heat in the coal gas retorts, and obtain thereby three or four thousand feet more gas to the ton of coal, but of a very low candle power, however. This poor gas was then, after purification in the usual way, carburetted either by naphtha vapor or "fixed" naphtha vapor, or by cannel gas. A very excellent quality of gas was thus made, and at a low rate.

The first instance of the use of such a process in this country, we believe, was with the company working under Tessié du Motay's patents, in Buffalo. It was proposed by this company to manufacture water gas and enrich it by means of carburetters placed in each house. The danger of the oil (gasoline) was recognized by the insurance companies, and the "*binary*" process of making gas was then inaugurated by Dr. Wilkinson, at that time (1872) chemist for the company. With some alterations this process is in use in all works where gas is enriched.

But coal gas manufacture was destined to a more radical change than this, in the adoption of the many processes for the production of

water gas subsequently enriched by naphtha. The cost of gas is hereby so greatly reduced that it seemed as if no better method could be suggested. Supplying a gas brilliantly white when burnt, of high gravity, affording great benefit, therefore, to consumers, the projectors of the new enterprises have already reaped, at least in New York, a goodly harvest.

But older companies could not abide such an invasion of their territories without remonstrance, and though naturally the competition at first caused fierce disputes, it ended as usual in a coalition.

It was during the heat of battle that the method we are to describe was invented. From an intimate acquaintance with all the methods in use, and especially those of coal and water gas, and the advantages and disadvantages of the several processes, Dr. A. W. Wilkinson, chemist of the Mutual Gas Light Company, devised the following plan, which was first tried experimentally at the works, then operated with several benches, and finally adopted on a large scale.

The ordinary clay retort of the gas works, but slightly modified, answers, though in subsequent experiments a somewhat different shaped retort was used, the retort being provided with a fall or "boot."

The essential feature of the process consists in reducing the carbonic acid to carbonic oxide, and at the same time of getting rid of all tar, acids and waste products. This is accomplished by forcing the gas through a bed of red hot charcoal. After the first charge of wood has been carbonized, the charcoal, instead of being drawn as with coke, is shoved back in the retort. The gas made from the second charge is therefore obliged to pass through this layer of red hot coal to reach the stand pipe at the rear of the "through" retort. The heat is pushed to get as large a yield of gas as possible, and the reduction of the carbonic acid correspondingly facilitated.

The water in the wood is also an active agent, since in this superheated state it forms water gas with the aid of the charcoal. The gas needs but slight purification. Nitrogen in the form of ammonia is virtually absent; little sulphur exists in any form, neither sulphuretted hydrogen nor carbon bisulphide being found, except in traces, while of tar there is not a trace.

To prevent too great an accumulation of charcoal, the retorts are drawn twice a day.

Fifty-three thousand eight hundred and thirty-two cubic feet of gas are produced from a cord of wood costing $5.25 per cord of 3,300 lbs., as computed from the average of six months.

The quantity of gas alone is thus four times as great as that which can be obtained from coal, costing an equal sum per ton as does wood per cord.

The crude gas has the following composition, as analyzed at the works by myself :

Hydrogen	44.10
Marsh gas	5.40
Carbonic oxide	33.75
Illuminants	none
Carbonic acid	10.50
Nitrogen	6.00
Oxygen	0.25
Ammonia	none
Sulphuretted hydrogen	none
	100.00

It is still customary with the Mutual Company to manufacture a poor quality of coal gas, which is, along with the wood gas, afterwards carburetted, and in which form it is termed "commercial" gas, and has a high candle power. An analysis of the coal gas, taken from the company's records from an analysis made at the works, shows it to be composed of :

Hydrogen	30.50
Marsh gas	41.00
Carbonic oxide	6.00
Illuminants	2.00
Carbonic acid	3.00
Nitrogen	16.00
Oxygen	1.50
Ammonia	trace.
Sulphuretted hydrogen	trace.
	100.00

The yield of coal gas is 14,645 cubic feet per ton of coal, costing $5.00. From this sum we must deduct the price received for coke, tar, and gas liquor.

Prior to admixture with naphtha vapor, the coal and wood gases are purified and passed to the storage holder. From this the gas enters an illuminator, so constructed that the naphtha running in is converted into vapor by steam heat, and thoroughly mixed with the gas. From the illuminator, the mixture of gas and vapor passes into super-

heated retorts, to be "fixed." 4.5 gallons of naphtha are used for every thousand feet of "commercial" gas.

As the naphtha is of good quality, no purification of the resulting gas is needed other than passing it through a coke box to remove any liquid naphtha.*

One hundred volumes of the "commercial" gas of the Mutual Company consists, at present, of 21 volumes of wood gas, 37.4 volumes of coal gas, and 41.6 volumes of naphtha gas.

An analysis of the "commercial" gas, showed it to contain :

Hydrogen Marsh gas	56.75
Carbonic oxide	11.25
Illuminants	15.25
Carbonic acid	1.00
Nitrogen	15.00
Oxygen	0.75
Ammonia	none.
Sulphuretted hydrogen	none.
	100.00

This analysis shows also, how closely the composition can be determined by separate analyses of its components, and how, by the speedy method of gas analysis introduced by Dr. Wilkinson, in use not only in the Mutual but other gas works, a complete control of each and every step in the process of manufacture is obtained. As the method has been fully described in the *London Gas Light Journal*, for August, 1877, but this brief allusion to it seems required. An addition was made in 1879 to the process whereby nitrogen could be determined and an account published in the *American Gas Light Journal*, of that year. The rapidity with which an analysis can be made, and the simplicity of the various steps, give it a decided advantage over other methods.

No new process of manufacture stops with the application of any single scientific discovery ; the adoption of wood, therefore, instead of coal, required several changes in the management of the retorts.

The want of coke for firing was the first requirement that made itself felt. Coke might, of course, be purchased from gas works, manufacturing by the older methods, but wood gas could only thus be manufactured in one or two of the larger cities.

* Traces of SI_2 are sometimes observable.

The furnaces were at the Mutual Works, therefore, supplied for a time from the coal benches; but, finally, grates were constructed, to allow the use of "pea" anthracite. The employment of hard coal was only feasible by an increased draught; but to obviate the use of a blower, yet accomplish this result, the following device was adopted.

At the base of the fire pot, an iron tube is inserted, having a blind end. This serves, on being heated red hot, by the fire, as a superheater for a jet of steam driven in through a central iron pipe, and passing nearly to the blind end of the exterior tube. The steam thus superheated passes next through a small injection pipe into the fire. A draught of air is drawn into the fire by this injector, and the combustion greatly accelerated. The steam also decomposes in presence of the coal, water gas is formed in abundance, and an intense heat, under absolute control, is attained.

The heat is greatly increased, too, by another ingenious device. Over the benches stretches a long, wrought iron tube, some two feet in diameter, and open at each end. The hot gases from the furnaces impinge upon this, heating the contained air. By means of suitable pipes, this heated air is drawn down by the steam injectors, and forced into the fires. A hot blast is thus procured. The saving of a dollar per diem for each fire, results from the combined use of anthracite and hot blast, over the old system of coke fires.

As regards the relative cost of "poor" coal or wood gas, it can be stated at 20 cents per thousand for coal to 9.9 cents per thousand for wood. Not only the four times greater amount of gas yielded enters in this calculation, but the large decrease in expense thereby caused in the less number of hands employed, and also the less cost of purification of wood gas made by this method. In the calculation of cost of coal gas the drawbacks in ammonia, tar, etc., have been considered. With wood there are none of these. But the Mutual Gas Light Company contends that it is a gas manufacturer, and therefore does not base its business on side issues.

After this brief outline of the special features of the mode of manufacture, we desire next to call attention to some rather remarkable facts developed in the chemical analysis of the "commercial" product. We have already detailed the analyses of the several constituents of the "commercial" gas, and shown how closely the analysis of the merchantable article agrees with what would be the theoretical result of mixing them in the proportions actually carried out on an enormous scale at the Mutual Works.

In a paper read before the American Association in Boston, August, 1880, Dr. E. G. Love, City Gas Examiner, reports the composition of the various gases sold in New York city.

Besides these, four other analyses of the Mutual gas are given; three made by Dr. Love, and one by Mr. H. C. Bowen, intended to show that there is no material difference in the quality of the gas made by the use of wood from that of coal. These were reported in the *American Gas Light Journal*, of Oct. 2, 1880. We insert both tables:

TABLE I.

CONSTITUENTS.	Manhattan Co.	Harlem Co.	Metropolitan Co.	N.Y. Mut'l Co.	N. Y. Co.	Municipal Co.
Hydrogen	45.79	46.53	35.41	10.57	27.14	26.25
Marsh gas	39.01	42.38	42.66	41.75	25.35	28.91
Carbonic oxide	6.31	3.14	9.17	9.53	26.84	27.12
Illuminants	6.38	6.31	7.41	15.41	14.63	15.80
Nitrogen	2.51	0.50	5.35	20.69	2.87	1.92
Carbonic acid	.....	1.08	.....	1.51	3.02	.....
Oxygen	.....	0.06	.....	0.54	0.15	.....
Sulphuretted Hydrogen	.....	trace	.....	trace	.....	.....
	100.00	100.00	100.00	100.00	100.00	100.00

TABLE II.

	I. July 16, 1880.	II. Aug. 5, 1880.	III. Sept. 8, 1880.	IV. Nov. 27, 1877.
Hydrogen	9.65	9.32	12.75	7.53
Marsh gas	43.55	42.40	39.21	48.63
Carbonic oxide	8.63	7.64	12.33	6.70
Illuminants	15.55	15.45	15.22	14.43
Nitrogen	19.92	22.79	19.36	19.85
Carbonic acid	1.48	2.16	0.89	
Oxygen	1.22	0.15	0.24	2.86
Sulphuretted Hydrogen	.....	.....	trace	
	100.00	100.00	100.00	100.00

Table No. I. differs quite widely in its statements, as published in the *Gas Light Journal*, from the way it was reported in the daily press at the time of the Boston meeting, four of the six analyses being much modified—two, however, being retained in exactly their original shape.

Thus with the Mutual gas the hydrogen, from being 28.87 per cent. falls to 10.57 per cent.; marsh gas rises from 22.95 to 41.75; carbonic oxide falls from 27.19 to 9.53, and nitrogen rises from 3.24

to 20.69 per cent. We are at a loss to explain these variations, especially as the quantity of illuminants is not modified. The gravity also remains as fluctuating between 0.703 and 0.808. The sulphur is 7.28 grains per 100 cu. ft., and the ammonia 82 grains per 100 cu. ft., in both analyses.

These discrepancies are, in comparison with the analyses of the commercial products of other companies, particularly noticeable. Yet Dr. Love has taken pains to show, by Table No. II., that analyses of the Mutual gas, ranging over a long interval, demonstrate its composition to be nearly constant. Thus, in comparison with other gases, the carbonic oxide was first stated to be 27 per cent., an amount in excess of that in any water gas enriched by naphtha, and a fact which does not accord at all with the process of manufacture of the Mutual gas, since we have shown that at least one-third is of a low grade of coal gas, which would contain about 6 per cent. carbonic oxide, and another third wood gas, with 30 per cent. Were these two gases mixed and distributed in equal proportion, there could only be 18 per cent. carbonic oxide, while as they form but 60 per cent. of the "commercial" gas, there would at most be but 10.8 per cent. of carbonic oxide. The analyses of Tables I. and II. agree to this state of things.

We are surprised also that a coal gas, such as that sent out by the Manhattan Company, should only contain 1.19 per cent., as in the first report. In Table I. it stands 6.31 per cent. Though in a foot note Dr. Love states: "I find considerable variation in composition, especially in those gases enriched by naphtha," we can hardly imagine them to take such curious fluctuations, since the process of manufacture precludes them.

However accurate such a method of analysis as Bunsen's may be, can it not be replaced with advantage by one which, though less correct, allows by the rapidity of execution, duplicate analyses, and thus gives a knowledge of the average composition of a commercial product? From personal experience, we know how tedious an analysis is, and how liable to error from mistakes, not only in the various steps of the method, but the subsequent calculations regarding temperature, pressure, moisture, etc., when carried out as indicated by Bunsen.

In Watt's Dictionary of Chemistry, **2**, 1036, we find the following:

"The effect of continuing the distillation too long, is that gases of a very feeble illuminating power, are evolved together with

nitrogen, which, when once mingled with the combustible gas, cannot be removed by any known method, and must seriously impair its illuminating power." We have shown, not only by our own analysis, but by Dr. Love's, that the Mutual "commercial" gas contains about 15 to 20 per cent. nitrogen. That this is not present as air, is seen from the only trivial quantity of oxygen. The nitrogen must have gained access, in great measure, from the fires around the retorts, as well as in small quantity from the leakage of air, the oxygen in the latter case being consumed in the retorts.

By an adjustment of the exhaust, the company attempts to keep the proportion of nitrogen in the "commercial" gas at 15 per cent., and there is not much variation from this figure.

No other New York company furnishes street gas with so high a percentage of a neutral gas.

According to Dr. Love's analysis, and his statement of the various candle powers, as given in Table III., the Mutual ranks as containing ten times as much nitrogen as the Municipal; yet, both having the same amount of illuminants, it is only three candle power lower. From photometric measurements at the College of the City of New York, the Mutual gas was found, on November 27th, to stand 25.5 candle power, and had 17 per cent. nitrogen.

TABLE III.

COMPANY.	Hydrogen.	Marsh Gas	Carbonic Oxide.	Total Non-Illuminants.	Illuminants.	Nitrogen.	Carbonic Acid.	Oxygen.	Candle Power.
Manhattan.....	45.79	39.01	6.31	91.11	6.38	2.51	....	....	19.76
Harlem	46.53	42.38	43.14	92.05	6.31	0.50	1.08	0.06	17.59.
Metropolitan ..	35.41	42.66	9.17	87.24	7.41	5.35	....	....	20.33
N. Y. Mutual..	10.57	41.75	9.53	61.85	15.41	20.69	1.51	0.54	26.53
New York	27.14	25.35	26.84	79.33	14.63	2.87	3.02	0.15	24.35
Muncipal	26.25	28.91	27.12	82.28	15.80	1.92	....	....	29.68

According to these facts, the old impression that the presence of nitrogen is destructive to the light-giving properties of street gas, must fall, or whatever holds goods for coal gas, is not found to follow in coal gas enriched by naphtha. Never before has gas been furnished in New York, of such brilliancy, as at present. Each company charges $2.25 per thousand. Let us suppose the Mutual Company delivers 3,000,000 cubic feet per diem; 15 per cent. of this, or 450,000 cubic feet, is nitrogen which, at $2.25 per 1,000, gives $1,023.50 per diem clear profit. This percentage of nitrogen does

not seem to cause any smoking of the flame; the company receives no more complaints on this score than do others. The consumption of naphtha is always about 45 gallons per 1,000 cubic feet of "commercial" gas, a quantity below that required in other gas works.

We specially desire, therefore, in connection with the description of the wood gas process, to point out these peculiarities regarding nitrogen, trusting new experimentation will develop more clearly the reasons for these phenomena.

Reports on American and Foreign Patents Relating to Chemistry.

American Patents.

Condensed from the Official Gazette of the **U. S. Patent Office**, by ARNO BEHR.

Dec. 7, 1880.

235,070.—*Process of treating wood, etc.* CHARLES B. CARTER.

A current of steam is passed over the wood, which has been subjected to distillation in a retort.

235,143.—*Manufacture of salt.* WILLIAM W. ELMER.

Brief: The object of the invention is to reclaim and purify "trash" salt, which accumulates about packing-houses, and for obtaining pure salt from old brine, and from impure salines.

235,148.—*Apparatus for condensing fumes.* AMOS E. GRIFFITHS.

235,170.—*Art of separating vegetable fibres from animal fibres.* GEORGE M. and ALFRED L. RICE.

The acid to be used is mixed with sawdust, or the dust of rags, and in this comparatively dry or mealy condition, more evenly distributed among the material to be treated.

235,193.—*Manufacture of artificial indigo.* ADOLPH BAEYER.

The dye-stuff is produced by the action of ferrous sulphate upon the sulpho-compound of orthonitrophenylpropiolic acid.

235,202.—*Sugar washing process and apparatus.* JOHN V. V. BOOREAM.

Mechanical process of preparing raw sugar for treatment, in a centrifugal machine.

235,203.—*Carbon pencil for electric lights.* JULIUS E. BRAUNSDORF.

Claim: A carbon pencil, provided with a central metallic conducting tube, filled with non-conducting material, for increasing or coloring the light.